TEACHING SCIENCE THROUGH ONLINE EDUCATION DURING THE COVID-19 PANDEMIC: SCIENCE TEACHERS' PRACTICES, SELF-EFFICACY BELIEFS, AND ATTITUDES TOWARD THE CHANGE

A Thesis Submitted to College of Graduate and Postdoctoral Studies

In Partial Fulfillment of the Requirements For the Degree of Master of Education In the

Department of Curriculum Studies

College of Education

University Of Saskatchewan

Saskatoon

By

Fazle Rafi

PERMISSION TO USE STATEMENT

In presenting this thesis in partial fulfillment of the requirements for a Postgraduate degree from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purposes may be granted by the professor who supervised my thesis work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in this thesis.

Requests for permission to copy or to make other uses of materials in this thesis in whole or part should be addressed to:

Head of the Department of Curriculum Studies
University of Saskatchewan, College of Education
Department of Curriculum Studies
Rm 3021-28 Campus Dr, Saskatoon SK S7N 0X1
Or,
Dean
College of Graduate and Postdoctoral Studies
University of Saskatchewan
116 Thorvaldson Building, 110 Science Place
Saskatoon, Saskatchewan S7N 5C9, Canada

ABSTRACT

The COVID-19 pandemic has had a remarkable impact on school (K-12) education worldwide. Institutions and teacher educators had to quickly respond to an unexpected and obligatory transition from face-to-face to remote teaching. During this teaching transition science teachers faced various challenges, particularly to inquiry-based activities as well as laboratory experiments employing online tools. Better understanding of the COVID-19 teaching situation of science teachers can aid teachers and various stakeholders concerned with providing quality science teaching and learning. Hence, this study explored science teachers' practices through the description of their experiences in the current context of COVID-19. Since teachers' perception of self-efficacy and attitudes affect teachers' pedagogical beliefs and teaching practices, this study also investigated teachers' perceptions of self-efficacy concerning teaching online remotely and teachers' attitudes toward the change of teaching transitions resulting from the COVID-19 pandemic. The instrument used to measure the three scales (teaching practices, self-efficacy, and attitudes toward the change) was a 39-item, web-based survey that was given to in-service Saskatchewan science teachers within seven Saskatchewan district school boards. The option for open-ended survey comments were kept ascertaining if teachers had any comments, or concerns in addition to the survey responses. Descriptive statistics, and inferential statistical tests were used to explore the differences of teaching practices, self-efficacy, and attitudes toward the change according to teachers' demographic characteristics. The study results indicated that teachers had to spend additional time in planning lessons, designing inquiry-based activities, and preparing assignments for online teaching during COVID-19 emergency remote teaching. Teachers had a low perception of self-efficacy for maintaining engagement with families and strengthening trust-based communication through online tools. Also, science teachers perceived that they had a moderate level of self-efficacy to perform the tasks related to their teaching practices during COVID-19 pandemic. Moreover, teachers reported less favorable attitudes toward the change that occurred during COVID-19 teaching. The study results are intended to be useful to the school divisions for planning and implementing adequate professional development training to enhance teachers' skills and knowledge for teaching science in online remote context.

ACKNOWLEDGEMENTS

First, I would like to remember most benevolent the almighty Creator for His graces, countless blessing, and strength to accomplish the study.

I wish to extend my appreciation and thanks to the following people and organization that made this study possible:

- To my ever supportive and humble supervisor Dr Tim Molnar for his generous cooperation, invaluable contributions, and instructions throughout my studies. His encouragement and directions are more than light to my path.
- To my committee members, Dr Amin Mousavi, and Dr Marguerite Koole for their candid and supportive feedback, and invaluable suggestions to accomplish my research. Thank you for your advice, expertise, and guidance along the way.
- To my academic unit, and Honorable Graduate Chair Dr Dirk Morrison for his constant inspiration and life changing guidance. Immense gratitude as always to Ms. Patricia Gillies for her support.
- To the superintendents of school boards, for allowing me to conduct my research within their schools, and for all the superlative support they had provided throughout data collection of my study.
- To the participants of the pilot study, who provided stimulating feedback to re-craft the survey instrument, and for giving up their time to contribute to this research project.

- To my wife, Sharmeen Akhter, for her unending support and encouragement; for all she had done to allow me to pursue my dream. I could not have done this without her inspiration.

DEDICATION

This dissertation is dedicated to my heavenly parents, who had been my source of inspiration and provided me the moral, spiritual, and emotional strength to fulfill my dreams. This research is also dedicated to the teachers who had to adapt virtual and online teaching during the sudden transition to online teaching due to the COVID-19 pandemic.

TABLE OF CONTENTS

LIST OF TABLES

LISTS OF FIGURES

1. INTRODUCTION

1.1 Background of the Study

The Online teaching transition during the COVID-19 school closure elicited challenges and opportunities for teachers and schools across the globe. This has necessitated teachers to modify their teaching pedagogies very quickly in a time of uncertainty to better educate their students (Sokal et al., 2020). Such a transition has also occurred in Saskatchewan. The rapid transition from face-to-face to remote teaching has entailed several challenges and constraints but also opportunities that need to be examined. Several recent studies indicate that the role of teachers is crucial for mitigating the harmful effects of school closures on students' education and wellbeing during the COVID-19 pandemic (Chadwick & Mcloughlin, 2020; Duffiled & O'Hare, 2020).

Before the COVID-19 school closures, many science educators were not enthusiastic with incorporating technology-based or distance education approaches in teaching science due to lack of appropriate technology and internet availability (Kennedy, 2014, as cited in Chadwick & Mcloughlin, 2020). However, during the emergency situation of COVID-19 pandemic, teachers had to embrace technology-based remote instruction. Many teachers had to further develop their technological abilities and skills to support learning (Duffield & O'Hare, 2020). In this vein, various forms of online teaching have emerged that were in existence prior to the COVID-19 transition; therefore, to better know and understand the current teaching characteristics, the processes, the outcomes, and the implications of online practices is desirable.

Siegel (2020) argues that there have been transformational challenges, and educators will not likely return to previous practice given the prolonged period of school closures forced upon teachers. Teachers will be forced to use electronic and online technology more extensively in their teaching. Like teachers in many countries around the world, Canadian teachers are using various technology-based instructional approaches for the delivery of their lessons. Many of them utilize online educational platforms like YouTube, learning management systems (LMS), emailing, digital libraries, discussion forums as means of asynchronous learning; in contrast, teachers use synchronous forms of learning by incorporating video conferences, interactive webinars, and chat-based online discussions (Lapada et al., 2020). Many teachers incorporated blended learning, a combination of distance education using technology with traditional face-to-face education, in their teaching practices that extends a platform for learners to experience independent online remote learning as well as face-to-face direct instruction (Lungu, 2013 as cited in Kaharuddin., 2020). For many subjects, particularly in science learning, practical activities and investigations are highly desired if not a curricular requirement. In this regard, the virtual laboratories helped teachers to promote students' inquiry-based knowledge base, and to overcome the problems faced by them in the online learning environment (Vasiladou, 2020). Of course, physical presence in school extends a real-time collaborative environment where teachers interact with their learners, provide guidance, and support, and give direction and feedback to student work which are essential for science learning. This prompts important questions, such as how these technological transformations have challenged and changed teachers' practices, and to what extent, if any, these changes have impacted science teachers' ability to perform teaching related tasks and attitudes toward the COVID-19 educational change.

The education sector in Canada, specifically school (K-12) education, has been heavily affected due to obstacles in delivering alternative forms of education during the pandemic (Dolighan & Owen, 2021). The school divisions in most provinces throughout Canada adopted a remote school teaching plan with varied educational policy and approaches during the pandemic.

According to the *People for Education, Canada*'s (2021) report, based on the public safety measurement and health protection protocols, school divisions have adopted the phased re-opening teaching that includes blended learning and remote learning for different age levels of learners. Most provincial public schools continue remote learning as second and third waves of COVID-19 persist; however, a few resumed in-person learning by following health and safety protocols. Thus, teachers' current teaching contexts and strategies vary as they deliver their instructions in synchronous and asynchronous online environments through the utilization of various technological devices such as smartphones, laptop computers, and tablet computers, along with networked connectivity (Noor et al., 2020). However, much is still unknown about the nationwide practice of online science teaching across the schools in the country. Examining what is occurring in Saskatchewan offers possible insight into more local situations and responses but also nationwide practice.

1.2 Statement of the Problem

The COVID-19 pandemic has fundamentally changed teaching practices. This rapid and emergency transition from face-to-face to remote teaching has likely entailed change that influences school teachers' teaching norms, beliefs, professional roles, teaching strategies, in response to a more virtual experience of teaching and learning which is a largely new experience for most of the school teachers (Noor et al., 2020). However, teachers faced a number of challenges and constraints to thrive in the different online practices and develop quality online teaching and learning that require careful instructional design and planning (Hodges et al., 2020). According to the study conducted by Tanık-Önal & Önal (2020), science teachers face particular challenges due to the limited opportunity to teach through experiment, procedures, lack of active student participation in inquiry-based activities, and unfamiliarly with simulated learning environments that allow students to complete laboratory experiments online). Consequently, understanding what support and professional development teachers will need to effectively make that transition going forward becomes critical in the context of the COVID-19 pandemic (Dolighan & Owen, 2021). This requires information concerning the experience of science teachers. Therefore, a focus on teachers' varied experiences, and gaining information on teachers' current instructional practices, classroom management, and professional roles with on online teaching and learning may aid instructional designers and administrators to design effective professional development that may better provide support for teachers in online learning environments (Dolighan & Owen, 2021). Despite the important work of past studies, there remains a lack of information regarding science teachers' practices in terms of lesson planning, preparing an inquiry-based model, the instructional delivery of inquiry-based lessons, classroom management, and professional responsibilities with on online teaching during the COVID-19 remote transformation.

Moreover, given that teachers' beliefs of self-efficacy, i.e. capacity, confidence and ability to organize and execute the pedagogical actions that lead to a positive learning environment, are highly associated with classroom practices (Beazidou et al., 2013, as cited in Poulou et al., 2019) there is a need to better understand these beliefs. At the same time, teachers' attitudes toward educational change are considered as one of the major determinants of the teachers' intention to perform one particular action (Kin & Kareem, 2017) and which is important to consider alongside the practices reported. Although researchers found a relationship between teachers' practices and their self-efficacy and attitudes toward change, studies do not focus exclusively on science teachers' practices and their perceptions associated with the COVID-19 teaching situation. Therefore, a study exploring science teaching practices toward the transition from face-to-face to an online learning environment would provide an opportunity to better understand teachers' experiences of instructional delivery and their confidence for teaching online. Teaching practices are influenced by teachers' self-efficacy and attitudes; therefore, investigating teachers' self-efficacy and attitudes are also desirable. In turn this may provide insight into how to better support teachers in an unprecedented transitional phase and in their future teaching whether a situation such as Covid returns or not. In other words, gaining information relating to the effectiveness of science instruction online in relation to teachers' gender, years of teaching experience, teaching grades, and teaching modalities might provide a broad understanding of adopted practices far using technology in a remote scenario.

Finally, in this new challenging situation of digital learning caused by the COVID-19 school closures, there is an urgency to supply adequate information for education policies and practices grounded in a better understanding of the found relations among teachers' practice, beliefs, and classroom culture. Although few recent studies have investigated the theme of COVID-19's impact on education from different perspectives, new research, assessments and evaluations can generate new information about this situation. Moreover, different contexts, data practices and analyses can be applied to increase the prevailing knowledge domain and consequently to better inform decision-making processes, policy development and implementation as practices at various levels in the school system (Huber & Helm, 2020).

1.3 Rationale and Purpose of the Study

The purpose of this study was to explore science teachers' descriptions of their practices and experiences in the current context of COVID-19 online remote teaching. More specifically, this study has investigated science teachers' experiences in the aspects of planning and preparing science lessons, inquiry-based science instructions including assessments, discussion and class activities, classroom management, and teachers' professional responsibilities to engage the community in learning in the context of the COVID-19 online remote teaching transition. Teachers' personal experiences and interactions relevant to specific practice-based situations, challenges and constraints beyond the mere description of field experiences are more likely to facilitate their construction of knowledge on teaching and learning (Carrillo & Flores, 2020). Hence, this study also addressed the pedagogical challenges, responsibilities, and professional limitations to develop inquiry-based science education in the emergency online remote teaching.

Teachers' beliefs about their capabilities to develop challenging and meaningful lessons, manage the classroom effectively, and perform their professional role are associated with the successful implementation of a positive learning environment (Poulou et al., 2019; Tschannen-Moran & Hoy, 2001). Moreover, teachers' self-efficacy is an influential predictor for the implementation of inquiry-based instructional practices and curriculum in the classroom (Bencze, Bowen, & Alsop, 2006, as cited in Laplante ,1997). Therefore, this study also aimed to investigate teachers' perceptions of self-efficacy beliefs for teaching online remotely in four main sources: mastery experience, vicarious experience, verbal persuasion, and emotional arousal (Bandura,1977). In addition, teachers' attitudes as precursors of behaviors better inform the sense of the images and ideas about teachers' thoughts, beliefs and intention toward the educational change (Kin & Kareem, 2017). Thus, this study intended to investigate teachers' attitudes which consist of three components: cognitive, affective and behavioural responses (Dunham et al., 1989; Elizur and Guttman, 1976, as cited in Kin & Kareem, 2017) toward the transition from face-to-face to remote teaching. Since the inclusion of demographics variables provide a broad understanding of any practical scenario, this study investigated teachers' practices, self-efficacy and attitudes toward online remote teaching during COVID-19 pandemic in light of demographic factors such as teachers' gender, type of internet access, teaching experience, school locations, and teaching grade level. These three perspectives or frameworks provide the foundation for grounding the study, the crafting of the survey tool to be employed and interpretation of results. These frameworks are explained more fully in the following section.

1.4 Theoretical Framework

The goal of my study was to explore the teachers' perspectives of teaching practices, self-efficacy, and attitudes toward the change during COVID-19 teaching. Hence, the theoretical framework of this study can be understood using three models: Danielson's theory of teacher evaluations or framework of teaching (1996), Bandura's (1977) self-efficacy theory, and Ajzen's (1985) theory of planned behavior: attitudes toward the change. The theoretical underpinning for determining teachers' practices to teach science using online tools in this study are based on the teachers' perceptions of the four domains of Danielson's theory of teacher evaluations or framework of teaching (1996). The instructional components of the framework is grounded in a constructivist view of learning and teaching and are aligned to four principles of teachers' evaluation : a) planning and preparation, b) classroom instruction, c) classroom management, and d) professional responsibility which are used by teachers to provide feedback well as allow teachers to make the necessary changes for improvement of instruction to increase student achievement (Danielson, 2013; Doerr, 2012). However, the foundation of Danielson's (2013) framework for teaching is based on the constructivist theory of learning developed by Dewey, Piaget, and Vygotsky (Danielson, 2007; Doerr, 2012). Although the framework of teaching (Danielson, 1996) is used for teacher evaluation purposes, considering teachers' perspectives on four domains of Danielson's (2013) teaching model can be critical to gain insight into teachers' teaching practice during COVID-19 teaching transition. However, Danielson's (2013) framework for teaching is rooted in the constructivist theory of learning developed by Dewey, Piaget, and Vygotsky (Danielson, 2007; Doerr, 2012; Kane & Staiger, 2012). Thus, teacher-incorporated classroom activities and instructions are prime indicators for classroom success (Vygotsky, 1978 as cited in Love-Kelly, 2020). However, performing these tasks are fundamentally influenced by Bandura's (1977) self-efficacy beliefs related to performance attainments.

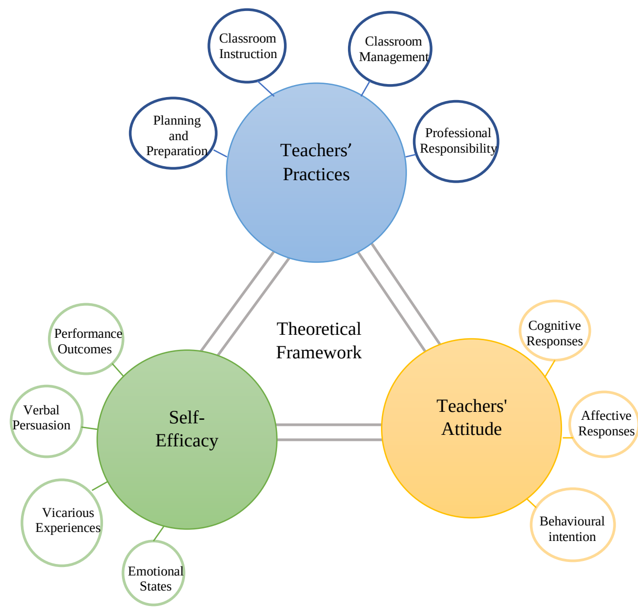
The teachers' ability to structure the classroom environment is explicitly dependent on the teachers' belief of self-efficacy to perform tasks that promotes students' success at challenging situations (Bandura, 1997; Capa-Aydin et al., 2018). Self-efficacy, theoretically grounded in Bandura's (1997) social cognitive theory, refers to "a belief in one's ability to organize and carry out the actions needed to produce desired results, and it provides a theoretical lens through which to evaluate teachers' ability and willingness to implement curriculum" (as cited in Cruz et al., 2020, p. 199) , and it provides a theoretical lens through which we can evaluate teachers' ability and willingness to implement online remote teaching. Bandura (1997) outlined four sources of information that individuals employ to judge their efficacy: mastery experiences (performance accomplishments), vicarious experiences, verbal persuasion, and physiological states (emotional arousal). However, teachers' may exhibit their perceived self-efficacy in their school-based teaching, specifically in the COVID-19 situation when their planned behaviors and feeling are affected by the instructional change in the new context, lack of face-to-face contact with students, and the need for concurrent technological demands (Kin & Kareem, 2017; Sokal et al., 2020).

In emergency online practices during the COVID-19 pandemic, teachers had to develop a set of potential skills and behaviors for creating productive online teaching environments.

Understanding the nature of teachers' attitudes toward change (TATC) is essential to carrying out desired teaching behaviors during the COVID-19 pandemic and must address the three components of attitudes: cognitive, affective, and behavioral intention (Breckler & Wiggins, 1989; Kin & Kareem, 2017; Sokal et al., 2020). According to Ajzen (1985), "attitude towards the behavior refers to the degree to which an individual has a favorable or unfavorable evaluation or appraisal of the behaviour in question, for example, starting to take steps to create a new business" (Tornikoski & Maalaoui, 2019, p. 537). People's positive perceptions help to promote their attitude towards the behavior and strengthen the intention to engage themselves in the activities pertaining to the behaviors (Kin & Kareem, 2017; Tornikoski & Maalaoui, 2019). Thus, investigating teachers' attitudes toward change due to the pandemic and technological transformation in the light of teachers' characteristics such as gender, teaching experiences, and teaching grades may inform teachers' perceptions and awareness level about specific technological change. Figure 1 below illustrated the entire combined theoretical underpinnings adopted for this study to address teachers' practices, self-efficacy beliefs, and attitudes toward the change.

Figure 1:

Theoretical Framework



Note: The theoretical framework of the study is adopted from the Danielson's, (2013) ‘The Framework For Teaching’, Bandura's, (1977) ‘Self-Efficacy Theory’, and Ajzen's, (2015) ‘Theory of Planned Behavior’.

1.5 Significance of the Study

Through this study, teachers will have the opportunity to share their opinions with co-teachers and other stakeholders of the institution about the strengths and weaknesses of their online teaching in the context of the COVID-19 teaching transition. Moreover, the results of this study can guide teachers' decision-making on instructional strategies, lesson delivery techniques, instructional media, classroom climate, and student assessment to promote student learning and engagement. Beyond improving teachers’ individual practice, this research is potentially useful to the school divisions for planning and implementing professional development trainings to enhance teachers' skills and knowledge on the necessary domain areas for teaching science in an online remote context. Additionally, educators from outside the current geographic locations may find this study relevant to their own efforts in contextualizing pedagogical approaches.

1.6 Delimitations of the Study

The following delimitations are present in this study:

- Since this study is exploratory and descriptive in nature It does not aim to identify cause-and-effect relationships between COVID-19 technological transformation and teaching practices. This study is not intended to measure the extent of changes that occurred in teachers' practices, self-efficacy, and attitudes before and after the COVID situation and does not consider any additional objective data.
- Teachers in the middle and high school levels typically evolve their principles, practices, and strategies to help develop their students' critical thinking skills; therefore, this study focused only on mid and high school science teachers, who have experienced the technological transformation of their teaching during COVID-19 pandemic.

1.7 Research Questions

To conduct the intended research, this study is seeking to answer the following research questions:

1. How do science teachers rate themselves in relation to four dimensions (*Classroom Instructions, Planning and Preparation, Classroom Management, Professional Responsibilities)* of their teaching practices in the context of COVID-19 pandemic?

2. Are there any significant differences in teaching practices when analyzed according to gender, type of internet access, years of teaching experience, population centre, and grade level?
3. What are the teachers' perceptions of their self-efficacy of teaching science in COVID-19 online teaching transition?
4. Are there any significant differences in teachers' self-efficacy when analyzed according to gender, type of internet access, years of teaching experience, population centre, and grade level?
5. What are the teachers 'attitudes toward change that occurred during the COVID-19 transition teaching?
6. Are there any significant differences in teachers' attitudes when analyzed according to gender, type of internet access, years of teaching experiences, population centre, and grade level?

1.8 Definition of Terms

There are several terms that are important to this study. As such, the following terms are operationally defined.

Teaching practices. A teacher's tasks that are associated with the implementation of the curriculum and the instructional strategies. They include planning and design of instructions, delivery of the instructions, classroom assessments, classroom management, quality and quantity of instruction provided, student/teacher interactions, classroom rapport and climate, monitoring of student progress, professional competence, and parental involvement (Wang et al., 1993).

Teachers' belief of self-efficacy. "Teachers' belief in their ability to effectively handle the tasks, obligations, and challenges related to their professional activity, plays a key role in influencing important academic outcomes (e.g., students' achievement and motivation) and well-being in the working environment" (Barni et al., 2019, p. 2), and that has a positive effect on student learning and classroom management approaches.

Teachers' attitudes toward the change. Teachers' thoughts, feelings and emotions about the educational change that encapsulate both the negative and positive views of cognitive, affective, and behavioral elements (Dunham et al., 1989).

Online teaching. The use of online tools to deliver lessons, activities, assignments, exams, and to communicate with the instructor and other students without needing to physically attend a class during a time of emergency when traditional classes cannot meet in-person (College of canyons, 2021)

Online instructional tools. Technologies or online resources that are used in delivery of educational lessons that incorporate active learning process, activities, and assessments (Ndihokubwayo et al., 2020).

Learning management system (LMS). A Learning management system is type of software designed to deliver, track, and manage training and educational courses over internet which offers virtual learning environments, online collaboration, track of learner progress, access, and record of the learners' performance (Cavus, 2013).

Online learning platform. An online learning platform is an integrated set of services or a group of technologies that "provide the learners with information (content); tools, such as social learning media; activities; and resources, that support and enhance their quest to learn new skills and knowledge and supports the learners' Personal Learning Environment (PLE)" (Clark, 2015, para 2).

Remote learning. Remote learning can occur synchronously or asynchronously when the learner and instructor are separated by time and distance and so that no physical presence in the classroom is required. Instructions are typically delivered using online learning tools; otherwise, it would be blended learning (Stauffer, 2020).

Emergency remote teaching (ERT). Emergency remote teaching (ERT) is a temporary shift of instructional delivery to an alternate delivery mode due to immediate crisis which involves the use of remote teaching instruction that would otherwise be delivered fully online or as blended courses, and that will return to that format once when things are settled and go back to normal (Bozkurt & Sharma, 2020).

E-Learning. E-Learning, or electronic learning, is the delivery of education and training through the electronic devices such as computers, tablets and even cellular phones that are connected to the internet, and facilitate learning anytime, anywhere (Lawless, 2019).

Danielson's four domains of teaching. The professional practice and responsibilities of teachers are categorized into four areas: planning and preparation, classroom environment, instruction, and professional responsibility. The domains are divided into subcategories called components that are more specific to each domain (Danielson, 1996).

1.9 Chapter Summary

This chapter provided an introduction to the research of teaching practices, teachers' self-efficacy, and attitudes towards the teaching during COVID-19 pandemic. Chapter I contains an introduction, statement of the problem, purpose of the study, theoretical framework, delimitations, research questions and definition of terms, and significance of the study. In Chapter II, a thorough review of the literature is discussed. The research methodology employed in this study is broadly discussed in chapter III, including: the population, instrumentation, procedures, and data analysis. Chapter IV contains the analysis and findings of the data collected in the study. Finally, in Chapter V, the summary of the findings of the study, limitations, and conclusion from those findings were discussed. Also included in this chapter are the implications and recommendations for practice resulting from the study as well as recommendations for future research are addressed in this chapter as well.

2. LITERATURE REVIEW

2.1 Introduction

To better understand and examine the teaching characteristics during COVID-19, I examined the literature related to past and recent contexts of online science teaching practices, teachers' perceptions of self-efficacy and their reactions toward the change. The process for selecting the literature included in the current study started with a search in the databases Web of Science (main collection), Google Scholar, and Education Resources Information Centre (ERIC). The literature review is explored through three major lenses. The first lens reviews the history of science teaching practices, Danielson framework of teaching and online remote teaching as a core tool for COVID-19 teaching transition. The second lens provides a summary of the literature related to teachers' perceptions of science teaching and perceptions of self-efficacy for online remote platforms. Finally, the literature review highlights literature through the lens of the teachers' attitudes toward the change during the COVID-19 pandemic teaching.

2.2 Teachers' Practices

2.2.1 Technology Based Science Teaching:

Educational technology and web-based online learning brought a dynamic change in current science education systems to actively engage in the acquisition of scientific knowledge and development of the nature of science and inquiry. According to The National Science Teachers Association's (NSTA) *Position Statement* report, the use of e-learning promotes students' inquiry and scientific investigations skills, students' engagement to their knowledge construction, and improves students' thinking and problem-solving skills the context of in science education and learning (NSTA, 2016). NSTA (2016), reports e-learning as an effective instructional method in the following ways:

- Online teaching provides science teachers with the opportunities to experience the appropriate use of technology in teaching and learning and improve their teaching practice.
- Use of well-designed virtual labs can enhance teachers' ability to develop scientific concepts and investigations among their students.
- Online teaching experiences provide opportunities for teachers to develop pedagogical skills to explain phenomena or design solutions to problems; and
- Effectively designed e-learning extends an environment that allow frequent interaction between teacher and learner which helps teachers to continuously monitor and adjust the dynamic learning environment.

In short, NSTA (2016) report provides important points about online remote learning and teaching, and how they facilitate science educators—especially those in rural areas or teaching specialized science subjects to engage their students to their learning practice by enhancing their active participation virtually. However, it is important to know the recent developments of online remote learning that are widely used in teaching inquiry-based science practices.

2.2.2 Learning Management Systems in Science Education:

A learning management system (LMS) is a type of software for delivering, tracking and managing Education (Cavus & Alhih, 2014). An LMS offers building computer-based courses that fosters an interactive learning environment online, can accommodate digital contents, variety of assessment, self-paced leaning, and knowledge sharing options among the learners

(Cavus & Alhih, 2014; Pandey & Pandey, 2009). An LMS also allow students to do coursework anywhere and anytime. According to Brown & Johnson (2007):

> Each LMS package has its own unique components yet some features that are common to most LMSs such as creation of class rosters (student record), control over registration processes, and the ability to create waiting lists, uploading and managing documents containing curricular content, delivery of course content over web-based interfaces, most often allowing remote participation by the instructor or pupil, creation and publication of course calendars, interaction between and among students, such as instant messaging, email, and discussion forums and methods of assessment and testing like creating pop quizzes. (as cited in Cavus & Alhih, 2014, p. 517).

Nowadays, learning management systems can have a promising effect on science teaching and learning as through an LMS teachers can represent scientific phenomena using digital contents, foster experimental study, and enable the organization of models and problem-solving applications (Cavus & Alhih, 2014). According to research carried out by Ekici et al. (2012), LMS use was found successful in improving system the effectiveness of teaching Basic Physics. Their study results indicated that teacher candidates have positive ideas about course instruction with the use of an LMS. The research carried out by Quarless and Nneto (2012) aimed to explore science instruction in blended learning mode using LMS. The results supports the idea of the use of an LMS as a potential instructional tool for as an innovative instruction for improved learning outcomes (Cavus & Alhih, 2014). Therefore, an LMS does not only customizes learning content, it also offers personalized and collaborative learning experience with flexibility. A standard LMS provides learners a unique learning space to share knowledge with their peers, foster problem-solving tasks, and facilitate collaborative discussion and learning. While learning management systems provide the opportunity to promote student-centered teaching and learning processes, teachers often face difficulties in encouraging student interaction through the use of an LMS (Barczyk & Duncan, 2013; Brady et al., 2010; Deng & Tavares, 2015; Minocha, 2009 as cited in Govender, 2010). The collaborative tools such as content-sharing social media and discussion forum which are often used within an LMS course may not always facilitate effective student engagement and peer interactions; therefore, it has been recommended to have intensive training for both students and teachers for the use of LMS in an optimal way to enhance student engagement (Govender, 2010). Thus, it becomes imperative to understand the factors that may influence teachers' attitudes toward using the LMS in learning effectively and the impediments they face to implement LMS that may also help instructional designers to design online courses to enhance students' learning experiences.

2.2.3 Online Synchronous and Asynchronous Learning

Within the context of remote learning, methods of student interaction and their engagement in online courses are usually classified as either synchronous or asynchronous environments (Shoepe, et al., 2020). "Synchronous distance learning refers to a learning activity that students and instructors are engaging in learning at the same time" (Lin and Gao, 2020, p. 170). In online synchronous environments, the students and teacher meet in a virtual live session using audio and/or video teleconferencing, virtual classrooms, and instant messaging (Ruiz, Mintzer & Leipzig, 2006 as cited in Lin & Gao, 2020). Students in synchronous online classes can instantly communicate with instructors and peers, and synchronous live activities are effective to build the strong relationships among the peers and the instructors by ensuring their active participation. (Francescucci & Rohani, 2019 as cited in Lin & Gao, 2020). On the other hand, asynchronous learning is a form online education that facilitate students' ability to access information and communicate and interact with their peers and instructors on their flexible time. (Ruiz, Mintzer & Leipzig, 2006, as cited in Lin & Gao, 2020). In asynchronous remote learning, students' participation is more flexible as it allows students and teachers to interact at a comfortable pace and helps leaners to self-pace their studies (Hrastinski, 2008; Pang & Jen, 2018, as cited in Lin & Gao, 2020). Asynchronous learning allows students to access their learning materials at their own time and schedule. As the asynchronous learning environment facilities self-spaced learning, it enables students to develop a higher order thinking skill because of its autonomous nature of learning path (Lin & Gao, 2020). In their experimental study, Lin, and Gao (2020) used synchronous and asynchronous methods to deliver their college courses during the COVID-19 pandemic in China. Their study summarized potential advantages and challenges of both methods as illustrated below:

Table 1

Comparison of Synchronous and Asynchronous Remote Learning Demonstrated in Lin and Gao's (2020) study

Learning Environment	**Advantages**	**Challenges**
Synchronous remote learning	• Can discuss learning content with peers, Easy and fun to communicate with peers and the instructor • More discussion opportunities • More actively participation	• Learners cannot self-control the learning pace • Too many LSMs that need to use for different courses • Some students do not actively participate the class • Leaners' may feel tired due to focus on the electronic device for a long time

Asynchronous remote learning	• Can choose to organize or structure learners according to needs and personal schedule. • Conduct deeper learning by watching or visiting the contents repeatedly	• Less classroom communication, peer interaction and discussion • Feeling distance from others that may demotivate learning • Not able to ask the instructor questions right away for feedback • Not fully understand the learning content through self-learning

2.2.4 Online Virtual Laboratories

Virtual laboratories have been used for teaching purposes inquiry-based science learning for distance education. With the scope of virtual laboratory environment, students can perform experiments at home and laboratory sessions to run as traditional laboratory (Vasiliadou, 2020). Although virtual laboratories are unable to replace entirely the functionality of the physical experiments in real laboratories it can be combined with physical laboratories or be used alone according to the necessity of the academic settings. According to Vasiliadou (2020), "during COVID-19 pandemic, students can perform the experiments online without any time limitations, receive instant feedback, familiarize with health and safety regulations, repeat the experiential activities and generate data for their assessment" (p. 482).

The simulation-based online laboratory extends the technology-based inquiry process which helps students to be more engaged in their inquiry activities and prepare more productively for their physical laboratory (Faulconer & Gruss, 2018). In contrast, one option for a non-traditional lab is eScience labs, "where kits are shipped directly to students globally and the experiments are performed at home, with the assistance of video tutorials, animations, and a lab manual" (eScience Labs, 2014 as cited in Faulconer and Gruss, 2018, p. 160). Alternatively, PhET Interactive Simulations, (2020) offers interactive simulation environments with over 150 interactive simulations for teaching and learning physics, chemistry, math, and other sciences. The comparison of virtual lab with traditional lab explored the in Faulconer and Gruss's (2018) review is illustrated below:

Table 2

The comparison of Traditional and Online Laboratory Modalities (Faulconer & Gruss, 2018)

Benefits	Traditional lab	Online or remote
Tangible results with sensory feedback	√	√
Comparative lower maintenance costs		√
Student expenditure	(variable)	√
Flexibility with class sizes	√	√
Replication		√
Anytime use		√
Multiple access opportunities		√
Disability access	√	√
Student-instructor interaction	√	(variable)
Minimal Precaution		√

2.2.5 Science Teaching Practices in COVID-19

During the COVID-19 pandemic, science teachers are challenged to organize teaching of not only theoretical knowledge but also practical aspects; they need to transfer their inquiry-based science practices and laboratory activities to an online environment. (Babinčáková &

Bernard, 2020). There is a growing body of research that has investigated science teachers practices during COVID-19 where online remote learning is central. Babinčáková and Bernard (2020) consolidated the experiences of secondary chemistry teachers from Slovakia, who earlier were adequately trained with the necessary skills and tools to run virtual classes, and online laboratory experiments. The study used online questionnaires to offer the teachers experience in using online teaching tools, live interactive demonstrations, and simulations to conduct their online experimental practices. This can help teachers' determine the pros and cons of carrying out experiments in this way, as well as well as explore reflections by their students about the experiences (Babinčáková & Bernard, 2020). The study results indicated that teachers would pick the basic techniques, such as photos/pictures of experiments with a description or recorded videoclips beside the simulation based online laboratories, and they noted positively that "during an online lesson they can run measurements quicker, or just show a video clip of a measurement taken earlier, and then focus on data analysis and conclusions" (Babinčáková & Bernard, 2020, p. 3298). At the same time, students reported that online tools or virtual laboratories could not help facilitating understanding the experimental procedures properly; and it limits the direct interaction between teacher and students which negatively affects their classroom collaboration. (Babinčáková & Bernard, 2020). While virtual lab is considered as a powerful educational tool that enables students to perform experiments at the comfort of their home, one limitation is that it requires a good technological skill. Students face challenges to foster their analytical skills due to lack of experiences to conduct experiments online.

Although the primary focus with Babinčáková and Bernard's (2020) study was to investigate teachers' experiences of using various online instructional tools in inquiry-based learning and challenges they face to meet their students' needs and expectations, there was no mention of how teachers attempted to engage their students' collaborative investigations with the use of online learning tools and virtual environments. Moreover, the absence of comparative samples did not allow the study to reflect teachers' inquiry-based practices online to a great extent. Therefore, there is a need for research that will provide insight into the detail more in-depth perceptions on teachers' inquiry-based practices in online learning environment along with their cognitive and affective responses as variables would be helpful.

A recent study by Johnson et al. (2022) explored the factors that are associated with teachers' ability to devote time to perform teaching related activities and planning during the emergency online remote teaching situation. According to Johnson et al. (2022), many teachers had no proper guidance and preparation time before initiating emergency remote teaching which urged teachers to devote increased planning time to design and implement effective instruction in this new context (Branch & Dousay, 2015 as cited in Johnson et al., 2022). The finding of the study revealed that factors such as teachers' technology literacy, age, positive school climate, instructional support etc. had effects on teachers' teaching and related time (Johnson et al., 2022) during COVID-19 teaching. However, the study was not intended to provide information on how teachers' other demographic factors such as teaching grades, school types or internet accessibility have affected teachers' planning and preparation during emergency remote teaching.

Otero-Mayer et al. (2021), in a quantitative study, explored how parent-teachers' communication took place during the COVID-19 teaching situation, as well as the way in which cooperation between families and schools could be established. The study results showed that most families did not have adequate technological literacy to communicate with their children's teachers. Moreover, the factors such as lack of internet access of families, families' educational qualifications etc. had negatively affected parent-school collaboration (Otero-Mayer et al., 2021). Therefore, it would be interesting to know the perceptions of science teachers in terms of communication between parent-teacher, how they establish trust with families, and the value of the culture of the students' family using online tools.

In a seminal study, Ozdemir (2021) in a qualitative study explored teachers' viewpoints who practiced online STEM activities in a science course during the transition process to distance education due to the COVID-19 pandemic. The research was carried out with six Science teachers of the 7th grades in public schools in Turkey through which teachers' opinions about online STEM implementation were obtained via a semi-structured interview. The study results indicated that "during the online STEM activities, students and teachers could easily and quickly access resources via the internet, and online STEM implementation contributed to developing students' 21st century skills, such as problem solving, accessing and analyzing data, and critical thinking"(Ozdemir, 2021, p. 854). Although, in this study, teachers had positive and negative feelings about online STEM implementations, and most teachers found online STEM implementations are beneficial for students to foster their scientific literacy (Ozdemir, 2021) . In another study, Noor et al. (2020) argued online teaching practices during the COVID-19 pandemic are confronted by "high-cost Internet packages, uncooperative learners, low attendance of learners, teachers' technology confidence, limited availability of educational resources, lack of ICT knowledge, and poor network infrastructure" (p. 169).

Ozdemir (2011) only included a small samples of high school teachers from the school region, and the research was carried out with 7th grade Science course teachers and students which weakens the generalizability of findings; however, employment of a different learning environments at various grade levels, with different units could detail more in-depth perceptions on teachers' practices and their cognitive and affective responses as variables. Moreover, understanding the different aspects of pre-preparation for online science courses, and revealing their preferred mode of online teaching would benefit to gain insight about teachers' professional growth plans that require teachers to identify areas of improvement, and conduct self-assessment which are central for the transition to remote education in COVID-19 pandemic.

In the studies cited above, teachers' science practices could be well addressed by using demographic data that would help to understand how teachers' individual factors ties to their competence and ability to implement online inquiry-based science practices during COVID-19. Therefore, more systematic studies that address the factors that influence teachers' science practices including the classroom management and family involvement in teaching in COVID-19 would be desirable. Finally, the second outbreak of the pandemic in 2021 and further lockdown of schools forced many educators to embrace online remote learning, and to use appropriate online resources to prepare them for decent further online teaching. Even for the post covid situation, it maybe these skills will be valuable, and teachers and their students will benefit from more effective blending of virtual and face-to-face environments.

2.2.6 Teaching Practices and Danielson's the Framework for Teaching (FFT):

Danielson's Framework is generally used for teacher evaluation purposes. The framework is generally used as an indicator of effective teaching and sets up a structure for gauging professional learning and the practice of teaching (Danielson, 2007, as cited in Doerr, 2012). The framework of teaching (Danielson, 2013) involves teachers' reflections and professional growth; however, "the integration of four domains (Planning and Preparation, the Classroom Environment, Instruction, Professional Responsibilities) as a holistic, interrelated framework to connect the common aspects of teaching serves as the foundation for a common tool examining the essentials of good teaching" (Caletha, 2017, p. 19). However, understanding the current education crisis and uncertainty in the education system due to adapting to COVID-19 pandemic, the Danielson Group (2020) has devised the existing framework for remote teaching. The framework for remote teaching (Danielson, 2021) prioritized the understanding of individual teacher's reflection on knowing and valuing their students and their families, what they learnt to create supportive online environments, and what changes they needed to bring in designing coherent instruction to facilitate student engagement. In this framework, the teaching activities

Table 3

The Four domains of Danielson's framework for Remote Teaching

Domain	Components	Features
Planning and Preparation	Demonstrating Knowledge of Students	• Knowledge of child and adolescent development • Knowledge of the learning process • Knowledge of Students' Intersecting Identities • Understanding of Students' Current Knowledge and Skills
	Demonstrating Knowledge of Resources	• Resources for classroom use • Resources to extend content knowledge and pedagogy • Resources for students
	Designing Coherent Instruction	• Tasks & activities to engage with meaningful contents. • Multiple strategies for flexible Learning • Lesson and unit structure • Instructional groups
The Classroom Environment	Creating an Environment of Respect and Rapport	• Teacher interaction with students • Student interactions with other students
	Managing Classroom Procedures	• Productive Collaboration • Student Autonomy and Responsibility Management of materials and supplies

		• Equitable Access to Resources and Support
Classroom Instruction	Using Assessment in Instruction	• Assessment criteria • Feedback to students • Student self-assessment and monitoring of progress
	Engaging Students in Learning	• Activities and assignments • Collaboration and Teamwork • Use of Instructional Materials and Resources
	Using Questioning and Discussion Techniques	• Discussion techniques • Student participation • Critical Thinking and Deeper Learning
Professional Responsibilities	Engaging families & communities	• Respect and Cultural Competence • Engagement of families in the shared vision of student success • Engagement of families to decision-making process

are divided into following 4 domains of teaching responsibility: 1) Planning and Preparation, 2) Classroom Environment, 3) Instruction, and 4) Professional Responsibilities (Danielson, 2007). Each domain contains multiples components that describe specific features of the domains. The features of domains components for framework for online teaching are illustrated below:

Earlier, Sweeley (2004) conducted a study to seek teachers' attitudes regarding Charlotte Danielson's four domains of teacher evaluation from 230 teachers in the State of Pennsylvania after the adoption of Danielson's framework by the Pennsylvania Department of Education in 2003. This study was replicated by Doerr (2013) to determine teachers' perceptions on the four domains of Danielson's framework for teaching. Both of the studies were intended to "understand how teachers can be held accountable for their actions in the classroom while increasing student achievement" (Doerr, 2013, p. 1). Doerr (2013) in his study used a quantitative Likert scale survey if teachers agreed or disagreed with the components of Danielson's (1996) framework for teaching. The results of both studies indicated that participants teachers agreed that the components within Danielson's four domains were effective in addressing their understandings concerning teaching and learning.

Although the framework for teaching (FFT) focuses on improvement of instructional practices and professional learning explicitly, scholars face significant challenges to substantiate the utility of all FFT domains in educational practices. According to Morris-Mathews et al. (2020), the instructional domain of Danielson's FFT has a smaller number of elements of the domains for individualized instructions such as teaching practices regarding students with disabilities. It was evident that "without a firm footing in these fundamental practices, the rubrics may not effectively differentiate between levels of performance for teachers of students with learning disabilities" (Morris-Mathews et al., 2020, p. 54). However, the effectiveness of FFT for self-paced learning and associated teaching practices are yet to be examined, and whether FFT rubrics would likely serve as a barrier to equitable and efficient learning opportunities.

Based on the evidence from past studies (Doerr, 2012; Caletha, 2017; Sweeley, 2004) , that Danielson's framework of teaching teachers and administrators were able to adopt new resource plan for teachers' professional development, supervision, and evaluation, utilizing this framework seems productive. These concepts can also aid the school divisions to devise teachers' professional development training that provides "teachers with the power and authority to provide classroom assistance according to the teachers' need" (Doerr, 2012, p. 71). Since the framework provides teachers with the opportunities to explore their teaching experiences and promotes the growth for professional development, this framework can be potentially useful to improve the teachers' perceptions about their teaching practices, and for better understanding of what support and training teachers will need to effectively teach in the context of the COVID-19 transition.

2.3 Teachers' Self-Efficacy

Teachers' instructional practices are composed of tasks concerning planning their instruction, implementation of the pedagogy, and effective classroom management. However, alongside pedagogical skills and content knowledge, teachers need to have the confidence in their abilities to perform tasks related to effective instructional practices which can positively affect student outcomes such as motivation and academic achievements (Duffin et al., 2012). Gaining insight into teacher self-efficacy in the COVID-19 context would therefore seem a desirable undertaking. According to Bandura (1997), self-efficacy beliefs stem from four sources: mastery experiences, vicarious experiences, verbal persuasion, and emotional and physiological states.

2.3.1 Mastery Experiences:

Mastery Experiences are a vital source for self-efficacy derived from the individual's previous actions (Haverback, 2020; Bandura, 1997). For example, when a teacher plans and teaches a lesson if the teacher is successful in their action, they will feel more efficacious when teaching such content in the future. During the teaching transition in COVID-19, "teachers [were] automatically building their mastery experiences while teaching online" (Haverback, 2020, p.4) which allowed teachers to explore the pedagogy of teaching in online.

2.3.2 Vicarious Experiences:

Individual's self-efficacy beliefs can be created by observing other's performing the same taskIf the performer is successful, the observers' self-efficacy beliefs will increase (Blonder et al., 2014; Haverback, 2020). For example, if a teacher observes a master teacher's performance that builds his or her vicarious experiences, and master teacher is successful in execution of the lesson, the observer's self-efficacy can rise. This experience is highly influential on teachers' self-efficacy for the adoption of new instructional technology skills (Blonder et al., 2014), particularly in the COVID-19 virtual situation when novice teachers had the opportunity to observe experienced teachers' videos for online teaching lessons.

2.3.3 Verbal Persuasion:

Verbal persuasion is one of the sources of self-efficacy that involves continuous feedback which strengthens people's personal efficacy to promote developmental skills (Bandura, 1977). According to Bandura (1994), "If people can be convinced verbally by others that they possess the capabilities needed to master a given task, they are likely to invest greater effort and sustain it when problems arise (as cited in Blonder et al., 2014; p. 5). Tschannen-Moran and Hoy (2007) stated that teachers having lack of mastery experiences can boost their efficacy using other sources such as vicarious experiences and verbal persuasion which promotes their sense of success, and personal efficacy. Thus, effective mentoring can promote one's positive sense of efficacy to perfom better in a challening situation. In online teaching plarform during COVID-19, teachers have more flexibility to work in a group to support each other, they are able to share their ideas , and most importantly, share positive verbal responses to one another.

2.3.4 Emotional and Physiological States:

People's abilties to perfom tasks are dependent on their emotional and physical state such as anxiety, stress, fatigue and mood (Bandura, 1997; as cited in Blonder et al., 2014). However, "if a teacher has positive feelings toward a pedagogical domain (confident, knowledgeable, prepared), these feelings may positively impact his or her self-efficacy" (Haverback, 2020, p. 3). On the other hand, if a teacher feels negatively toward a pedagogical domain (unprepared, nervous, and unknowledgeable), these feelings can negatively impact his or her self-efficacy beliefs. Thus, teaching in virtual environment in COVID-19 situation challenges teachers to maintain or develop confidence and positive emotional states so they can perform their pedagogical tasks.

Although Bandura's four sources of self-efficacy are considered as powerful cognitive determinants of people's future behaviors, researchers also contend that "outcome expectations may significantly determine future behavior irrespective of whether individuals believe they are competent or not to carry out the task" (Marzillier & Eastman, 1984). Further, Nabavi (2012), from her findings reported that self-efficacy, as a construct of social cognitive learning theory (SCLT) is not fully systematized to address the broader personality and where minimal attention was given to motivation, conflict, and emotion which may change over the lifespan. As the self-efficacy beliefs and outcome expectations both influence human behavior, investigating how teachers' degree of perceived beliefs are related to the teaching and learning practices is important.

2.3.5 Relating Teachers' Self-efficacy to Teaching Practices

Previous studies have emphasized that teachers' self-efficacy is a crucial factor influencing teachers' performances (e.g., instructional practices, motivating styles, pedagogical beliefs, and effort); teachers with high self-efficacy utilize a variety of instructional strategies to enhance autonomy-supportive learning, student engagement and achievement outcomes, and to overcome the teaching challenging situations (Fives & Alexander, 2004; Heneman et al., 2006; Lin, Gorrell, & Taylor, 2002; Skaalvik & Skaalvik, 2007; Tschannen-Moran et al., 1998; Woolfolk & Hoy, 1990; Woolfolk, Rosoff, & Hoy, 1990; as cited in Duffin et al., 2012).

Similarly, teachers' ability to structure the classroom environment is explicitly dependent on teachers' belief of self-efficacy to perform tasks to promote students' success at challenging situations (Bandura, 1997; Capa-Aydin et al., 2018). A more comprehensive relationship between classroom behaviors and teachers' self-efficacy can be understood in Gibson and Dembo's (1984) study that measured teachers' sense of efficacy for teaching. Moreover, subsequent studies also linked teachers' self-efficacy to the lesson planning and presentation, classroom management, questioning (Saklofske et al., 1988) and teacher success in implementing innovative instructions (Stein & Wang, 1988). Therefore, teachers' self-efficacy beliefs became fundamental for resources planning and preparation, as well as for creating a classroom Environment of Respect and Rapport. Although the importance and relationship of teachers' self-efficacy and their practices is clear, understanding science teachers' self-efficacy is important to foster e inquiry-based teaching practices.

2.3.6 Science Teachers' Self-Efficacy

Science teachers possess beliefs about their scientific pedagogical knowledge that influence their teaching practices (Mobley, 2015). For example, teachers' lack of confidence in implementing inquiry-based activities and scientific knowledge cause teachers' poor performance in science teaching. Mobley (2015) states the science teaching as follows:

> Teaching science content in an integrated STEM context is a complex act placing great cognitive and emotional demands on teachers, many of whom lack experience with this manner of teaching and may also lack the content knowledge necessary to navigate multidisciplinary requirements associated with integrating STEM subjects. (p. 7)

Bandura (1997) reported finding a positive correlation between teachers' self-efficacy, and implementation of inquiry-based instructional practices and curriculum in the classroom (Bencze et al.,2006). Palmar (2006) in his study indicated that mastery experience plays an important role to develop science teachers' content knowledge, pedagogical competency, sense of support, and to build the foundation of efficacious science teaching. Nonetheless, these factors are also critical to strengthen teachers' belief in ability to successfully teach integrated STEM or inquiry-based science teaching (Mobley, 2015); a central focus of the Saskatchewan science curriculum and those of other jurisdictions. In this connection, several studies used scales to measure teachers' self-efficacy such as *Science Teaching Efficacy Belief Instrument (STEBI)* by Enochs & Riggs, (1990) and *Self-Efficacy to Teach Science in an Integrated STEM (SETIS)* scale (Mobley, 2015). While informative these scales were not directly aligned with investigating science teachers' self-efficacy for teaching online remotely.

2.3.7 Online Teaching Self-Efficacy During COVID-19

Online teaching transition during COVID-19 pandemic escalated challenges for teachers around the word. Teachers' confidence for teaching online differ from in-person teaching as they started to teach virtually, with little or no experience (Haverback, 2020). During COVID-19, teachers were required to transform their practices including pedagogical knowledge, instructional strategies, classroom environment, and assessment format into online virtual platform. As a result, teachers face challenges in the application of instructions, information-communication, organizing virtual teaching related activities, online learning resources, and communication with students (Ma et al., 2021; Verma et al., 2020). Moreover, Haverback (2020), in his study indicated that teachers teaching in online must employ some "essential characteristics with sudden onset of COVID-19, it is especially vital that teachers feel efficacious in what they are teaching" (p. 6). Thus, it is arguably important to address how teachers perceive their self-efficacy beliefs in terms of mastery experience, vicarious experience, verbal persuasion, and physiological states to implement virtual teaching practices in COVID-19 pandemic. If teachers' self-efficacy (TSE) for teaching online during the pandemic varies from teaching in physical face-to-face contexts then gaining insight into science teachers' understanding of their experience with, for example inquiry-based teaching, and their science teaching ability generally, would be productive.

Teachers' working conditions as form vicarious experiences and verbal persuasion are critical to teachers' self-efficacy to perform teaching tasks and achieving their sense of success (Farkas et al., 2000; Johnson, 1990; Johnson and Birkeland, 2003; Murnane et al., 1991, as cited in Kraft et al., 2021). In a study, Kraft et al. (2021) captured how supportive working conditions such as principals' feedback, collaboration with colleagues etc. played a critical role in obtaining their sense of success which is critically associated to teachers' self-efficacy to perform teaching related tasks. The study results (Kraft et al., 2021) found that inadequate institutional support as a form of working condition has negatively impacted in obtaining teachers' sense of success which modulates their own sense of self-efficacy during the COVID-19 pandemic teaching. This finding (Kraft et al., 2021) is consistent with that of Fackler & Malmberg's (2016) study results for investigating effects of teacher, classroom, school and leadership characteristics on teachers' self-efficacy in non-pandemic context. According to Fackler & Malmberg's (2016), school principal's leadership skills, school feedback culture, and institutional strategies of teacher support as a source of verbal persuasion positively effect Teachers' Self-Efficacy (TSE). Thus, it would be interesting to see how science teachers' self-efficacy during COVID-19 pandemic teaching are influenced by those sources of vicarious experiences and verbal persuasion.

In a different study, Pressley and Ha (2021) explored the effect of COVID-19 teaching transition on teachers' self-efficacy, specifically instructional and engagement efficacy. They used Teacher Sense of Efficacy Scale (TSES) (Tschannen-Moran & Hoy, 2001) to collect survey data from United States teachers during fall 2020 of the school year. The study was carried out when teachers were considering both virtual and hybrid or all in-person model of teaching. The study results (Pressley and Ha, 2021) revealed that teachers' self-efficacy for instructional delivery and student engagement were low as they had experienced the new teaching requirements. Also, the results suggested no statistical differences in teachers' efficacy when compared with years of teaching experience, teaching location, previous accolades, or instruction level. However, study didn't reveal any information regarding effect of varied demographic characteristics such as gender, teachers' access to the internet etc. on teachers' self-efficacy.

Although few recent studies addressed the changes in teachers' self-efficacy in relation to teaching online during the COVID-19 crisis, there is a lack of research examining science teachers' perceptions of their self-efficacy in the context of the technological transformation in COVID -19 pandemic, and how their self-efficacy may vary across demographics. Therefore, this study explores factors associated with science teachers' self-efficacy in fostering science teaching practices during COIVID-19 pandemic.

2.4 Teachers' Attitudes Toward Change

Generally, people to learn act according to their behaviors which are strongly associated with their emotions; and emotions are modulated by desirable or undesirable attitudes toward change. The concept of teachers' attitudes toward the change is rooted in Ajzen's (1985) theory of planned behavior which specifically described how an individual's behavior is associated with performing a specific behaviour. Although Ajzen's (1985) planned behavior did not reveal the processes of the change behavior, it served as a theoretical foundation for an individual's attitude towards organizational change (as cited in Sokal et al., 2020).

The term teacher attitudes toward change were coined by Dunham et al. (1989), in developing the attitudes toward change scale (ATCS) which was successfully used to measure Korean vocational high school teacher attitudes toward school change. Attitudes toward the change is a try-dimensional concept which has three components: cognitive, affective and behavioural components (Breckler & Wiggins 1989; Dunham et al.,1989; Farley & Stasson 2003; Oreg 2006; Piderit 2000, as cited in Kim & Kareem, 2017). Generally, the cognitive component deals with the individual's beliefs and thoughts about any situation or person's behavior; the affective component (affect) deals with a person's feelings toward the person or object; and the behavioural component address person's behavioral intention to take action towards a person or situation (Breckler & Wiggins 1989; Dunham et al.,1989).Consistent with this principle, Kin & Kareem, (2017) adopted ATCS to develop teacher attitudes toward change (TATC) model, the model was intended to effectively identify and assess critical attitudes in the face of school change. According to Kin & Kareem, (2017):

> Cognitive responses to change are the teachers' beliefs about the need for change, the importance of the change and the favourability of outcomes (i.e. the extent to which the change will be personally and organizationally beneficial and the knowledge required to manage change). Affective responses to change refer to teachers' feelings about the change – feeling satisfied or anxious about change; it is the tendency of teachers to enjoy changes in schools. Behavioural reaction to change examines the extent to which teachers would take action to support or initiate change. (p. 44).

However, the study by the Kin and Kareem (2017) was limited to definitive causal direction among the three dimensions of TATC, and further investigation was suggested on their reciprocal relationship with demographic factors in an exploratory manner for a better understanding of TATC (Kin & Kareem, 2017). Recent studies in science practices provide new insights about teachers' attitudes and help us gain a better sense of the images and ideas that teachers hold about inquiry-based science teaching and learning. Few studies directed attention to the significance on teachers' attitudes in science teaching and in particular attitudes toward inquiry-based learning (IBL)(Hofer & Lembens, 2019).What results there were revealed that science teachers' positive attitudes are critical for planning, implementing and reflecting upon IBL activities such as discussing the methods, laboratory procedures, reliability of data etc. (Hofer & Lembens, 2019). However, less is known about the teachers' feeling or attitudes when they place their students within the Inquiry Based Learning (IBL) environment in understanding concepts in an online classroom.

2.4.1 Teachers' Attitudes Toward Online Teaching

Technology can have positive effects on education, but not all people consider it effective. While many educators are comfortable with technological change, others do not welcome technological change and do not enjoy the challenge (Edison & Geissler, 2003). An assessment of teachers' attitudes toward technological change may contribute to instructional researchers and evaluators better understanding factors associated with maintaining or improving science teaching practices.

Several studies have indicated that teachers' attitudes toward computers have significant implications for their behaviour in the use of computers for teaching (Davis, 1989; Francis, Katz, & Jones 2000; Kellenberger & Hendricks, 2003; Lawton & Gerschner 1982; Troutman 1991, as cited in Edison & Geissler, 2003). Edison & Geissler (2003), in their study used a sub-scale to measure attitude toward technology and investigated relationships between technology acceptance or resistance and differentially distributed demographics. The finding of their study indicated several personal factors that contribute to general attitude toward technology. Suggesting that, teachers' feelings about the adoption of technology must be addressed to understand the associated personal and demographic factors for the acceptance or resistance to technology in the context of remote teaching.

A study Cavas et al. (2009), indicated that there were positive correlations between science teachers' attitudes toward technology integration. Some studies found that there is no significant relationship between teacher's age and attitudes (Massoud et al., 1991) toward the teaching with technology. However, study results also showed teachers' ages have significant effects on the teachers' attitudes, where teachers with longer teaching experiences had more positive attitudes toward the online teaching (Chio, 1992; Blankenship, 1998 as cited in Cavas et al., 2009). Since Implementation of science instruction strongly depends on the attitudes of science teacher, additional studies on differences of science teachers' attitudes with varied demographics would help more to understand the science teachers' acceptance or resistance of computer technologies.

2.4.2 Teachers' Attitudes Toward the COVID-19 Teaching

The COVID-19 pandemic presented an urgent need for a global change in teaching, many teachers quickly shifted their teaching practices from face-to-face to remote online teaching. Recent studies indicated that some teachers believed the moving from face-to-face to online remote was very logical decision for learners learning and safety; however, some teachers felt online lessons highlighted inequities (Sokal et al., 2020), caused unnecessary burden on teachers and parents, and teachers' feelings of concern were less effective in remote teaching (Sokal et al., 2020). Sokal et al. (2020), in their study revealed that during the COVID-19 pandemic teachers' affective and cognitive attitudes toward change became less favorable, and teachers' behavioural attitudes toward change were not altered to any large extent.

Since the ongoing COVID-19 pandemic provides a rare opportunity for teachers to explore how they will engage students in developing their scientific literacy. Teachers face challenges engaging students with inquiry-based activities through online learning which may affect teachers' thoughts and feelings about the change to online teaching. Therefore, investigating science teachers' attitudes toward change as an indicator for teachers' readiness for change and resistance to change (Bouckenooghe, 2010) is desirable. Considering such experience against demographics factors (gender, age, teaching modalities, technology accessibility, teaching grades, and school types) may also provide useful insight into what is productive or not regarding science teaching practice.

2.5 Implications of the Literature Review

Despite the important work of the scholars, there remains a lack of information regarding teachers' practices, efficacy and attitudes toward the online remote transformation during COVID-19. These gaps in information include the following:

- Although the review of the literature found a relationship between teachers' practices and their self-efficacy or attitudes, studies do not focus exclusively on science teachers' practices and their perceptions associated with the COVID-19 teaching situation. Therefore, more reliable data are needed for a better understanding of effective online inquiry-based science practices, how their attitudes and self-efficacy beliefs affect the COVID-19 teaching, and barriers that prevent teachers integrating technology into their instructional practices during COVID-19 teaching transition.
- Moreover, a comfortable and respectful classroom environment is a necessary component of teachers' practices that cultivates a culture for learning and creates a safe place for risk

taking (Doerr, 2012). Further, teachers-learner interactions, teacher collaboration and building relationships with family members are highly critical for co-construction of knowledge among students (Biasutte, 2011; Doerr, 2012) and greatly influential for cohesion of learning communities (Komninou, 2017). A gap in the research exists in the context and circumstances in which science teachers have had to develop above-mentioned practices, and to understand how those features in teaching are integrated in science teaching in the transition from the face-to- face to the online remote format.

- In methodological terms, the majority of the articles reviewed used qualitative methods with small samples. Although very few studies conducted investigations through a quantitative research design, the lack of diverse and larger populations population coverage, and representations of data analysis did not reveal the insights that are needed to avoid teachers' instructional disconnect during the COVID-19 pandemic. In addition, contextual factors as well as variability in teachers' teaching grades, gender, experiences, and teaching modalities have remained unexplored in past studies.

When acknowledging that the current circumstance of emergency remote teaching may remain in post COVID era and that teachers might need to switch from face-to-face teaching to online when required, gaining knowledge on the associated factors to online remote teaching is central to integrating technology to support their teaching practices. Therefore, a more systematic and theoretical analysis is required to conceptualize a typology that may fill these gaps in knowledge.

2.6 Summary of the Literature Review

The research provided a distinct overview of the research philosophy of different methodological approaches through which I can underpin my methodological approach, research strategy, data collection techniques and analysis procedures. Furthermore, the findings of the previous studies helped me in designing my research to examine the perspectives of science teachers with different teaching experiences, qualifications, and genders that may enrich the literature regarding high school science teaching during the COVID-19 pandemic and post covid situation.

The discussion carried out in the literature relating to online remote teaching during COVID-19 pandemic contributed to understanding the factors associated with teachers' practices to foster scientific literacy in their online classrooms. The implications of the existing literature suggest an increased demand for knowing about science teachers' practices during the COVID-19 teaching transition, and how teachers' perceptions of self-efficacy and attitudes impact inquiry-based science practices. Therefore, there is an urgency to conduct research studies that will present the varied levels of knowledge, and the perceptions of teachers that are necessary to improve teachers' ability to incorporate online remote instruction in science practices. Finally, investigating the teachers' perspectives in a practical context using quantitative research would help to include more subjects and enable more generalization of results; and the expected results of research would contribute to teachers' professional development programs to embed online remote instructions in their science practices by creating the most equitable opportunity for students' academic success.

3. METHODOLOGY

3.1 Introduction

The purpose of the study was to explore teachers' practices, self-efficacy, and attitudes toward the change, and to identify their relationships with the teacher demographics. Based on the research questions, an exploratory, descriptive-research methodology was adopted to explore science teaching practices in the context of online teaching during COVID-19. According to Doerr (2012), "descriptive studies are primarily concerned with finding out what exists and rely on observation and survey methods to collect descriptive data. This type of design is appropriate for this study because there is a focus on identifying perceptions" (p. 95). For this study, an online survey questionnaire was used which was comprised of three different scales: (a) Teaching Practices, (b) Teachers' Self-efficacy, (c) Teachers' Attitudes Toward the Change. Moreover, the teaching practices scale was split into 4 dimensions (a) Classroom Instruction, (b) Planning and Preparation, (c) Classroom Management, and (d) Professional Responsibility based on Danielson framework of teaching (2007). The demographic variables used to compare the teachers' measuring scales were: (i) gender, (ii) type of internet access, (iii) years of teaching experience, (iv) population center of teaching, and (v) grade level of teaching. Comprehensive descriptions of the research design, research participants, research instruments, and the procedures will be discussed in this section.

3.2 Research Design

3.2.1 Participants and Setting

The participants for this study were in-service mid and high school teachers teaching science in Saskatchewan urban and rural schools who completed the study survey. The province has 18 public school divisions and over 13,000 teachers in publicly-funded schools in

Saskatchewan (Saskatchewan Teachers' Federation, 2020). The data were gathered from the participating teachers employed during the 2020-2021 school year. Selection procedures were based on convenience sampling, but care was taken to ensure that the participants are selected based on the criteria of mid and high school science teaching who are currently teaching science in online learning platforms. Convenience sampling is the most frequently used sampling technique in quantitative studies that is affordable, easy and the subjects are readily available, "where members of the target population that meet certain practical criteria, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate are included for the purpose of the study" (Etikan, 2016, p. 2).

3.2.2 Demographics:

The results from recent research indicated that teachers' gender, length of service in teaching, population center, and access to the technology are among the most important predictors of online-learning teaching (Dea & Negassa, 2019; Pressley & Ha, 2021; Pellerone, 2021). However, teaching in different modalities is also considered a strong predictor for effective teaching (Carrol & Burke, 2010). When investigating teachers' practices, self-efficacy, and attitudes, I was also interested in making comparisons regarding science pedagogy across the different grade levels. Therefore, my exploration of teaching practices, self-efficacy, and teachers' attitudes toward change had considered the demographics factors: (i) gender, (ii) type of internet access, (iii) years of teaching experience, (iv) population center of teaching, and (v) grade level of teaching. The participants could answer questions related to demographic factors at the beginning of the survey questionnaire (See Appendix B). The first 7-items of the survey questionnaire are associated with teachers' demographic characteristics. The items 6 to 7, two demographic characteristics used in the survey questionnaire: percentage of online instructional delivery used by teachers before and doing COVID-19 pandemic teaching; however, these were not being used to investigate the differences of teaching practices, self-efficacy, and attitudes (See Appendix D). Participants of the school divisions were made aware that the survey questionnaire that they were invited to complete were completely anonymous.

3.3 Procedures

3.3.1 Instrumentation

The main purpose of this study was to explore teachers' practices during their experience of COVID-19 based on Danielson's (1996) framework of teaching. The first 16-items of the survey instrument (Appendix B) address four domain areas of Danielson's (2020) framework for remote teaching (Danielson, 2020) which were restructured by the Danielson group in the focus of online remote teaching during the COVID-19 pandemic by keeping the themes same of original Danielson framework of teaching (1996) . The four domain areas are: planning and preparation, the classroom environment, instruction, and professional responsibilities. Each domain area was divided into serval components or sub-domains, and then into elements (Table-4). The sub-domains and elements were classified by indicator statements on a level of performance matrix ranging from unsatisfactory, basic, proficient, to distinguished (Danielson, 2020). The survey items for teaching practices study were developed from the indicator statements in each element area at the proficiency level of the performance matrix. This part of the survey accompanied the 7-point Likert scale questions that include the ratings: strongly disagree, disagree, somewhat disagree, neither agree or disagree, somewhat agree, agree, and strongly agree (Appendix A, Part -B).

The survey items 24 to 32 in the survey instrument, (See Appendix B) related to teachers' perception of teachers' self-efficacy belief are adopted from Mobley's (2015) Self-Efficacy to Teach Science in an Integrated STEM (SETIS) scale. Mobley (2015) developed the

SETIS instrument with acceptable validity and reliability for the measurement of the latent factors describing science teachers' self-efficacy to teach science within an integrated STEM framework. The SETIS survey instrument consisted of 19 items on a 1-4 Likert-type scale within three factors (Social, Personal, and Material) which was administered to active elementary, middle, and high school science teachers currently teaching STEM courses using convenience sampling technique. Internal consistency (homogeneity) was addressed using the Cronbach coefficient alpha test. For Factor 1: Social with its ten items had a reliability of 0 .917, Factor 2: Personal, had a reliability index of 0.918 with its five items, and Factor 3: Material, had a reliability index of 0.878 with its four items (Mobley, 2015).

All eight-items (item 24 to 32, Appendix B) of 5-point Likert scale included a rating of teachers' confidence ranges from not confident at all, slightly confident, somewhat confident, fairly confident, to completely confident to perform certain tasks related to technology integrated teaching and learning took place during COVID-19 pandemic. As survey items for the teachers' self-efficacy were adopted from Mobley's (2015) SETIS scale, items only related to science teaching were selected and slightly modified in the context of online remote teaching in COVID-19 pandemic. For example, an original item response of "I am confident in my ability to elicit support from my supervisors (principals, administrators, school district) to teach integrated STEM effectively" was added and contextualized as "I am confident in my ability to elicit support from my supervisors (principals, administrators, school district) to teach science effectively in online". For some items, the word "STEM" was replaced with the word "Science" and added "Online learning platform" to contextualize the survey questionnaire to the COVID-19 online teaching transition.

The survey items of 33 to 39 in the survey instrument, (Appendix A, Part-D) addressed teachers' attitude toward the change which were based on Teachers' Attitude Toward the Change Scale (TATCS) (Kin & Kareem, 2017). TATCS was originally constructed by adapting the Attitudes toward Change Scale (ATCS) which was initially developed by Dunham et al. (1989). A total of 936 teachers from 47 high-performing secondary schools completed the TATCS survey which contained 17 items with three factors model: (a) cognitive, (b) behavioural, and (c) affective reaction to change. In the assessment of internal consistency, the Cronbach's alpha scores for three constructs of TATCS – *Affective*, *Cognitive* and *Behavioural* – were 0.778, 0.816, and 0.757, respectively. The developed instrument exhibited normed chi-square with required threshold of <5 with a value of 4.412, Tucker–Lewis index (TLI) = 0.966, and comparative fit index (CFI) = 0.977 which indicated high goodness-of-fit (Kin & Kareem, 2017).

However, TATCS items were slightly modified in the context of technological transformation in COVID-19 pandemic. For example, the item used to inquire about the affective reaction to change (AFF) in TATCS scale was *"Change frustrates me"*. This was re-worded and contextualized as *"I feel frustrated with the change in teaching due to the adoption of online teaching tools during Covid-19 pandemic teaching"*. The domains and subdomains are categorized by indicator statements on a level of performance rating ranges from *strongly disagree*, *disagree*, *somewhat disagree*, *neither agree nor disagree*, *somewhat agree*, *agree*, to *strongly agree*. Table 4 below lists the student self-report measures, the subscales/domains, and the primary sources of the terms for each of the subdomains.

Table 4

Data Instrument's Scales

Scales	Domains	Sub-domains	Survey items (Appendix B)	Sources
Teachers' Practices	Instructions	Using assessment in instruction	8	• Danielson's (2020) Framework of remote teaching.
		Engaging students in learning	9,10, 12	
		Using questioning and discussion techniques	11	
	Planning and preparation	Demonstrating knowledge of resources	13	
		Demonstrating knowledge of students	14	
		Designing coherent instruction	15,16,17	
	Classroom Management	Creating an environment of respect and rapport	18,19	
		Managing classroom procedures	20	
	Professional responsibilities	Communicating with families	21,22,23	
Teachers' Self-Efficacy	Mastery experiences		24,25,26,28,30,	• Self-Efficacy to Teach Science in an Integrated STEM (SETIS) scale (Mobley, 2015)
	Vicarious experiences		27	
	Verbal persuasion		29	
	Physiological and emotional states		31,32	
Teachers' Attitudes Toward Changes	Affective Reaction to change		33,34	• Teachers' Attitude Toward the Change Scale (Kin & Kareem, 2017)
	Cognitive response to change		35,36	
	Behavioral Reaction to change		37,38,39	

Each scale of the survey instrument contained one open-ended comment section to allow each respondent to make additional statements and provide more open-ended responses.

3.3.2 Pilot Test

The pilot test for the survey is a vital step within the questionnaire design process allowing evaluation concerning how people respond to the overall questionnaire and specific questions. A pilot test was conducted among science teachers with the developed questionnaire to gauge the feasibility of the survey instrument. The aim of the pilot test was to understand how respondents comprehend and answer the survey questionnaire. More specifically, the prime objective of a pilot trial is to “provide sufficient assurance to enable a larger definitive trial to be undertaken”(Lee et al., 2014, p. 1). Moore et al. (2011) described the pilot testing as a structured way that measures internal consistency of the questions by obtaining respondents’ perspectives on the questionnaire. After collecting item responses from the pilot test, Cronbach's alpha reliability analysis was conducted to check the internal consistency of the survey instrument.

3.3.3 Pilot Test Sampling

It is arguably important to set an estimated sample size for a pilot trial to obtain the desired value of Cronbach’s alpha. If the sample size is too small, the test will lack power and the confidence interval will be too wide (Bonett, 2002); however, large sample sizes often represent waste of the resources and can be contrary to feasibility of a study (Julious, 2005). Bonett (2002) derived a closed-form sample size estimation formula with a desired confidence interval (CI) width as a function of sample size that can be used in approach to calculate the sample size for a coefficient alpha test. Bujang et al. (2008), in their article presented a sample size table based on the calculation of Bonett (2002) formula that guides sample size estimation for Cronbach’s alpha test for reliability studies. Bujang et al. (2008) contended that for a single coefficient alpha test, the approach, by assuming the Cronbach's alpha coefficient equals to zero in the null hypothesis, will yield a smaller sample size of less than 30 to achieve a minimum desired effect size of 0.7. As the aim of my pilot study was to evaluate the internal consistency of a survey instrument which has 39 items with a five-point Likert scale for every item, the coefficient of Cronbach's alpha in the null hypothesis and alternative hypothesis were assumed to be equal to 0.0 and 0.7, respectively. Based on alpha value fixed at 0.05, the minimum sample size requirement is set to 10 in order to achieve power of 80.0%, and this calculation is based on the formula introduced by Bonett (2002).

3.3.4 Pilot Test Procedure

The pilot test was performed with 14 in-service teachers teaching science in Saskatchewan schools. Initially, there were 39 items with Likert scale format, and organized in three scales: teaching practices, teachers' self-efficacy, and teachers' attitudes toward change. The survey for the pilot phase was also conducted online. The teachers were also asked to provide feedback on (a) clarity of instruction, (b) clarity of survey questions, and (c) survey procedures. Most of the participants indicated that instructions and survey questions were clear and easily understood. However, participants' recommendations on mundane errors such as typos, grammatical errors, jumbled question order, and unnecessary repetitiveness were taken in consideration to refine the final instrument. Moreover, the pilot stage helped me to better estimate the required time to complete the final survey.

3.3.5 Internal Consistency of the Pilot Test

The coefficient alpha, developed by Cronbach (1951), is the most commonly used index for estimating the internal consistency reliability of measurement instruments for questionnaires (Terry & Kelley, 2011, Cortina, 1993). Since the reliability analysis is used to reduce errors during the analysis of responses to questionnaires, the Cronbach alpha test was used to check the internal consistency of the pilot survey items. The 39 items of the survey instrument were divided into three factors or scales: (1) Teaching practices; (2) Teachers' self-efficacy; and (3) Teachers' attitudes toward the change. Reliability analysis of the science teaching practices scale produced a Cronbach's alpha coefficients of reliability of 0.975 of total 16 items (Mean 77.1 and SD= 21.53) (See Appendix F). Participants rated each item using a 7-point Likert-type scale. For teachers' self-efficacy scale, there were 9 items of 5-point Likert-type, and Cronbach's alpha coefficients of reliability was measured 0.947 (Mean = 31.6 and SD = 7.82). (See Appendix F). On the other hand, the Cronbach's alpha coefficient for teachers' attitudes toward the change scale had a value of 0.954 (Mean= 27.1 and SD= 7.78) (See Appendix F) for seven items of 7-point Likert format. As the alpha value for the three scales of the interment presented a high value (> 0.8) during the pilot test, no items were removed from the instrument and indeed retained all 39 items for main survey. However, the survey item in teachers' attitudes toward the change scale, the statement "I feel frustrated with the change in teaching due to the adoption of online teaching tools in my teaching practices" had an inter-item correlation value of 0.482 and would show an increased level of Cronbach's alpha of 0.976 if the item was deleted. For that reason, the item was excluded when data analyses were conducted regarding the research questions.

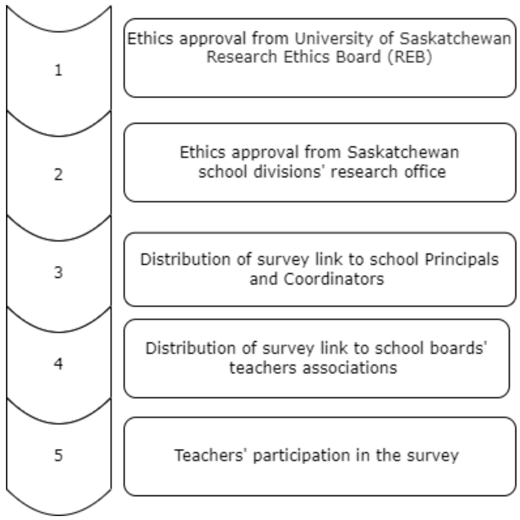
3.4 Ethical Considerations

3.4.1 Institutional Review and Approval

Initially, research needs approval from the university research review board, school division research committees, and local permissions (Creswell & Poth, 2017). Prior to data collection, research application, survey instrument, digital consent form with survey link, and a participant recruitment poster were submitted to the University of Saskatchewan Research Ethics Board (REB) for study approval (Appendix A). Once REB approval was obtained, research applications were submitted to Saskatchewan School Divisions' Research Review Committee offices. Initially, applications were submitted to fifteen school divisions. The Research Advisory Committee (RAC) of each school division and representatives had screened the application based on ethics, research methodology, and disruptions to the schools, and benefit to school divisions, education and/or society. Each school division has its own guidelines and administrative procedures to conduct research within the school division. Specifically, the approval processes included considering the goals of the study, a study timeline, place, students, and faculty involved as well as assurances of confidentiality and protection of participants, and how the survey findings would be disseminated. Overall, eight school divisions finally approved the study to conduct survey within their school divisions. The Superintendent of Education for each school division had issued a letter of approval to conduct research and distributed the invitation poster and survey link to science learning coordinators and school principals of the respective school divisions. Moreover, the survey preamble with a link to the survey were sent to school divisions' teachers associations with the intension of increasing survey responses. Additionally, two reminder emails were sent to the school divisions to re-disseminate the survey link to teachers for increasing participation. Below are the steps that I had experienced to reach my survey link to the teachers' participants.

Figure 2:

Steps of the Survey Procedure



3.4.2 Final Survey and Data Collection

In total 65 participants were participated in final survey. To avoid the limitations due to COVID-19 restrictions the final survey was conducted online. The SurveyMonkey software was used to design and collect the survey data. As stated earlier, the school board's Superintendent of Education disseminated the survey link and Participant Poster (Appendix A) to their science teachers. The electronic survey consisted of two parts: a) a participant consent form, b) survey questionnaire. Consent to participate in the study was assumed by the willingness to answer the survey questions online. An eight-week plan was devised for data collection for this investigation which is illustrated in the Table 5 below:

Table 5

Timeline for the Data Collection

Recommended Timeline	Type of Tasks
First and Second week (Pre-testing Stage)	Piloting the survey questionnaire.
Third week (Pre-testing Stage)	Testing the internal consistency of the questionnaire based on the data collected from the pilot study and preparing the final survey questionnaire.
Fourth- Eight Week	Invitation to selected participants for participating in the study, and online data collection.

3.4.3 Disclosure and Consent:

The first page of the electronic survey was the informed consent form (see Appendix A) which outlined the research information such as the purpose of study, procedures, benefits and risks, anonymity, confidentiality, data storage, withdrawal process, follow up process, and consent statement which indicated that participants had no obligation to complete the survey. All the respondents participated in the study by accessing the survey link (see Appendix A). No email was sent directly to the participants from the researcher. The survey link was distributed to teachers by their respective administrations. In the SurveyMonkey application, the *Anonymous Responses* collector option was enabled so as to not track and store identifiable respondent information in survey results.

3.4.4 Anonymity

All electronically collected data were saved to the University of Saskatchewan computer with full encryption. The storage period of the data is five years post-publication, after which the data will be destroyed. Messaging in the consent form informed participants' responses to survey would be completely anonymous. All the participants participated in the study by accessing the survey link. No personally identifiable information was captured unless participants voluntarily offered personal or contact information in the comment fields; however, the tracking of individual internet protocol (IP) was enabled to identify and reject the duplicate responses from the dataset.

3.4.5 Voluntariness

Messaging in the consent form clearly indicated that participation in the survey was voluntary and there would be no repercussions for non-participation. Additionally, participants were informed they could choose only those questions of the survey that they were comfortable with and that they could cease participation at any time by closing their browser. Participants were informed that once the survey was submitted by them their data could not be removed from the system and that such data would not be traceable back to the respondent.

3.4.6 Storage and Confidentiality

In the consent form participants were informed that data and records created by this study are owned by the University of Saskatchewan and that access to all the information are kept confidential and only the researcher and principal investigator (PI) can use them. Participants were also informed that all survey information would be retained and hosted on a SurveyMonkey server which has a Master Services Agreement with University of Saskatchewan which in turn prevents misuse and/or misappropriation of information. After data collection, data was transferred to a University of Saskatchewan (Usask) computer, and was fully encrypted by Usask VPN, password. The data was also uploaded into Usask cloud storage to prevent them from loss. Participants were also informed that the result of this study would be disseminated as dissertation work to ProQuest digital publication, peer reviewed journal, and international conference. Once the study has been completed survey results and the findings would be shared to school boards using confidential email. Individual identities were used in any reports or publications that may result from this study.

3.5 Method of Data Analysis

Data obtained from the online survey tool were transferred to IBM SPSS 28.0.0.0 software for statistical analysis. The descriptive statistics were used to present the overall impression of the demographic data (Question 1- Question 7), and for the dependent survey items (Question 8 – Question 39) (See Appendix C). The mode of data analysis consisted of frequency distribution (means and standard deviations) for the descriptive items relating to dimensions of teaching practices, perceptions of teachers' self-efficacy, and teachers' attitudes toward the change.

The tests of normality were used to assess the normality of data as normal data is an underlying assumption in parametric testing (Appendix D). I used the Shapiro-Wilk test for assessing normality of the dimensions. Generally, if the Sig. value of the Shapiro-Wilk Test is greater than 0.05, the data is considered as normal. The test statistics are shown in the table (See appendix C). The inferential statistics such as independent samples t-test (for two independent samples), and one way ANOVA test (for more than two independent samples) were conducted to explore the differences between teacher demographics for dependent survey items. Before performing the parametric test, assumption of homogeneity of variance was verified by Levene's test of homogeneity of variances. The p-value for Levene's Test must be above 0.05 to satisfy the assumption of homogeneity of variance. Moreover, if the ANOVA revealed significant differences, the post hoc Turkey HSD (Honestly Significant Difference) test was performed to determine where the differences occurred between groups.

For non-normally distributed data, I used non-parametric Kruskal-Wallis test (considered the non-parametric alternative to the one-way ANOVA) to determine if there are statistically significant differences between two or more groups of an independent variable for a dependent item. While for two samples of the independent variable, a Mann Whitney U test was used to find the significant differences in dependent item according to independent groups. Finally, the analyzed data were then interpreted and explained by various graphs and tables that helped to summarize the data in a coordinated and accessible fashion.

3.6 Chapter Summary

This chapter outlined the research questions, and the research methodology for this study. Likert-type scales in an online survey questionnaire were used to collect quantitative data. The purpose of the survey was to gather data about teaching practices, teacher self-efficacy, and teachers ‘attitudes toward the COVID-19 change. This study used a quantitative exploratory research methodology employing statistical data analysis that saves lot of energy and resources for the research descriptions (Bryman, 2001, p. 20). In Chapter 4, the survey results and data related to the research questions are presented and discussed.

4. RESULTS

This chapter reports the demographic data, and data analysis results for each research question. The independent variables of gender, type of internet access, years of experience, population center, and teaching grades were used in demographic questions (Q1 to Q7) of the survey (see Appendix B). As indicated in Chapter three, all questions in the dependent category were classified under the following areas/scales: (a) Teaching practices, (b) Teachers' self-efficacy, and (c) Teachers' attitude toward the change. Furthermore, all questions dealing with teaching practices were divided into four dimensions of teaching: (a) classroom instructions, (b) planning and preparation, (c) classroom environment, and (d) professional responsibilities. The data from completed questionnaires were imported from SurveyMonkey to the IBM SPSS Statistics Data Editor, and then analyzed according to the approach outlined in Chapter Three.

In the first section, data associated with participants in the study, and their demographics within their schools are presented using descriptive statistics (mean and standard deviation). Research questions were analyzed using descriptive statistics, differences in teaching practices, self-efficacy, and attitudes toward the change according to demographic variables. Next, results related to the differences in dependent variables (survey items) according to the teachers' variables (teacher demographics: gender, type of internet access, years of experience, population center, and teaching grades) were analyzed using parametric and non-parametric tests. Mean differences and standard deviations were listed for each variable with a statistical significance score of less than 0.05 ($p < 0 .05$), where the term p-value indicates the probability of observed difference having occurred. The final section of this chapter consists of a summary of the research findings.

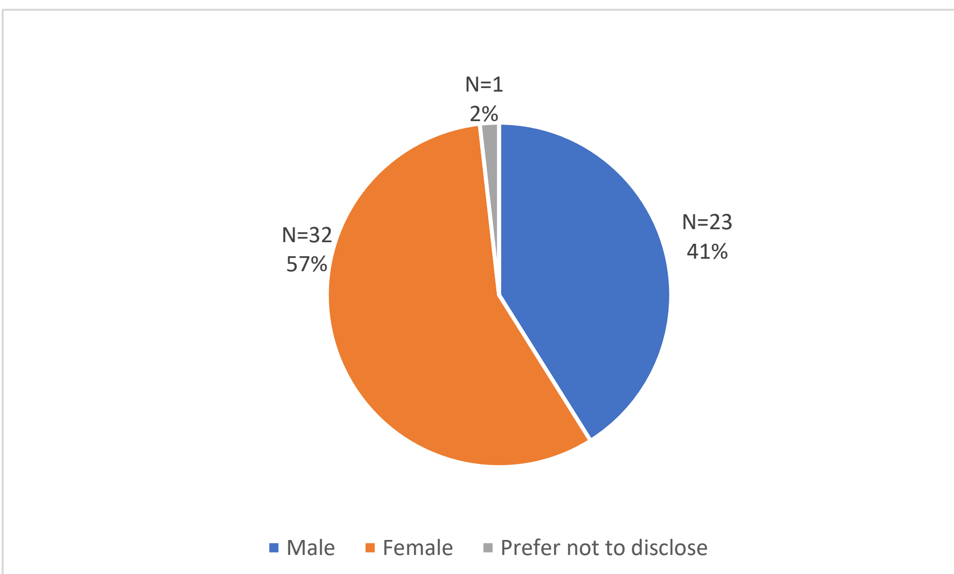
4.1 Analysis of Demographic Data

The participants in this study were high school Science teachers within seven Saskatchewan school divisions. As mentioned in chapter 3, the online survey link was distributed to principals and science coordinators within the school divisions, who then had the choice to forward the survey to their teachers. Overall, 65 participants attempted the survey and partially completed the questionnaire, thereby implying digital consent as mentioned earlier. All missing data responses were excluded for the descriptive analysis.

The predominant number of teachers in the school divisions participating in the survey were female as illustrated in the Figure 3. The gender distribution of the 56 teachers in the sample who provided gender information was 41.1% male (N = 23) and 57.1% female (N = 32) (see Fig. 3 and Appendix C).

Figure 2

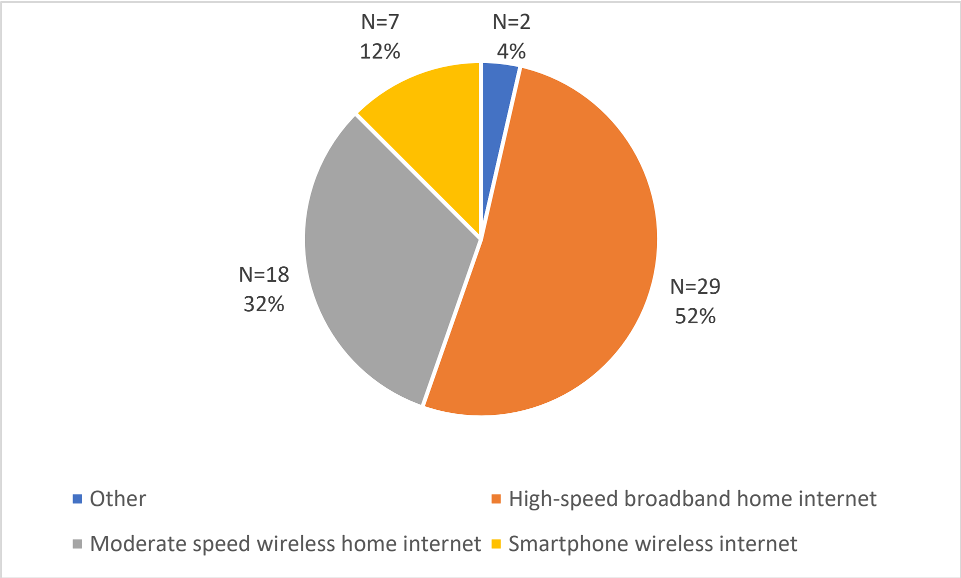
Gender of the Participants



Nearly half of teachers, 52%, (N=29) (See Fig. 4) reported that they use high-speed broadband home internet connections to teach online during covid-19 remote teaching, while around 32 %, (N=18) of respondents said they use moderate speed wireless connections for their online instructional delivery. The use of smartphone internet for teaching was the lowest among the teachers with 12 % (N=7). Also, 4% of the teachers (N=2) reported that they use both moderate and smartphone wireless internet for their teaching (See Fig. 4 and Appendix C).

Figure 3

Type of Internet Access Used to Teach Online



In the teaching experience categories, 12.5 % (N=7) (see Fig 5) teachers had less than 4 years of teaching experience, 16.1 % (N=9) were in the 4-6 years category, 16.1 % (N=9) were in the 7-10 years category, 14.3% (N=8) were in the 11-15 years category, and 19.6 % (N=11) were in 16-20 years category whereas maximum number of teachers 21.4% (N= 12) surveyed have twenty years of teaching experience (See Fig 5 and Appendix C).

Figure 4

Years of Teaching Experiences

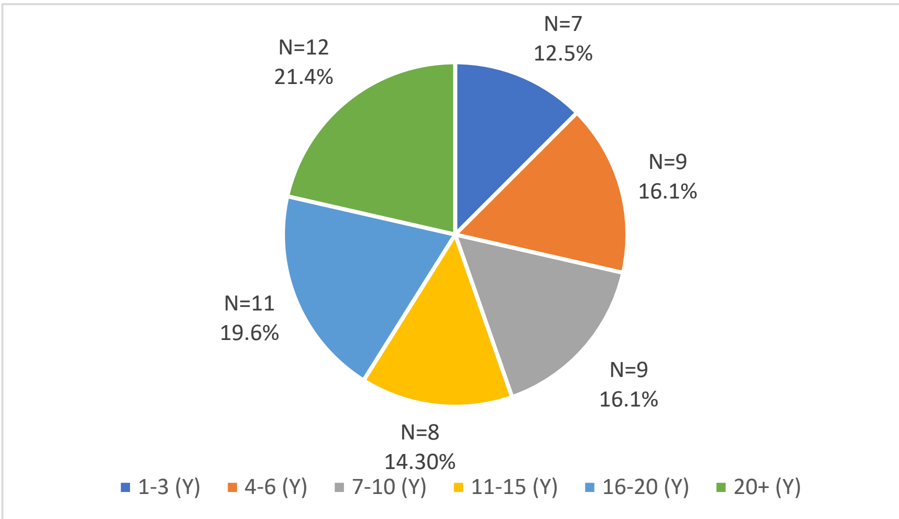
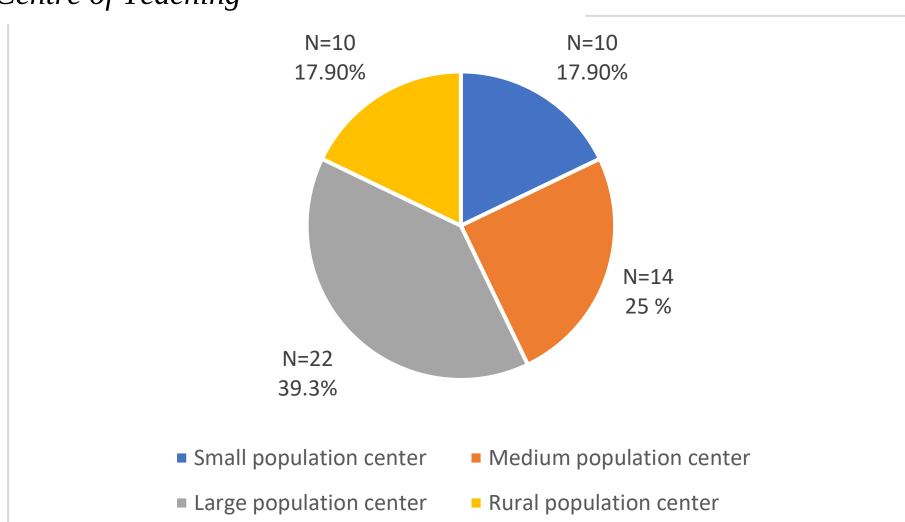


Figure 6 indicates that highest percentage of teachers participating in the survey were from large population centers with 39.3% (N=22), 25% (N=14) teachers were from medium population centers, and equal 17.9% (N=10) teachers attained the survey teaching in small and rural population centers respectively (See Fig. 6 and Appendix C).

Figure 5

Population Centre of Teaching



Finally, Figure 7 shows the percentage of grade levels or subjects taught by responding science teachers in the school divisions. For the clarity of the data representation, I used the bar chart instead of a pie chart to illustrate data responses for teaching grades. Most taught subjects include Science Level-10 with 20.3% (n=31), followed by Biology Level 30 with 13.7 % (N=21), and both Science Grade 9 and Health Science Level 20 with 11.1 % (N=17) each. Earth Science Level 30 was the least commonly taught subject with 0.7% (N=1); however, 8.5% (N=13) respondents also were referring others grade levels including Computer Science level 20, Mathematics, Social Studies 20, Geography 20 etc. (See Fig. 7 and Appendix C).

Figure 6

Teachers' Teaching Grade Levels

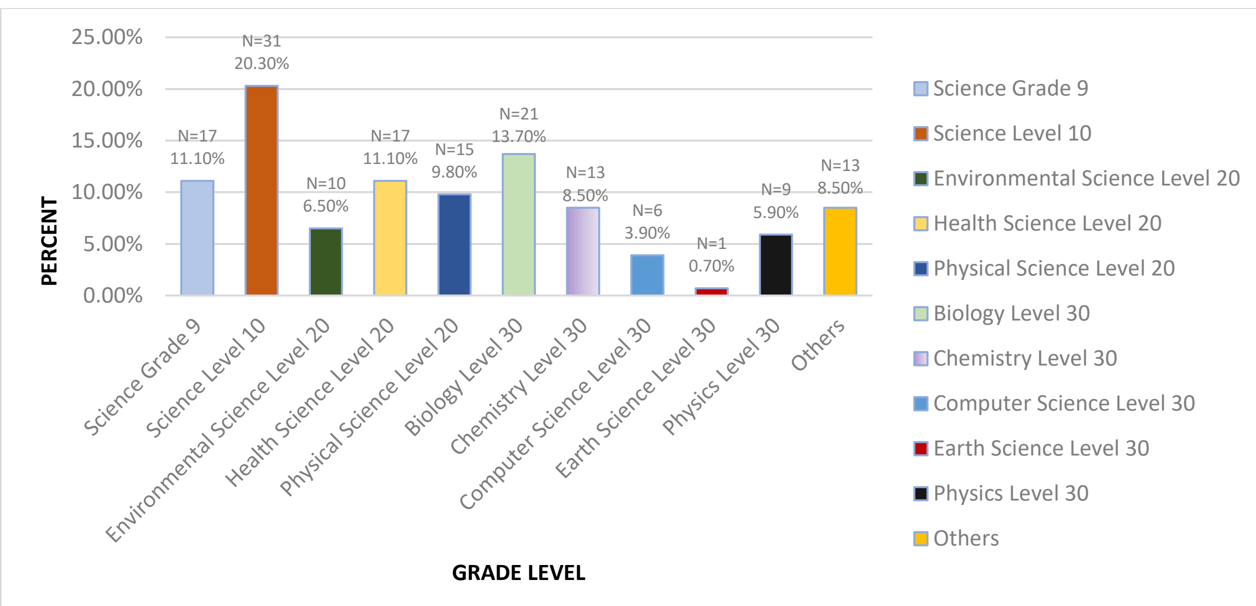
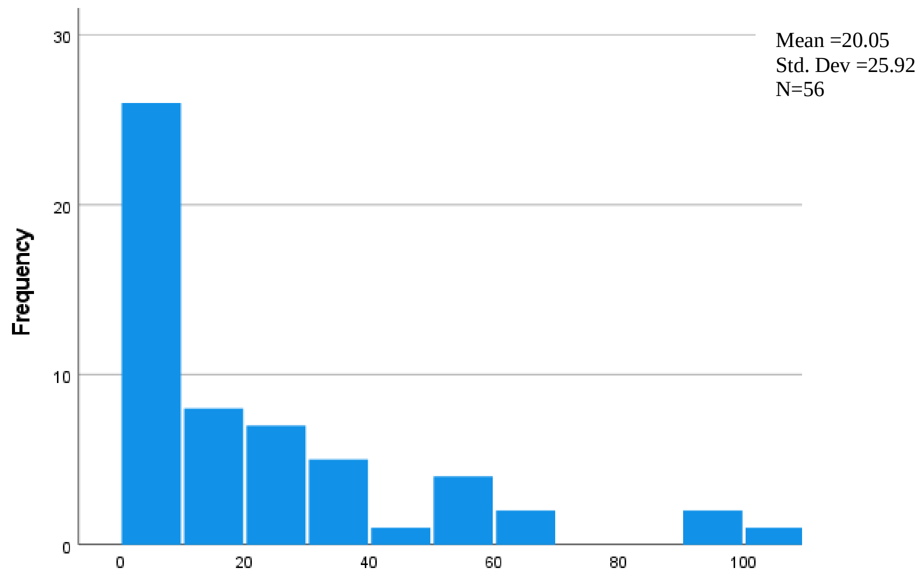


Figure 8 below reflects the percentage of the online mode of delivery teachers had experienced in their teaching prior to COVID-19 pandemic. The mean for the percentage of participants who taught online prior to the COVID-19 pandemic was 20.05, with std. deviation

=25.92. Out of 56 respondents a maximum of 21 participants reported that they had 0 % of the online mode of instructional delivery before COVID-19 pandemic (see Figure 8).

Figure 7

Percentage of Online Teaching Before COVID-19 Pandemic

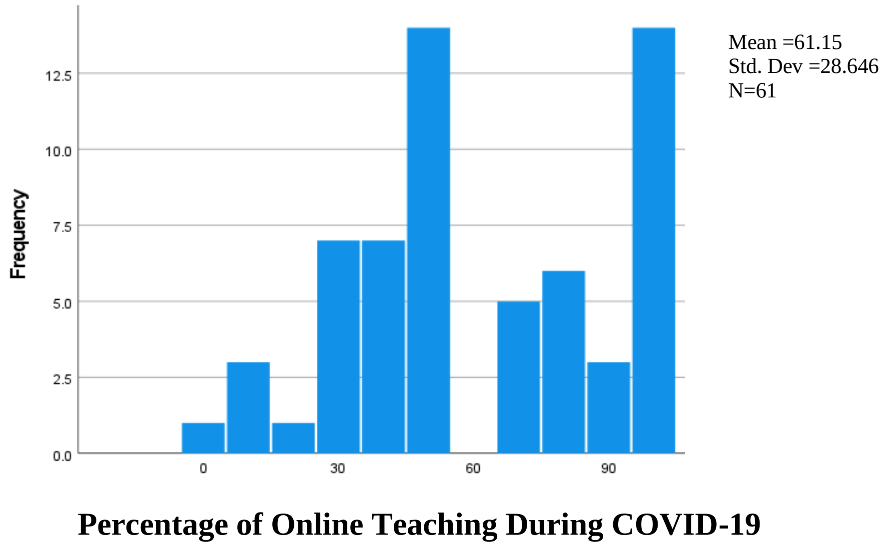


Percentage of Online Teaching Before COVID-19 Pandemic

On the other hand, as illustrated in Figure 9 the mean for the percentage of participants who taught online during COVID-19 pandemic was 61.15, with SD =28.646. Out of a total of 65 respondents, 14 reported that 50% of their teaching was online during the COVID-19 pandemic.

Figure 245

Percentage of Online Teaching During COVID-19 Pandemic



4.2 Internal Consistency of Survey Instrument

Cronbach's alphas were conducted to measure the internal consistency or reliability of the survey instrument used for this study which consisted of 38 items after the removal of one item from the pilot study as presented in Table 6. (See more detailed results in Appendix D). The Cronbach alpha coefficient values for this study were quite good which indicated items are internally consistent. For the survey scale of teaching practices had four dimensions: classroom instruction, planning and preparation, classroom environment, professional responsibilities, and all 16 items were added together to create the teaching practices score. However, the self-efficacy used all 9 items (had single dimension), and teachers' attitudes toward the change used 7 items (had single dimension) to measure the Cronbach's alphas for this study. Means, standard deviations, number of items, and Cronbach's alphas for research variables are presented in Table 6.

Table 6

Reliability of the Study Instrument

Scales	Mean	SD	Number of Items	Cronbach's Alpha
Teaching practices	4.66	1.00	16	0.903
Teachers' self-Efficacy	3.44	0.801	9	0.904
Teachers' attitudes toward the change	3.92	1.09	7	0.901

4.3 Analysis of Research Questions

4.3.1 Teachers' Teaching Practices

Research Question 1: How do science teachers rate themselves in relation to four dimensions (*Classroom Instruction, Planning and Preparation, Classroom Environment, Professional Responsibilities)* of their teaching practices in the context of COVID-19 pandemic?

To explore research question 1, items 8-23 on the instrument were used to measure teachers' teaching practices in four different dimensions. All questions were presented with a seven-point Likert scale. Details regarding the frequency distribution of survey items are also available in Appendix C.

Classroom Instruction

Data pertaining to teacher's teaching practices within the dimension of classroom instructions are presented in Table 7. The dimension had total mean of 4.37 and SD 1.18. Based on the result, item (10) "My use of online instructional tools better enables me to engage students in self-directed learning" with mean value 4.8431 (SD= 1.33) had the highest score. The item (8) "My use of online assessment tools better enables me to gauge my students' understanding of topics or concepts in science" had second highest mean in the dimension with 4.51 (SD = 1.69).

While the lowest mean is item (11) “My use of online instructional tools better enables me to engage students in collaborative discussion, questioning and reflection to advance student higher-level thinking and discourse” with mean value 3.7692 (SD= 1.86). Despite the moderate mean score in the item (9) “to engage students in scientific inquiry activities that support students’ deep learning of the content” with 4.3846 (SD=1.69), the high standard deviation suggests a strong variation in teacher rating. Moreover, looking at s*omewhat agree* through *strongly agree* responses, the areas teachers reported the highest agreement concerning their online use of online tools enabling them to engage students in self-directed learning, to gauge students’ understanding of topics in science, and to engage students in scientific inquiry activities. However, using *strongly disagree* through *somewhat disagree*, most respondents did not agree that online tools helped them to engage students in collaborative discussion and activities. Details regarding the frequency distribution of survey items are also available in Appendix C.

Table 7

Descriptive Statistics of Teaching Practices: Classroom Instruction

Classroom Instruction

	Items	N		Mean	Std. Deviation
		Valid	Missing		
8	My use of online assessment tools better enables me to gauge my students’ understanding of topics or concepts in science.	52	13	4.5192	1.69764
9	My use of online teaching resources better enables me to engage students in scientific inquiry activities that support students’ deep learning of the content.	52	13	4.3846	1.69375
10	My use of online instructional tools better enables me to engage students in self-directed learning.	51	14	4.8431	1.33225

11	My use of online instructional tools better enables me to engage students in collaborative discussion, questioning and reflection to advance student higher-level thinking and discourse.	52	13	3.7692	1.86417
12	My use of online instructional tools better enables me to engage my students intellectually in lesson activities.	52	13	4.3846	1.35984
	Dimension			4.3798	1.18538

Planning and Preparation

The planning and preparation dimension had the highest overall mean (4.9885) and SD=1.18 as seen in Table 8. In the area of planning and preparation, the relationship between the two items with the highest means and the two items with the moderate means deserve to be highlighted. On the item (14), “When designing a lesson for online teaching, I consider my students’ scientific knowledge and skills of adopting digital learning instructions”, and item (16) “I spend additional time designing inquiry-based classroom activities for teaching science online” the means were 5.67 (SD= 1.18) and 5.28 (1.49) respectively. However, the item (15), “I spend additional time designing coherent science instructions for teaching science online”, and the item (17) “I spend additional time designing assignments and discussion techniques for teaching science online” with means of 4.69 (SD= 1.61) and 4.73 (SD= 1.63) respectively, indicated moderate level of planning and preparation during COVID-19 online teaching. Overall, five items were in the high range of teaching practices within this dimension. Using *somewhat agree* through *strongly agree* responses, 88.5% of teachers reported they considered students’ scientific knowledge and skills of adopting digital learning instructions at the time of designing a lesson for online teaching; 77% teachers reported that they spent additional time designing inquiry-based classroom activities as planning for teaching science online. In contrast, using the responses *somewhat disagree* through *strongly disagree*, 23 % of teachers reported they did not spend additional time designing coherent science instructions for teaching science online, designing assignments and discussion techniques for students during COVID-19 remote teaching. Details regarding the frequency distribution of survey items are also available in Appendix C.

Table 8

Descriptive Statistics of Teaching Practices: Planning and Preparation

	Planning and Preparation	N		Mean	Std. Deviation
		Valid	Missing		
13	Through online teaching, I can enrich my knowledge of using a variety of scientific online resources, which promote my resource planning, and aid in maintaining a log of resources for student reference.	52	13	4.5577	1.60163
14	When designing a lesson for online teaching, I consider my students' scientific knowledge and skills of adopting digital learning instructions.	52	13	5.6731	1.18357
15	I spend additional time designing coherent science instructions for teaching science online.	52	13	4.6923	1.61535
16	I spend additional time designing inquiry-based classroom activities for teaching science online.	52	13	5.2885	1.49950
17	I spend additional time designing assignments and discussion techniques for teaching science online.	52	13	4.7308	1.63438
	Dimension			4.9885	1.13719

Classroom Management

The classroom management dimension had three items with total dimension mean 4.68 and standard deviation of 1.576; the data for this dimension is outlined in Table 9. The lowest item mean in this dimension was item (18) "the online teaching tools allow me to establish a positive and collaborative classroom environment where all members feel supported, respected, and connected” with mean 4.65 (SD= 1.46) . However, the highest item means were item (20) “I can establish a central set of shared classroom routines and procedures to promote students’ autonomy in my online science classroom”, and item (19) “Through online instruction, I have reflected on my readiness to resolve conflicts, to develop trust, and to build a sense of belongings and positive relationships among students” means of 4.94 and 4.80 respectively. Looking at *somewhat agree* through *strongly agree* responses, 64.5 % teachers reported that through online teaching they were able to reflect their readiness to build a sense of belonging, and positive relationships among students; and they were able to establish a central set of procedures to promote students’ autonomy in online science classroom. Using the same responses 57.7% teachers reported that online teaching tools helped them to establish a positive and collaborative classroom; however, 21.2 % of teachers neither agreed nor disagreed about the statement. Details regarding the frequency distribution of survey items are also available in Appendix C.

Table 9

Descriptive Statistics of Teaching Practices: Classroom Management

		N			Std.
	Classroom Management	Valid	Missing	Mean	Deviation
18	The online teaching tools allow me to establish a positive and collaborative classroom environment where all members feel supportive, respected, and connected.	52	13	4.6538	1.46708
19	Through online instruction, I have reflected on my readiness to resolve conflicts, to develop trust, and to build a sense of belongings and positive relationships among students.	52	13	4.8077	1.37254
20	I can establish a central set of shared classroom routines and procedures to promote students’ autonomy in my online science classroom.	52	13	4.9423	1.57696
	Dimension			4.6894	1.10997

Professional Responsibility

Teachers' responses for professional responsibility dimension of Teaching Practices were illustrated in Table 10. This dimension had an overall mean of 4.48 (SD= 1.60) with three items. The items (22 and 23) "I can easily interact with families as well as community members to inform them about the school's new instructional programs and bring the community into the decision-making process", and "Online teaching tools allow me to make individual contact with every parent/guardian to establish a communication plan in ways that respect their values and cultural backgrounds" had the moderate means of 4.38 (SD=1.69) and 4.36 (SD= 1.84) respectively. The item (21), "online teaching tools allow me to communicate with families and community members to discuss about students' academic progress and cognitive prompts on the scientific inquiry practices" had the highest mean with 4.69 (SD= 1.67) in the dimension.

Table 10

Descriptive Statistics of Teaching Practices: Professional Responsibility

		N			Std.
		Valid	Missing	Mean	Deviation
21	The online teaching tools allow me to communicate with families and community members to discuss about students' academic progress and cognitive prompts on the scientific inquiry practices.	52	13	4.6923	1.67494
22	Through the online teaching tools, I can easily interact with families as well as community members to inform them about the school's new instructional programs and bring the community into the decision-making process.	52	13	4.3846	1.69375

23	The online teaching tools allow me to make individual contact with every parent/guardian to establish a communication plan in ways that respect their values and cultural backgrounds.	52	13	4.3654	1.84740
	Dimension			4.4808	1.60529

Moreover, looking at *somewhat agree* through *strongly agree* responses, the majority of teachers agreed with all three items that online tools allowed them to communicate with families and community members effectively. Details regarding the frequency distribution of survey items are also available in Appendix C.

4.3.2 Differences in Teaching Practices According to Demographic Variables

Research Question 2: Are there any differences in teaching practices when analyzed according to gender, year of teaching experiences, grade level, population center, and type of internet access?

The survey items for the teaching practices are classified into four dimensions: classroom instruction, planning and preparation, classroom management, and professional responsibility. The tests of normality were used to assess the normality of data as normal data is an underlying assumption in parametric testing. I used the Shapiro-Wilk test for assessing normality of the dimensions. Generally, if the Sig. value of the Shapiro-Wilk Test is greater than 0.05, the data is considered as normal. For the classroom instruction dimension, the Sig. value of Shapiro-Wilk test was 0.157 which indicate that the data comes from a normal distribution (see Appendix D). However, for the dimensions of planning and preparation, classroom management, and professional responsibility the p-values of the Shapiro-Wilk test were 0.049, 0.036, and 0.003 respectively (see Appendix D) which indicated the non-normal distribution of data.

Therefore, the parametric independent t-test was conducted to investigate the significant differences of the classroom instruction dimension of teaching practices alongside the demographic variable of gender, and the parametric one way-ANOVA for more than two samples of the demographic variables. Before performing the t-test and One-way ANOVA, Levene's test of homogeneity of variances (See Appendix D) were checked to meet the assumptions for conducting those tests. On the other hand, due to the skewed and non-normal distribution of the samples, non-parametric Kruskal-Wallis tests were conducted for the demographic variables with more than two groups, including types of internet access, population center, grade level and teaching experience. Moreover, a Mann-Whitney U test was conducted for each of non-normal dimensions of teaching practices alongside the demographic variable of gender. The alpha level as determinant of significance was 0.05. The mean, standard deviation, and significance of teaching practices according to their dimension among participant demographics are displayed in Tables 11-15.

Differences in Teaching Practices According to Gender

The differences in teaching practices according to gender are displayed in Table 11. The result of independent t-test indicated that there was no significant difference in the scores for Male and Female samples ($t(44) = 0.749$, $p = 0.229$) for classroom instruction dimension (see appendix). Also, the results of the Mann-Whitney tests revealed that there was no significant effect for gender on the dimensions of planning and preparation ($U=294.5$, $z=0.708$, $p=0.479$), Classroom Management ($U=250.5$, $z=-0.267$, $p=0.790$), and professional responsibility ($U=298$, $z=0.791$, $p=0.429$) (see appendix D). Although none of the differences in teaching practices were significant, worth mentioning is that the means for the planning and preparation category was higher than others which may be indicative to the significant changes which instrument did not reveal. Further details regarding this analysis are available in Appendix D.

Table 11

Differences in Teaching Practices According to Gender

Teachers' Practices		N	Mean	Std. Deviation	Difference
Classroom Instruction	Male	21	4.6286	1.14592	
	Female	25	4.3660	1.21679	Non-significant (0.229)
	Total	46	4.4859	1.17930	
Planning and Preparation	Male	21	5.0381	1.09292	Non-significant (0.479)
	Female	25	5.1920	1.06063	
	Total	46	5.1217	1.06623	
Classroom Management	Male	21	4.9524	.98481	Non-significant (0.790)
	Female	25	4.8133	1.17094	
	Total	46	4.8768	1.08037	
Professional Responsibility	Male	21	4.5556	1.48823	Non-significant (0.429)
	Female	25	4.7467	1.68402	
	Total	46	4.6594	1.58307	

Differences in Teachers' Practices According to Type of Internet Access

A one-way ANOVA test, and series of Independent-Samples Kruskal-Wallis test were performed to compare the effect of type of internet access on the dimensions of teachers' practices, and which were presented in Table 12. The result of one-way ANOVA revealed that differences in teacher practices for the classroom instruction was not found to be significant F (2,49)=1.314, p=0.278 with regard to the type of interest access teachers had to teach online during COVID-19 pandemic (See table Appendix D). However, Independent-Samples Kruskal-Wallis tests results showed that planning and preparation H (2) = 1.527, p= 0.466, classroom management H (2) = 2.753, p= 0.252, and professional responsibility H (2) = 1.659, p= 0.436, all were insignificant according to the types of internet access teachers used. Further details regarding this analysis are available in Appendix D.

Table 12

Differences in Teaching Practices According to Type of Internet Access

		N	Mean	Std. Deviation	Difference
Classroom Instruction	High-speed broadband home internet	27	4.3389	1.21689	Non-significant (0.278)
	Moderate speed wireless home internet	18	4.1889	1.19503	
	Smartphone wireless internet and others	7	5.0286	.93401	
	Total	52	4.3798	1.18538	
Planning and Preparation	High-speed broadband home internet	27	4.8815	1.25178	Non-significant (0.466)
	Moderate speed wireless home internet	18	4.9444	1.07551	
	Smartphone wireless internet and others	7	5.5143	.73808	
	Total	52	4.9885	1.13719	
Classroom Management	High-speed broadband home internet	27	4.8642	1.05109	Non-significant (0.252)
	Moderate speed wireless home internet	18	4.5000	1.18404	
	Smartphone wireless internet and others	7	5.3333	.63828	
	Total	52	4.8013	1.07306	
Professional Responsibility	High-speed broadband home internet	27	4.3951	1.69473	Non-significant
	Moderate speed wireless home internet	18	4.2963	1.64452	
	Smartphone wireless internet and others	7	5.2857	.95119	(0.436)
	Total	52	4.4808	1.60529	

Differences in Teaching Practices According to Years of Teaching Experiences

The differences in dimensions of teaching practices according to years of teaching experience are presented in Table 13. A result of One-way ANOVA revealed that there was no significant differences in teacher practices for the classroom instruction F (5, 46)=1.630, p=0.171 with regard to years of teaching experiences. (See table Appendix D). Independent-Samples

Kruskal-Wallis tests results showed that planning and preparation H (5) = 0.859, p= 0.973, Classroom Management H (5) = 6.145, p= 0.292, and professional responsibility H (5) = 4.846, p= 0.435, all were insignificant according to the years of teaching experiences (See Appendix D). Although none of the differences in teaching practices were significant, it is worth mentioning that the means of year of experience was highest for planning and preparation dimension.

Table 13

Differences in Teaching Practices According to Years of Teaching Experiences

		N	Mean	Std. Deviation	Difference
Classroom Instruction	1-3	8	4.2750	1.05796	Non-significant (0.171)
	4-6	8	5.0500	.97248	
	7-10	8	4.6250	1.25783	
	11-15	8	4.4750	.97943	
	16-20	11	4.4182	1.14701	
	20+	9	3.5278	1.39084	
	Total	52	4.3798	1.18538	
Planning and Preparation	1-3	8	5.0000	1.33095	Non-significant (0.973)
	4-6	8	5.2750	.62278	
	7-10	8	5.1500	.89921	
	11-15	8	5.0000	1.29173	
	16-20	11	4.7818	1.41550	
	20+	9	4.8222	1.21838	
	Total	52	4.9885	1.13719	
Classroom Management	1-3	8	4.3750	1.22717	Non-significant (0.292)
	4-6	8	5.2083	.61560	
	7-10	8	5.2083	.73328	
	11-15	8	4.8750	1.23362	
	16-20	11	4.9091	1.24803	
	20+	9	4.2593	1.03786	
	Total	52	4.8013	1.07306	
Professional Responsibility	1-3	8	4.4583	1.56284	Non-significant (0.435)
	4-6	8	5.2083	.94176	
	7-10	8	4.9583	1.43026	
	11-15	8	4.0417	2.16346	
	16-20	11	4.6061	1.56928	
	20+	9	3.6667	1.68325	
	Total	52	4.4808	1.60529	

Differences in Teaching Practices According to Population Centre

Differences in teaching practices were also not found to be significant regarding population center of teaching which were displayed in Table 14. The result of the ANOVA test showed that there was non-significant difference in classroom instruction for teachers according to the population center; F (3, 47) =1.832, p=0.154. The results of Kruskal-Wallis tests also indicated that the effect of population center of teaching was insignificant for the dimensions of planning and preparation H (3) = 0.255, p= 0.968, classroom management H (3) = 5.438, p= 0.142, and professional responsibility H (3) = 6.649, p= 0.084. Further details regarding this analysis are available in Appendix D.

Table 14

Differences in Teaching Practices According to Population Centre

		N	Mean	Std. Deviation	Difference
Classroom Instruction	Small population center	8	5.2000	.78558	
	Medium population center	9	4.1500	.84261	Non-significant
	Large population center	24	4.2417	1.23567	(0.154)
	Rural Areas	10	4.0800	1.33400	
	Total	51	4.3441	1.16862	
Planning and Preparation	Small population center	8	5.1500	.65683	Non-significant
	Medium population center	9	4.8444	1.03333	(0.968)
	Large population center	24	4.9000	1.36158	
	Rural Areas	10	5.0600	1.00687	
	Total	51	4.9608	1.13068	
Classroom Management	Small population center	8	5.3750	.70006	Non-significant
	Medium population center	9	4.8519	1.31351	(0.142)
	Large population center	24	4.5417	1.07142	
	Rural Areas	10	4.7000	.80814	
	Total	51	4.7582	1.03726	
Professional Responsibility	Small population center	8	5.6250	.67700	
	Medium population center	9	3.9630	1.27415	Non-significant
	Large population center	24	4.1389	1.73321	(0.84)
	Rural Areas	10	4.6000	1.63148	
	Total	51	4.4314	1.58085	

Differences in Teachers' Practices According to Number of Taught Grades/Courses:

Table 15 contains the data comparing the number of taught grades or courses and the dimensions of teachers' practices of teachers. The one-way ANOVA for classroom instruction dimension was not significant with $F(4, 46) = 0.407$, $p = 0.803$. Moreover, according to the Kruskal-Wallis tests indicated that the effect of number of taught grades or courses had no effects on the dimensions of planning and preparation *H* (4) = 2.728, *p*= 0.604, classroom management *H* (4) = 2.728, *p*= 0.668, and professional responsibility *H* (4) = 6.344, p= 0.175, (See Appendix D). Therefore, the levels of teaching practices do not differ by teachers' teaching grades.

Table 15

Differences in Teaching Practices According to Number of Taught Grades/Courses

		N	Mean	Std. Deviation	Difference
Classroom Instruction	One Course	20	4.5300	1.19345	
	Two Courses	12	4.0667	1.41764	
	Three Courses	8	4.2000	.90079	Non-significant (0.803)
	Four Courses	7	4.6214	1.25561	
	Five and more Courses	4	4.2000	1.07083	
	Total	51	4.3559	1.18443	
Planning and Preparation	One Course	20	5.0600	1.18072	
	Two Courses	12	5.1000	1.06344	
	Three Courses	8	4.7000	1.10065	Non-significant (0.604)
	Four Courses	7	5.3429	1.16456	
	Five and more Courses	4	4.2000	1.42361	
	Total	51	4.9843	1.14811	
Classroom Management	One Course	20	4.9333	1.10607	Non-significant (0.668)
	Two Courses	12	4.8611	.77144	
	Three Courses	8	4.6667	1.20844	
	Four Courses	7	4.8571	1.35888	
	Five and more Courses	4	4.0000	1.18634	
	Total	51	4.7908	1.08107	
Professional Responsibility	One Course	20	4.9333	1.47731	
	Two Courses	12	4.2500	1.74729	Non-significant (0.175)
	Three Courses	8	4.7083	1.41912	
	Four Courses	7	3.9524	1.88000	
	Five and more Courses	4	3.0000	.98131	
	Total	51	4.4510	1.60669	

4.3.3 Teachers' Perceptions of Self-Efficacy

Research Question 3. What are the teachers' perceptions of their self-efficacy of teaching science in covid-19 online remote teaching transition?

Items 24-32 on the instrument were used to explore teachers' perceptions of their self-efficacy to teach science using online tools during the COVID-19 pandemic. All of the items were presented with a five-point Likert scale (*Not confident, slightly confident, somewhat confident, confident, and completely confident*). The overall mean for the teachers' self-efficacy scale was 3.44 with standard deviation 0.801 (Table 16). The mean and standard deviation for questions within the self-efficacy scale are presented in table 16. The items (24, 25, and 26), "Obtain the materials/resources necessary to teach science online", "adapt to new teaching situations such as those necessary to teach science online", and "Use my current knowledge, skill and teaching experience to teach science effectively incorporating online teaching tools" had the highest means of 3.80 (SD= 0.99), 3.84 (SD=0.99), and 3.74 (SD=1.02) respectively in the scale. All three items represent self-efficacy source of *mastery experiences* that requires experience in overcoming obstacles through effort and perseverance.

The item (31) "Foster student enthusiasm for learning science while teaching on an integrated online remote learning platform" had the lowest item mean in the entire teacher self-efficacy section at a mean of 2.92 (SD= 1.11), that represents *physiological and emotional* sources of teachers' self-efficacy. Interestingly, teachers also had comparatively lower level of self-efficacy in the items (28 and 30) regarding confidence to grow students' excitements, interest, and motivation; and in the area of formative assessments with means of 3.09 (SD=1.10) and 3.28 (SD= 0.97) which demonstrated source of teachers' *mastery experiences.*

Using the responses *fairly confident* to *completely confident*, 73.1 % teachers feel confident that they can obtain the resources necessary to teach science online, 69.2% feel they are able to adapt to new teaching situations, and 62 % feel confident to use their current knowledge to teach science effectively online, indicating that teachers have a higher perceived self-efficacy in those areas. However, teachers' levels of self-efficacy were low in the area to foster student enthusiasm for learning science, to grow excitement, interest, and motivation to learn science online. Finally, the overall mean was not exceptionally low, and three other items (27, 29, 32) in this scale were within the moderate range. Details regarding the frequency distribution of survey items are also available in Appendix C.

Table 16

Descriptive Statistics of Teachers' Self-Efficacy

		N			
	Teachers' Self-Efficacy	Valid	Missing	Mean	Std. Deviation
24	Obtain the materials/resources necessary to teach science online.	52	13	3.8077	0.99091
25	Adapt to new teaching situations such as those necessary to teach science online.	52	13	3.8462	0.99773
26	Use my current knowledge, skill and teaching experience to teach science effectively incorporating online teaching tools.	50	15	3.7400	1.02639
27	Collaborate effectively with other teachers in planning science learning activities for online instruction.	52	13	3.5962	1.12476
28	Get students to experience excitement, interest, and motivation to learn about phenomena in the natural world using online tools.	52	13	3.0962	1.10719
29	Elicit support from my supervisors (principals, administrators, school district) to teach science effectively in online.	51	14	3.4510	1.17156
30	Formatively assess student learning of discipline-specific content while teaching science in online.	52	13	3.2885	0.97692
31	Foster student enthusiasm for learning science while teaching on an integrated online remote learning platform.	52	13	2.9231	1.11753
32	Overcome challenges created by online remote environments to teach science.	52	13	3.3462	1.00751
	Scale			3.44	0.801

4.3.4 Differences in Teachers' Perceptions of Their Self-Efficacy According to Demographic Variables

Research Question 4. Are there any differences in teachers' self-efficacy when analyzed according to gender, year of teaching experiences, type of internet access population centre, and grade level?

The fourth research question concerned teachers' perceptions of their self-efficacy and impact of teachers' demographic characteristics on their self-efficacy. As the normal data is an underlying assumption in parametric testing, Shapiro-Wilk test of normality was used to assess the normality of data for the teachers' self-efficacy (See Appendix D). The test statistics are showed that (See appendix D) the sig. value of Shapiro-Wilk test was 0.260 which indicated that the data for the teachers' self-efficacy were normally distributed. The parametric independent t-tests and One way-ANOVA tests were performed to explore the differences in Teachers' Perceptions of Their Self-Efficacy according to the demographic variables. Before performing the t-test and One-way ANOVA, Levene's test of homogeneity of variances (See Appendix D) were checked to meet the assumptions for conducting those tests. The alpha level as determinant of significance was 0.05. The mean, standard deviation, and significance of teaching practices according to their dimension among participant demographics are displayed in tables 17-21.

Differences in Teachers' Perceptions of Their Self-Efficacy According to Gender:

The differences in perceptions teachers' perceptions of their self-efficacy according to gender in Table 17. According to the result of independent sample t-test there was no significant difference between male and female for teachers' perceptions of their self-Efficacy with t (44) = 0.656, p= 0.258. Further details regarding this analysis are available in Appendix D.

Table 17

Differences in Teachers' Self-Efficacy According to Gender

	N	Mean	Std. Deviation	Difference
Male	21	3.6032	.76946	
Female	25	3.4498	.80742	Non-significant
Total	46	3.5198	.78537	(0.258)

Differences in Teachers' Self-Efficacy According to Type of Internet Access

The data examining differences in ratings of teachers' self-efficacy according to type of internet access is presented in Table 18. The one-way ANOVA test revealed that there were no significant differences between type of internet access teachers had in their ratings of teachers' self-efficacy, F (2, 49) = 0.052, p =0.95 (See appendix D). Therefore, the teachers' efficacy does not differ by the type of internet access of online teaching.

Table 18

Differences in Teachers' Self-Efficacy According to Type of Internet Access

Type of internet access	N	Mean	Std. Deviation	Difference
High-speed broadband home internet	27	3.4156	.94160	
Moderate speed wireless home internet	18	3.4950	.67245	Non-significant (0.95)
Smartphone wireless internet and others	7	3.4603	.57172	
Total	52	3.4491	.80158	

Differences in Teachers' Self-Efficacy According to Years of Teaching Experiences

Table 19 contains the data comparing teachers' years of teaching experiences and the teachers' perceptions of their self-efficacy. A one-way ANOVA test was conducted to evaluate the impact of years of teachers' teaching experiences on perceptions of their self-efficacy. The analysis revealed that there was non-significant effect of years of teaching experiences on teachers' self-efficacy to teach online during COVID-19 pandemic $F(5,46) = 0.560$, $p = 0.730$ Further details regarding this analysis are available in Appendix D.

Table 19

Differences in Teachers' Self-Efficacy According to Years of Teaching Experiences

	N	Mean	Std. Deviation	Difference
1-3	8	3.2527	.71094	
4-6	8	3.5139	.68477	
7-10	8	3.6389	.90218	
11-15	8	3.7639	.79113	Non-significant
16-20	11	3.3232	.85556	(0.730)
20+	9	3.2716	.91306	
Total	52	3.4491	.80158	

Differences in Teachers' Self-Efficacy According to Population Centre

The differences in perceptions of teachers' self-efficacy according to population centre of teaching is outlined in Table 20. An analysis of variance showed that the relation of population centre to teachers' self-efficacy was significant, $F(3, 47) = 2.889$, $p = 0.045$, where the association is significant at the 0.05 level ($p < 0.05$, see Appendix D). Also, estimated partial eta-squared value revealed larger effect size (partial $\eta^2 = 0.156$) for population centre on teachers' self-efficacy . A post hoc Tukey test showed that teachers' self-efficacy of small population center and medium population center differed significantly at 0.038, $p < .05$; large population center group, and rural area groups were not significantly different from others, lying somewhere in the middle (See Appendix D). Therefore, teachers' self-efficacy for a small population center is significantly higher than medium population center. Further details regarding this analysis are available in Appendix D.

Table 20

Differences in Teachers' Self-Efficacy According to Population Centre

	N	Mean	Std. Deviation	Difference	Effect Size Partial Eta Squared (η^2)
Small population center	8	4.0972	0.56167		
Medium population center	9	3.0888	0.74661		
Large population center	24	3.3657	0.79077	Significant at $p<0.05$	0.156
Rural Area	10	3.3222	0.75259		
Total	51	3.4231	0.78701	(0.045)	

Differences in Teachers' Self-Efficacy According to Grade Level

An ANOVA test was performed to compare the effect of number of taught courses/grades on teachers' self-efficacy which is presented on Table 21. The result showed the effect of number of grades taught on teachers' self-efficacy was not significant, $F(4, 46) = 0.274$, $p = 0.893$ (See Appendix D).

Table 21

Differences in Teachers' Self-Efficacy According to Number of Taught Grades/Courses

No of Taught Grades/Courses	N	Mean	Std. Deviation	Difference
One Course	20	3.5289	.77980	
Two Courses	12	3.3148	.98454	
Three Courses	8	3.2361	.84711	Non-significant (0.893)
Four Courses	7	3.4762	.37796	
Five and more Courses	4	3.5556	.94716	
Total	51	3.4274	.79399	

4.3.5 Teachers' Attitudes Toward the Change

Research Question 5: What are the teachers 'attitudes toward change that occurred during the covid-19 transition teaching?

The purpose of this research question was to inquire into teacher's attitudes toward the change during the COVID-19 teaching transition. Items 33-38 were used to explore teachers' attitudes with their means scores along with the standard deviations that are presented in table 22. The overall scale means was 3.92 with standard deviation of 1.09.

The items (37, 38) "I would encourage others to support the changes that occurred in education during the COVID-19 pandemic", and "I intend to do whatever possible to support the changes that occurred in my teaching during the COVID-19 pandemic" demonstrated teachers' behavioral reactions toward change. Both items had the highest overall means with 4.05

(SD=1.21) and 4.19 (SD=1.29) respectively and indicator of teachers' positive attitudes toward the educational change that took place during the COVD-19 pandemic. The item (33), "I am enthusiastic and excited about the changes that took place during the COVD-19 pandemic because of the incorporation of online instructional tools in my science teaching" had the lowest mean with 3.69 (SD= 1.25) within the scale and that represented teachers' affective reaction toward the change. Moreover, next two items (34, 35) had moderate means with 3.90 (SD= 1.28) and 3.80 (SD=1.28) that expressed the teachers' affective reaction toward the change.

As reflected by the scores for survey items 33 and 34, using the responses somewhat agree to strongly agree, 45.5% of teachers were enthusiastic and excited by incorporating online instructional tools their science teaching; and 42.4 % had positive attitudes toward and believed that teachers would benefit from the change that occurred in education during the COVID-19 pandemic. Interestingly, 35.8 % of teachers neither agreed or disagreed to the item (34) regarding the digital transformation of teaching during COVID-19 to help them to perform better at school and that was the highest percentage score within the scale. Details regarding the frequency distribution of survey items are also available in Appendix C.

Table 22

Descriptive Statistics of Teachers' Attitudes Toward the Change

	Teachers' Attitudes Toward the Change	N Valid	N Missing	Mean	Std. Deviation
33	I am enthusiastic and excited about the changes that took place during the COVD-19 pandemic because of the incorporation of online instructional tools in my science teaching.	55	10	3.6909	1.35909
34	I appreciate the digital transformation of teaching during COVID-19 which will help me to perform better at school.	53	12	3.9057	1.28996
35	I believe most of my colleagues will benefit from change that occurred in education during COVID-19 pandemic.	52	13	3.8077	1.28397
36	The digital transformation of teaching that occurred during the pandemic is beneficial for my school.	52	13	3.8846	1.36703
37	I would encourage others (e.g: colleagues, principal, administrators) to support the changes that occurred in education during COVID-19 pandemic.	52	13	4.0577	1.21128
38	I intend to do whatever possible to support the changes that occurred in my teaching during the COVID-19 pandemic.	52	13	4.1923	1.29915
	Scale			3.92	1.098

Differences in Teachers' Attitudes Toward the Change

Research Question 6. Are there any differences in teachers' attitudes when analyzed according to gender, type of internet access, year of teaching experiences, population center, and grade level?

The research question regarding the teachers' attitudes toward the change and impact of teachers' demographic characteristics are discussed in this section. The Shapiro-Wilk test of normality was used to access the normality of data for the teachers' attitudes toward the change. The test statistics showed that (see appendix C) the Sig. value of Shapiro-Wilk test was 0.819 which indicated that the data for the teachers' attitudes toward the change were normally distributed. The parametric independent t-tests and one way-ANOVA tests were performed to explore the differences in teachers' attitudes when analyzed according to gender, year of teaching experiences, grade level, population centre, and type of internet access. The mean, standard deviation, and significance of teachers' attitudes toward the change among participant demographics are displayed in Tables 23-27.

Differences in Teachers' Attitudes Toward the Change According to Gender

An independent-samples t-test was conducted to compare teachers' attitudes toward the change in male and female population, and results were displaced in the Table 23. There was no significant difference in the scores for Male (M=4.1746, SD =1.02398) and Female (M=3.7976, SD = 1.13525); t (47) = 1.199, p= 0.118 for teachers' attitudes toward the change. Further details regarding this analysis are available in Appendix D.

Table 23

Differences in Teachers' Attitudes Toward the Change (TATC) According to Gender

	Gender	N	Mean	Std. Deviation	Difference
Teachers' Attitudes Toward the change	Male	21	4.1746	1.02398	Non-significant (0.118)
	Female	28	3.7976	1.13525	
	Total	49	3.9592	1.09425	

Differences in Teachers' Attitudes Toward the Change According to Type of Internet Access

The differences in teachers' attitudes toward the change according to type of internet access are displayed in Table 24. The effect of type of internet access for online teaching on teachers' attitudes was not significant (F (2, 52) = 3.128, p= 0.052). Therefore, it can be said that teachers' attitudes toward the change for online teaching is not significantly affected by the speed of internet. Although the differences in teachers' attitudes toward the change were not significant, it is worth mentioning that the smartphone wireless internet and others category had higher mean than others. Further details regarding this analysis are available in Appendix D.

Table 24

Differences In Teachers' Attitudes Toward According to Type of Internet Access

	N	Mean	Std. Deviation	Difference
High-speed broadband home internet	28	3.8452	1.09988	Non-Significant
Moderate speed wireless home internet	19	3.6842	.79910	(0.052)
Smartphone wireless internet and others	8	4.7708	1.41684	
Total	55	3.9242	1.09892	

Differences in Teachers 'Attitudes Toward the Change According to Years of Teaching Experiences

An ANOVA test was performed to compare the effect of years of teaching experiences on teachers' attitudes toward the change which is presented in the table 25. An analysis of variance showed that the effect of years of teaching experiences on teachers' attitudes toward the change was no significant. ($F(5, 41) = 0.728$, $p= 0.606$). While not significant, teachers with 7-10 years of experiences had higher mean scores on attitudes than other groups. Further details regarding this analysis are available in Appendix D.

Table 25

Differences in Teachers' Attitudes Toward According to Years of Teaching

Years of Experience	N	Mean	Std. Deviation	Difference
1-3	8	3.5417	.46930	Non-Significant (0.606)
4-6	8	4.2292	1.09811	
7-10	8	4.4167	.84984	
11-15	9	3.9630	1.01303	
16-20	12	3.7917	1.30292	
20+	10	3.7167	1.44455	
Total	55	3.9242	1.09892	

Differences in Teachers' Attitudes Toward the Change According to Population Centre

The differences in teachers' attitudes toward the change according to population center are presented in Table 26. According to the results of one-way ANOVA there was no significant differences were found within the population center of teaching variable when comparing this variable with of teachers' attitudes toward the change, ($F (3, 50) = 2.619$, $p= 0.061$) (See Appendix D). Although the differences in teachers' attitudes toward the change were not significant for population centre, small population center group had higher mean than others. Further details regarding this analysis are available in Appendix D.

Table 26

Differences in Teachers' Attitudes Toward the Change According to Population Centre

Population Center	N	Mean	Std. Deviation	Difference
Small population center	8	4.6667	0.90851	Non-Significant (0.061)
Medium population center	10	3.3333	0.81271	
Large population center	26	3.8077	0.98848	
Rural Areas	10	4.0167	1.35047	
Total	54	3.8858	1.07127	

Differences in Teachers' Attitudes Toward the Change to According to the Grade Level

An ANOVA test was performed to compare the effect of teachers' number of taught grades/courses on teachers' attitudes toward the change, and the results are displayed in Table 27. An analysis of variance showed that the effect of number of taught grades/courses on teachers' attitudes toward the change was not significant, ($F (4, 49) = 1.580$, $p= 0.195$). Although no significant differences were found, those teachers teaching only in one grade or course reported higher scores in teachers' attitudes toward the change. Further details regarding this analysis are available in Appendix D.

Table 27

Differences in Teachers' Attitudes Toward the Change According to Grade Level

No of Grades/ Courses Taught	N	Mean	Std. Deviation	Difference
One Course	20	4.3083	.93857	
Two Courses	13	3.5897	1.20496	Non-Significant (0.195)
Three Courses	9	3.8333	1.47196	
Four Courses	7	3.9762	.54796	
Five and more Courses	5	3.1667	.96465	
Total	54	3.9074	1.10206	

4.4 Teachers' Open-Ended Survey Comments

As part of the questionnaire items, participants were also invited to share comments on three scales of this study: teaching practices, teachers' self-efficacy, and teachers' attitudes toward the change that occurred during COVID-19 pandemic online teaching. The purpose of the open-ended comments was to understand how teachers' practices during COVID-19 teaching may have affected by other factors and shaped their self-efficacy and attitudes. Teachers had the opportunity to comment on their responses to the questionnaire items in the survey. The section addresses teachers' comments on teaching practices, teachers' self-efficacy, and teachers' attitudes that were expressed with similar or identical thoughts.

Comments on Teaching Practices:

Of the responses, teachers' common concerns included with the need for appropriate instructional resources that directly support students in acquiring inquiry-based science knowledge in online classroom (4) [1]. The science teachers appeared to require more support or a high standard in response to formative assessment (4) of student learning while teaching science in online. One participant shared,

> I put things on the Google Classroom, so [the students] had activities to work through, but I did not do any assessment. I did not like marking anything since students submitted things in such a non-standard format. I mean some took photos or scans of their work, others filled in digital copies of assignments; but I found sifting through that and figuring out how to collect things was difficult. As such I posted answer keys for all the assignments turning them into formative assessment opportunities and turned to having exams be the only summative assessment.

Another participant reiterated this challenge as students' internet accessibility was a concern for implementing formative assessments: "formative assessments have been especially difficult in establishing assignments or quizzes/tests that students do independently without using the internet or other household members".

---

[1] The number appearing at the end of a comment reflects the number of respondents who expressed identical or similar opinions to that stated.

Another concern was the lack of school policy or suitable digital tools to communicate with families and parents (5) in ways that respect their values and cultural backgrounds. One respondent indicated, “I found using the online tools to be a poor way of communicating with families. Email and phone are far superior. My school division favoured Google Classroom as the tool of choice - parents don't see enough in there for it to be an effective form of communication”. Moreover, teachers expressed concerns about parents’ communication as many parents have minimal technological experiences (2). One participant reported, “Not all parents/guardians have technology to access or the skills to use them effectively”. Some teachers thought building trust and respect parents’ values and cultural backgrounds (2) through online teaching tools was difficult.

Comments on Teachers’ Self-Efficacy:

Some teachers’ comments indicated a lower level of efficacy to engage students in their virtual classroom. One of the respondents stated, “Students were NOT excited to learn online and were RARELY engaged. I didn't see any enthusiasm and while I had assessments online, there was never a way to see if students were cheating so I am not overly confident with the assessments used”. Moreover, two teachers indicated low level of self-efficacy to communicate with students and families because of their inadequate technological skills, and inefficient internet access to teaching. For instance, one teacher reported, “It was hard to communicate with some students/parents as they lacked technology, or the skills required to use the technology. I would say about 30% of the students were in this category.”

Teachers perceived that receiving professional development, coaching, or mentoring from schools are critical to enhance their confidence to teach successfully and collaborate in a virtual instruction. Another response from a science teacher was, “I did not enjoy remote teaching, it may have been the worst/most challenging situation I have experienced. Many of us struggled with the lack of support/PD/instruction in the use of google classroom or creating your own website to help deliver the course”. This suggests that professional development (PD), and mentoring with genuine encouragements are necessary to enhance teachers’ self-efficacy to teach science online during unusual circumstances such as the COVID-19 pandemic.

Comments on Teachers’ Attitudes Toward the Change:

Teachers’ made comments on their attitudes toward the change that occurred during emergency remote teaching were based on their satisfaction toward online teaching, perceived utility and compatibility, and their experiences on teaching practices during the COVID 19 pandemic. Some teachers thought that science learning was less adaptable to online education. Teachers faced challenges to incorporate hands-on science activities, and collaborative student works in both synchronous (real time), asynchronous platforms which negatively impacted their attitudes toward this change. On a related note, a respondent stated,

> Prior to this I was already using Google Classroom and other Google Apps to enhance classroom experiences extensively. So, integrating technology was not unfamiliar to me. However, the integrity of learning was not reinforced during COVID-19 digital learning. It was a dumpster fire. Even now, after returning to full time classroom instruction, I spend half my time doing remedial teaching as there are huge gaps and inconsistencies in prior learning. Science is constructive in the learning process and having no experience in some topics makes it near impossible to be successful moving forward of these concepts are not covered.

Some respondents stated that they had to spend prolonged time for planning and preparing science lesson and classroom activities to teach online. One of the participants responded, “my worry comes from two things; I'm afraid students knowing they have a fallback will attend class less, and that as teachers we've added an expectation with no "support". There's no added time to take care of or maintain a Google Classroom. I'm afraid we've made it easier for students and harder for teachers”.

Even with the number of negative concerns raised, some teachers found online teaching beneficial (2). Teachers stated it has been beneficial for them to obtain teaching materials and engage students in collaborative class activities. One participant reported, “I teach with the Online Learning Centre and was assigned to this position before the Covid pandemic. I love online teaching, it suits me”. Some teachers also thought that addition of online teaching tools was very supportive to engage students in science classes, and they are enthusiastic to use these tools in future teaching. Another respondent stated, “some great technology was found and integrated into my science classes. In the future some of these technology resources could be implemented in my traditional lessons”. Thus, teachers seem to hold positive attitudes toward online teaching COVID-19 online teaching can also serve as a reference for the future consideration of distance learning during any transformational learning time.

4.5 Chapter Summary

The findings for this study were described in two sections: a) description of the survey items, and b) differences of teaching practices, self-efficacy, attitudes according to the teachers' demographics. Both sets of reports indicate that participants' responses for the teaching practices scale. Specifically, most of the teachers agreed that they had to spend additional time in planning lessons, to establish a positive and collaborative classroom environment, and to communicate with students’ families and community members. In comparing the survey scores from each dimension, results showed that teachers’ teaching practices including the dimensions of classroom instruction, planning and preparation, classroom management, professional responsibility revealed no significant differences between demographics. Findings also indicated that science teachers perceived a low level of self-efficacy to perform the tasks related to their teaching practices. The findings also indicated teachers’ attitudes toward the changes that took place during the COVD-19 pandemic were moderately positive. Generally, teachers are excited and encouraged to support the changes that occurred in education during COVID-19 pandemic. More detailed discussions about the study findings will be addressed in the next chapter.

5. DISCUSSIONS, CONCLUSIONS, AND IMPLICATIONS

5.1 Introduction

For this research, the developed survey was grouped into three areas: (a) teachers' teaching practices during the COVID-19 teaching transition, (b) teachers' self-efficacy related to their teaching practices, and (c) teachers' attitudes toward the change during COVID-19 pandemic teaching. However, to address these three areas, the Danielson's (2020) framework of remote teaching, Self-Efficacy to Teach Science in an Integrated STEM (SETIS) scale developed by Mobley, 2015, and Teachers' Attitude Toward the Change Scale (TATC) (Kin & Kareem, 2017) scale were modified and combined to create a single survey of 39 questions. Moreover, the teaching practices grouping included: (a) classroom instruction, (b) planning and preparation, (c) classroom management, and (d) professional responsibility. In chapter 4, questions in each of these areas represented as dependent variables, and their relationship to the demographic variables of gender, type of internet access, years of experience, population center, and teaching grade level were presented.

Chapter 5 contains three sections: discussions and conclusions, limitations, and implications. Discussion and conclusion included a summary that reveals the significant findings from the data analysis of the survey, and the demographic variables used for the study, and synthesis of the participants' open-ended responses. Limitations included describing the study limitations, and the explanation of how these limitations have influenced the research findings. The final section, implication included suggestions for school administrators and teachers and opportunities for future research.

5.2 Discussions and Conclusions

5.2.1 Summary of the Findings (Demographics)

The majority of the respondents were female (57.1%), having more than 20 years (21.4 %) of teaching experiences. They were evenly distributed in terms of school setting: 39.3 % of the respondents were employed in large population center schools, 35.2% in medium population center schools, and in rural schools, and 17.90% equally in small population center and in urban schools. Further, most commonly taught subjects include Science level-10 with 20.3%, followed by Biology level-30 with 13.7 %, and both Science grade-9 and Health Science level-20 with 11.1 % each. Therefore, results indicated that female teachers were more likely to have enthusiasm to participate in this study. Moreover, experienced science teachers, teaching in science-10, and life sciences, and teaching in larger population center took time to engage and complete the survey.

5.2.2 Summary of the Findings (Research Questions)

R.Q 1 How do science teachers rate themselves in relation to the four dimensions (Classroom Instructions, Planning and Preparation, Classroom Management, Professional Responsibilities) of their teaching practices in the context of COVID-19 pandemic?

Science Teachers' Teaching Practices

Teachers' overall perceived experiences during the COVID-19 pandemic teaching were productive. Teachers' scores for teaching practices within this sample were high for the planning and preparation dimension with means of 4.98 and 4.68, respectively. Within the planning and preparation dimension, items pertaining to design a lesson for online teaching, and teachers' additional time spent on designing inquiry-based classroom activities, assignments and discussion techniques for teaching science online had high scores. Items and results within this dimension indicated that teachers perceived that they had to spend additional time in planning lessons, designing inquiry-based activities, and assignments for online teaching. This finding supports the notion of Johnson et al., (2022)'s research of teachers' teaching-related time during COVID-19. According to Johnson et al., (2022), teachers devoted a huge amount of time to engage students in teaching and teaching-related activities during COVID-19 emergency remote teaching which strained teachers' mental health and wellbeing (Collie, 2021, as cited in Pressley & Ha, 2021). Moreover, Johnson et al., (2022) research mentioned that teachers also spent additional time communicating with students and parents; they invested more time in prerecording lessons, recording and uploading videos to the media. Therefore, it can be said that teaching during the pandemic may have caused teachers to spend additional time not just for instruction but also for planning and preparing of the instructional activities.

The classroom instruction dimension had the lowest mean (4.37) among all the teaching practices dimensions. The item*, my use of online instructional tools better enables me to engage students in collaborative discussion, questioning and reflection to advance student higher-level thinking and discourse* had the lowest mean (3.76) of all the items within the teaching practices section. This finding connects to a study by Hargreaves, (2021) related to classroom instruction which acknowledged that teachers had difficulty increasing their own technological proficiency such as mastering digital tools for developing lessons, designing collaborative works, and assignments. Therefore, it can be concluded that online teaching may have impacted most science teachers' instructional delivery as they struggled to effectively use synchronous and asynchronous digital learning tools to engage students in their classes.

The professional responsibility dimension had the second lowest mean (4.48), but was still at the moderate level. The two items with the lowest means within the dimension were: *The* *online teaching tools allow me to make individual contact with every parent/guardian to establish a communication plan in ways that respect their values and cultural backgrounds* (4.365) and *through the online teaching tools, I can easily interact with families as well as community members to inform them about the school's new instructional programs and bring the community into the decision-making process* (4.38). Both items' results indicated that teachers had a low perception of maintaining engagement with families and strengthening trust-based communication through online tools during the COVID-19 teaching transition. This result can be compared with a previous study by Otero-Mayer et al. (2021) concerning the teachers' perception of establishing relationships with families online which found that parents' lack of technological skills had negatively impacted parent-teacher communication in this new situation. On the other hand, older studies highlighted how school -parent communication has positive effects on students' academic achievements and social progress. (Epstein, 2001; Murphy, 2008; Stuck, 2004; as cited in Otero-Mayer et al., 2021). Nevertheless, the present findings suggest that it will be beneficial to devise a communication plan to establish a trusted relationship with family and parents.

R.Q2: Are there any differences in teaching practices when analyzed according to gender, type of internet access, years of teaching experience, population centre, and grade level?

Differences in Teaching Practices

The dimensions of teaching practices were compared to gender, type of access, years of teaching experience, population centre, and grade level. There were no significant differences found in teaching practices when analyzed according to teachers' demographics. Contrary to my findings, some concurrent and past studies in pandemic and non-pandemic contexts showed the influence of the factors such as instructor's gender, grade level, teaching experience, type of internet access etc. on teaching practices for different samples at different levels (Dea & Negassa, 2019; Johnson et al., 2022, Otero-Mayer et al., 2021). For example, Johnson et al. (2022) found that teachers' ages had an effect on teachers' planning and preparation during the COVID-19 teaching transition; young teachers had a higher proclivity to invest time in planning COVID-19 teaching related activities. In another study in pre-COVID context, Dea & Negassa (2019) found that there were statistically significant differences in teachers' instructional practices when compared with years of teaching experiences. Dea and Negassa, (2019) found teachers with less professional experience (1-5 and 6-10 years) were relatively more skillful in adapting the instructional tools and teaching strategies compared to the relatively more experienced ones (11-15 years) in a non-pandemic teaching context. In a different study, Otero-Mayer et al., (2021) found lack of internet access was the main barrier to the effective communication with families during COVID-19 pandemic teaching. Further research with different geographic samples and different subjects such as language, arts, social studies etc. may reveal the impact of teachers' demographics on the teaching practices would prove illuminating.

R.Q 3: What are the teachers' perceptions of their Self-efficacy of teaching science in COVID-19 online teaching transition?

Teachers' Perceptions of Self-Efficacy

The rapid closure of schools and transition to online learning due to the COVID-19 pandemic has brought changes in science teaching practices which influenced teachers' self-efficacy to teach online in these unique circumstances. In this study, the teachers' self-efficacy scale had nine items with an overall mean of 3.44. The items and results within this scale indicated that science teachers perceived that they had a moderate level of self-efficacy to perform the tasks related to their teaching practices while transitioning to online teaching environments. Teachers' confidence to foster student enthusiasm for learning science online had lowest mean (2.92) which was an indicator of teachers' emotional reaction, while another item of the same indicator pertaining to challenges created by online remote environments had moderate mean (3.34). From these results teachers appeared to face new challenges in their teaching, which led teachers to experience an increase in stress and anxiety from teaching related tasks and planning which in turns may have caused a decrease in teachers' self-efficacy.

The two items with the second and third lowest means were in relation to the teachers' ability to *get* 1) *students to experience excitement, interest, and motivation to learn about phenomena in the natural world using online tools* (3.09), and 2) *formatively assess student learning of discipline-specific content while teaching science in online (3.28).* Both items are associated with the teachers' ability related to their *mastery experiences*. The results indicated that teachers felt low efficacy to motivate their students in learning science and assess student learning using online tools. This may exist because the teachers may have had no or less previous *mastery experiences* for teaching science remotely or teaching in hybrid classes. The study results somewhat support Pressley and Ha's (2021) study which found that teachers had lower efficacy at the beginning of COVID-19 teaching, and that teachers' average self-efficacy scores were less as teachers did not have mastery experiences with virtual classroom teaching during COVID-19 transition. As noted by researchers Pellerone (2021) and Pressley & Ha (2021), teachers may also have felt less confident in their ability to effectively handle their teaching tasks because of the new challenges they faced for transitioning to hybrid and virtual instructional formats.

The items demonstrating teachers' *vicarious learning* and *verbal persuasion* included *teachers' ability to* 1) *collaborate effectively with other teachers in planning science learning* (3.5*),* and 2) *elicit support from their supervisors (principals, administrators, school district) to teach science effectively in online* (3.45) which had moderate means. These findings align with the findings of Kraft et al., (2020) where researchers examined the protective role of teacher working conditions during the COVID-19 pandemic. According to Kraft et al. (2020), "teachers were less likely to experience declines in their sense of success when they worked in schools with strong communication, targeted training, meaningful collaboration, fair expectations, and authentic recognition during the pandemic" (p. 1). Also, Fackler and Malmberg (2016) in their study found that, respondents also have had their self-efficacy impacted by the cooperation from the principal and school community which are considered as important sources of vicarious learning and verbal persuasion within the school environment. Given the results of the study, teachers who received professional development to teach in virtual environments were able to improve their level of confidence to complete their teaching tasks (Kraft et al., 2020; Pressley & Ha, 2021). Furthermore, the school environment is likely to have played an important role in attaining teachers' higher level of self-efficacy as mentioned by Tschannen-Moran and Hoy (2007).

R.Q 4: Are there any differences in teachers' self-efficacy when analyzed according to gender, type of internet access, years of teaching experience, population centre, and grade level?

Differences in Teachers' Self-Efficacy

The items of teachers' self-efficacy were compared to demographic characteristics; however, the only significant differences in teachers' perception of their self-efficacy was found when compared with the population center of teaching. An ANOVA and post hoc Tukey test showed that teachers' self-efficacy for small population center and medium population center differed significantly. Specifically, teachers' self-efficacy for small population center were significantly higher than the medium population center. However, the teachers' self-efficacy for large population center, and rural area were not significantly different from others. It must be noted that the significance differences in teachers' self-efficacy may be due to a smaller number of teachers from small population center participated in the survey.

Pressley and Ha (2021) in their study found teachers self-efficacy has no significant effect when compared according to teachers' age, years of teaching, teaching location and types of internet access. In this case findings are contrary to the current research in the other direction. The present study explored science teachers' self-efficacy during COVID-19 teaching within Saskatchewan school divisions, and the results differed from other concurrent and past studies. Since self-efficacy, according to Bandura (1986) is 'strongly' related to the contextual factors, further research exploring the effect of contextual factors or demographics on teachers' self-efficacy would be beneficial.

R.Q 5: What are the teachers 'attitudes toward change that occurred during the COVID-19 transition teaching?

Teachers' Attitudes Toward the Change

The current study inquired into teacher's attitudes toward the COVID-19 teaching transition based on the Teacher Attitudes Toward Change (TATC) Scale (Kin & Kareem, 2017). The 6-item scale measured three components of teachers' attitudes including cognitive, affective, and behavioural responses to change for their teaching during COVID-19 teaching transition.

The overall scale mean was 3.92 which indicated teachers' attitudes toward the change were moderately low during the COVID-19 pandemic teaching.

The item, *I am enthusiastic and excited about the changes that took place during the COVD-19 pandemic because of the incorporation of online instructional tools in my science teaching* had the lowest mean within the scale which demonstrated the source of teachers' attitudes of their affective reaction toward the change. Moreover, the items, *I appreciate the digital transformation of teaching during COVID-19 which will help me to perform better at school,* and *I believe most of my colleagues will benefit from change that occurred in education during COVID-19 pandemic* had moderate means which demonstrated teachers' cognitive reaction toward the change. The study results suggested that for both cognitive and affective attitudes teachers' attitude toward change became less favourable, and teachers' affective attitudes toward change were significantly lower during COVID-19 teaching. It is possible that the challenges of using online tools for student engagement, spending extensive time on preparation, and concerns about the student achievement may have led teachers to have negative feelings about the change in teaching (Sokal et al., 2020). According to Kin & Kareem (2017), "the affective component of attitudes can impact decision processes which will affect the formulation of TATC and make the change more difficult to be implemented" (Kin & Kareem, 2017, p. 465). Hence, it is important to set planned instructions by schools to make science teachers aware of the merits and drawbacks of new the change in learning which may effectively enhance teachers' cognitive and affective responses to change (Kin & Kareem, 2017).

However, items that demonstrated teachers' attitudes of behavioral reactions that had the highest mean within the scale were: *I would encourage others to support the changes that occurred in education during COVID-19 pandemic,* and *I intend to do whatever possible to* *support the changes that occurred in my teaching during the COVID-19 pandemic*. The findings suggested that teachers had moderately positive attitudes toward the change in teaching during the COVD-19 pandemic. This result aligns with the previous study of Sokal et al., 2020), where teachers' behavioural responses to change were also higher than cognitive and affective responses at the beginning of the pandemic but did not change significantly with time. Sokal et al., (2020) used a longitudinal study to examine how teachers' attitudes toward the COVID-19 teaching response differ during the first three months of the pandemic. Sokal et al., (2020) pointed out that teachers had less willingness to use the online remote teaching as an alternative to in-person teaching due to lack of teaching resources and institutional support which had affected their thoughts and feelings. Therefore, the teachers' behavioural responses as well as thoughts and feelings may have important effect on attitudes toward the transitional teaching to support online teaching.

R.Q 6: Are there any differences in teachers' attitudes when analyzed according to gender, type of internet access, years of teaching experiences, population centre, and grade level?

Differences in Teachers' Attitudes Toward the Change

As survey items of teachers' attitudes toward the change were compared to teachers' demographic characteristics, there were no significant differences in teachers' attitudes toward the change were found for the teachers' demographics. Although the differences in teachers' attitudes toward the change were not significant for the type of internet access, it is worth mentioning that the smartphone wireless internet user category had higher mean than others. Therefore, it can be said that teachers' attitudes toward the change for smartphone internet users were higher than the moderate and high-speed home internet users which may be because of the availability of resources, and less challenges with technology adoption with smartphone users. Nevertheless, the skills necessary for teaching in the virtual environment using smartphones would appear to require less technical proficiency than using computers. Moreover, while not significant, teachers from small population center had higher mean scores on attitudes than other groups. The result indicated that teachers from small population center are favorable towards the online teaching during COVID-19 pandemic. This may be because of teachers received adequate training on the use of online learning tools during COVID-19 pandemic which may had influenced their positive attitude towards the online teaching.

However, when comparing our results to those of similar studies of COVID-19 pandemic, Sokal et al. (2020) in their study did not address the effect of teachers' demographics on the teachers' attitudes toward the change for teaching online during COVID-19 pandemic. Sokal et al. (2020) compared teachers' attitudes based on their teaching time in between April to June in 2020, and their study found significant changes in teachers' attitudes toward the change with time. At the beginning of the pandemic teachers exhibited a positive attitude which significantly decreased with time (Sokal et al., 2020). In another research for non-pandemic conditions, Kin & Kareem (2019) has pointed out that teachers' attitudes toward the change were affected by the effective leadership role of the institution. Kin & Kareem (2019) found significant differences of the teachers' attitudes when compared with the support teachers received from their schools during several stages of change in their teaching. In the face of such results, it can be suggested that concerted efforts should be taken in the near future to see how the other factors (time, organizational support etc.) affect teachers' attitudes toward the changes during COVOD-19 pandemic.

5.2.3 Discussions on Teachers' Open-Ended Survey Comments

The option for open-ended survey comments were kept ascertaining if teachers had any questions, comments, or concerns in addition to the survey questions. Teachers' open-ended comments to teaching practices, self-efficacy, and attitude toward the change were placed in groups that expressed the same or similar opinions, then response themes were discussed accordingly, and how these comments relate to quantitate data and research findings.

Comments on Teachers' Practices

A majority of teachers' comments about their teaching practices during COVID-19 addressed the need for appropriate online educational resources or learning platforms that can support students in acquiring inquiry-based science knowledge in online classroom. Moreover, teachers reported that they need more instructional support to assess of student learning while teaching science in synchronous and asynchronous online platforms. However, findings connect the survey results for teachers' requirements of additional time in planning and designing inquiry-based activities, and assignments for online teaching. These additional time requirements created new challenges to incorporate formative and summative assessment as a regular and consistent part of classroom teaching during the COVID-19 pandemic.

Another concern reported by the teachers was the lack of school policy to communicate with parents consistently and systematically in ways that respect parents' values and cultural backgrounds. Teachers expressed concerns about parents' communication as many parents were less confident to use online tools and didn't feel connected to the school community. Some teachers also reported that building trust and respecting parents' values and cultural backgrounds through online teaching tools was difficult. A similar pattern of results was obtained in the quantitative part which indicated that teachers had a low perception of engagement with families and strengthening trust-based communication through online tools during the COVID-19. Hence, teachers believed that schools would benefit from having a communication plan or policy that would support teachers to establish a positive rapport with families during emergency online learning.

Comments on Teachers' Self-Efficacy

Teachers' open-ended comments in terms of their perceptions of self-efficacy related to teaching science during COVID-19 pandemic indicated a lower level of efficacy to engage students in their virtual classroom. Interestingly, this basic finding is consistent with the survey results for the items related to the teachers' confidence or *mastery experiences* to foster student enthusiasm for teaching science. It is important to note that teachers even with mastery experiences face challenges to teach in a new environment which may negatively affect their teaching self-efficacy (Tschannen-Moran et al., 2001, as cited in Pressley & Ha, 2021). Both direct and open-ended survey results indicated that the transition to online teaching environments had a negative impact on teachers' perceived self-efficacy in completing teaching tasks.

In discussing how vicarious learning and verbal persuasion influenced teachers' self-efficacy, some teachers' comments indicated that receiving professional development, coaching, or mentoring from schools are critical to enhance their confidence to teach online successfully and collaborate in a virtual instruction. On this basis, Fackler & Malmberg 2016) stated that the support from school principal and school community may work as a source of verbal persuasion to enhance teachers' self-efficacy (as cited in Pressley & Ha, 2021). In contrast, the survey results indicated moderate increase in self-efficacy levels when teachers received peer or administrative encouragement. This aspect of the research suggests that adequate levels of professional development (PD) run by teachers within the district or feedback culture as a source of vicarious experiences and verbal persuasion may enhance teacher's self-efficacy in areas that teachers are struggling.

Comments Teachers' Attitudes Toward the Change:

Teachers' comments pertaining to their attitudes toward the change during COVID-19 teaching were mixed with positive and negative in tone. Some teachers had negative attitudes toward the online teaching as they had to spend prolonged time for planning and preparing science lesson and classroom activities to teach science online. Similarly, some teachers' comments indicated that lack of institutional support to use online tools effectively in science teaching, and collaborate among their colleagues, students and parents have led teachers to have negative feelings. However, some of the teachers' comments showed that teachers had positive attitudes toward the online teaching during COVID-19 which may also serve as a reference for the future consideration of distance or blended learning in post-pandemic education. This is consistent with what has been found in survey data which indicated teachers were enthusiastic and excited about the changes that took place during the COVD-19 pandemic because of the incorporation of online instructional tools in their science teaching.

5.3 Limitations

This study has several limitations and requires further examination and additional Research.

- The generalizations from this study were limited to the population from which this sample was taken. The study was conducted on science teachers currently teaching science in public schools in Saskatchewan, Canada. The sample size for this study was limited to the number of respondents who volunteered to participate in this study. Should the study be recreated at a different location with a different group of populations within the Canada, results may vary. However, the knowledge may be deemed transferable by the reader if the context is similar.

- Since this study was quantitative in nature, self-reported survey data was used to collect the teachers' perspectives stated in this study, and the results were solely based on statistics from the survey. This may limit the accuracy of the respondents' answers which might be one of the limitations of the study. As self-reported perceptions do not necessarily reflect actual performance, and the common method variance as a result of self-reported data may impact some of the relationships between the variables (Podsakoff & Organ, 1986).
- The instrument used in the study was the result of combining scales regarding teachers' practices, self-efficacy and attitudes toward the COVID-19 teaching transition. One concern about the findings of the study is the participants' non-response bias that occurred when participants for the selected sample were unwilling to complete the survey. Hence, the data from non-response bias are systematically different from those who participated; and it significantly reduces the statistical power of the survey analysis (Prince, 2012). To avoid non-response bias of the participants, the survey was kept as simple as possible, with a limited number of questions for each construct. Furthermore, in the data analysis section, inferential statistical methods were used to exclude the missing data to compensate for non-response items in the survey. This may affect to gain teachers' perspectives in a broader range on curricular context, instructional practices, and their professional vision of teaching.

- Another source of limitation of this research was participants' response bias to questions as intentional or accidental. This kind of bias occurred as some respondents gave a neutral response or *Agree/Disagree* answers to all the questions asked. Moreover, the careless responding and acquiescence response bias occur when respondents don't bother to read the questions before choosing same answers, and participants pay insufficient attention to the survey contents (Barnette, 1999; Huang, Curran, Keeney, Kam and Meyer 513 Poposki, & DeShon, 2012; Maniaci & Rogge, 2014; Schmitt & Stults, 1985; Woods, 2006, as cited in Kam & Meyer, 2015). Kam & Meyer (2015) reported that careless responding influenced establishing correlations among the variable constructs in their study. Since the survey data represents a number of acquiescent and careless responses, these may have effects on the item correlations, and may have significantly weakened associations of the survey items to the external variables.

5.4 Future Research

Through this research there may be possibilities for further examination that can assist others who plan to study this topic or implement similar methodology.

- This study may allow for replication in other geographic locations to determine to what extent teachers' practices have changed due the COVID-19 technological transformation. The use of this survey may allow others to utilize it to examine further teachers' perspectives, challenges, concerns, and levels of importance of each domain area. Future studies could investigate the causal relationships amongst the constructs analyzed in this study, and the association between the scales with demographic indicators. This may demonstrate more clearer pictures related to teachers' feeling about the transitional teaching. Moreover, future research should examine strategically the factors that influence teachers' self-efficacy and attitudes toward the change for online teaching which would be useful in ongoing efforts to support teachers' teaching practices. The results may serve to develop teachers' professional development in response to post-COVID teaching.

- In order to ensure that the survey instrument is usable for different subgroup, further research is also needed to understand the influence of teachers' demographics such as teachers' qualification, academic rank, and ethnicity on teaching practices as past studies revealed a significant effect of teacher and school characteristics on teachers' practices (Francisco, 2020; Adebayo & Sagaya, 2016). Since longitudinal research involves collecting data over an extended period of time, and typically enhances casual inferences over cross-sectional research which involves collecting data at a single point in time (Rindfleisch et al., 2008). More generally, a longitudinal study employing observational method can be used to document how changes occur within teachers' classroom practices in relationship to their self-efficacy and attitudes toward the change in response to COVID-19 teaching transition.
- Data collected in this study were through self-report measures. There may be possibilities arising from this work for further studies that could be conducted by interviewing teachers and providing adequate time for a professional discussion in an attempt to find data that is more in depth. By conducting such qualitative or mixed method studies to identify areas of concern and support the quantitative data with relevant themes of importance, a thorough study would provide additional information to interpret that would provide further insight.

5.5 Implications

This exploratory study investigated how Saskatchewan science teachers perceived the use of online teaching during COVID-19 teaching transition. The findings from this study demonstrated how teachers' opinions of their teaching practices, associated self-efficacy, and attitudes toward the change may impart useful information to school divisions, administrators, and education stakeholders to support transformational learning.

Participant teachers reported that they have faced sweeping, unprecedented changes to teaching science during the COVID-19 pandemic. Majority of science teachers reported that they had struggled to include investigations and hands-on learning for students on virtual environment. Some of them may have lacked technological knowledge and skills to create compatible materials for online learning, and they had to make many adjustments that made their teaching especially challenging. As teachers agreed to continue some form of distance learning in post-pandemic situation, science teachers need adequate professional development training, resources, and strategies to help increase student engagement in learning remotely. Moreover, guidance on how to incorporate technology effectively into their teaching practices with hands-on learning opportunities (e.g., labs, inquiry activities) to support students' science learning are mostly desirable. Therefore, policymakers and administrators will need to ensure that supports for teachers — including internet access, training as well as digital materials to promote science learning — are provided when schools set any hybrid or distance learning strategy in future.

One particular curricular aspect that deserves urgent attention is the lack of technological standards for teachers to communicate with parents and families. Teachers reported that a standard online communication policy and appropriate online tools can positively effect on communication between teachers and families. Thus, a newer digital communication policy could be incorporated to create better opportunities for parents to develop a positive relationship with the school. Although some school divisions have developed polices and have been using specific digital tools to allow parents access to student achievement records. Teachers particularly expressed a need for ways to motivate and engage parents, to involve parents in school's instructional decisions, and to establish a rapport in ways that respect their values and cultural backgrounds. It is also suggested to rethink and redesign the school's communication plan to incorporate more one-on-one meetings to strengthen the relationship with parents.

At the same time, teachers expressed they had to spend additional time designing coherent science instructions, preparing digital classroom materials, and assignments and discussion for their students while teaching online. To ease the teachers' workload, educational assistants could be assigned to work with them that may enrich the instructional delivery of the program. Additionally, a dedicated online support center or resource bank of online based curriculum materials for instructors to support their teaching (whether blended or online) could help promote online teaching practices and will aid to teachers' planning and preparation.

In terms of formative assessments, teachers and schools may consider integrating new digital applications and software (like Clickers, Socrative, Kahoot, Plickers etc.) which may aid teachers to gauge student understanding of science; and help teachers to check their teaching effectiveness. Finally, school boards should provide adequate levels of training, and resources including trained personnel to teachers to engage themselves in planning, exchange feedback, and properly utilize the learning resources. Overall, school divisions and principals should develop an environment within school to promote teachers' self-efficacy and attitudes toward the change by providing adequate feedback, opportunities to grow through professional development, and technological support in their teaching as the transformation continues post pandemic.

References

Adebayo, F. A., & Sagaya A.A. (2016). Teachers' capacity building and students' academic performance among public junior secondary schools in Kwara State. *British Journal of Educations, Society & Behavioral Science, 12*(3), 1-10. https://doi.org/10.9734/BJESBS/2016/19759

Al-Bayyati, H. A. (1971). A rule of thumb for determining a sample size in comparing two proportions. *Technometrics*, *13*(3), 675–677. https://doi.org/10.1080/00401706.1971.10488828

Ajzen I. (1985). From intentions to actions: A theory of planned behavior. In: Kuhl J., Beckmann J. (eds) *Action Control*. *From cognition to behavior* (pp. 11-39). *SSSP Springer Series in Social Psychology*. Berlin, Springer, Heidelberg. https://doi.org/10.1007/978-3-642-69746-3_2

Ajzen, I. (2015). The theory of planned behaviour is alive and well, and not ready to retire: a commentary on Sniehotta, Presseau, and Araújo-Soares. In *Health Psychology Review*. https://doi.org/10.1080/17437199.2014.883474

Babinčáková, M., & Bernard, P. (2020). Online experimentation during covid-19 secondary school closures: Teaching methods and student perceptions. *Journal of Chemical Education*, *97*(9), 3295–3300. https://doi.org/10.1021/acs.jchemed.0c00748

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*. *84*(2), 191-215. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, A. (1997). Self-efficacy: *The exercise of control.* NY: W.H. Freeman and Co.

Barni D, Danioni F and Benevene, P (2019). Teachers' self-efficacy: The role of personal values and motivations for teaching. *Front. Psychol. 10*:1645. https://doi.org/10.3389/fpsyg.2019.01645

Beazidou, E., Botsoglou, K., & Andreou, E. (2013). Classroom behavior management practices in kindergarten classrooms: An observation study. *Έρευνα Στην Εκπαίδευση*. https://doi.org/10.12681/hjre.8794

Beltman, S., Mansfield, C., & Price, A. (2011). Thriving not just surviving: A review of research on teacher resilience. *Educational Research Review*, *6*(3), 185-207. https://doi.org/10.1016/j.edurev.2011.09.001

Bencze, J. L., Bowen, G. M., & Alsop, S. (2006). Teachers' tendencies to promote student-led science projects: Associations with their views about science. *Science Education*, *90*(3), 400–419. https://doi.org/10.1002/sce.20124

Bernadowski, C., Perry, R., & Del Greco, R. (2013). Improving preservice teachers' self-efficacy through service learning: Lessons learned. *International Journal of Instruction*, *6*(2), 67–86.

Biasuttie, M. (2011). The student experience of a collaborative e-learning university module. *Computers & Education 57* (3), 1865–1875. https://doi.org/10.1016/j.compedu.2011.04.006.

Blonder, R., Benny, N., & Jones, G. (2014). Teaching self-efficacy of science teachers. In R. H. Evans, J. Luft, & C. L. Czerniak (Eds.), *The role of science teachers' beliefs in international classrooms: from teacher actions to student learning* (pp. 3–16). Sense Publisher. https://doi.org/10.13140/2.1.3503.7441

Bonett, D. G. (2002). Sample size requirements for testing and estimating coefficient alpha. *Journal of Educational and Behavioral Statistics*, *27*(4), 335–340. https://doi.org/10.3102/10769986027004335

Bouckenooghe, D. (2010). Positioning Change Recipients' Attitudes Toward Change in the Organizational Change Literature. *The Journal of Applied Behavioral Science*, *46*(4), 500–531. https://doi.org/10.1177/0021886310367944

Bozkurt, A., & Sharma, R. C. (2020). Emergency remote teaching in a time of global crisis due to Coronavirus pandemic. *Asian Journal of Distance Education*, *15*(1), i–vi. https://doi.org/10.5281/zenodo.3778083

Bujang, M. A., Omar, E. D., & Baharum, N. A. (2018). A review on sample size determination for Cronbach's Alpha Test: A simple guide for researchers. *Malaysian Journal of Medical Sciences*, *25*(6), 85–99. https://doi.org/10.21315/mjms2018.25.6.9

Breckler, S., & Wiggins, E. (1989). Affect versus evaluation in the structure of attitudes. J*ournal of Experimental Social Psychology, 25*(3), 253-271. https://doi.org/10.1016/0022-1031(89)90022-X

Brown, A., & Johnson, J. (2007). Five advantages of using learning management system. Retrieved 08 January, 2007. Retrieved from https://www.microburstlearning.com/

Bryman, A. (2001) Social Research Methods. Oxford University Press, Oxford.

Caletha, W. (2017, December). *Exploring teacher effectiveness as measured by the Danielson framework for teaching and student achievement outcomes: pursuing an understanding of leading students to excellence-PULSE Study* (No. 277). Digital Commons at National Louis University. https://digitalcommons.nl.edu/cgi/viewcontent.cgi?article=1291&context=diss

Capa-Aydin, Y., Sungur, S., & Uzuntiryaki, E. (2009). Teacher self-regulation*: Examining a multidimensional construct. Educational Psychology*, *29*(3), 345-356. https://doi.org/10.1080/01443410902927825

Carrillo, C., & Flores, M. A. (2020). COVID-19 and teacher education: a literature review of online teaching and learning practices. *European Journal of Teacher Education*. *43*(4), 466-487. https://doi.org/10.1080/02619768.2020.1821184

Carrol, N., & Burke, M. (2010). Learning effectiveness using different teaching modalities. *American Journal of Business Education (AJBE)*. https://doi.org/10.19030/ajbe.v3i12.966

Cavas, B., Cavas, P., Karaoglan, B., & Kisla, T. (2009). A study on science teachers' attitudes toward information. *The Turkish Online Journal of Educational Technology*, *8*(2), 20–32.Retreived from https://files.eric.ed.gov/fulltext/ED505935.pdf

Cavus, N., & Alhih, M. (2013). Learning management systems use in science education. P*rocedia, Social and Behavioral Sciences, 143,* 517-520. https://doi.org/10.1016/j.sbspro.2014.07.429

Chadwick, Ruth & Mcloughlin, Eilish. (2020). Impact of COVID-19 crisis on science teaching and facilitation of practical activities. *Medical Letter on the CDC & FDA, 290*. https://doi.org/10.35542/osf.io/vzufk.

Christodoulou, E., Kalokairinou, A., Koukia, E., Intas, G., Apostolara, P., Daglas, A., & Zyga, S. (2015). The test - retest reliability and pilot testing of the "New technology and nursing students' learning styles" questionnaire. *International Journal of Caring Sciences, 8*(3), 567–576.

http://www.internationaljournalofcaringsciences.org/docs/6_Christodoulou_original_8_3.pdf

Choi, J., Peters, M., & Mueller, R. O. (2010). Correlational analysis of ordinal data: From Pearson's r to Bayesian polychoric correlation. *Asia Pacific Education Review*. https://doi.org/10.1007/s12564-010-9096-y

Clark, D. (2015, July 27). *Delivering the Learning Platform in Instructional Design*. A Big Dog and Little Dog's Performance Juxtaposition. http://www.nwlink.com/%7Edonclark/hrd/sat5.html

Corry, M., & Stella, J. (2018). Teacher self-efficacy in online education: A review of the literature. *Research in Learning Technology*, *26*(1063519), 1–12. https://doi.org/10.25304/rlt.v26.2047

College of canyons. (2021). *Remote instruction*. Retrieved from https://www.canyons.edu/academics/onlineeducation/remoteinstruction.php

Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology*. https://doi.org/10.1037/0021-9010.78.1.98

Creswell, J. (2014). *Research designs: Qualitative, quantitative and mixed method approaches, 4th ed.* Thousand Oaks, CA: Sage.

Cruz, R., Manchanda, S., Firestone, A., & Rodl, J. (2020). An examination of teachers' culturally responsive teaching self-efficacy. *Teacher Education and Special Education, 43*(3), 197-214. https://doi.org/10.1177/0888406419875194

Danielson, C. (1996). *Enhancing professional practices*: *A framework for teaching*. Alexandria, VA: Association of supervision and curriculum development.

Danielson, C. (2007). *Enhancing Professional Practice: A Framework for Teaching (Professional Development)* (2nd ed.). Association for Supervision & Curriculum Development.

Danielson, C. (2013). *The Framework for teaching evaluation instrument, 2013 instructionally focused edition*. Retrieved from https://usny.nysed.gov/rttt/teachers-leaders/practicerubrics/Docs/danielson-teacher-rubric-2013-instructionally-focused.pdf

Danielson group. (2021). *Danielson framework for remote teaching.* Retrieved from https://danielsongroup.org/downloads/framework-teaching?download

Doerr, S. E. (2012). Charlotte danielson's theory of teacher evaluations: A quantitative study of teachers' perceptions on the four domains (Order No. 3499681). Available from ProQuest Dissertations & Theses Global. (945731520). Retrieved from https://www.proquest.com/dissertations-theses/charlotte-danielsons-theory-teacher-evaluations/docview/945731520/se-2?accountid=14739

Dolighan, T., & Owen, M. (2021). Teacher efficacy for online teaching during the COVID-19 pandemic. *Brock Education Journal*, 30(1). https://doi.org/10.26522/brocked.v30i1.851

Duffin, L. C., French, B. F., & Patrick, H. (2012). The teachers' sense of efficacy scale: confirming the factor structure with beginning pre-service teachers. *Teaching and Teacher Education*, *28*(6), 827–834. https://doi.org/10.1016/j.tate.2012.03.004

Duffield, S. and O'Hare, D. (2020) Teacher resilience during coronavirus school closures. Leicester: British Psychological Society. Retrieved from https://www.bps.org.uk/sites/www.bps.org.uk/files/Member%20Networks/Divisions/DECP/Teacher%20resilience%20during%20coronavirus%20school%20closures.pdf

Dunham, R.B., Grube, J.A., Gardner, D.G., Cummings, L.L. and Pierce, J.L. (1989) The development of an attitude toward change instrument, unpublished discussion Paper 124, *Strategic Management Research Centre*, Washington, DC.

Edison, S. W., & Geissler, G. L. (2003). Measuring attitudes general technology: Antecedents, hypotheses and scale development. *Journal of Targeting, Measurement and Analysis for Marketing*, *12*(2), 137–156. https://doi.org/10.1057/palgrave.jt.5740104

Ekici, F.T., Kara, İ., & Ekici, E. (2012). The primary student teachers' views about a blended learning application in a basic physics course. *The Turkish Online Journal of Distance Education*, *13*, 291-310. Retrieved from https://atif.sobiad.com/index.jsp?modul=makale-detay&Alan=sosyal&Id=AWCu9IXNoDuH9Br_eGqQ

Etikan, I. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1. https://doi.org/10.11648/j.ajtas.20160501.11

Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: a preservice elementary scale. *School Science and Mathematics. 90*(8), 694–706. https://doi.org/10.1111/j.1949-8594.1990.tb12048.x.

Etikan, I. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1. https://doi.org/10.11648/j.ajtas.20160501.11

Eyisi, D. (2016). The usefulness of qualitative and quantitative approaches and methods in researching problem-solving ability in science education curriculum. *Journal of Education and Practice*, *7*(15), 91–100. https://files.eric.ed.gov/fulltext/EJ1103224.pdf

Fackler, S., & Malmberg, L. E. (2016). Teachers' self-efficacy in 14 OECD countries: Teacher, student group, school and leadership effects. *Teaching and Teacher Education*, *56*, 185–195. https://doi.org/10.1016/j.tate.2016.03.002

Faulconer, E. K., & Gruss, A. B. (2018). A review to weigh the pros and cons of online, remote, and distance science laboratory experiences. *The International Review of Research in Open and Distributed Learning*, *19*(2). https://doi.org/10.19173/irrodl.v19i2.3386

González-Gómez, F., Guardiola, J., Martín Rodríguez, Ó., & Montero Alonso, M. Á. (2012). Gender differences in e-learning satisfaction. *Computers and Education*. https://doi.org/10.1016/j.compedu.2011.08.017

Govender, D. W. (2010). Attitudes of students the use of a Learning Management System (LMS) in a face-to-face learning mode of instruction. *Africa Education Review*, *7*(2), 244–262. https://doi.org/10.1080/18146627.2010.515394

Haverback, H. R. (2020). Middle level teachers quarantine, teach, and increase self-efficacy beliefs: using theory to build practice during covid-19. *Middle Grades Review*, *6*(2), 6.Retrieved from https://scholarworks.uvm.edu/cgi/viewcontent.cgi?article=1167&context=mgreview

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020, March, 27). *The difference between emergency remote teaching and online learning*. educause review . Retrieved from https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

Hofer, E., & Lembens, A. (2019). Putting inquiry-based learning into practice: How teachers changed their beliefs and attitudes through a professional development program. *Chemistry Teacher International*, *1*(2). https://doi.org/10.1515/cti-2018-0030

Huber, S., & Helm, C. (2020). COVID-19 and schooling: evaluation, assessment and accountability in times of crises--reacting quickly to explore key issues for policy, practice and research with the school barometer. *Educational Assessment, Evaluation and Accountability*, *32*(2), 237-270. https://doi.org/10.1007/s11092-020-09322-y

Johnson, A. D., Schochet, O. N., Castle, S., Horm, D., & Phillips, D. A. (2022). Predictors of first-grade teachers' teaching-related time during COVID-19. *AERA Open*, *8*(1)-1-14, 233285842110677. https://doi.org/10.1177/23328584211067798

Julious, S. A. (2005). Sample size of 12 per group rule of thumb for a pilot study. *Pharmaceutical Statistics*, *4*(4), 287–291. https://doi.org/10.1002/pst.185

Kaharuddin, A., (2020). Contributions of technology, culture, and attitude to english learning motivation during COVID-19 outbreaks. *Systematic Reviews in Pharmacy*, *11* (11), 76-84. https://doi.org/doi:10.31838/srp.2020.11.13.

Kin, T. M., & Kareem, O. A. (2017). Measuring teacher attitudes change: An empirical validation. *International Journal of Management in Education*, *11*(4), 437–469. https://doi.org/10.1504/IJMIE.2017.086909

Komninou, I. (2017). A case study of the implementation of social models of teaching in e-learning: "The social networks in education", Online course of the inter-orthodox centre of the Church of Greece. TechTrends, 62(2), 146–151. https://doi.org/10.1007/s11528-017-0247-4

Kraft, M. A., Simon, N. S., & Lyon, M. A. (2021). Sustaining a sense of success: The protective role of teacher working conditions during the COVID-19 pandemic. *Journal of Research on Educational Effectiveness*, *14*(4), 727–769. https://doi.org/10.1080/19345747.2021.1938314

Lawless, C. (2019, August 6). *What is eLearning?* LearnUpon. https://www.learnupon.com/blog/what-is-elearning/

Lee, E. C., Whitehead, A. L., Jacques, R. M., & Julious, S. A. (2014). The statistical interpretation of pilot trials: Should significance thresholds be reconsidered? *BMC Medical Research Methodology*. https://doi.org/10.1186/1471-2288-14-41

Laplante, B. (1997). Teachers' beliefs and instructional strategies in science: Pushing analysis further. *Science Education*, *81*(3), 277–294. https://doi.org/10.1002/(SICI)1098-237X(199706)81:3<277::AID-SCE2>3.0.CO;2-A

Lapada, A. A., Miguel, F. F., Robledo, D. A. R., & Alam, Z. F. (2020). Teachers' COVID-19 awareness, distance learning education experiences and perceptions institutional readiness and challenges. *International Journal of Learning, Teaching and Educational Research*, *19*(6), 127–144. https://doi.org/10.26803/ijlter.19.6.8

Lin, X., & Gao, L. (2020). Students' sense of community and perspectives of taking synchronous and asynchronous online courses. *Asian Journal of Distance Education*, *15*(1), 169–179. Retrieved from https://files.eric.ed.gov/fulltext/EJ1289947.pdf

Love-Kelly, L. M. (2020, January). *Teachers' perceptions of culturally responsive pedagogy's influence on instructional strategies* (No. 8938). Walden Dissertations and Doctoral Studies. Retrieved from https://scholarworks.waldenu.edu/dissertations/8938

Marzillier, J., & Eastman, C. (1984). Continuing problems with self-efficacy theory: A reply to Bandura. *Cognitive Therapy and Research*, *8*(3), 257–262. https://doi.org/10.1007/bf01172996

Massoud, S. L. (1991). Computer attitudes and computer knowledge of adult students. Journal of Educational Computing Research, 7(3), 269-291. https://doi.org/10.2190/HRRV-8EQV-U2TQ-C69G

Ma, K., Chutiyami, M., Zhang, Y., & Nicoll, S. (2021). Online teaching self-efficacy during COVID-19: Changes, its associated factors and moderators. *Education and Information Technologies*, 1–23. https://doi.org/10.1007/s10639-021-10486-3

Mobley, M. C. (2015). *Development of the setis instrument to measure teachers' self-efficacy to teach science in an integrated stem framework* (No. 33554) . University of Tennessee. Retrieved from .https://trace.tennessee.edu/utk_graddiss/3354

Moore, C. G., Carter, R. E., Nietert, P. J., & Stewart, P. W. (2011). Recommendations for planning pilot studies in clinical and translational research. In *Clinical and translational science*. https://doi.org/10.1111/j.1752-8062.2011.00347.x

Morris-Mathews, H., Stark, K. R., Jones, N. D., Brownell, M. T., & Bell, C. A. (2020). Danielson's framework for teaching: convergence and divergence with conceptions of effectiveness in special education. *Journal of Learning Disabilities*, *54*(1), 66–78. https://doi.org/10.1177/0022219420941804

Nabavi, R. T. (2012). Bandura's social learning theory & social cognitive learning theory. *Theories of Developmental Psychology*, 3–22.

https://www.researchgate.net/publication/267750204_Bandura's_Social_Learning_Theory_Social_Cognitive_Learning_Theory

National science teaching association (NSTA). (2016). *NSTA Position Statement: The Role of E-Learning in Science Education*. Retrieved from https://www.nsta.org/

Ndihokubwayo, K., Uwamahoro, J., & Ndayambaje, I. (2020). Usability of electronic instructional tools in the physics classroom. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(11), em1897. https://doi.org/10.29333/ejmste/8549

https://doi.org/10.22521/edupij.2020.93.4

Noor, S., Isa, F. M., & Mazhar, F. F. (2020). Online teaching practices during the COVID-19 pandemic. *Educational Process: International Journal*, *9*(3), 169–184. https://doi.org/10.22521/edupij.2020.93.4

Otero-Mayer, A., González-Benito, A., Gutiérrez-de-Rozas, B., & Vélaz-de-Medrano, C. (2021). Family-School cooperation: An online survey of parents and teachers of young children in Spain. *Early Childhood Education Journal*, *49*(5), 977–985. https://doi.org/10.1007/s10643-021-01202-4

Ozdemir, E. B. (2021). Views of science teachers about online stem practices during the covid-19 period. *International Journal of Curriculum and Instruction*, *13*(1), 854–869. https://files.eric.ed.gov/fulltext/EJ1285828.pdf

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and Policy in Mental Health and Mental Health Services Research*. https://doi.org/10.1007/s10488-013-0528-y

Palmer, D. H. (2006). Sources of self-efficacy in a science methods course for primary teacher education students. *Research in Science Education*, *36*(4), 337–353. Retrieved from http://crl.du.ac.in/ical09/papers/index_files/ical-40_119_263_2_RV.pdf

Pandey, S. R., & Pandey, S. (2009). Developing a more effective and flexible learning management system (LMS) for the academic institutions using Moodle. In the proceeding of the international conference on academic libraries (pp. 249-254). Delhi, India: University of Delhi.

PhET Interactive Simulations. (2020). *PhET*. https://phet.colorado.edu

Poulou, M., Reddy, L., & Dudek, C. (2019). Relation of teacher self-efficacy and classroom practices: A preliminary investigation. *School Psychology International*, *40(*1), 25-48.https://doi.org/10.1177/0143034318798045

Pressley, T., & Ha, C. (2021). Teaching during a Pandemic: United States teachers' self-efficacy during COVID-19. *Teaching and Teacher Education*, *106*, 103465. https://doi.org/10.1016/j.tate.2021.103465

Quarless, D., & Nieto, F. (2013). Exploring hybrid instruction in science: using lms for contextual, interdisciplinary active learning enrichment. *Journal of Educational Technology Systems*, *41*(3), 279–292. https://doi.org/10.2190/et.41.3.f

R. Evans. (2014). Overview of the role of teacher beliefs in science education. In C. Evans, R., Luft, J., Czerniak, C., Pea (Ed.), *The Role of Science Teachers' Beliefs in International Classrooms* (pp. 17–31). Sense Publishers,.

Saklofske, D. H., Michayluk, J. O., & Randhawa, B. S. (1988). Teachers' efficacy and teaching behaviors. *Psychological Reports*, *63*(2), 407–414. https://doi.org/10.2466/pr0.1988.63.2.407

Siegel, M. (2020). *5 Major Shifts Needed Post-COVID-19 to Transform Education*. K-12 EDUCATION. Retrieved from https://www.govtech.com/education/k-12/five-major-shifts-needed-post-covid-19-to-transform-education.html

Setia, M. (2017). Methodology series module 9: Designing questionnaires and clinical record forms - Part II. *Indian Journal of Dermatology, 62*(3), 258-261. https://doi.org/10.4103/ijd.IJD_200_17

Shoepe, T. C., McManus, J. F., August, S. E., Mattos, N. L., Vollucci, T. C., & Sparks, P. R. (2020). Instructor prompts and student engagement in synchronous online nutrition classes. *American Journal of Distance Education*, *34*(3), 194–210. https://doi.org/10.1080/08923647.2020.1726166

Sokal, L., Trudel, L. E., & Babb, J. (2020). Canadian teachers' attitudes toward change, efficacy, and burnout during the COVID-19 pandemic. *International Journal of Educational Research Open*, *1*(September), 100016. https://doi.org/10.1016/j.ijedro.2020.100016

Stein, M.K. and Wang, M.C. (1988) Teacher development and school improvement: the process of teacher change. *Teaching and Teacher Education, 4*, 171-187. http://dx.doi.org/10.1016/0742-051X(88)90016-9

Stauffer, B. (2020, April 2). *What's the difference between online learning and distance learning?* Applied-Educational-Systems. https://www.aeseducation.com/blog/online-learning-vs-distance-learning

Sweeley, T. M. (2004). Teachers' attitudes charlotte Danielson's four domains of teacher evaluation. (Widener University). ProQuest Dissertations and Theses, 190-190 p. Retrieved from https://research.proquest.com.library.uark.edu/docview/305057791?accountid=8361.

People for Education. (2021, January 25). *Tracking Canada's education systems' response to COVID-19*. Retreived from https://peopleforeducation.ca/our-work/tracking-canadas-education-systems-response-to-covid-19/

Powell, Katherine C., & Kalina, Cody J. (2009). Cognitive and social constructivism: Developing tools for an effective classroom. *Education, 130*(2), 241-250

Tanık-Önal, N., & Önal, N. (2020). *Teaching science through distance education during the covid19 pandemic*. *International Online Journal of Education and Teaching (IOJET),* 7(4). Retreived from https://files.eric.ed.gov/fulltext/EJ1271081.pdf

Teachers' Federation Saskatchewan. (2020). *Governance handbook.* https://www.stf.sk.ca/sites/default/files/governance_handbook_2020_21_1.pdf

Teo, T. (2014). Unpacking teachers' acceptance of technology: Tests of measurement invariance and latent mean differences. *Computers and Education*. https://doi.org/10.1016/j.compedu.2014.01.014

Terry, L., & Kelley, K. (2011). Sample size planning for composite reliability coefficients: Accuracy in parameter estimation via narrow confidence intervals. *British Journal of Mathematical and Statistical Psychology*, *65*(3), 371–401. https://doi.org/10.1111/j.2044-8317.2011.02030.x

Tornikoski, E., & Maalaoui, A. (2019). Critical reflections – The theory of planned behaviour: An interview with Icek Ajzen with implications for entrepreneurship research. *International Small Business Journal: Researching Entrepreneurship*, *37*(5), 536–550. https://doi.org/10.1177/0266242619829681

Tschannen-Moran, M., & Hoy, A.W. (2001). Teacher efficacy: Capturing an elusive construct. T*eaching and Teacher Education*, *17*, 783-805. https://doi.org/10.1016/S0742-051X(01)00036-1

Tschannen-Moran, M., & Hoy, A. W. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education*, *23*(6), 944–956. https://doi.org/10.1016/j.tate.2006.05.003

Vasiliadou, R. (2020). Virtual laboratories during coronavirus (COVID-19) pandemic. *Biochemistry and Molecular Biology Education*, *48*(5), 482-483. https://doi.org/10.1002/bmb.21407

Verma, A., Verma, S., Garg, P., & Godara, R. (2020). Online teaching during covid-19: perception of medical undergraduate students. In *Indian Journal of Surgery*. *82*(3), 299–300. https://doi.org/10.1007/s12262-020-02487-2

Wang, M., Haertel, G., & Walberg, H. (1993). Toward a knowledge base for school learning. *Review of Educational Research*, *63(*3), 249-294. https://doi.org/10.2307/1170546

White, C. (2017, December). *Exploring teacher effectiveness as measured by the Danielson framework for teaching and student achievement outcomes: pursuing an understanding of leading students to excellence-pulse study* (No. 277). Digital Commons at National Louis University. https://digitalcommons.nl.edu/diss/277

APPENDIX A (A) :

PARTICIPANT RECRUITMENT POSTER

Department of Curriculum Studies

College of Education

University of Saskatchewan

RESEARCH IN '*A Survey on Science Teachers' Perspectives of their Teaching Practices DuringCOVID-19 Emergency Online Teaching Transition*".

We are looking for volunteers to take part in a study of

Teaching Science Through Online Distance Education During the Covid-19 Pandemic: Science Teachers' Practices, Self-Efficacy Beliefs, And Attitudes Toward the Change.

As a participant in this study, you would be asked to participate in an online survey

Your participation would involve *a single* session
which is approximately **20** minutes.

Click on the link below to participate to the survey:

https://www.surveymonkey.ca/r/3DR2N6F

QR code:

For more information about this study, or to volunteer for this study,
please contact:
Fazle Rafi
Dept. of curriculum studies
at
306-8803929 or
Email: *far419@mail.usask.ca*

APPENDIX A (B):

PARTICIPANT'S SURVEY CONSENT FORM (ONLINE)

Title of the Research:

Teaching Science Through Online Distance Education During the Covid-19 Pandemic: Science Teachers' Practices, Self-Efficacy Beliefs, And Attitudes Toward the Change.

Research Supervisor:

Dr Tim Molnar, Assistant Professor,

College of Education,

University of Saskatchewan.

Email : tim.molnar@usask.ca

Researcher and Institutional Affiliation:

Fazle Rafi (Graduate Student),

Dept of Curriculum Studies,

College of Education,

University of Saskatchewan.

Email : far419@mail.usask.ca

Purpose of the Study:

- The COVID-19 pandemic has fundamentally changed the teaching practices, in various way. The purpose of this study is to explore science teachers' practices and their experiences in current context of COVID-19 online remote teaching. More specifically, this study will investigate science teachers' experiences in the aspects on planning and preparation of science lessons, inquiry-based science instructions including assessments, discussion and class activities, classroom management, and teachers' professional responsibilities in the context of COVID-19 online remote teaching transition.
- This study also aims to investigate teachers' perceptions of self-efficacy beliefs for executing pedagogical tasks in online remotely teaching, and teachers' attitudes toward the transition from face-to-face to remote teaching.

Procedures:

- You will be asked to participate in an online questionnaire survey regarding their experience, perception and knowledge on their current science learning practices in the context of COVID-19 online remote teaching. There will be 39 Likert scale questions which will take not more than 20 minutes to complete. Upon completion, your response will be automatically saved in SurveyMonkey server for researcher use.

Potential Risks:

- There are no known or anticipated risks to you by participating in this research. As the survey will be conducted fully online, there is no harm or risk associated stress because of participation in the study.

Benefits of this Study:

- The study will provide useful information to you regarding current science teaching practices in COVID-19 teaching transition. The study results may influence teachers' ability to align the integration of technology with the implementation of common core state standards in science teaching. In addition, this study is also aid current online learning practitioners to discover new approaches, to extend the reader's experience, or to confirm what is known and what is unknown concerning online learning.
- Besides, results of the study could help influence instructional decisions at the school site. School administrations may utilize the investigation results to develop the appropriate professional training practice appropriate blended learning model within their school environment.

Compensation

- You will be offered a small gift as a way to compensate you for any inconvenience related to your participation. It is important for you to know that it is unethical to provide undue compensation or inducements to research participants and, if you agree to be a participant in this study, this form of compensation to you must not be coercive. If you would not otherwise choose to participate if the compensation was not offered, then you should decline

Confidentiality:

- The result of this study will be disseminated as dissertation work to ProQuest digital publication.
- All collected data will be reported through statical procedures, the results will be interpreted through graphs, charts, and tables.
- Anonymity, privacy, and confidentiality related to your participation and your identity will be guaranteed as much as possible in the given the context.
- This survey is hosted by Survey Monkey. Your data will be stored in facilities hosted in Canada. Please see the following for more information on the Survey Monkey Privacy Policy.
- Data and records created by this project are owned by University of Saskatchewan. Access to all the information will be kept in confidential and only primary researcher will use them.

Storage of Data:

- All electronic collected data will be saved to University of Saskatchewan computer will full encryption.
- The storage period of the data is five years post-publication.

Right to Withdraw:

- Your participation is voluntary, and you can participate in only those questions of the survey that you are comfortable with.
- You can decide not to participate at any time by closing your browser or choose not to answer any questions you do not feel comfortable with. Survey responses will remain anonymous. Since the survey is anonymous, once it is submitted it cannot be removed.
- Your right to withdraw data from the study will apply until August 15. After this, it is possible that some form of research dissemination will have already occurred, and it may not be possible to withdraw your data.

Follow up:

- Since your participation in the study is anonymous, to obtain results of the study, please email to far419@mail.usask.ca, or tim.molnar@usask.ca

Questions:
If you have any questions concerning the research project, please feel free to ask at any point; you are also free to contact the researcher at the numbers provided if you have other questions. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

Consent to Participate: (This is implied by the completion of the online survey)

(a) Written Consent

Include the following statement: "I have read and understood the description provided; I have had an opportunity to ask questions and my/our questions have been answered. I consent to participate in the research project, understanding that I may withdraw my consent at any time. A copy of this Consent Form has been given to me for my records."

- ○ Yes
- ○ No

Next

APPENDIX B:

SURVEY QUESTIONNAIRE

PART A
Demographic Questions

Q1. What is your Gender?

- Male
- Female

Q2. What type of internet access do you have to teach online remotely?

- High speed broadband home internet
- Moderate speed wireless home internet
- Smartphone wireless internet
- Others (please specify) ________________

Q3. **How many years total teaching experience do you have?**

- 1-3
- 4-6
- 7-10
- 11-15
- 16-20
- 20+

Q4.**What population centre or rural area were you serving in the majority of your science teaching before Covid-19 and currently?**

- Small population center (population between 1000-29,999, i.e. Davidson, North Battleford)
- Medium population center (population between 30000-99,999, i.e. Prince Albert, Moose Jaw)
- Large population center (population between 100, 000 or more, i.e. Saskatoon, Regina)
- Rural (Areas outside the population centres)

Q5. **What grade level do you currently teach (Select all that apply)**

- Science Grade-9
- Science Level-10
- Environmental Science Level-20
- Health Science Level-20
- Physical Science Level-20
- Biology Level-30
- Chemistry Level-30
- Computer Science Level-30
- Earth Science Level-30
- Physics Level-30
- Others___________

Q6. Using the scale below please indicate the percentage of the online mode of delivery you had considered in your teaching prior to COVID-19 pandemic.

(Using a sliding scale in survey instrument)

- 0 % ------------------------------ 100 %

Q7. Using the scale below please indicate the percentage of the online mode of delivery you have been considering in your teaching during COVID-19 pandemic.

(Using a sliding scale in survey instrument)

- 0 % ------------------------------ 100 %

PART B

Based on your knowledge and experience of teaching in COVID-19 context, to what extent do you agree with the following aspects of planning and preparation, classroom environment and professional responsibilities of your teaching.

Please indicate your opinion about the following statements using the scale below:

Strongly disagree, Disagree, Somewhat disagree, Neither agree or disagree,

Somewhat agree, Agree, and Strongly agree

In response to the Covid-19 context:

Item Number	Items	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
8	My use of online assessment tools better enables me to gauge my students' understanding of topics or concepts in science.							
9	My use of online teaching resources better enables me to engage students in scientific inquiry activities that support students' deep learning of the content.							
10	My use of online instructional tools better enables me to engage students in self-directed learning.							
11	My use of online instructional tools better enables me to engage students in collaborative discussion, questioning and reflection to advance student higher-level thinking and discourse.							
12	My use of online instructional tools better enables me to engage my students intellectually in lesson activities.							
13	Through online teaching, I can enrich my knowledge of using a variety of scientific online resources, which promote my resource planning, and aid in maintaining a log of resources for student reference.							
14	When designing a lesson for online teaching, I consider my students' scientific knowledge and skills of adopting digital learning instructions.							
15	I spend additional time designing coherent science instructions for teaching science online.							
16	I spend additional time designing inquiry-based classroom activities for teaching science online.							
17	I spend additional time designing assignments and discussion techniques for teaching science online.							

18	The online teaching tools allow me to establish a positive and collaborative classroom environment where all members feel supportive, respected, and connected.							
19	Through online instruction, I have reflected on my readiness to resolve conflicts, to develop trust, and to build a sense of belongings and positive relationships among students.							
20	I can establish a central set of shared classroom routines and procedures to promote students' autonomy in my online science classroom.							
21	The online teaching tools allow me to communicate with families and community members to discuss about students' academic progress and cognitive prompts on the scientific inquiry practices.							
22	Through the online teaching tools, I can easily interact with families as well as community members to inform them about the school's new instructional programs and bring the community into the decision-making process.							
23	The online teaching tools allow me to make individual contact with every parent/guardian to establish a communication plan in ways that respect their values and cultural backgrounds.							

Please offer any further comment you may have concerning any of these aspects.

Part C

This section of the questionnaire concerns teacher confidence relative to technology for teaching and learning that took place during COVID-19 pandemic. For each statement below, respond using the scale below:

Not confident at all, Slightly confident, Somewhat confident, Fairly confident, Completely confident

I am confident in my ability to…………

Item No.	**Items**	**Not confident at all**	**Slightly confident**	**Somewhat confident**	**Fairly confident**	**Completely confident**
24	Obtain the materials/resources necessary to teach science online.					
25	Adapt to new teaching situations such as those necessary to teach science online.					
26	Use my current knowledge, skill and teaching experience to teach science effectively incorporating online teaching tools.					
27	Collaborate effectively with other teachers in planning science learning activities for online instruction.					
28	Get students to experience excitement, interest, and motivation to learn about phenomena in the natural world using online tools.					
29	Elicit support from my supervisors (principals, administrators, school district) to teach science effectively in online.					
30	Formatively assess student learning of discipline-specific content while teaching science in online.					

31	Foster student enthusiasm for learning science while teaching on an integrated online remote learning platform.					
32	Overcome challenges created by online remote environments to teach science.					

Please offer any further comment you may have concerning any of these aspects.

PART D

The following questionnaire contains the statements regarding the Teachers' Attitudes Toward the Change (TATC) in science teaching during the digital transformation of the COVID-19 pandemic. Please indicate to what extent do you agree or disagree with the following statements using the scale below:

Strongly Disagree, Disagree, Somewhat Disagree, Neither Agree or Disagree, Somewhat agree, Agree, Strongly agree

Item No.	Items	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
33	I am enthusiastic and excited about the changes that took place during the COVD-19 pandemic because of the incorporation of online instructional tools in my science teaching.							
34	I feel frustrated with the change in teaching due to the adoption of online teaching tools in my teaching practices.							
35	I appreciate the digital transformation of teaching during COVID-19 which will help me to perform better at school.							
36	I believe most of my colleagues will benefit from change that occurred in education during COVID-19 pandemic.							
37	The digital transformation of teaching that occurred during the pandemic is beneficial for my school.							
38	I would encourage others (e.g: colleagues, principal, administrators) to support the changes that occurred in education during COVID-19 pandemic.							
39	I intend to do whatever possible to support the changes that occurred in my teaching during the COVID-19 pandemic.							

Please offer any further comment you may have concerning any of these aspects.

Overall Comment:

Thank You !!!

Appendix C: Data Tables for Survey Responses

Table 28

Frequencies and Precents for Demographics

Gender		
Gender	N	Percent
Male	23	41.10%
Female	32	57.10%
Prefer not to disclose	1	1.80%
Total	56	100%
Type of Internet Access		
Type of Internet Connection	N	Percent
Other (please specify)	2	3.60%
High-speed broadband home internet	29	51.80%
Moderate speed wireless home internet	18	32.10%
Smartphone wireless internet	7	12.50%
Years of teaching experience		
Years of Teaching	N	Percent
1-3 (Y)	7	12.50%
4-6 (Y)	9	16.10%
7-10 (Y)	9	16.10%
11-15 (Y)	8	14.30%
16-20 (Y)	11	19.60%
20+ (Y)	12	21.40%
Population center		
Population center	N	Percent
Small population center	10	17.90%
Medium population center	14	25.00%
Large population center	22	39.30%

Rural population center	10	17.90%
Grade Level		
Grade Level	N	Percent
Science Grade 9	17	11.10%
Science Level 10	31	20.30%
Environmental Science Level 20	10	6.50%
Health Science Level 20	17	11.10%
Physical Science Level 20	15	9.80%
Biology Level 30	21	13.70%
Chemistry Level 30	13	8.50%
Computer Science Level 30	6	3.90%
Earth Science Level 30	1	0.70%
Physics Level 30	9	5.90%
Others	13	8.50%

Table 29

Frequency Distribution of Teaching Practices

Frequency distribution of Classroom Instruction

Item No.	Items	Strongly disagree		Disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Agree		Strongly agree	
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
8	My use of online assessment tools better enables me to gauge my students' understanding of topics or concepts in science.	3	5.80%	6	11.50%	5	9.60%	7	13.50%	13	25.00%	14	26.90%	4	7.70%
9	My use of online teaching resources better enables me to engage students in scientific inquiry activities that support students' deep learning of the content.	3	5.80%	7	13.50%	6	11.50%	6	11.50%	14	26.90%	13	25.00%	3	5.80%
10	My use of online instructional tools better enables me to engage students in self-directed learning.	1	2.00%	1	2.00%	8	15.70%	6	11.80%	17	33.30%	15	29.40%	3	5.90%
11	My use of online instructional tools better enables me to engage students in collaborative discussion, questioning and reflection to advance student higher-level thinking and discourse.	8	15.40%	7	13.50%	10	19.20%	7	13.50%	5	9.60%	14	26.90%	1	1.90%
12	My use of online instructional tools better enables me to engage my students intellectually in lesson activities.	1	1.90%	4	7.70%	9	17.30%	12	23.10%	12	23.10%	14	26.90%	0	0.00%

Frequency distribution of Planning and Preparation

Item No.	Items	Strongly disagree		Disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Agree		Strongly agree	
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
13	Through online teaching, I can enrich my knowledge of using a variety of scientific online resources, which promote my resource planning, and aid in maintaining a log of resources for student reference.	2	3.80%	5	9.60%	7	13.50%	7	13.50%	14	26.90%	13	25.00%	4	7.70%
14	When designing a lesson for online teaching, I consider my students' scientific knowledge and skills of adopting digital learning instructions.	0	0.00%	1	1.90%	3	5.80%	2	3.80%	13	25.00%	20	38.50%	13	25.00%
15	I spend additional time designing coherent science instructions for teaching science online.	2	3.80%	5	9.60%	5	9.60%	7	13.50%	14	26.90%	14	26.90%	5	9.60%
16	I spend additional time designing inquiry-based classroom activities for teaching science online.	1	1.90%	2	3.80%	5	9.60%	4	7.70%	12	23.10%	17	32.70%	11	21.20%
17	I spend additional time designing assignments and discussion techniques for teaching science online.	2	3.80%	5	9.60%	5	9.60%	7	13.50%	12	23.10%	16	30.80%	5	9.60%

Frequency distribution of the classroom management

		Strongly disagree		Disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Agree		Strongly agree	
Item No.	Items	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
18	The online teaching tools allow me to establish a positive and collaborative classroom environment where all members feel supportive, respected, and connected.	1	1.90%	4	7.70%	6	11.50%	11	21.20%	13	25.00%	13	25.00%	4	7.70%
19	Through online instruction, I have reflected on my readiness to resolve conflicts, to develop trust, and to build a sense of belongings and positive relationships among students.	3	5.80%	0	0.00%	3	5.80%	12	23.10%	17	32.70%	14	26.90%	3	5.80%
20	I can establish a central set of shared classroom routines and procedures to promote students' autonomy in my online science classroom.	2	3.80%	2	3.80%	6	11.50%	8	15.40%	10	19.20%	17	32.70%	7	13.50%

Frequency distribution of the Professional Responsibility

		Strongly disagree		Disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Agree		Strongly agree	

Item No.	Items	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
21	The online teaching tools allow me to communicate with families and community members to discuss about students' academic progress and cognitive prompts on the scientific inquiry practices.	1	1.9%	7	13.5%	5	9.6%	9	17.3%	8	15.4%	16	30.8%	6	11.5%
22	Through the online teaching tools, I can easily interact with families as well as community members to inform them about the school's new instructional programs and bring the community into the decision-making process.	3	5.8%	7	13.5%	5	9.6%	10	19.2%	8	15.4%	17	32.7%	2	3.8%
23	The online teaching tools allow me to make individual contact with every parent/guardian to establish a communication plan in ways that respect their values and cultural backgrounds.	6	11.5%	6	11.5%	1	1.9%	12	23.1%	7	13.5%	17	32.7%	3	5.8%

Table 30

Frequency distribution of the Teachers' Self-Efficacy

Frequency distribution of the Teachers' Self-Efficacy											
		Not confident at all		Slightly confident		Somewhat confident		Fairly confident		Completely confident	
Item No.	Items	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
24	Obtain the materials/resources necessary to teach science online.	1	1.90%	5	9.60%	10	19.20%	23	44.20%	13	25.00%
25	Adapt to new teaching situations such as those necessary to teach science online.	0	0.00%	8	15.40%	6	11.50%	24	46.20%	14	26.90%
26	Use my current knowledge, skill and teaching experience to teach science effectively incorporating online teaching tools.	1	2.00%	5	10.00%	13	26.00%	18	36.00%	13	26.00%
27	Collaborate effectively with other teachers in planning science learning activities for online instruction.	3	5.80%	6	11.50%	11	21.20%	21	40.40%	11	21.20%
28	Get students to experience excitement, interest, and motivation to learn about phenomena in the natural world using online tools.	7	13.50%	5	9.60%	19	36.50%	18	34.60%	3	5.80%
29	Elicit support from my supervisors (principals, administrators, school district) to teach science effectively in online.	2	3.90%	12	23.50%	8	15.70%	19	37.30%	10	19.60%
30	Formatively assess student learning of discipline-specific content while teaching science in online.	2	3.80%	8	15.40%	20	38.50%	17	32.70%	5	9.60%
31	Foster student enthusiasm for learning science while teaching on an integrated online remote learning platform.	7	13.50%	10	19.20%	18	34.60%	14	26.90%	3	5.80%
32	Overcome challenges created by online remote environments to teach science.	1	1.90%	11	21.20%	15	28.80%	19	36.50%	6	11.50%

Table 31

Frequency distribution of the Teachers' Attitudes Toward the Change

Frequency distribution of the Teachers' Attitudes Toward the Change															
Item No.	Items	Strongly Disagree		Disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Agree		Strongly agree	
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
33	I am enthusiastic and excited about the changes that took place during the COVD-19 pandemic because of the incorporation of online instructional tools in my science teaching.	4	7.30%	5	9.10%	16	29.10%	14	25.50%	12	21.80%	3	5.50%	1	1.80%
34	I appreciate the digital transformation of teaching during COVID-19 which will help me to perform better at school.	4	7.50%	1	1.90%	13	24.50%	19	35.80%	10	18.90%	6	11.30%	0	0.00%
35	I believe most of my colleagues will benefit from change that occurred in education during COVID-19 pandemic.	3	5.80%	3	5.80%	16	30.80%	14	26.90%	11	21.20%	5	9.60%	0	0.00%

36	The digital transformation of teaching that occurred during the pandemic is beneficial for my school.	4	7.70 %	3	5.80 %	12	23.10 %	15	28.80 %	12	23.1 0%	6	11. 50 %	0	0.00 %
37	I would encourage others (e.g: colleagues, principal, administrators) to support the changes that occurred in education during COVID-19 pandemic.	1	1.90 %	3	5.80 %	14	26.90 %	15	28.80 %	12	23.1 0%	7	13. 50 %	0	0.00 %
38	I intend to do whatever possible to support the changes that occurred in my teaching during the COVID-19 pandemic.	2	3.80 %	2	3.80 %	11	21.20 %	15	28.80 %	14	26.9 0%	7	13. 50 %	1	1.90 %

APPENDIX D:

DATA TABLES FOR SURVEY ANALYSIS

Table 32

Reliability Statistics: Teaching Practices

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.903	.900	16

Table 33

Item-Total Statistics: Teaching Practice

Item No	Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
8	My use of online assessment tools better enables me to gauge my students' understanding of topics or concepts in science.	69.9608	226.158	0.664	0.899	0.894
9	My use of online teaching resources better enables me to engage students in scientific inquiry activities that support students' deep learning of the content.	70.0784	227.514	0.632	0.703	0.895
10	My use of online instructional tools better enables me to engage students in self-directed learning.	69.6078	240.563	0.500	0.537	0.900
11	My use of online instructional tools better enables me to engage students in collaborative discussion, questioning and reflection to advance student higher-level thinking and discourse.	70.6863	221.420	0.679	0.697	0.893
12	My use of online instructional tools better enables me to engage my students intellectually in lesson activities.	70.0588	236.976	0.572	0.740	0.898
13	Through online teaching, I can enrich my knowledge of using a variety of scientific online	69.9216	229.234	0.642	0.918	0.895

	resources, which promote my resource planning, and aid in maintaining a log of resources for student reference.					
14	When designing a lesson for online teaching, I consider my students' scientific knowledge and skills of adopting digital learning instructions.	68.8039	250.921	0.281	0.621	0.905
15	I spend additional time designing coherent science instructions for teaching science online.	69.7843	225.093	0.726	0.996	0.892
16	I spend additional time designing inquiry-based classroom activities for teaching science online.	69.1961	250.121	0.225	0.408	0.908
17	I spend additional time designing assignments and discussion techniques for teaching science online.	69.7451	225.274	0.712	0.994	0.892
18	The online teaching tools allow me to establish a positive and collaborative classroom environment where all members feel supportive, respected, and connected.	69.8235	232.028	0.644	0.707	0.895
19	Through online instruction, I have reflected on my readiness to resolve conflicts, to develop trust, and to build a sense of belongings and positive relationships among students.	69.6667	244.507	0.386	0.441	0.903
20	I can establish a central set of shared classroom routines and procedures to promote students' autonomy in my online science classroom.	69.4902	236.175	0.499	0.592	0.900
21	The online teaching tools allow me to communicate with families and community members to discuss about students' academic progress and cognitive prompts on the scientific inquiry practices.	69.7451	224.834	0.698	0.880	0.893
22	Through the online teaching tools, I can easily interact with families as well as community members to inform them about	70.0980	225.570	0.679	0.858	0.893

	the school's new instructional programs and bring the community into the decision-making process.					
23	The online teaching tools allow me to make individual contact with every parent/guardian to establish a communication plan in ways that respect their values and cultural backgrounds.	70.0980	226.130	0.596	0.723	0.897

Table 34

Reliability Statistics: Teachers' Self efficacy

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.904	.906	9

Table 35

Item-Total Statistics: Teachers' Self efficacy

Item No	Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
24	Obtain the materials/resources necessary to teach science online.	27.3800	42.526	0.657	0.563	0.895
25	Adapt to new teaching situations such as those necessary to teach science online.	27.3400	41.372	0.753	0.675	0.888
26	Use my current knowledge, skill and teaching experience to teach science effectively incorporating online teaching tools.	27.4800	40.132	0.820	0.740	0.883
27	Collaborate effectively with other teachers in planning science learning activities for online instruction.	27.6000	40.327	0.705	0.588	0.891
28	Get students to experience excitement, interest, and motivation to learn about phenomena in the natural world using online tools.	28.1200	41.128	0.666	0.712	0.894
29	Elicit support from my supervisors (principals, administrators, school district) to teach science effectively in online.	27.7600	42.349	0.527	0.437	0.906
30	Formatively assess student learning of discipline-specific content while teaching science in online.	27.9200	42.891	0.628	0.483	0.897
31	Foster student enthusiasm for learning science while teaching on an integrated online remote learning platform.	28.2800	41.226	0.642	0.681	0.896
32	Overcome challenges created by online remote environments to teach science.	27.8800	41.169	0.734	0.594	0.889

Table 36

Reliability Statistics: Teachers' Attitudes Toward the Change

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.794	.817	7

Table 37

Item-Total Statistics : Teachers' Attitudes Toward the Change

Item No	Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
33	I am enthusiastic and excited about the changes that took place during the COVD-19 pandemic because of the incorporation of online instructional tools in my science teaching.	23.2500	28.034	0.665	0.571	0.741
34	I feel frustrated with the change in teaching due to the adoption of online teaching tools in my teaching practices.	23.4615	40.136	-0.181	0.192	0.901
35	I appreciate the digital transformation of teaching during COVID-19 which will help me to perform better at school.	23.0385	26.548	0.829	0.754	0.710
36	I believe most of my colleagues will benefit from change that occurred in education during COVID-19 pandemic.	23.0962	28.598	0.637	0.630	0.747
37	The digital transformation of teaching that occurred during the pandemic is beneficial for my school.	23.0192	26.529	0.752	0.771	0.721
38	I would encourage others (e.g: colleagues, principal, administrators) to support the changes that occurred in education during COVID-19 pandemic.	22.8462	28.094	0.734	0.737	0.731
39	I intend to do whatever possible to support the changes that occurred in my teaching during the COVID-19 pandemic.	22.7115	29.464	0.556	0.425	0.762

Tests of Normality

Table 38

Tests of Normality

Tests of Normality for Teaching Practices						
Dimensions	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Classroom instruction	0.113	52	0.095	0.967	52	0.157
Planning and Preparation	0.108	52	0.182	0.955	52	0.049
Classroom Management	0.131	52	0.026	0.952	52	0.036
Professional responsibility	0.155	52	0.003	0.926	52	0.003
a. Lilliefors Significance Correction						

Tests of Normality for Teachers' Self-Efficacy						
Teachers' Self-Efficacy	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
	0.13	52	0.029	0.972	52	0.26
a. Lilliefors Significance Correction						

Tests of Normality Teachers' Attitudes Toward the Change						
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Teachers' Attitudes Toward the Change	0.073	55	.200*	0.987	55	0.819
*. This is a lower bound of the true significance.						
a. Lilliefors Significance Correction						

Differences in Teaching Practices According to Demographic Variables

Table 39

Independent T-test: Differences in Teaching Practices According to Gender

		Levene's Test for Equality of Variances		t-test for Equality of Means			
						Significance	
		F	Sig.	t	df	One-Sided p	Two-Sided p
Classroom Instruction	Equal variances assumed	.428	.516	.749	44	.229	.458
	Equal variances not assumed			.753	43.390	.228	.456

Table 40

Mann-Whitney U Test: Differences in Teaching Practices According to Gender

Null Hypothesis	Mann-Whitney U	Test Statistic (z Score)	Sig.[a,b]	Decision
The distribution of Planning and Preparation is the same across categories of Gender.	294.5	0.708	.479	Retain the null hypothesis.
The distribution of Classroom Management is the same across categories of Gender.	250.5	-0.267	.790	Retain the null hypothesis.
The distribution of Professional Responsibility is the same across categories of Gender .	298	0.791	.429	Retain the null hypothesis.

Table 41

ANOVA: Differences in Teachers' Practices According to Type of Internet Access

Classroom Instruction

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.648	2	1.824	1.314	.278
Within Groups	68.014	49	1.388		
Total	71.661	51			

Table 42

Independent-Samples Kruskal-Wallis Test : Differences in Teachers' Practices According to Type of Internet Access

Summary	Test Statistic	Degree of Freedom	Sig.[a,b]	Decision
The distribution of Planning and Preparation is the same across categories of Type of Internet Access.	1.527	2	0.466	Retain the null hypothesis.
The distribution of Classroom Management is the same across categories of Type of Internet Access.	2.753	2	0.252	Retain the null hypothesis.
The distribution of Professional Responsibility is the same across categories of Type of Internet Access.	1.659	2	0.436	Retain the null hypothesis.

Table 43

ANOVA : Differences in Teaching Practices According to Years of teaching experiences

Classroom Instruction

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.784	5	2.157	1.630	.171
Within Groups	60.877	46	1.323		
Total	71.661	51			

Table 44

Independent-Samples Kruskal-Wallis Test Summary
Differences in Teaching Practices According to
Years of teaching experiences

	Test Statistic	Degree of Freedom	Sig.[a,b]	Decision
The distribution of Planning and Preparation is the same across categories of Years of Teaching Experience.	0.859	5	0.973	Retain the null hypothesis.
The distribution of Classroom Management is the same across categories of Years of Teaching Experience.	6.145	5	0.292	Retain the null hypothesis.
The distribution of Professional Responsibility is the same across categories of Years of Teaching Experience.	4.846	5	0.435	Retain the null hypothesis.

Table 45

ANOVA : Differences in Teaching Practices According to Population Centre

Classroom Instruction

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.149	3	2.383	1.832	.154
Within Groups	61.134	47	1.301		
Total	68.283	50			

Table 46

Independent-Samples Kruskal-Wallis Test Summary: Differences in Teaching Practices According to Population Centre

	Test Statistic	Degree of Freedom	Sig.[a,b]	Decision
The distribution of Planning and Preparation is the same across categories of Population Center of Teaching	0.255	3	0.968	Retain the null hypothesis.
The distribution of Classroom Management is the same across categories of Population Center of Teaching	5.438	3	0.142	Retain the null hypothesis.
The distribution of Professional Responsibility is the same across categories of Population Center of Teaching	6.649	5	0.084	Retain the null hypothesis.

Table 47

ANOVA: Differences in Teachers' Practices According to Number of Taught Grades

Classroom Instruction

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.395	4	.599	.407	.803
Within Groups	67.748	46	1.473		
Total	70.143	50			

Table 48:

Independent-Samples Kruskal-Wallis Test Summary Differences in Teachers' Practices According to Number of Taught Grades

	Test Statistic	Degree of Freedom	Sig.[a,b]	Decision
The distribution of Planning and Preparation is the same across categories of Number of Taught Courses/Grades	2.728	4	0.604	Retain the null hypothesis.
The distribution of Classroom Management is the same across categories of Number of Taught Courses/Grades	2.368	4	0.668	Retain the null hypothesis.
The distribution of Professional Responsibility is the same across categories of Number of Taught Courses/Grades	6.344	4	0.175	Retain the null hypothesis.

Differences in Teachers' Perceptions of Their Self-Efficacy

Table 49:

Independent Samples t-test : Differences in Teachers' Perceptions of Their Self-Efficacy According to Gender

Independent Samples t-test

	Levene's Test for Equality of Variances		t-test for Equality of Means			
					Significance	
	F	Sig.	t	df	One-Sided p	Two-Sided p
Equal variances assumed	.168	.684	.656	44	.258	.515
Equal variances not assumed			.659	43.264	.257	.514

Table 50

ANOVA: Differences in Teachers' Self-Efficacy According to Type of Internet Access

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.069	2	.035	.052	.950
Within Groups	32.700	49	.667		
Total	32.769	51			

Table 51

ANOVA: Differences in Teachers' Self-Efficacy According to Years of teaching experiences

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.881	5	.376	.560	.730
Within Groups	30.888	46	.671		
Total	32.769	51			

Table 52

ANOVA: Differences in Teachers' Self-Efficacy According to Population Centre

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.822	3	1.607	2.889	.045
Within Groups	26.147	47	.556		
Total	30.969	50			

Table 53

Tukey HSD: Differences in Teachers' Self-Efficacy According to Population Centre

The Population centre of Taching (I)	The Population centre of Taching (J)	Mean Difference (I-J)	Std. Error	Sig.
Small population center	Medium population center	1.00838*	.36243	.038
	Large population center	.73148	.30450	.091
	Rural areas	.77500	.35380	.141
Medium population center	Small population center	-1.00838*	.36243	.038
	Large population center	-.27690	.29154	.778
	Rural areas	-.23338	.34271	.904
Large population center	Small population center	-.73148	.30450	.091
	Medium population center	.27690	.29154	.778
	Rural areas	.04352	.28074	.999
Rural areas	Small population center	-.77500	.35380	.141
	Medium population center	.23338	.34271	.904
	Large population center	-.04352	.28074	.999

Table 54

ANOVA Partial Eta Squared Effect Size: Differences in Teachers' Self-Efficacy According to Population Centre

Tests of Between-Subjects Effects

Dependent Variable: Teachers' Self-efficacy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4.822[a]	3	1.607	2.889	.045	.156
Intercept	509.529	1	509.529	915.876	<.001	.951
Population Centre	4.822	3	1.607	2.889	.045	.156
Error	26.147	47	.556			
Total	628.563	51				
Corrected Total	30.969	50				

a. R Squared = .156 (Adjusted R Squared = .102)

Table 55

ANOVA: Differences in Teachers' Self-Efficacy According to Grade Level

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.733	4	.183	.274	.893
Within Groups	30.788	46	.669		
Total	31.521	50			

Table 56

Independent Samples Test: Differences in Teachers' Attitudes Toward the Change According to Gender

		Levene's Test for Equality of Variances		t-test for Equality of Means			
						Significance	
		F	Sig.	t	df	One-Sided p	Two-Sided p
Teachers' Attitudes Toward the change	Equal variances assumed	.179	.675	1.199	47	.118	.237
	Equal variances not assumed			1.217	45.333	.115	.230

Table 57

Differences in Teachers' Attitudes Toward the Change According to Type of Internet Access

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.003	2	3.502	3.128	.052
Within Groups	58.209	52	1.119		
Total	65.212	54			

Table 58

Differences in Teachers' Attitudes Toward According to Years of Teaching

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.510	5	.902	.728	.606
Within Groups	60.702	49	1.239		
Total	65.212	54			

Table 59

Differences in Teachers' Attitudes Toward the Change According to Population Centre

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.260	3	2.753	2.619	.061
Within Groups	52.563	50	1.051		
Total	60.824	53			

Table 60

Differences in Teachers' Teachers' Attitudes Toward the Change to Grade Level

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.353	4	1.838	1.580	.195
Within Groups	57.018	49	1.164		
Total	64.370	53			

APPENDIX E:

DATA TABLES FOR OPEN ENDED QUESTIONS

Table 61

Open-ended Responses

Teachers' Practices	Comments
1	I found that although I spent a significant amount of time using online teaching tools as a way to connect with parents and community members, it only reached a small portion of people who were open to these new ways of communication, and who had the time to explore these new avenues. Some parents said they were too busy adapting to restrictions in their workplace and in their private lives. Some had poor or no internet. Others had no technology/device for their kids to use, and some large families had one device for all of their children to share. Between helping with students' assignments at home, rapidly learning and checking daily each child's educational platforms like SeeSaw, Google Classroom, My School Sask, and Edsby, let alone make time for their own work both professional and domestic, this left little time for parents to communicate with teachers. Parents wanted to support our change to virtual learning, but were quickly burned out. I had to rely on phone calls and texting to communicate with parents.
2	I don't know which online teaching tools you are referring to. I have yet to see a way to bring community members in. I'm not sure how contacting parents in an online format respects their cultural backgrounds.
3	Google Classroom did not permit parent access in my school division.
4	Not all parents/guardians have technology to access or the skills to use them effectively.
5	It felt like teaching toward a one-way mirror. They could see me but I didn't really know what was happening on their end of things. As I said students did not want to turn their video on or audio on while I had them join Zoom classes. I put things on the Google Classroom so they had activities to work through but I did not do any assessment. I did not like marking anything since students submitted things in such a non-standard format. I mean some took photos or scans of their work, others filled in digital copies of assignments; but I found sifting through that and figuring out how to collect things was difficult. As such I posted answer keys for all the assignments turning them into formative assessment opportunities and turned to having exams be the only summative assessment.
6	For the last question, no, I found using the online tools to be a poor way of communicating with families. Email and phone are far superior. My school division favoured Google Classroom as the tool of choice - parents don't see enough in there for it to be an effect form of communication.
7	Do you know of tools I do not? What tools allow for the ideal world you are asking me exists. Autonomy, inquiry, communication with families and community, respect cultural backgrounds...Wow. These questions make many assumptions about the use of online platforms. Expectations for students and families regarding engagement in online learning was very loose at the division level regardless of communicated "expectations". The lack of high standards meant students did not have to participate consistently and parents did not always participate or communicate regardless of the expectations. If I set a high standard for students and parents that was not reflected in the support I received from the administration. I believe teaching online CAN be effective and rewarding for teachers and students but this

Teachers' Self-Efficacy	Comments
1	Formative assessments have been especially difficult - in establishing assignments or quizzes/tests that students do independently without using the internet or other household members.
2	I am flexible and capable but I do not know what is happening on the students end of things. I felt very blind that way. You couldn't trust what you were getting back from students was actually done by those students. (They could have copied, texted a friend, had a sibling or parent help; all things that students do during the typical learning process but not appropriate for assessment.)
3	Students were NOT excited to learn online and were RARELY engaged. I didn't see any enthusiasm and while I had assessments online, there was never a way to see if students were cheating so I am not overly confident with the assessments used.
4	Again, online delivery was unplanned and cobbled together at the last minute. Although, I may have learned new ways to deliver science education remotely, the overall experience was horrible. It was a failed experiment because we are not given the ability to create equally high standards in the online setting as we are in the classroom.
5	I did not enjoy remote teaching, it may have been the worst/most challenging situation i have experienced. Many of us struggled with the lack of support/PD/instruction in the use of google classroom or creating your own website to help deliver the course.
	has not been the case when admin sets up expectations for students and parents that are written are hollow when it comes to enforcement and promises of support from admin are nothing more than platitudes.
8	It was hard to communicate with some students/parents as they lacked technology or the skills required to use the technology. I'd say about 30% of the students were in this category. Made for a lot of additional workload.

Teachers' Attitudes toward the Change	Comments
1	It is always great to grow professionally and to learn new things. I am happy that I learned how to use online programs for instruction, and I still rely on them some of the time, for example, when I have a student with a prolonged absence, or when I am gone for the day. However, putting a lesson online is much too time-consuming for the fraction of good it does. It is an inferior way of teaching and learning, and I will only use it as a last resort.
2	Looking forward and have high hopes that this COVID teaching experience will be useful in future offline classes as well.
3	I feel worried that some of the online things we were expected to maintain (Google Classroom or potentially other platforms) are going to be expected in the future. In some ways it is helpful for students who have to be away from class. My worry comes from two things; I'm afraid students knowing they have a fallback will attend class less, and that as teachers we've added an expectation with no "support". There's no added time to take care of or maintain a Google Classroom. I'm afraid we've made it easier for students and harder for teachers.

4	I teach with the Online Learning Centre, and was assigned to this position BEFORE the Covid pandemic. I love online teaching, it suits me.
6	The building and continued expectation of having a full online presence from all of our classes, while classroom teaching has continued, has been extremely stressful. Once it is built and put together I will certainly continue to use online platforms for students to access for their own purposes since I have the resources gathered. It was extremely time consuming, frustrating, and draining to do. It was also difficult to meet the need of student access issues and limitations, as many faced either technology or wifi access issues.
7	The changes I saw were not good
	Online teaching can be meaningful and create and more diverse and adaptable experience for students. However, this has not been the case for implementing digital learning in our school division. Prior to this I was already using Google Classroom and other Google Apps to enhance classroom experiences extensively. So integrating technology was not unfamiliar to me. However the integrity of learning was not reinforced during covid19 digital learning. It was a dumpster fire. Even now, after returning to full time classroom instruction, I spend half my time doing remedial teaching as there are huge gaps and inconsistencies in prior learning. Science is constructive in the learning process and having no experience in some topics makes it near impossible to be successful moving forward of these concepts are not covered.
	Some great technology was found and integrated into my science classes. In the future some of these technology resources could be implemented in my traditional lessons.
	RPSD is in the midst of huge changes from online expectations to new student record systems to replacing Power school with Edsby. Many of us are experiencing too much change too fast. I don't think we have had enough PD or enough time to get comfortable with most of this though the expectations seem very high.

APPENDIX F:

PILOT SURVEY (RELIABILITY ANALYSIS)

Teaching Practices

		N	%
Cases	Valid	10	71.4
	Excluded[a]	4	28.6
	Total	14	100.0

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

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.975	.976	16

Item Statistics

	Mean	Std. Deviation	N
My use of online assessment tools better enables me to gauge my students' understanding of topics or concepts in science.	4.5000	1.71594	10
My use of online teaching resources better enable me to engage students in scientific inquiry activities that support students' deep learning of the content.	4.5000	1.58114	10
My use of online instructional tools better enable me to engage students in self-directed learning.	5.1000	1.52388	10
My use of online instructional tools better enable me to engage students in collaborative discussion, questioning and reflection to advance student higher-level thinking and discourse.	4.1000	1.79196	10
My use of online instructional tools better enable me to engage my students intellectually in lesson activities	4.1000	1.59513	10
Through online teaching, I can enrich my knowledge of using a variety of scientific online resources which promote my resource planning, and aid in maintaining a log of resources for student reference.	4.9000	1.44914	10
When designing a lesson for online teaching, I consider my students' scientific knowledge and skills of adopting digital learning instructions.	5.4000	1.42984	10
I spend additional time designing coherent science instructions for teaching science in online.	5.6000	1.57762	10
I spend additional time designing inquiry-based classroom activities for teaching science in online.	5.3000	1.41814	10
I spend additional time designing assignments and discussion techniques for teaching science in online.	5.3000	1.56702	10
The online teaching tools allow me to establish a positive and collaborative classroom environment where all members feel supportive, respected, and connected.	4.4000	1.77639	10
Through online instruction, I have reflected on my readiness to resolve conflicts, to develop trust, build a sense of belongings and positive relationships among students.	4.5000	1.64992	10
I can establish a central set of shared classroom routines and procedures to promote students' autonomy in my online science classroom.	5.2000	1.54919	10
The online teaching tools allow me to communicate with families and community members to discuss students' academic progress and cognitive prompts on the scientific inquiry practices.	5.1000	1.37032	10
Through the online teaching tools, I can easily interact with families and community members to inform about the school's new instructional programs and bring the community into the decision-making process.	4.6000	1.50555	10
The online teaching tools allow me to make individual contact with every parent/guardian to establish a communication plan in ways that respect their values and cultural backgrounds.	4.5000	1.71594	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
My use of online assessment tools better enables me to gauge my students' understanding of topics or concepts in science.	72.6000	401.822	.859	.	.973
My use of online teaching resources better enable me to engage students in scientific inquiry activities that support students' deep learning of the content.	72.6000	413.822	.739	.	.974
My use of online instructional tools better enable me to engage students in self-directed learning.	72.0000	410.222	.832	.	.973
My use of online instructional tools better enable me to engage students in collaborative discussion, questioning and reflection to advance student higher-level thinking and discourse.	73.0000	408.222	.724	.	.975
My use of online instructional tools better enable me to engage my students intellectually in lesson activities	73.0000	418.222	.661	.	.976
Through online teaching, I can enrich my knowledge of using a variety of scientific online resources which promote my resource planning, and aid in maintaining a log of resources for student reference.	72.2000	407.067	.936	.	.972
When designing a lesson for online teaching, I consider my students' scientific knowledge and skills of adopting digital learning instructions.	71.7000	413.122	.838	.	.973
I spend additional time designing coherent science instructions for teaching science in online.	71.5000	405.167	.885	.	.972
I spend additional time designing inquiry-based classroom activities for teaching science in online.	71.8000	410.400	.896	.	.972
I spend additional time designing assignments and discussion techniques for teaching science in online.	71.8000	407.289	.856	.	.973
The online teaching tools allow me to establish a positive and collaborative classroom environment where all members feel supportive, respected, and connected.	72.7000	408.233	.731	.	.975
Through online instruction, I have reflected on my readiness to resolve conflicts, to develop trust, build a sense of belongings and positive relationships among students.	72.6000	406.489	.822	.	.973
I can establish a central set of shared classroom routines and procedures to promote students' autonomy in my online science classroom.	71.9000	405.211	.902	.	.972
The online teaching tools allow me to communicate with families and community members to discuss students' academic progress and cognitive prompts on the scientific inquiry practices.	72.0000	408.667	.963	.	.972
Through the online teaching tools, I can easily interact with families and community members to inform about the school's new instructional programs and bring the community into the decision-making process.	72.5000	407.833	.884	.	.972
The online teaching tools allow me to make individual contact with every parent/guardian to establish a communication plan in ways that respect their values and cultural backgrounds.	72.6000	402.489	.849	.	.973

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
77.1000	463.878	21.53782	16

Teacher’s Self-Efficacy

Case Processing Summary

		N	%
Cases	Valid	10	71.4
	Excluded[a]	4	28.6
	Total	14	100.0

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

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.947	.949	9

Item Statistics

	Mean	Std. Deviation	N
Obtain the materials/resources necessary to teach science online.	3.5000	1.08012	10
Adapt to new teaching situations such as those necessary to teach science online.	3.6000	1.07497	10
Use my current knowledge, skill and teaching experience to teach science effectively incorporating online teaching tools.	3.7000	1.15950	10
Collaborate effectively with other teachers in planning science learning activities for online instruction.	3.5000	.97183	10
Get students to experience excitement, interest, and motivation to learn about phenomena in the natural world using online tools.	3.4000	.84327	10
Elicit support from my supervisors (principals, administrators, school district) to teach science effectively in online.	3.7000	1.05935	10
Formatively assess student learning of discipline-specific content while teaching science in online.	3.4000	1.17379	10
Foster student enthusiasm for STEM disciplines while teaching in an integrated online remote learning platform.	3.4000	.96609	10
Overcome challenges created by online remote environments to teach science.	3.4000	.96609	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Obtain the materials/resources necessary to teach science online.	28.1000	48.322	.777	.	.941
Adapt to new teaching situations such as those necessary to teach science online.	28.0000	48.222	.789	.	.941
Use my current knowledge, skill and teaching experience to teach science effectively incorporating online teaching tools.	27.9000	48.322	.713	.	.946
Collaborate effectively with other teachers in planning science learning activities for online instruction.	28.1000	47.878	.917	.	.934
Get students to experience excitement, interest, and motivation to learn about phenomena in the natural world using online tools.	28.2000	49.956	.880	.	.937
Elicit support from my supervisors (principals, administrators, school district) to teach science effectively in online.	27.9000	46.767	.916	.	.934
Formatively assess student learning of discipline-specific content while teaching science in online.	28.2000	47.956	.727	.	.945
Foster student enthusiasm for STEM disciplines while teaching in an integrated online remote learning platform.	28.2000	49.733	.770	.	.942
Overcome challenges created by online remote environments to teach science.	28.2000	50.622	.698	.	.945

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
31.6000	61.156	7.82020	9

Teacher's Attitudes Toward the Change

Case Processing Summary

		N	%
Cases	Valid	10	71.4
	Excluded[a]	4	28.6
	Total	14	100.0

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

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.954	.957	7

Item Statistics

	Mean	Std. Deviation	N
I am enthusiastic and excited about the changes that took place during the COVD-19 pandemic because of the incorporation of online instructional tools in my science teaching.	3.9000	1.19722	10
I feel frustrated with the change in teaching due to the adoption of online teaching tools in my teaching practices.	3.5000	1.26930	10
I appreciate the digital transformation of teaching during COVID-19 which will help me to perform better at school.	4.0000	1.15470	10
I believe most of my colleagues will benefit from change that occurred in education during COVID-19 pandemic.	3.8000	1.47573	10
The digital transformation of teaching that occurred during the pandemic is beneficial for my school.	3.8000	1.22927	10
I would encourage others (e.g: colleagues, principal, administrators) to support the changes that occurred in education during COVID-19 pandemic.	4.2000	1.22927	10
I intend to do whatever possible to support the changes that occurred in my teaching during the COVID-19 pandemic.	3.9000	1.19722	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
I am enthusiastic and excited about the changes that took place during the COVD-19 pandemic because of the incorporation of online instructional tools in my science teaching.	23.2000	45.289	.858	.862	.946
I feel frustrated with the change in teaching due to the adoption of online teaching tools in my teaching practices.	23.6000	50.267	.482	.705	.976
I appreciate the digital transformation of teaching during COVID-19 which will help me to perform better at school.	23.1000	44.100	.985	.984	.937
I believe most of my colleagues will benefit from change that occurred in education during COVID-19 pandemic.	23.3000	42.011	.855	.937	.948
The digital transformation of teaching that occurred during the pandemic is beneficial for my school.	23.3000	43.789	.937	.915	.940
I would encourage others (e.g: colleagues, principal, administrators) to support the changes that occurred in education during COVID-19 pandemic.	22.9000	44.322	.899	.961	.943
I intend to do whatever possible to support the changes that occurred in my teaching during the COVID-19 pandemic.	23.2000	43.956	.955	.957	.939

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
27.1000	60.544	7.78103	7