Alberta Teachers' Innovations in Classroom Practice Arising from Use of Technology in Online Learning as a Result of COVID-19

by

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Abstract

In this study, a small sample of Alberta teachers were interviewed about their use of technology in the classroom through three specific time-periods during the COVID-19 pandemic: pre-COVID-19, during COVID-19 and post COVID-19. The Cynefin Framework was used to find changes in technology use by teachers in their classrooms during this time. The Cynefin Framework is a sense-making framework. This framework is ideal to use for analysis of technology use during COVID-19. The Cynefin Framework represents three ontologies: order, disorder, and unorder. My findings show that all of these were present for teachers during COVID-19. Pre-COVID-19 is the ordered ontology which houses the best practices of classroom teaching and Professional Development in the Clear and Complicated Domains. The disordered ontology was the time when governments were ordering schools and some businesses to close. When school boards ordered schools to go online, this imposed ordered is called the unordered ontology. The unordered ontology represents the Chaotic and the Complex Domains. The Complex Domain is the domain where innovations occur. Technology that teachers continued to use post-pandemic was always modified slightly by them to suit their teaching topics or style. This has implications for how teachers should be taught to use various technologies, both in the undergraduate classroom and as Professional Development for the experienced teacher.

Preface

This thesis is an original work by Darlene Joyce Bakker. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name “Alberta teachers’ innovations in classroom practice arising from use of technology in online learning as a result of COVID-19”, Study ID: Pro00116666, Feb. 24, 2022.

Dedication

I dedicate this thesis on technology and education to my grandchildren. The use of technology in education will change as you move through your schooling. I hope this study leads to a deeper understanding of best and better practices in technology use.

Acknowledgements

I would like to thank Dr. Cathy Adams for taking the time to be my supervisor. Her guidance and suggestions have always been sound. I would also like to thanks my examining committee: Dr. Patricia Boechler, Dr. Mike Carbonaro, and Dr. Sharla King for taking the time to do a thorough reading of my thesis. Your suggestions have improved the final product. I would also like to thank Dr. Bonnie Watt and Dr. Greg Thomas. Your support of not only myself but of the Secondary Education Graduate students is more encouraging than you will ever know.

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Lastly, thanks to my family. My husband Wayne who has never questioned why am I doing this, he only asked how he could be of help. To my children: Lachlan for walking to summer school with his mom; Hillary for sharing part of this journey as she completes a Certificate in Administration; Dr. Twila Bakker for producing digital copies of my examples, figures, and charts, and inserting them into the text; and, Ardelle for reminding me that it is good to study even without having a direct application for the knowledge gained.

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1. Alberta Teachers' Innovations in Classroom Practice

Pandemics change education. The1918 flu pandemic brought changes to what education looked like. Li and Malmendier (2022) found that the 1918 Spanish Flu epidemic had a measurable impact on how numerous students returned to education once the schools were opened. There were some more immediately apparent effects, such as one cited in the University of Hawai‘i News (2020), noting the University of Hawai‘i responded to the 1918 Spanish Flu Pandemic by offering subscription courses for the nursing program—what Albertans know as correspondence or distance learning courses—where the written assignments could be completed and returned by mail. In the University of Hawai‘i News (2020), Brown, an associate history professor, at the University of Hawai‘i at Mānoa, states that "They (pandemics) are the original social and political disruptors, and sometimes that can be really positive". This study will identify what teachers report as changes to their use of digital technology due to school systems implementing the use of digital technology to address online learning and instruction during the COVID-19 pandemic.

Background of the Problem

Alberta Education (2016) in the Rationale and Philosophy section of the Information and Communication Technology program of studies, states that one intent of the curriculum is to have students understand how technology impacts themselves and society. Also, students will learn the advantages and the disadvantages of using technology and this knowledge will come through engaging with technology in their core classes. Technology can be used to deliver information to both the teacher and the student. Students and teachers can use technology to gather information to solve problems. Students using technology can improve their skill levels associated with various tasks and technology can be used for entertainment. Teachers are

familiar with all these uses of technology, but their perceived use of technology in pre-COVID-19 teaching versus their perceptions of technology use in post-COVID-19 in-person teaching may be very different. Things changed quickly when the COVID-19 virus became part of our lives. In the initial phase of the pandemic, from March 2020 to June 2020, UNESCO recommended school classes be taught online. UNESCO reports fifteen countries ordered nationwide school closures and a further fourteen countries ordered localized closures during this time. Marshall McLuhan (2003), in *Understanding Media*, tells us that "Each form of transport not only carries, but translates and transforms the sender, the receiver, and the message" (p. 127). As the delivery, or transport, of lessons has changed for both the sender and receiver, teacher and student, how will this change the teachers' use of technology in the classroom? Will the teacher relish and maintain the change brought about through technology, or might the change in technology increase the power or speed of some aspect of the classroom and therefore be retained? McLuhan's concept of media ecology must be understood to have a deeper understanding of the changes. As an English scholar, McLuhan had a deep understanding of the plethora of meanings and stories that can be tied to words. Similarly, Strate (2008) used the dictionary to provide insight to this phrase.

Breaking this into two parts, media and medium will be defined first. Media is the plural of medium. A partial definition from Merriam-Webster (n.d.) dictionary online defines "medium" as:

1 a) something in a middle position; b) a middle condition or degree; mean

2 a) means of effecting or conveying something

3 a) condition or environment in which something may function or flourish

The definition of ecology is:

1 a) branch of science concerned with the interrelationship of organisms and their environments

2 the totality or pattern of relations between organisms and their environment

3 human ecology

4 environment, climate

Definition 3 of a medium refers to the environment or the surroundings where something exists. Ecology in 1 is the complex relations between a specific organism and its environment.

In the same way that working with technology requires a less mainstream philosophy, like McLuhan's philosophy of technology, the unusual time of study where technology use in the classroom moves from in-person to online because of COVID-19 and then back to in-person, requires a less mainstream methodology such as the Cynefin Framework. The Cynefin Framework is a model that is used to study complex situations and is frequently used during disasters where innovations in procedure or processing are revealed. A full description of how the Cynefin Framework is used in this study will be given later. Innovations that develop because of disasters are often retained in future work or retained with a slight modification. As the researcher is looking for innovations in the teacher's use of technology, the Cynefin Framework is an excellent fit.

Statement of the Problem

Very few research accounts describe large-scale pedagogical change, especially in relation to disaster. Often the current articles on changes in pedagogy reflect a small change such as Pearson (2012), Crocco et al. (2011) or Frasure et al. (2007) who examine single lessons where disaster information is embedded in a classroom topic to provide relevance to the topic

being taught. These small examples of changes in pedagogy, although important, are small compared to the changes wrought by COVID-19.

UNESCO (2020) identified COVID-19 as a severe disruptor of education systems. Emergency teaching at all levels of study, amid the COVID-19 pandemic, relied heavily on a switch from in-person instruction to online methods. This switch has uncovered changes to the use of technology by the teacher. These changes include but are not limited to teachers' pedagogy, students' learning, and assessment of that learning, as well as general administration of the classroom. This begs the question of all the changes that teachers have made to support learning during the interruption of COVID-19, which changes in technology use will the teachers select to continue to use in the in-person classroom?

The COVID-19 pandemic has created a unique opportunity to study teachers' change of technology use in a compressed time frame. During the pandemic, almost every teacher was required to change their practice and their technology use. No longer being able to meet in person, teachers began using communication tools such as Google Meet, Zoom, Facebook Chat or Messenger, Microsoft Teams and WhatsApp, depending on the composition of the groups who were meeting. Lessons now addressed not only the content of the curriculum but needed to continue to be engaging to the student and deliverable over the Internet. Although assessment takes various forms during a normal school year, this too was confounded by the pandemic. Gone was the equity of the classroom; present was the inequity of technological resources and dedicated work spaces.

The objective of this study is to determine how some teachers found a pedagogical silver lining in the COVID-19 pandemic with a change in their use of technology for teaching. Even before the COVID-19 pandemic, DeVaney et al. (2009) identified a gap noting that "additional

research is needed to examine the effects of major disasters on children, teachers, and schools over time" (p. 33). Further narrowing this gap identified by DeVaney et al. (2009), Vosslamber (2011) discusses how he changed his course structure, organized course material into discrete units, and reviewed assessment methods following the Canterbury earthquake. Vosslamber (2011) draws the focus to a smaller question: that of technology use by the teacher in the classroom. What changes in using technology will the teacher take back to the in-person classroom? What changes in using technology would the teacher consider trying in the future? A yet more targeted question in knowledge is identified by Prieto-Ballester et al. (2021) as "whether the obligatory use of (integrated and communications technology) ICTs brought about by COVID-19 will merely become an anecdote, or whether it will change the training paradigm, including, once and for all, true integration of ICTs." Narrowing this question further, this study will look at how the teachers learned to use the technology to see if that is a part of why technology use is retained.

Purpose of the Study

This qualitative study investigates teachers' change in technology use. Seven participants recruited for the study were Division 3 and 4 teachers from Alberta who taught during each of three time periods, pre-COVID-19, during COVID-19, and post-COVID-19. These teachers from Division 3, teaching grades 7–9, and Division 4, teaching grades 10–12, were chosen by using a "snowball technique" as described by Berg (2001).

Significance of the Study

During the COVID-19 pandemic, teachers were in the position of essential workers. They were coping with a new way of doing their job of delivery of curriculum while still fulfilling the lesser known part of their job that includes monitoring their students for general wellness. Both

tasks were complicated by online teaching in an emergency situation. Moon (2004) says that reflective practice is a multi-faceted and continuous practice. Turcato (2018) found that after the Fort McMurray wildfire teachers needed to tell their story. The Alberta teachers of the COVID-19 pandemic also need to reflect and tell their stories. At the time of this research, already the teacher's ability to perceive the changes from the pandemic was diminishing. In the fall of 2022, a teacher stated during an interview that, "For time's sake, you might want to have these questions given out earlier. Seriously, because this is a while ago". The teacher indicated that they needed time to reflect because the time span that had elapsed seemed so great to them. In reality, the time span was April 2020 to December 2022, or just over 20 months. Recommendations to preserve this pandemic history are documented by Jones et al. (2021) and Kosciejew (2022). The researcher sees this thesis as a small part of this historical collection.

Teachers worked with an extensive amount of technology during this time. The information on what and how they learned to use technology is important for pre and in-service teachers. The world continues to change with how technology is used. Teachers must understand the effects, both the positives and the pitfalls that accompany that use.

Primary Research Questions

Question: What digital technology do teachers perceive they will take back to their in-person classrooms from their online emergency teaching experience during the COVID-19?

Sub-question: How has a teacher learned to use that technology?

Research Design

The seven participants were Alberta school teachers who taught during three distinct time periods–pre-COVID-19, during COVID-19, and after COVID-19. Each teacher was interviewed individually in a one-half hour interview over Zoom. The topics discussed were the technology

used during each time period. How the technology changed from one time period to the next was discussed as was how the teachers learned how to use the technology in each time period.

Assumptions, Limitations and Scope (Delimitations)

Assumptions: The researcher assumes the interviewees will respond truthfully to the questions. The first teacher recruited from each division was known to the researcher and volunteered to be a participant. They also volunteered to find other participants.

Limitations: There was only one interview with each interviewee so there was only one opportunity for a teacher to discuss technology use. This restricted the time that the interviewer had to build a trusting rapport with the interviewee. There was no opportunity to follow up on interview information or questions that became apparent after transcription. Although many teachers took technology use back to the classroom post-COVID-19, without follow-up interviews it is impossible to tell whether the change is lasting. A second interview would also have provided the opportunity to determine whether teachers continued to learn new technologies and implement them in their classrooms via the same method as they employed during COVID-19 emergency teaching. Last, the cohort of students that the teacher sees in subsequent years will have a different experience with technology as a result of the students' use of technology during COVID-19. How will the students' understanding of technology impact the teacher's use of technology?

Scope: The study was limited to 10 teachers who taught in Alberta Public Schools during three periods–pre, during, and post-COVID-19.

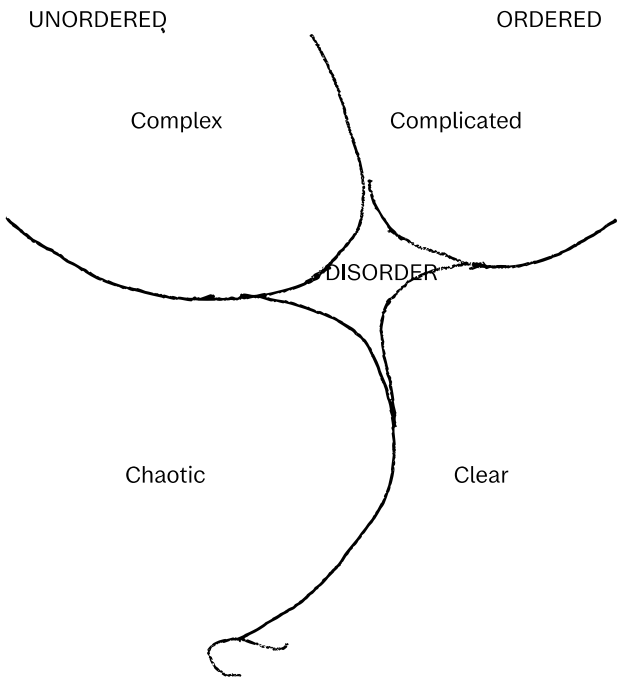
Definition of Terms

Cynefin

To understand what the Cynefin Framework means, we must look at the definition of the Welsh word cynefin. From *Y Geiriadur Mawr, The Complete Welsh-English* dictionary, "cynefin" means: 1) acquainted, familiar and 2) habitat (*Y Geiriadur Mawr*, 1971). The Welshman, David Snowden, one originator of the method and creator of the name, uses the background or context of the problem to develop a fuller understanding of the problem. Snowden recognizes decisions are influenced by many surrounding factors, or following the second entry: the habitat where the original situation or experience occurred. In fact, Kurtz and Snowden (2003) states that cynefin "is more properly understood as the place of our multiple affiliations, the sense that we all, individually and collectively, have many roots, cultural, religious, geographic, tribal, and so forth" (p. 467). The factors that influence individual decisions are important to examine but vary dramatically from person to person. To use the Cynefin Framework it must be contextualized for each participant and situation. Questions can be used to gather some insight into what each teacher's individual context is.

Figure 1

Cynefin Framework



Disaster

A search for literature in March 2020 with the search terms “pandemic” and “education” yielded no results. A further search of “natural disaster” and “education” and “schools” yielded bountiful results. From this literature, Osofsky and Osofsky (2018) define disaster as:

> tragic events that frequently cause catastrophic physical damage to homes, buildings, trailers, trees, power lines, and other physical structures. Often even more important is the tragic physical and psychological disruption to individuals, families, and communities that are affected by the physical damage and the psychological fallout caused by the destruction of community infrastructure, resources, and other types of support. (p. 115)

This definition is very comprehensive of all the disasters described in the literature and applies to the pandemic situation found in Alberta, other parts of Canada and perhaps other parts of the world. For example, although there is no physical damage to buildings or infrastructure, there is

damage to the access of telecommunication systems. First, telecommunication systems became very necessary for students across Canada and much of the world. Often the parent(s) were working from home and must use the family's physical computer. The bandwidth required in-home to support both working parents and students may be significantly more than the bandwidth required in pre-COVID-19 times. A level of technological dis-affordances based on situations like a lack of uniform access to computers or the Internet for both teacher and student needs to be considered. In pre-COVID-19 times with students and staff using both school computers and school Internet, everyone within the school or class had similar access to technology. There was a potential lack of access because of the sudden shift to emergency online teaching. With both students and parents working from home, there may not have been computers for everyone and in some places, the bandwidth or gigabytes of data per month was insufficient. Second, as an example of common pandemic problems, health care and hospitals in numerous parts of the world have been stretched to capacity or beyond. Third, the restriction on gathering together raised concerns for the mental well-being of individuals who are isolated through the lack of access to their community support. Comparable to this definition, the Government of Alberta allowed single individuals to cohort with two other individuals during this time, to avoid the emotional distress identified by Pfefferbaum and North (2020) or psychological fallout as identified in the definition of a disaster. The characteristics of the COVID-19 pandemic match with the definition of a disaster, as provided by Osofsky and Osofsky (2018). This definition shows that COVID-19 was a time of chaos and therefore it became possible and desirable to use the Cynefin Framework to look at the changes in the teachers' pedagogy.

Exaptation (Exaptive)

(n.) a trait, feature, or structure of an organism or taxonomic group that takes on a function when none previously existed or that differs from its original function which had been derived by evolution

exaptive (adj.) (Merriam-Webster, n.d.)

Exaptive is the term Snowden uses to describe the repurposing of a process, activity, knowledge, or situation to provide a new way of doing something.

Summary

On March 11, 2020, the Director-General of the World Health Organization (WHO) declared the COVID-19 pandemic. In response to the global health crisis, schools around the world went to online teaching scenarios. Digital technology took on a new importance in the process of teaching and learning in the emergency situation. Merriam-Webster (n.d.) defines pedagogy as the art, science, or profession of teaching. The profession of teaching was interrupted by the COVID-19 pandemic. Van Manen (2012) recognizes the pedagogical relationship to be complex. He also recognizes the "process of self-development and self-understanding" that the adult, in this case teacher, must embrace (p.10) is most important for students to be able to learn. How will this self-development and self-understanding affect the teachers' perceptions of their use of technology? How will their pedagogy change to meet their new circumstances? What will be the longer lasting effects that COVID-19 imprints on the pedagogical use of technology? The changing times around us clarify that teachers' use of digital technology for educational purposes will probably change pre/post COVID-19. There are many affordances of technology. The students may find security or happiness in hearing their teachers' voices or watching videos of them lecturing. This almost familiar routine may be an affordance

of technology that both the teachers and students enjoy. Now is a unique opportunity to study this phenomenon and give teachers a chance to tell their stories while telling us how they perceive their pedagogical use of technology for teaching has changed.

During COVID-19, teachers have been responsible for student learning, and sometimes also the student's emotional well-being, which is being influenced by the COVID-19 pandemic. The responsibilities of today's teachers are comparable to the actions of the teachers in Fort McMurray and the teachers Ward and Shelley (2008) reported on after Hurricane Katrina.

The problem of this study was defined shortly after WHO declared the COVID-19 pandemic on March 11, 2020. The University of Alberta was preparing to go online for teaching and learning. After agreeing to a meeting with a fellow graduate student to make payments for a student academic conference, which was canceled because of COVID-19, the researcher spoke to the Chair of the Secondary Education Department. Even though he was packing his books up to teach from home, he had the time to inquire about how research was progressing. When the researcher presented their ideas about the teachers' change in technology use because of online teaching during the pandemic, he suggested that if the questions were a little broader that the researcher would get responses that would allow for much discussion. Shortly after this, it became apparent that online teaching would be part of the education system around the world for some time and, from anecdotal information, teachers were finding methods of using technology that they were going to continue to use. With this information, the researcher crafted the questions.

After the questions were crafted, the researcher approached the Alberta Teachers' Association, who were seeking research projects, to use the questions in a questionnaire that would be distributed to all Alberta teachers. This would have given a broad scope for the

recognition of what the teachers had learned and implemented. The project was refused by the Alberta Teachers' Association in the fall of 2021, which led to a smaller study focused on fewer school boards.

2. Literature Review

At the beginning of the COVID-19 pandemic, a search of pandemic and education in the library yielded no results. A search for disaster and education in the library yielded over 100 results. The researcher began reading these academic papers, some of which are included here. Common topics in the research became apparent across the literature on disaster. An example of this was that trauma and resilience were discussed as part of every disaster. Osofsky et al. (2015) for example discuss the resiliency of pupils after both the Deepwater Horizon Oil Spill and Hurricane Katrina.

After the flood of the Souris River in Minot, North Dakota, Hintz (2013) noted how the Minot community came together to accommodate learning where the schools that were destroyed or made unusable by the flood. Churches, community centers and an armory were pressed into service as new learning spaces. The school board looked to the future and built a new school at a cost of 6 million dollars because they had to purchase land instead of rebuilding on the existing site. The original site was designated as being in a 1 in 100-year flood area when, in reality, it had flooded twice in the last 50 years. Hintz shows the great support the community gave to the leadership of the school district and the students and staff of the schools.

The Fort McMurray fire, May 16, 2016, is a well-known disaster in Alberta. Turcato (2018) found that teachers from the Fort McMurray area were in an emergency teaching situation. Not only were the teachers responsible for the students' learning, they were also responsible for their students' lives during the evacuation. After being driven out of Fort

McMurray by the wildfire, students were taken in by other school boards to continue schooling or the students did not complete the course work that remained for the 2015–2016 academic year. Turcato (2018) studied Fort McMurray teachers after they returned to the school following the wildfire. The study found that all the teachers experienced some trauma after the emergency was over. Similar to Turcato (2018) who described teacher trauma after the Fort McMurray wildfire and Ward and Shelley (2008) who discussed teachers' experiences of trauma after disasters such as Hurricane Katrina, Lee et al. (2017) studied students in post-disaster situations such as Hurricane Katrina and found that students also experienced some trauma.

The COVID-19 pandemic is the second emergency teaching situation that Albertans experienced in recent years, but this emergency was also Canada-wide and world-wide. This pandemic has been a disaster with different repercussions than the Fort McMurray fire. The COVID-19 pandemic placed students and teachers out of the schools and into emergency learning and teaching situations.

Greening and Dollinger's (1992) findings imply natural disasters change people in lasting ways. Knowing this, it is important to minimize negative change for teachers and students and maximize the positive changes that can result from natural disasters. Based on this idea, this study will examine some changes teachers made to their pedagogy regarding digital technology during the years 2020–2022 of the COVID-19 pandemic. It is probable that a teacher will continue to use the most beneficial changes while teaching in their in-person classroom, identifying a positive change that resulted from the chaos of the early COVID-19 pandemic.

On December 13, 2021, the researcher contacted David Sulz, who at the time was an academic librarian working with members of the Faculty of Education at the University of Alberta, for help to do an effective literature search. A search of the literature was conducted

with his help. The following six reasons for teachers' use of technology were considered when preparing the search terms for the literature review.

1. Support for student - students can review lesson while doing homework, student can access when not in class,
2. Administration - reduces time by copying class over from year to year, tracks student work (See-Saw), easy way to keep parents in the loop, easy marking
3. Relationship - develop with all the students
4. Students use technology - to gather information, to participate
5. Professional Development

Search string used

(noft(pandemic OR "covid 19") AND noft(tech OR technolog*) AND noft(practice* OR pedagog* OR classroom OR teacher*) AND noft(primary OR elementary OR secondary OR "k-12" OR "high school")) AND stype.exact("Scholarly Journals" OR "Books" OR "Dissertations & Theses")

This search yielded literature related to various aspects of COVID-19 and the use of technology in the classroom. Some papers provided information on why the technology-use being discussed was changed. Sometimes it would just state that a change was made without the discussion of "why". This literature search resulted in about several articles that spoke to the general topic. An alert, attached to the search, notified the researcher of new articles meeting the criteria as they were published. The alert was renewed at every prompt so the researcher could remain current on the latest research.

The literature found by the search can be organized into the following categories: teachers as infrastructure, teaching and knowledge management, teachers as innovators, and teachers as learners.

Teachers as infrastructure

Infrastructure is often considered as being a physical structure. When we think about disasters in an educational setting, we most often consider the physical buildings where instruction occurs to be the infrastructure. This is the loss that is most commonly discussed and valued when discussing the effect of a hurricane, earthquake, or fire. There is literature that discusses visible problems, such as damages to school buildings and equipment, in North Dakota, as noted by Hintz (2013). However, we must consider discussions such as Mutch and Gawith (2014) where they say of their study of the New Zealand earthquakes that they "undertake a cross-case analysis in order to contribute to increased understanding of the role of schools in disaster response and recovery". (p. 55) This mention of schools is of the common meaning of school, as a collective noun, which might include not only the teachers but the greater community of the teachers' families, support staff and volunteers who work in the area.

In an extension of the infrastructure discussion, Stangeland (2010) investigated nurses as the human infrastructure of a disaster. Another situation where people are considered infrastructure is described by Krob (2008), where the problems of Tulane University after Hurricane Katrina are discussed. The university could not fill information technology positions with qualified people because the trained staff had evacuated. The positions were eventually filled by contract workers who received training on the job. Similarly, teachers can be considered the human infrastructure of the education system. The province of Alberta requires that education students, as pre-service teachers, have at least four years of training and education to

become a teacher. It is difficult to place a dollar value saved by retaining the teachers, but it will be costly and difficult to replace teachers if more than the usual number leave the profession after a disaster such as COVID-19.

Activities that support teachers in their work, such as communication with students and guardians and organization of teaching materials and resources, occur daily, yet there is little formal study on these activities. These are often topics that are not considered when discussing teachers and their work. The communications that come from the school, such as field trip forms, report cards and calls home, often come via the teacher. Management of teaching materials such as board games, posters, worksheets and exams all require storage. These teaching materials were not available to teachers at the beginning of the COVID-19 pandemic and their replacements will be discussed here.

Communication

Burgin et al. (2023) looked at culturally responsive teaching in schools and online during COVID-19. Teachers found they were less able to equalize educational opportunities for students during COVID-19 while education was online. This was especially true in English as a second language, homes or homes that experienced overcrowding or violence. Moldavan et al. (2021) discussed how the digital divide is more apparent for students of color and those in marginalized urban communities during the pandemic so to prepare for the future, math educators must look at equipment that is required to implement equity-oriented technology integration. Culturally responsive teaching is part of what makes teachers infrastructure of the education system. The structure is invisible when it is working and the result is glaring when the structure is absent. These studies do not answer how teachers decided which technology to use or how they used it.

Storage

Disasters occur. Events, such as the North American ice storm in 1998, the 2010 volcanic eruptions in Iceland, the 2011 earthquakes in New Zealand and Japan, the 2016 wildfire in Fort McMurray, and the global pandemic of COVID-19 in 2020 interrupt teaching and learning which results in changes in schooling situations after every disaster. With a wildfire or a hurricane, the school buildings or physical infrastructure may be destroyed or damaged. When a school is destroyed, there is little, or no thought given to what the teacher loses in prepared materials. Filing cabinets, binders and worksheets and exams are not a usual topic of academia, but the changes to this aspect of teachers' practice during COVID-19 has been significant. Howat et al. (2012) discuss the recovery process after a disaster, such as a hurricane. They found the staff was responsible for processing the insurance claims and working with government agencies. Losing material goods is significant to a teacher.

Teaching and knowledge management

Eutsler et al. (2021) used the Connectivist Theoretical Framework to analyze Twitter to find nodes of retweeting and analyze them. After Eutsler et al. (2021) found the nodes in the Twitter network, they identified the nodes by author type, such as educational organization, news media, educator, parent or other. There was then a further analysis of the comments, likes and retweets for each group and, from that information, the researchers did a further search on the general type of knowledge each author shared in tweets. This analysis is useful as it identified three recommendations that would be helpful in online teaching: 1) a checklist to help with the new routine, 2) build student-student interactions to encourage collaborative learning, and 3) adopt one remote teaching process that students and parents are familiar with. These three recommendations could be viewed as innovations because they result from a chaotic situation at

the beginning of the pandemic and they were identified by the people in the midst of the chaos, not by an external expert.

Resource organization

Dindar et al. (2021) compare technology acceptance between teachers experienced in using the Qridi LMS and teachers who began using the LMS during the COVID-19 pandemic. Both groups were equal in their ability to use and were satisfied with the LMS. The teachers who did not use the LMS prior to COVID-19 perceived that there was less support for learning the LMS than did the teachers who used the LMS prior to the pandemic. This might suggest that the teachers who learned to use the LMS because of the pandemic but without the perceived support of experts might have developed the skills themselves. It would be informative to look at the use of the learning management system by the teachers who learned to use it on their own versus those who received instruction on how to use it. Are there innovative practices in using the LMS by the group that learned without instruction?

Assessment

By using an open-ended questionnaire with 700 teachers from France, Germany, Israel and Italy, Cusi et al. (2022) identified difficulties and techniques used to overcome the complications with assessment that were experienced during the COVID-19 lockdown. Teachers reflected on what was learned and how they will incorporate some of that in to their practice. Cusi et al. (2022) found that assessment in mathematics during lockdown and post-lockdown times affected the praxis of teachers in a variety of ways.

Lesson Delivery

An et al. (2021) recognized that there are a different set of skills required to teach online. This is important to the central question of this thesis as the probe examines which skills and

technology practices the teacher carries forward to their in-person class. An et al.(2021) identified flipped learning and family involvement as part of the "new normal" in education in post-COVID-19 times. The "new normal" would be identified as an innovation in the Cynefin Framework because it emerged for specific teachers from the chaos of the COVID-19 pandemic.

Dodd et al. (2021) discussed how they moved outreach online and what the impacts were when four universities moved their widening participation and outreach (WPO) for pre-university students online during the COVID-19 pandemic. One innovation that arose from this situation was that high school students learned to use the learning management system (LMS). This helped the student feel more prepared for Higher Education and helped the student feel as if they belonged in higher education. If this is innovation is kept by the universities in future years as part of their outreach for pre-university students, it would be an innovation as identified by the Cynefin framework.

Teachers as innovators

Kesterson et al. (2023) touched on many of the topics of Professional Development. The sample size was small, with only nine participants and skewed to the academic end, with seven of the teachers having graduate level degrees. The innovations discussed in this paper are not necessarily innovations in the Cynefin sense, that will be taken back to an in-person classroom, although the participants indicated they would continue to use technology in their classrooms. This study does not explain how the teachers learned to use the technology or if the teachers used technology in a novel way.

Dolighan and Owens (2021) identified online Professional Development sessions or additional qualifying courses online as having higher self-efficacy in online learning. Davis-Singaravelu (2022) looked at how Professional Learning Communities may sit between theory

and practice. Specifically, they looked at how Pathways, an online platform, was used in the United Kingdom for school improvement. Although not the focus of the paper, there is a small discussion on how the platform, Pathways, may be useful in helping teachers with professional learning around technology and for making decisions for district improvement. In this way, School Improvement Pathways is regarded as a 'light touch' advisory and research team. Professional learning is important for teachers. However, the teachers do not receive the recognition for completing professional learning, instead the school or the district is regarded in a better light when the students score well on standardized tests. Peppler-Beechey and Weingarten (2021) produced a report through the School of Applied Health Sciences at the Michener Institute of Education at the University Health Network for eCampus Ontario about micro-credentials for health care professionals. This report discussed issues with micro-credentialing, how micro-credentials could or would align with regulatory colleges, and how micro-credentialing assists students.

Gamification

Haruna et al. (2021) studied gamification regarding students' perceptions of motivation and learning in a resource poor situation. The students indicated that the gamified class was more engaging and enjoyable than the traditional class. The authors suggested that the use of gamification in an educational system may be positive.

Bajko et al. (2016) found that gamification increased student engagement when the game elements were part of the curriculum. However, the impact on grades is uncertain. Bajko et al. (2016) stated that the gamification of courses needs tools and expertise to complete.

Community of practice

Almost every teacher in Alberta has changed the delivery of their course material for a period of time during COVID-19. During the pandemic, teachers have taught student cohorts on the quarter system where both students and teachers were online or both students and teachers were in-person. Sometimes a teacher would need to quarantine, but the students might remain in class with a substitute teacher. In this situation, it was not uncommon for the teacher to deliver the lesson through a Google Meet. The instructor's screen for the Google Meet would be shared on the Interactive Whiteboard, providing continuity for the student by the teacher's presence on Google Meet being managed by the substitute teacher in the classroom. The teachers have worked with many platforms for content delivery, for student interaction and parent communication. This change in technology use may be significant in revising or broadening pedagogy and needs to be documented and studied. There are only a very few shallow references to change in technology use. The deeper, more meaningful examples need to be recorded and shared as part of the professional growth process, which is part of the aim of this study.

Chen et al. (2023) suggested that middle school and university teachers could move away from the two preferred methods of teaching which are live or a combination of live and recorded lectures. They suggest that using Massive Open Online Courses (MOOC) might be beneficial for learning. They also recommend that teachers should have more technology training. This does not answer the question of what technology use teachers will take back to their classroom.

Gözüm et al. (2022) reviewed how ICT is used by early childhood instructors during COVID-19. They explained how technology was used as a scaffolding device by the child. The teacher must be able to communicate with both the adult and the child while recognizing that the

device serves a different purpose in each case. Gözüm et al. recognized the need for a self-efficacy tool for early childhood educators to evaluate its use in distance education.

Teachers as learners

The research of this thesis will be a contribution to the general body of knowledge of how teachers taught in the emergency online teaching situation, brought on by the COVID-19 pandemic, by looking specifically at their use of digital technology. If the change in pedagogy results in providing additional support for students or if the teacher is going to continue to use the change while in-person, then it will be valuable for pre-service or in-service teachers to know. These changes might be shared with teachers in various Professional Development opportunities or with pre-service teachers in their pedagogy or technology classes. When teachers change their technology use in a manner that provides support or other valuable structures to students, then there are valuable skills to be learned by other educators.

Thaheem et al. (2022) compared online teaching at the postsecondary level in Pakistan and Indonesia. They found little difference between the two countries. Although Canada is regarded as wealthier, Canada was no more prepared for remote online education, especially at the secondary education level. Thaheem et al. (2022) recommend that the way forward is to blend technology, either synchronously or asynchronously, into education.

Chiner et al. (2023) found that more Professional Development might help change teachers' perceptions of the safety of the Internet for students with intellectual disabilities. This study pointed to the importance of targeted learning for the use of technology, but it does not address the question of how teachers change the use of technology to suit their classroom. López-Castro and López-Ratón, (2023) also discussed Internet safety for students in primary

education. The focus of this study was on students and their families and, therefore, is not relevant.

Doz et al. (2022) recommended that future studies should focus on how ICT could help in meaningful interactions between teachers and students. Grundmeyer and Peters (2016), before the pandemic, discussed the continuously changing situations of teaching and learning. Pre-service teachers who had two years of 1:1 laptop experience recognize the importance of ongoing Professional Development that is required to leverage the use of technology in the classroom. This recognizes that younger teachers understand the importance of ongoing education in technology. This study supports the idea that teachers need to learn to use technology, but not how or why they might choose to use it in a particular way.

Summary

The literature showed disasters have an effect on education, schooling, students and teachers. Many of the consequences of the disaster are consistent between disasters. The consistency of the consequences provides a reason to prepare a path forward to mitigate the known problems that occur because of disasters.

Losing any infrastructure is serious and costly. When a building is lost to a fire or flood, a new one can be built over a period of time. Free spaces in other buildings can be used in the interim. It is costly to build a new building but it can be done and often in a timely fashion. The new building will often be more modern and useful. However, if the infrastructure lost are people such as nurses, doctors, or teachers the replacement is not as quick. The replacements do not have the years of experience that is associated with a skilled nurse, doctor or teacher. There is a loss in the greater body of experiential knowledge, such as successful teaching techniques and course preparation, when people leave professions en masse. Lesson delivery and assessment

are two of the most identifiable activities associated with teaching. The changes to lesson delivery and assessment that have occurred because of COVID-19 have not been studied or recorded. These changes, such as gamification, need to be examined to see if they are meeting the needs of current students. For example, do the games have engaging attributes for all students.

The recognition of the need for ongoing support in using technology indicated that the teachers needed access to a broader community of practice. Pre-service teachers also realized that they needed regular training in technology use. Although technology is ubiquitous in our personal environments, there is no definitively correct method for implementing technology use in the school system.

The foregoing articles discussed different aspects of the school system during COVID-19. Still, the gap in how teachers changed their technology has not been addressed. To get to the core, it is necessary to look at the process of change that occurred with technology use in the classroom.

Theoretical framework

A specific search of literature for COVID-19 and Cynefin Framework yielded few articles but showed that the framework was being used to look at the change that resulted from COVID-19 pandemic to healthcare institutions and educational institutions.

The Cynefin Framework was developed by Snowden and Boone during their time at IBM. In November 2007, a reprint of the original article was published in Harvard Business Review (HBR). Rubin et al. (2020) used the Cynefin Framework to identify various and conflicting points of view in the Danish health system during the initial phase of COVID-19 pandemic. The Cynefin Framework is then used to examine how these points of view intersect

with each other and why the various bodies of government respond differently. du Plessis et al. (2022) identified the higher education institutions of South Africa as being in disarray at the beginning of the COVID-19 pandemic. The Cynefin Framework was used to understand the actions and strategies used to make sense of the various changes the staff and schools made during the pandemic. Caldera et al. (2022) examined different aspects of teaching engineering when emergency remote teaching began. To do this, they used the Cynefin Framework to classify various barriers to technology use. Kempermann (2017) identified the Cynefin Framework as a source for common reference language and a framework to discuss complexity, and a method to identify decisions and actions. Kempermann also recognized that the Cynefin Framework can be used to solve complicated or chaotic questions that might be generated by a catastrophe. These studies show that the Cynefin Framework has been successfully applied to educational settings where COVID-19 is the disrupter.

3. Methods

Philosophy

McLuhan, in *Understanding Media* says, "the best way to get to the core of a form is to study its effect in some unfamiliar setting" (p. 394). The COVID-19 pandemic provides this setting for technology use in schools. This time frame provides the opportunity to study how technology use has changed, how teachers have changed, and what remains in this changed form as time goes forward.

The Cynefin Framework Ontologies

Many studies involve only one ontology. The Cynefin Framework represents three ontologies: order, un-order, and disorder. This study occurred during a time when all three ontologies were present.

Ordered

The Clear Domain and the Complicated Domain are part of the ordered ontology. Kurtz and Snowden (2003) refer to the ordered domains as having knowable causes and effects.

Disordered

The Disordered Domain is found in the center of the framework. When the World Health Organization (WHO) declared the COVID-19 pandemic on March 11, 2020, the world was sent into disorder. Travel plans, school plans, work plans were all in disarray.

Unordered

School boards and governments around the world declared that school would proceed online. This imposed order onto a disordered system. The unordered ontology is represented by the Complex and Chaotic Domains.

Movement between Ontologies

Kurtz and Snowden (2003) used the Cynefin Framework to help people make sense of complexities that appeared when some or all of order, rational choice and intent are removed. Of particular interest to this study is the concept of order, where this framework identifies three ontologies: order, un-order, and disorder. The early pandemic was a time of un-order for teachers and students. Classes still existed–their location changed from a physical building to a virtual classroom. Teachers still taught–the lessons were delivered as a video-recording that the student could watch at their convenience or live over a service such as Google Meet or Zoom. Homework was collected via digital copies being handed in, instead of the paper copies being physically collected. There was order in the classroom, but it was a very different order. The Cynefin Framework makes it possible to identify possible innovations that resulted from this time of un-order.

The visual representation of the Cynefin Framework respects these ontologies with the ordered domain being divided into clear and complicated while the un-ordered domain is divided into chaotic and complex. The domain of disorder is in the center. This framework must also be represented as three dimensional. (See Figure1 on page 8) The curve at the lower end of the diagram indicates a drop off the cliff as the boundary identified between Clear and Chaos.

Snowden and Boone's Cynefin Framework has been applied in a variety of areas such as Elford's (2012) study of ergonomics, Rubin and de Vries's study of "Diverging sensemaking frames during the initial phases of the COVID-19 outbreak in Denmark, and Puik and Ceglarek (2015) in their paper "The quality of a design will not exceed the knowledge of its designer; an analysis on Axiomatic information and the Cynefin Framework". In 2014, the Cynefin Centre for Applied Complexity was established at Bangor University, Bangor, Wales. The Cynefin Framework can be used to examine situations in the past, but it can also be used to establish paths forward by organizations.

Teachers face situations that involve many decisions each day. Each teacher is an individual with different skills and knowledge. The attributes of individual teachers make a difference when discussing which domain that the particular teacher might be operating in for any decision they make. In the context of the classroom, teachers are leaders. Continuing with the comparison, a senior teacher or a teacher with advanced knowledge in a particular area may be considered an expert. Snowden and Boone (2007) states that the leaders (teachers) using the framework must define that framework with not only historical examples from their own contexts but also possible future events.

Theoretical Framework

The Cynefin Framework is five separate domains or areas that have various boundaries between them. It is a model that shows a three-dimensional space where the boundaries between the spaces vary from being represented by a cliff, a bridge and a shallow river. The Cynefin Framework, originally developed by Kurtz and Snowden (2003), will be used to identify and classify innovations. The Cynefin Framework is a sense making framework. One attribute of the framework is that it is used to identify innovations developed during times of chaos. March 11, 2020–June 30, 2022, can be identified by staff and students as a time of chaos within the school system. UNESCO (2020) also identifies the pandemic as a severe disruptor of education systems. That identification as a severe disruptor contributes to identifying this early pandemic phase as a time of chaos. When teachers operating in a state of chaos, such as the COVID-19 pandemic, take counsel from experts, their peers or seek information from other sources on methods of delivering curriculum to their students, there is the opportunity for innovation in pedagogy. Teachers who can find new affordances for the technology they know, or learn new technology that serves a purpose for instructing and student learning, may well change a situation from chaotic to an opportunity for innovation and find a silver lining in the COVID-19 pandemic. Pre-service or practicing teachers may benefit from direct examples of teachers using and discovering these, new to them, affordances. These affordances could be shared via in-services or through Professional Development opportunities. This research examines how teachers changed and adapted their technology use during the COVID-19 pandemic.

Khirwadkar et al. (2020) in their essay on how parents, students and teachers have re-imagined mathematics education identify the need for using an appropriate framework for understanding the issue being discussed. With this in mind, the responses gathered through

interviews were categorized through the Kurtz and Snowden (2003) Cynefin Theoretical Framework. This framework is used to examine how decisions are made in various contexts, such as clear, complicated, complex, and chaotic. Specifically, the focus was on decisions made by leaders and teachers regarding technology use in a time of chaos, when instruction moved from in-person to emergency online instruction and how this can inform teachers' future decisions on technology. There are also questions on the teacher's technology use pre-COVID-19, so changes in technology use may be noted. The responses were coded according to which aspect of the Cynefin framework applies and how that is identified.

The Cynefin Framework is used in various fields of study, including but not limited to health care, business, and library and information sciences. This phenomenological framework is used to look at the environment around the topics being discussed. Much of the literature found when searching technology use during COVID-19 does not explain the reasoning, or environment, behind the changes in technology use, but the literature adds background to the time of teaching during COVID-19. To establish the commonalities within the literature, this study used the names of the Cynefin Framework domains as labels for sections. See Figure 1.

Kurtz and Snowden (2003), talk about the need to "build the framework" for each situation. The general shape of the framework is the same each time it is drawn, but each area will hold different aspects of the discussion that is being looked at. To use the Cynefin Framework in education, this study examined how a teacher used technology in their usual teaching practice and how they acquired that knowledge in technology as delineated by the Cynefin Framework.

Building the Framework

Clear. First, look at a teacher operating in the Clear Domain. This domain is defined by historical data from the teacher, based on what the teacher typically does every day. The domain includes the education, experience, subject taught, school climate, and personality of the teacher, as well as many other particulars. This teacher is operating in an area where situations require straightforward thinking for the teacher themself. Snowden and Boone (2007), states that the Clear Domain requires leaders (teachers) to sense, categorize, and respond. Following this pattern, the teacher would sense the room. This might include observing and taking in student behavior, questions, topics to be covered, materials available in the classroom, the ability level of the students, and a myriad of other influences. After this, the teacher categorizes the teaching situation of the day. Numerous days of teaching the same students, the same topics in the same room may lead to complacency. This categorization then extends to how the teacher delivers the message for the students. This is a common and comfortable space for the teacher and is their usual method of presentation of material. The Clear Domain is the domain of best practices.

Complicated. A teacher operating in the Clear Domain has multiple ways to move into the Complicated Domain. The Complicated Domain is part of the ordered ontology. An example of a teacher moving between Clear and Complicated would be when a teacher operating in the Clear Domain attends a Professional Development day. First, the teacher must decide (sense) which information session might be most valuable to their teaching strategies. Most teachers, with experience, have taught a lesson or part of a lesson, looked out at a sea of blank faces, and started over. When the change is a response to the information gained at a Professional Development day, or via instruction by experts, the shallow river described by Snowden has been crossed. Here, the sensing would be the “looking out at the class”, analyzing is the

identification of “blank faces” and responding is starting the lesson over from a different starting point. A second example might involve the teacher analyzing which part of a Professional Development session that they attend is valuable to them. After the analysis, the teacher will alter their instruction to students if they wish to be more effective as a result of attending the Professional Development. Information flows freely between the two domains of Clear and Complicated when individuals wish to move the information. For a teacher, the knowledge on subjects such as classroom management or subject matter delivery would be given to the teacher by an expert in the Complicated Domain. The teacher, in the Clear Domain, would take that information back to their classroom, where the teacher operates in the Clear Domain and the implementing that process should result in something similar to what the expert indicated would happen. This is the boundary that results in multiple small improvements when individuals cross forth and back from Clear to Complicated and back. Although information is often delivered by an expert in person, it is also possible that the information can be delivered via an expert on the Internet or in a book. Individual teachers would implement different parts of the Professional Development depending upon their knowledge, skill level and subject taught.

Abaci et al. (2021), experts in their field, look at Teacher Professional Learning in Scotland regarding the support provided by the university team during the emergency remote teaching that occurred during COVID-19. As experts in Teacher Professional Learning,the this group operates in the Complicated Domain of the Cynefin Framework.

Teachers acting in the Complicated may be master teachers or administration who provide possible paths to change. It may also be the teacher themselves who is the expert in the area. Snowden and Boone (2007) says in this Complicated Domain a leader (teacher) must sense, analyze and respond.

If the change is made because an education consultant, or expert, or person in power indicated the change should be made, then the change will be deemed as taught by experts. It is common for teachers to act as experts for fellow teachers.

Complex. The Complex Domain is often built out of the Chaotic Domain. In the Complex Domain, there is more than one correct answer. This is the domain of new thinking. In this domain, leaders (teachers) first probe the situation, then sense what is happening, and then finally respond. During the COVID-19 pandemic, at a minimum, the teachers in this study were required to teach online. As they worked through class after class of online learning, they collected and thought about or probed the responses they were receiving from students. As always, the teachers would modify their instruction based on their sense of how the online instruction was being received by the students. Their response would be a modified version of the method of instruction. Snowden and Boone (2007) says that when innovations are developed outside of the Chaotic/Complex interaction, they are often overlooked because they are unnecessary. No one changes what they perceive to be working well.

Chaos. The Chaotic Domain is the domain of turbulence. Decisions must be made quickly. The COVID-19 pandemic is an example of a situation causing people to be in the Chaotic Domain. The leaders (teachers) in this domain must act, sense, and then respond in this domain. Teachers and school boards had about a week to establish how to deliver mass education in an online environment. This was the action. Teachers then identified how to improve their teaching, or sense, in the online environment. Their response would be to improve their method of online instruction or change to a different approach for online instruction. Snowden and Boone (2007) says that this domain is where most innovations are born.

Movement within the Framework

Movement within the framework represents a change in the situation. This change is often, but not always, considered growth. The movement between clear and complicated is a movement of controlled growth. Movement from clear to complex usually follows a disaster, however, small lengths of time spent in the Chaotic Domain can help to immunize against catastrophic change (Fierro et al. 2010). In the school situation, these periods of immunization might be fire drills or lockdowns where the staff is unaware they will be occurring. The specifics of the movement between the domains of the Cynefin framework are discussed more in depth below.

Clear-Complicated. There is a slight gradient between the Clear Domain and the Complicated Domain. Kurtz and Snowden (2003) compare this boundary to a shallow river, which everyone can cross easily. Each teacher's day and use of technology looks slightly different. How a teacher uses technology daily is in the Clear Domain. This is part of the media ecology, or the surrounding information that affects the media use. The Cynefin Framework also takes an ecology approach in that no two people are ever in exactly the same situation. Their knowledge is always unique, and this influences their reactions to situations.

A few articles from the literature review will be examined through the Cynefin Framework to look at technology change. These articles provide a background to the time and chaos associated with the beginning of the pandemic.

The Clear Domain is also known as the domain of best practice. For teachers, it is their everyday routine with technology. Each teacher's technology use will be individual. A biology teacher may use the Interactive Whiteboard to show a video of a coral reef, while a math teacher might use the board to draw lines and demonstrate geometry. The Clear Domain borders on the

Complicated Domain and on the Chaotic Domain. The border between Clear and Complicated is relatively easy to move back and forth across. If the teacher attends a Professional Development event sponsored by the school division or the Alberta Teachers' Association, then the information will be delivered by an expert in the field. The teacher will then learn how to use this new information and it will become the teacher's new best practice, part of their activities in the Clear Domain. The teacher can also learn from another teacher, online, or from a book and each example would also be considered learning from an expert.

Teachers in Francom et al. (2021) indicated that some of them would continue with using websites they had found during COVID-19 pandemic. As well, other teachers commented that their communications skills with parents had improved and that would be a good thing going forward. We do not know how these teachers could initially find the websites or perhaps learn to use communication technology to engage with the parents. We do not know who or what was the source of information for these two technology changes, but the guiding person or directive could be considered the expert in the field. The teacher learned how to use the technology and carried it back into their new expanded context in the Clear Domain. The bridge over a shallow rivere between Clear Domain and Complicated Domain is very easy to pass through.

Charania et al. (2021) found that teachers who had a greater ability to integrate technology into education through problem-based learning during pre-COVID times were more able to use technology with problem-based learning during COVID lockdown. This is in alignment with teachers who have taken the time to learn from experts and move their methods from the Clear Domain to the Complicated Domain. After integrating the new material into their regular teaching practice, the teacher is working in the Clear Domain again.

Clear-Chaos. The division between Clear and Chaotic is shown as a steep cliff. It is also possible for a scenario in the Chaotic Domain to return to the Clear Domain if the stressors are removed from the system. The scenario that returns to the Clear Domain is changed from having the unorder imposed on it. However, parts of the change are adapted into best practices. Fierro et al. (2010) suggest that we consider this to be a form of immunization, which is a temporary movement from simple to chaotic-not enough to destabilize the whole system, but a change which brings new perspectives. When classes moved back to in-person after COVID-19, most of them looked very similar to pre-COVID-19, but there are usually some differences. This thesis will explore the differences and similarities regarding the use of technology.

Complicated-Complex. A bridge is used to represent the flow between the Complicated and the Complex Domains. The process from Clear, through Complicated and across a bridge to Complex requires more work than moving across the shallow river from Clear to Complicated. An example of Complex might be considered being a teacher going to graduate school. The teacher has to pick a subject, apply to schools, be accepted, pay, go, pass and a myriad of other things. The knowledge they were seeking might not be available in the path they chose or they may have to assimilate the information they want from numerous sources they find in their studies. This process is not a simple Professional Development Day.

Chaos-Complex. For a scenario to be moved from the Chaotic to the Complex Domain requires more work than moving between the two domains of Clear and Complicated in the ordered ontology. To represent this work, a bridge between the two domains is used. The bridge must be built by the people in the Chaotic Domain, in this case teachers. Often, this bridge is a novel approach to the problem and requires a different thought process. It can be a repurposing of a thing or method that already exists. This exaptive process was identified in Ranjitsinh

Disale's application speech for Teacher of the Year, which he won, from the Brainwaves Video Anthology during the COVID-19 Pandemic. When the government of India closed the schools and insisted that all teaching and learning go online, Disale was ready. WhatsApp is a common messaging application in India. He repurposed it to provide links for homework and instruction. The end of term marks were very important for the students because the results would determine which schools the students could attend going forward. The marks had to be reliable. With WhatsApp he was able to have every student complete a different but parallel exam and could give the students a fair grade.

Abas (2021) uses Community of Inquiry theory to reflect on his change in teaching of pre-service teachers during the COVID-19 pandemic when he moved from in-person to online instruction. His ability to reflect on his teaching through the use of this tool may mean that he has had prior experience with or instruction regarding the Community of Inquiry Theory. Meech and Koehler (2023) discuss instructor leadership that is associated with Community of Inquiry and propose that the leadership of the instructor is fundamental to a Community of Inquiry's teaching and learning experience. When looking at Abas's reflective experience through the lens of the Cynefin Framework, we see that the experience with Community of Inquiry, where the instructor must maintain a social, cognitive and teaching presence in order to provide a good educational experience while instructing online prevents Abas from moving from the Clear Domain to the Chaotic Domain and instead, by using his knowledge of Community of Inquiry which was gained by reading or instruction, he is able to move from the Clear Domain to the Complicated Domain via his use of knowledge gained about online instruction through his study of Community of Inquiry which in this case would be judged to be the experts providing knowledge for better practices to move to the Complicated Domain instead of the Chaotic

Domain. Unless Abas is required to continue to meet online, this will not be a permanent change and their instruction will return to the Clear Domain of Best Practices.

By employing the Cynefin Framework to identify and discuss the changes in technology use that the teachers experience as a result of the pandemic, this study documents some changes in using technology that teachers have made as a result of the teaching situation during the COVID-19 pandemic. The Cynefin Framework is used to make sense of these changes in technology use experienced by teachers by looking at how the situations of those three time periods: pre-pandemic, emergency online teaching, and post-pandemic return to classroom teaching changed.

Study Design

Ethics

Work began on an Ethics Application in December 2021. The first attempt was inadvertently submitted on December 15, 2021 and the researcher had to resubmit a slightly different application on January 29, 2022. Ethics Approval for study Pro00116666 was received on Feb. 24, 2022.

On February 25, 2022, the researcher approached the Graduate Program Advisor for Secondary Education for information on how to access the various listservs so that a recruitment email could be sent. The researcher then sent the approved email, which included Ethics information, on February 26, 2022, to the following listservs: eps-sess-all-owner, edpysessionals-owner, elemed-sessional-bo., edsec-sessional-own., edgrad-bounces, elemed-gradstu-phd-., elemed-gradstu-med-., and edsec-grad-stu-ft-o. On February 28, 2022, the edsec-grad-stu-ft-o. sent the email to their listserv. The other listservs never sent the email out. This email, see Appendix A, asked for the following qualifying events:

1. Were you teaching in person (in Alberta in a K–12 school) prior to the COVID-19 pandemic being declared in March 2020?

2. Did you participate in online teaching as a result of the COVID-19 pandemic?

3. Are you/have you returned to the in-person classroom?

These questions identified for the recipients what the criteria necessary for participating in the study were. The second ask of the email was for a referral to an additional teacher who fulfilled the three requirements. A Snowball Participation Email see Appendix B was sent to referrals. The researcher had nine written replies from this email and four verbal responses. These responses represented southern Alberta, central Alberta, eastern Alberta and northern Alberta. The written responses were recorded in a Google Form with names and email addresses. The verbal responses were recorded by name. Each person who responded was promised a response, including the findings, after the project was completed. Some responses were from teachers employed by school boards close to or in Edmonton. A friend of the researcher, who is a principal of an elementary school east of Edmonton, was willing to have volunteers of the school staff participate in the study if they were willing. One of the staff members responded as willing, but unfortunately, it was shortly after the researcher had a medical situation that prevented that interview during the summer and a mutually agreeable time after that could not be found.

The researcher replied to all responses received from the email sent through the listserv. Ethics approval also stated that the approval of the school principal was required before the staff from the school could be interviewed. School boards close to Edmonton require an application to and approval from the Capital Activities Program (CAPS) before research can be conducted in their jurisdictions. The CAPS application requires information regarding which schools are being requested for participation and who the in-school contacts are within the particular school. The

CAPS deadlines for various divisions within the Edmonton area vary. The researcher felt that applying to one board and then using the feedback to apply for other boards would streamline the process.

An individual from a school board in central Alberta responded to the initial email sent to the listserv, however, the principal of the school did not feel able to make the decision to allow interviews to be conducted with the staff of that school. That email was received at the end of June. The researcher awaited feedback on the proposal submitted to CAPS before considering submitting it to the division office of the central Alberta school district, knowing that if approval was granted by the division office that the principal could still refuse to allow the staff to be interviewed.

The first CAPS application was submitted on May 12, 2022. When no information was received from CAPS and after speaking to other researchers who had completed the CAPS process, the researcher tried to submit for permission to research in a second board on August 23, 2022. The CAPS system would not accept the application. The researcher reached out to the CAPS email and was given the following response “Unfortunately, your application is stuck in the system it is because it has the colon ":" in the file name "V2.Initial Response agreement:consent Participation Email UofA.pdf". I am not sure how you are able to add a colon in the file name. Windows and Mac both do not allow colons in the file name.” (email between dbakker @ualberta and sjoshee@ualberta.ca).

On August 24, 2022, a second submission for permission to conduct research in the first school board was submitted. Suggested edits for the application to conduct research were given very promptly, and the researcher completed these edits. On August 26, 2022, the application for consent to research was forwarded to the school board and on October 4, 2022, a positive

response was received in the email. The decision was made to not apply to a second board through CAPS.

A chance meeting with a long-time friend led to two more participants. The friend secured the principal's permission for both interviews, which the researcher received from the principal's school email before the researcher interviewed.

Participants

This study uses interviews with Division 3 and 4 teachers in Alberta to discuss changes to their use of technology in their classrooms, beginning with their use of technology in the classroom in pre-pandemic times, moving to technology use during emergency online teaching, and then discussing how they use technology in their classrooms now. The participants in this study were school teachers who taught in the province of Alberta during three specific time periods: pre-COVID-19, online during COVID-19, and in the in-person classroom after June 2020. These teachers were all Division 3 and 4 teachers. The teachers were diversified in the subjects they taught and the size of communities they came from. Some had completed some graduate level training, some had not. One had left their employment to pursue more graduate education. No incentives were provided for participation in the interviews. Eventually, seven teachers of the possible ten teachers approved by the ethics committee were interviewed. Each teacher interviewed signed a Teacher Consent letter. See Appendix C.

The researcher began the plan of the study to access teachers who had taught in-person prior to COVID-19, online during emergency online teaching, and finally back in the classroom in the province of Alberta. These distinctions are important because not all teachers taught in person prior to COVID-19, for example Argyll school in Edmonton operated online as did the Alberta Distance Learning Centre (ADLS) prior to the COVID-19 pandemic. During the

emergency online teaching, some teachers were still teaching in an in-person classroom, depending on their assignment.

Interviews were chosen by the researcher to have a standard way of gathering data but with the flexibility to request clarification of answers. The questions were structured to ask about technology use pre-COVID-19, during emergency online teaching and then back in the in-person classroom. These groupings, by time, in relation to the COVID-19 pandemic, instead of by technology used, allow for changes in technology use for each individual to be understood. Using interviews to gather information allowed the researcher the opportunity to gather information around why the changes in technology use were made, not just the bare fact that there was a change.

Questions, Transcriptions and Coding

The interviews were recorded via the free version of Zoom. The free version of Zoom allows for recording of a video of a maximum of 40 minutes. All the interview questions were read from a sheet of questions that had been approved by the ethics committee see Appendix D. Occasionally, an additional question was asked to clarify part of the response to a question.

After all the interviews were completed, the transcription of each interview was done using Google Voice Typer. This was accomplished by starting the mp4 playing the interview and then clicking on the Google Doc and then on the Voice Typer microphone icon. Google Voice Typer did not always transcribe exactly what was spoken. Corrections were made to ensure that the interviewee's words were correct. If the interviewer's words on the recording matched the questions that were asked, there was no correction made to the transcription, even if that transcription was not exact. Additional questions or clarifications were transcribed as spoken.

The researcher noted two interesting occurrences while transcribing the interviews. First, Google Voice Typer seemed to make a more accurate initial transcription of the interviews when the interviewer had conversed over Google Meet with the interviewee several times prior to the interview. The researcher had tried to use Voice Typer to transcribe interviews for their Research Assistantship work, but the accuracy was so poor that those transcriptions were done by hand. The second interesting occurrence was when a teacher was going to say a word that might be offensive and had warned the researcher that the word being used might be offensive. Google Voice Typer blurred the word out with several asterisks. Google Voice Typer worked well, but better for people the researcher had conversed with over Google Meet.

After the transcription was completed, the researcher read each interview and made notes to decide on what categories could describe the technology used by the teachers. This decision on naming categories was based on how the teacher used the original tool in their teaching practice. The following categories were present in most of the interviews: organization of classroom materials, delivery of lessons, storage of ideas, communication with parents and students, Community of Practice, and gamification of curriculum. Once the categories were decided upon, the researcher chose a felt marker in six different colors and read the transcripts and mark with an appropriate color every time a mention was made of technology that reflected the category associated with that color. The researcher then taped three pages of blank paper together and labeled them pre, during, and post. On each super page, formed by three sheets taped together, the researcher drew rough representations of the Cynefin Framework. The results from the coding of the interviews were then transferred to the Cynefin Framework and the tracing of that technology use was traced and recorded through the three time periods.

Trustworthiness

As discussed by Adler (2022) and Stahl et al. (2020), the trustworthiness of the acquisition and analysis of the data in a qualitative study must be paramount in the study. As shown in previous sections of this work, the medium or the surrounding ecology of the study will never be the same. The data must be collected and analyzed with diligence and care.

The questions were reviewed by friends and family members who are all active or retired teachers. Their suggestions were incorporated into the final questions. During each interview, the questions were read from a script so that the information each teacher gave would be in response to the same question. The transcription of the interviews was done after all the interviews were completed. After the first interview, because of a response given by that participant, the researcher always asked the remaining participants if a pre-service teacher would benefit from a course about Google Classroom.

For the analysis of each technology, the information was tracked through the Cynefin Framework, for each time period, pre, during and post pandemic. The technology was tracked by type and by teacher. During one of the online classes about *Understanding Media* when the researcher was discussing the progress on the thesis, the researcher held up a taped-up sheet to show the analysis process. The researcher was later told by another participant that the paper looked like a scroll. This led the researcher to understand that although three distinct time periods are noted in the analysis, the process is on a time continuum, with the breaks between pre, during and post being different for each teacher. Snowden and Boone (2007) identify that the Chaotic Domain is often the best place for innovation to occur. Innovations are often taken back to regular life because of their usefulness. These changes or innovations in technology use

are what the researcher is seeking in the analysis. This will provide answers to how the teacher has changed their technology use over the COVID-19 time period.

4. Results

Limitations of the Study

The development of a research group for this study was done via the Snowball Technique, where interview subjects find other subjects to participate (Tracy, 2013). The first group invited to participate were the graduate students who were on the Faculty of Education graduate students list. Graduate students who participated in the study were requested to ask other teachers in their school to participate as well. The interview subjects were limited to Alberta certified teachers who taught any grade K–12 classes during the three identified time periods. It was also assumed that the answers the respondents gave to the questions were truthful and honest. Three limitations to the study have been identified: 1) the researcher had no control over who would respond to the email invitation, 2) there may have unknowingly been a bias in the structure of the questions, and the sample size of seven is quite small. Although the researcher had ethics approval for up to ten interviews, it became apparent that seven interviews would generate sufficient data to work with. These seven participants are identified by a pseudonym that is a surname with no courtesy title, such as Mr. or Mrs.

Given the research constraints, the scope of this study was a tiny segment of many Alberta teachers. The pandemic was worldwide and most teachers worldwide moved to the emergency online teaching from in-person teaching. Given that this was a world-wide event, a pedagogical change that occurred and was reported in Alberta may interest teachers in other parts of the world. There are constraints on school boards within Alberta imposed by the Information and Communication Technology curriculum. Also, within other Alberta curriculums, such as

math or science, there are technology outcomes that should be met. These technology outcomes may not be entirely consistent across Canada and so it was deemed that it would be more useful to study the greater community of Alberta teachers instead of the teachers at one individual school board or teachers across Canada.

The focus of this study was on innovations in technology use, so not all changes in a teacher's use of technology were discussed thoroughly. For example, if the teacher has changed their teaching for online delivery, but will not take that change back to in-person instruction, the change was not regarded as an innovation. The districts that the interviewed teachers came from varied from urban to rural. All teachers interviewed were well acquainted with technology, and one division was one of the first divisions in Alberta to use Chromebooks for teaching. The Chromebooks were so new at that time that they were stopped at the border because the border agents did not know what they were. Some divisions originally used the Hapara classroom Management System. The Hapara system allowed the teacher to not only see what the student was working on, but also the teacher could close tabs in a student browser. These teachers were therefore from forward looking districts that sought new ways to engage their learners via technology.

What follows is a report of the interviews that discuss the time periods of pre-COVID-19, during COVID-19, and post-COVID-19 divided by technological concept. Interviews were collected from seven teachers who worked for three different school districts in Alberta. These teachers are identified by the surnames: Casault, Allen, Helle, Hunt, Bettenson, Dow, and Corriveau. Technologies were grouped into broader categories: Communication, Storage, Resource organization, Assessment, Lesson delivery, Gamification, Community of Practice, and Teachers as learners. Other uses as characterized by the teacher's use of the technology. The

eight categories were chosen to be broad enough to provide context and narrow enough to allow individual responses to technology use to be shown in contrast. The following, Table 1, is a listing of interviewees with their subject areas and grade level assignment.

Table 1

Teacher Pseudonyms with Subject Area and Grade Level Groupings

Name	Subject	Division
Casault	Math	3
Allen	Physical Education, Social Studies	3
Helle	Art, English	3
Hunt	English	3
Bettenson	Social Studies	4
Dow	Math, Science	3 & 4
Corriveau	Math	3

Teachers as Infrastructure

Communication

During COVID-19, teachers let go of their usual environment of the classroom, where much of the communication was done in person. Their understanding of the classroom environment had changed. They grasped it in a new way. Casault discusses communication in pre-COVID-19 times this way: “SchoolZone was the platform for communication with parents”. When discussing communication with students, the response was, “I set up Google Classroom and then never used it”. During COVID-19, this changed. Casault said, (they) “Had to learn Google Classroom to communicate with the students”. Post COVID-19 Casault has found that communication with students can be summed up this way, "The first thing that they do when they come in my room, they look at the lesson today. Working through Google Suite and having everything shared from, like syllabi to textbooks, to lesson plans. Kept that".

In fact, communication overlays many other topics that the teachers identified as changed because of COVID-19. Teaching is an art form that requires careful navigation of the communication channels among teachers, parents, and students. Helle found they used Google Classroom for only one specialized class during pre-COVID-19. During COVID-19, Google Classroom was “great for reminding students of deadlines”. Post COVID-19 Helle uses Google Classroom differently. Helle says, “The first day of school ... I can have the whole year mapped out for them (the student). It has been amazing in bridging that gap in communication. I’m finding parent-teacher interviews are becoming a lot less like my kid is doing how well or how poorly? There’s just no surprises.”.

In pre-COVID-19 times, Hunt used Google Classroom when students were writing a composition. Hunt would want “them to add their document to Google Classroom so that I could provide feedback”. Moving into post-COVID-19 times, students “send me a message in Classroom. I’m buzzed. If they send an email, they have to wait until I check my email. Now they will send a message ‘Can you take a look at this’. They are shy. They don’t want to get up (in front of the class)”.

Storage

Prior to COVID-19 storage of teaching materials, quizzes and tests were mostly kept in hard copy. Sometimes these were in binders or sometimes they were kept in filing cabinets. Allen says, “Being able to take something, because a lot of my stuff was paper, and scanning it into Google Classroom. No big deal.”.

Post-COVID-19 Hunt is almost paperless. Hunt has a “whole shelf of binders behind me, that I haven’t picked up in three years. Everything’s in Google Drive. Everything’s digital. If I

need to print it for them, I print it, but unless I have an old key in a binder, I don't go to the binders".

Corriveau said pre-COVID-19, "I teach three different maths so I have three binders on my desk.". During COVID-19 they said, "It's Google Drive 7,8, and 9. That's my filing cabinet". Post COVID-19 it has become, "A place to add supplementary material that I used while teaching during COVID and I still use it now. Those videos are all saved and you can reuse them, so same with the notes on the iPad.".

Teaching and knowledge management

Resource organization

The interchange of physical and digital storage occurred rapidly. The topic of storage overlaps with organization, but the topics are sufficiently different to be discussed separately. Pre-COVID-19, Casault used Google to organize theirself. During COVID-19, for Casault, classes had both asynchronous and synchronous components. The students had access to the lesson plan slides and instructions before class. If the students had questions, the questions could be answered during the synchronous time. Post COVID-19, Casault has "everything organized in Google Suite. Google Classroom has links to my Google website. Google Sites enables you to put hyperlinks in and list assignments. I have links to online textbook versions. I would be working about five days ahead so students could look at it ahead of time if they wanted to. I would hyperlink the documents and they would be read only because the student knows that when it is assigned that it will be through Google Classroom and they get their own copy. It's kept me organized, and the kids organized."

Helle says that prior to COVID-19, "Lessons were written down, and I had a procedure sheet, kept in a binder in transparent protectors. There was one binder for the class and it was

passed around". During COVID-19, "I had to have a Google Slide presentation to accompany my lessons. I had to digitize everything that I had and then upload it to Google Classroom, which is amazing because I can rely on that from year to year". Post-COVID-19, "The kids bring their Chromebooks everyday so they all have access to all the procedures right at their fingertips in their Google Classroom".

Assessment

Teachers have preferences for grading and assessment. Pre-COVID-19 teachers might accept assignments online or in-person. Assessments might be written or oral. During COVID-19, teachers who had assessed student work only by having the student write on paper had to find a new method. During COVID-19, Casault gave little value to tests "because of the necessary policing. We don't have the technology out there for monitoring students while they're taking quizzes.".

Bettenson gave "Grade 12 Social Studies a test. Just let me know when you want it and I will roll it out to you and release it. You have so much time to finish it".

Bettenson, during COVID-19, found that "when diplomas were optional, 75% of the students wrote. They felt they had lost a lot and that their grad might not be normal. It was a rite of passage."

Allen found that, during COVID-19, students were willing to make videos for assessment using FlipGrid. Post-COVID-19, "I (Allen) would say something about FlipGrid, they (the students) would say 'We're so done with FlipGrid'".

Post-COVID-19, Corriveau uses video for formative assessment this way:

"I give them a question and they have to respond with their work so they'll talk to the camera. A lot of them are more tech savvy than me. They'll either have their phone and

they'll be videoing from it as they are writing or others will just have their paper and hold it up after and show me, but they walk me through step by step. It is just a completion mark".

Dow used Google forms for exams. They prepared "five to six versions. Sometimes just shuffled the questions, sometimes change the variables".

Lesson Delivery

To recognize the message of technology associated with delivering school classes online, we must recognize the change of scale of technology use and the change in pattern that was introduced into the lives of teachers and students. Allen used little technology in pre-COVID-19 times. Their technology use was limited to VHS, DVD and some virtual reality. During COVID-19 using "Google Meet for Physed felt creepy and an invasion of their privacy". Allen later used Flipgrid where "the students would take these cool, funny short videos where they'd be meeting up with friends.". This technology is Flipgrid. Post-COVID-19, Allen suggests students use "Google Read and Write- This is how you can use it to edit some of your work. Listen to it. Put it in a different accent. Hear what you're saying." Allen often goes "online to watch the news".

Corriveau found during COVID-19 that some parts of the curriculum were time consuming to prepare to present online. Corriveau "now look(s) forward to teaching those units because I know I have some many resources at my fingertips".

Teachers as innovators

Gamification

The classroom is often the group of people the student is most engaged with. During COVID-19, this became more apparent. Gamification may be introduced to promote student engagement, introduce a sense of play, engage with the curriculum, or complement and extend

the curriculum. Pre-COVID-19, Hunt used Kahoot! Post-COVID-19, Hunt continues to use gamification by including Gimkit for the gamification of studying. “They (the students) love it because they actually sit there and need to know the right answers to be able to snap everybody out of existence. … I always ask at the end of a class that we’ve given them -Is there one term that you know now that you didn’t know before we started to play?”.

Dow said that “there’re lots of online games that I used during COVID-19. Anything with games online- they love it and they’re willing to play those games. I would say they seem to really enjoy that part of it and anything you can make into a game or somehow gamify it, they seem to be attracted, which I get it because like they’re all really into ... video games. They connect through video games and COVID definitely made them connect that way as well”.

Prior to COVID-19, Corriveau used iPads and QR code scanners around the school for technologically gamified scavenger hunts with curricular outcomes.

Community of practice

At the beginning of emergency online teaching, teachers scrambled for ideas to improve their teaching and to support the students. Participation was high in various Communities of Practice, but the organization of these communities was low. Pre-COVID-19, Casault attended Professional Development offered by the division. During COVID-19 Casault used a combination of guidance provided by the division and personal experience form taking online classes. They also began using YouTube for ideas and methods. Post-COVID-19, Casault continued using YouTube.

Helle identified that learning to use technology during COVID-19 happened through internet searching. Post-COVID-19, the teachers in Helle’s subject area in the division, met as a faculty and started a shared Google Drive specific to their subject.

Pre-COVID-19 Hunt followed groups on Facebook or Instagram to learn about technology. During COVID-19, Hunt communicated with their teaching staff.

Pre-COVID-19 Bettenson went to their teaching staff first. During COVID-19, this changed to Googling and YouTube searches.

Teachers as learners

During emergency online teaching, administration often formally paired members of staff to work together. Teachers team taught so there was someone else to talk to and engage with to keep the lesson interesting.

> Bettenson noted that: "technology took a lot away from the process of teaching and what I mean is it's that human contact, it's how to connect. It's how to connect. It's to have the kids present, because just because they say they're in your class, we learned that because the bandwidth is easier if they turn off their video, and that's great, except then you don't know that they are even there".

Hunt mentioned that during COVID-19, being in front of the camera meant you were on screen all the time unless you muted the camera, which leads the students to think you are not there. The solution that was devised was to create an additional breakout room with only the teacher in it. The teachers could still monitor the requests for help and it would appear that the teacher was helping other students while, in fact, they were in their individual breakout room.

Hunt often records a video of the lesson if they are going to be away. This helps the supply teacher. Hunt keeps the video for future use if the student needs to review the lesson.

Bettenson recalled an incident post COVID-19, when the schools were in but people were isolating if ill or exposed. Teachers would be out of the classroom with a substitute in the room to cover those classrooms which were not isolating. That pushed the comfort level of technology

use. The teacher could post all the material in Google Classroom, have a Google Meet with the substitute teacher and could be potentially present via computer for any problems that arose in the non-isolating classrooms.

5. Discussion

Shapiro et al. (2020) and Johnson et al. (2021) identified that the move to online instruction was troublesome for students and teachers alike. By June 2020, Shapiro et al. concluded that the move to online instruction was disruptive for university students. The students found themselves in isolated situations and instructors had fewer resources to work with. Shapiro et al. (2020) stated "that a better approach is required going forward" (p. 2530). Johnson et al. (2021) identified many of the problems and pitfalls at the beginning of online teaching of physical education, including large class sizes and lack of knowledge of instructional technology.

Alabdulaziz (2021) indicated that 98 percent of respondents felt that the COVID-19 pandemic could be the gateway to future use of technology in mathematics classrooms. Alabdulaziz viewed the pandemic as a time of innovation. However, when looking at the results of his study through the Cynefin Framework, one does not know if the teachers were guided to make a particular change in technology use or whether they learned the change on their own. Also unknown is how many of the teachers will retain their change in use of technology once they are back in the in-person classroom.

Chiu's (2021) systematic review of technologies used in chemical education is a valuable resource for anyone who teaches chemistry. This review would be useful for chemistry teachers of both the Division 3 and Division 4 in Alberta. It provides a useful summary of types of technology to use and how that technology would be useful. This could provide an excellent starting point for teachers to integrate technology into their classrooms and may be a source of

expert information for a teacher to enhance their teaching from the clear to the Complicated Domain and then back to the Clear Domain.

Deák et al. (2021) discussed fifteen different models in pedagogical approaches that deal with STEM education. This article was positioned to show pedagogical approaches that improve the use of technology in the school system. Teachers who used this article to implement technology use in their classroom would regard it as an expert source and this would move their teaching in an orderly fashion, from the Clear Domain to the Complicated Domain, where they acquire new skills. When the new skills are integrated into everyday teaching strategies, the skills become part of the Clear Domain for that teacher.

Quezada et al. (2020) discussed how a teacher education college moved online. The move resulted from experts in the area of technology having input into better practices associated with the various fields of teaching. There is no information regarding whether the change becomes permanent. However, it would be interesting to see if teachers trained online have a different use of technology.

Exaptive Process

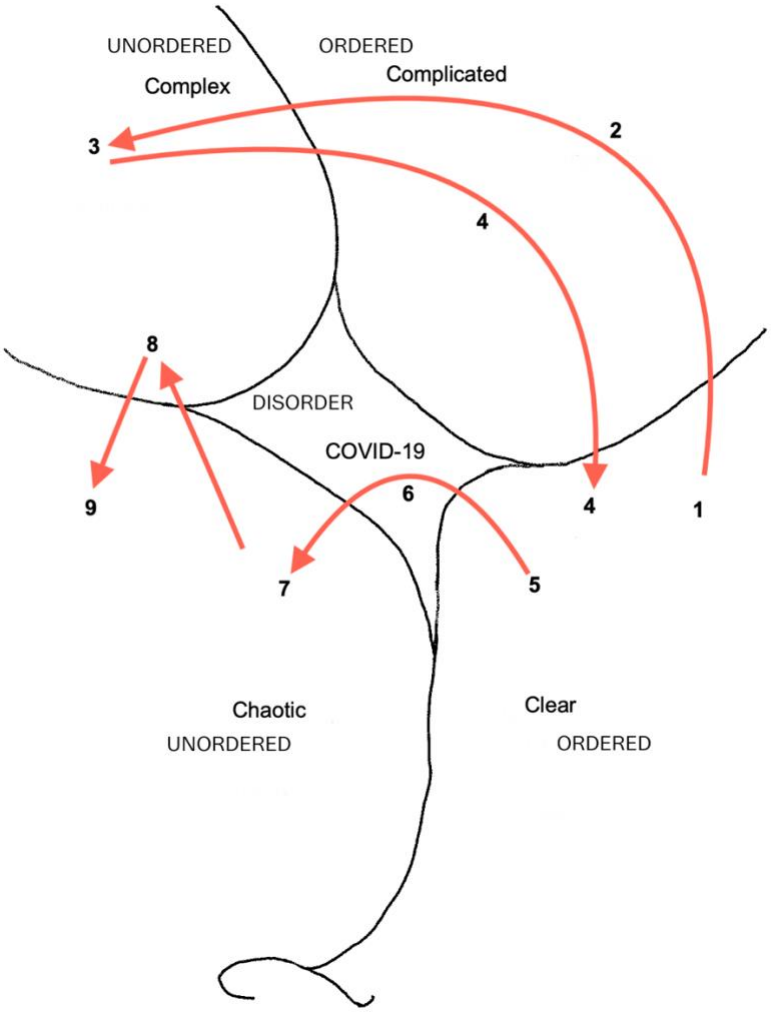
When WHO declared the COVID-19 pandemic on March 11, 2020, the reaction of governments and school boards from around the globe indicated that there would be a massive change in how education was delivered from the teacher to the student. Numerous changes happened in a week's time. Educators were left scrambling for presentation methods to reach their students. Some teachers initially used Google Classroom, or equivalent, as a replacement for the physical classroom they had to leave, while others reimagined the teaching-learning situation without the classroom. This reimagining of the teaching process can be seen in the exaptive process in the Cynefin Framework. The exaptive process with technology is when you

adapt an existing form of technology for a new use. Many of the nominees for Teacher of the Year in 2020 showed examples of exaptive processes in their nomination interviews. Incorporation of an exaptive process occurs when the teacher visits the Complex Domain from the Chaotic Domain. In the Complex Domain, the teachers gather tools to make the Chaotic Domain more manageable. The educator is still operating in the domain of chaos, but they are building bridges to the Complex Domain via individual thought processes. This is different for every teacher, as everyone has unique experiences and resources to draw from. What follows is an exploration of the exaptive processes for a nominee for World Teacher of the Year 2020. This public video allows insight into the individual teacher's development, whereas this study is by ethical necessity anonymized.

Dr. Marina Kharitonashvili from Tibilsi, Georgia, a nominee for Teacher of the Year in 2020, through the Varkey Foundation, explained to students how to do experiments at home. She taught Geography and Core Science of Geography.

Figure 2

Example of the Exaptive Process Visualized through the Cynefin Framework



Before addressing the analyse of the results, this is a real world public example of the application of the Cynefin Framework to a teacher's background and innovative pedagogy. Kharitonashvili has a PhD., as well as a Master of Geography. Using the Cynefin Framework, Figure 2, to understand her training, it begins in the Clear Domain (1). The decision is made to acquire more knowledge. This moves them from Clear to the Complicated Domain (2). The boundary between Clear and Complicated is described as a shallow river or a slippery slope. This boundary is easy to cross. Just as there are two direction of movement from the Clear Domain,

there are also two directions of movement from the Complicated Domain. The first direction is back to the Clear Domain, such as, after a Professional Development Day to implement the new learning that has been gleaned from the event; the second direction is acquisition of knowledge such as a graduate level degree by moving to the Complex Domain. The decision to enter Graduate School moves them from the Complicated Domain to the Complex Domain (3). The acquisition of information is more difficult in the Complex Domain than in the Complicated Domain because the information in the Complicated Domain may need to be synthesized from more than one source.

The gradient between the Complicated and the Complex Domain as described by The Cynefin Co. website is "an interesting valley that you would like to linger in but you must move on." There must be constraints applied to the movement from Complex back to Complicated or the new Clear Domain (4). In Kharitonashvili's case the constraint applied is the fulfillment of the degree requirements.

Looking at this teaching process through the Cynefin Framework, Kharitonashvili, later completing their Masters and Doctorate pre-COVID-19, is in the Clear Domain (5) which is part of the Ordered Ontology, when COVID-19 begins. Their teaching is suddenly moved into the Disordered Domain (6). The Ministry of Education required students to stay home. The requirement to stay home is order that is imposed on a situation. This moves Kharitonashvili into the Chaotic Domain (7) of the Unordered Ontology. The boundary between the Clear Domain and the Chaotic Domain is characterized by a steep cliff.

Dr. Kharitonashvili was able to access information in the Complex Domain to aid their students' learning during COVID-19. This was possible, in part, because they had completed graduate work in the area of geography. This graduate work enabled them to build a bridge from

the Chaotic Domain to the Complex Domain (8). The bridge was built with the knowledge they had gained through their graduate work. Kharitonashvili was able to introduce new methods of teaching in the Chaotic Domain because of the knowledge they gained through graduate studies.

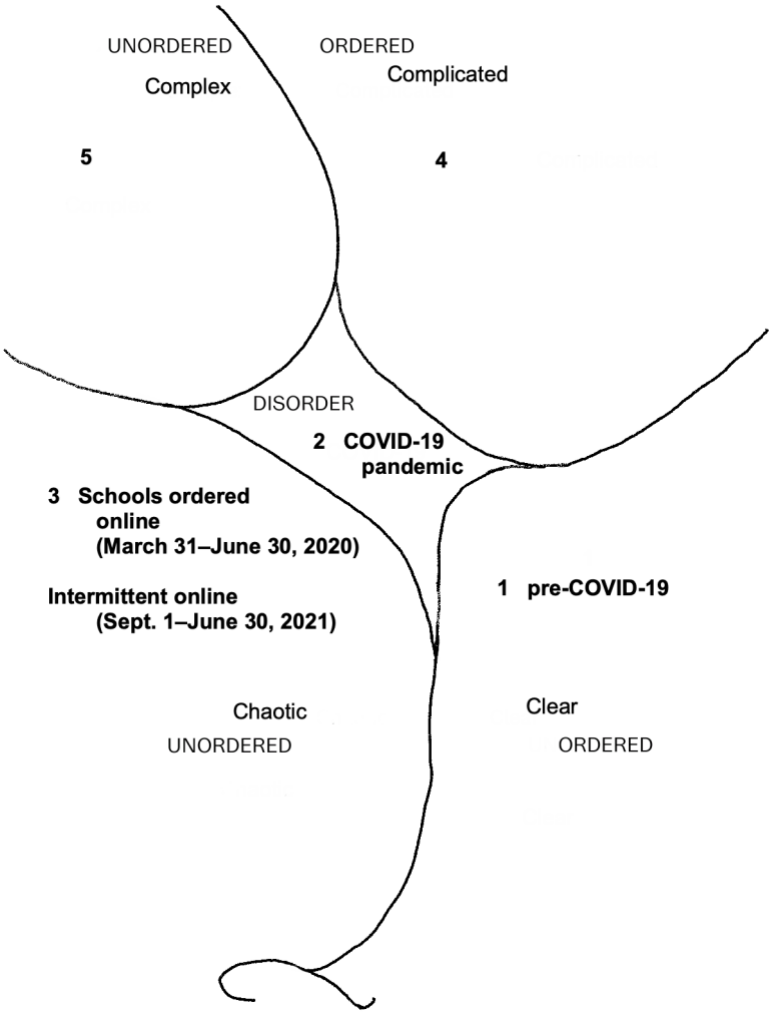
For example, Kharitonashvili promoted a school club, Let's Explore Our Universe, during the online teaching period. Prior to COVID-19, the club operated across grades levels and prepared presentations in foreign languages. This preparation was followed by a trip to the point of interest where the students gave presentations about the point of interest. When travel was not possible during COVID-19, Dr. Kharitonashvili asked the students to prepare tourist guide talks for various protected areas around the world. This used their unique knowledge of geography to help the students. These videos were uploaded to a YouTube Channel. Through this, the students learned to use various programs to make videos. Dr. Kharitonashvili went to the roof of their house and videoed a lesson on the physical geography of Tbilisi in which they challenged other teachers to record and upload videos to the YouTube channel. This video came to the attention of the Ministry of Education for the country of Georgia and they were asked to provide a webinar on how to produce interesting online classes for students. These lessons were produced over the summer and were shown on television during the school year. Not all students in Georgia have access to computers or the Internet and so showing the lessons on television provided a new way of equalizing access to high-quality content (9).

After reviewing videos of many of the teachers who were accepted for the teacher of the year award, the researcher wondered what Alberta teachers had gained in skills relating to technology use as a result of the pandemic. This resulted in the following question:

What use of digital technology have teachers taken back to their in-person classrooms from their online emergency teaching experience during the COVID-19?

Figure 3

Times of Ordered, Disordered and Unordered Contexts



Using the lens of the Cynefin Framework, this research analyzes changes in teachers' technology use around the specific time period of the COVID-19 pandemic. With this in mind, in Figure 3, for this study, the pre-COVID-19 Pandemic time frame functions in the Clear Domain of the Cynefin Framework (1). The time from the declaration of the COVID-19 Pandemic,

March 11, 2020 until the schools began online is the time of Disorder (2). Schoolboards imposed order (unorder is the ontology) on the situation by declaring that education would continue via emergency online teaching (3). This time, when the schools were directed to be online until they were back to in-person classrooms, is the time of Chaos on the Cynefin Framework as shown on Figure 2. March 31, 2020 until June 30, 2020 identifies the time period of the Chaotic Domain that is discussed in this thesis. At the beginning of September 2020, the schools returned to in person classroom learning and this is again in the Clear Domain except for the brief online sessions. The Complicated Domain (4) is where learning is provided by experts. This could occur through Professional Development or direction from a knowledgeable peer. The Complex Domain (5) involves gathering data from more than one source and synthesizing the information you need. This could be completing Graduate Studies or a participating in a number of different Communities of Practice to synthesize the information you need.

In pre-COVID-19 times, the teachers used many digital technologies to complete their job. These same technologies might also be used in post-COVID-19 times, but perhaps differently. To give a fuller perception of the starting point of the teachers regarding their technology use, the researcher would like to be inclusive of all the technologies shared. From the pre-COVID-19 period, Clear Domain on the above diagram, some technologies that were discussed with the researcher, including some that were the students' own devices, include: hardware such as cameras, computer, Chromebooks, digital video disc (DVD), document camera, iPad, laptop, overhead projector, projector, tablets, video camera, video home system (VHS), whiteboards; and, software such as Excel, Flipgrid, Google Platform, Google Classroom, Google Slides, Hāpara, Kahoot!, Lightroom, Microsoft Word, PowerSchool, photo editing apps such as GIMP, PowerPoint, Quick Response (QR) Code scanner, Reflector 4 app, Remind,

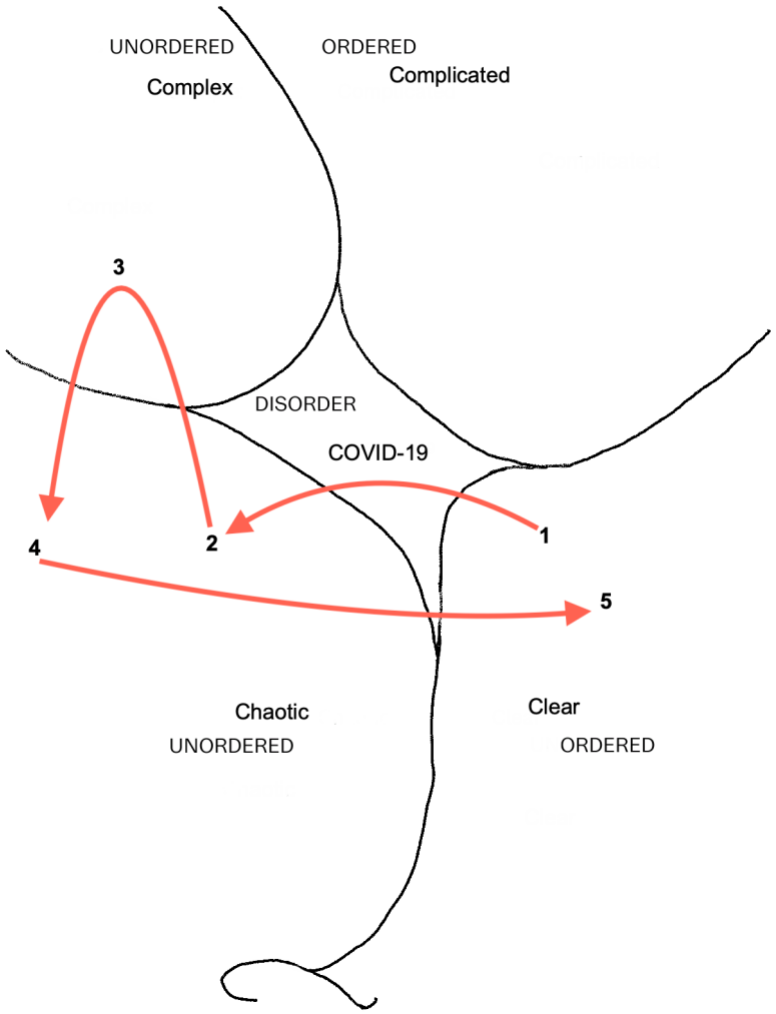
SchoolZone, SMART Board, stop motion films, video clips, video editing suite, virtual reality (VR), and Microsoft Word. In what follows, these digital technologies are discussed in groupings according to their innovative use in the classroom—including communication, gamification, delivery of lessons, assessment, organization of materials, storage, community of practice and source of help. This study is focused on what changes in technology use the teacher took back to their in-person classroom after the COVID-19 emergency online teaching. The exaptive processes are of most interest to the researcher because these processes are novel solutions to a problem the teacher experienced during COVID-19 online teaching. They may show some difference in pedagogical development when held in contrast to ready-made solutions provided by an outside source.

Teachers as Infrastructure

Communication

Figure 4

Casault's Communication with Students

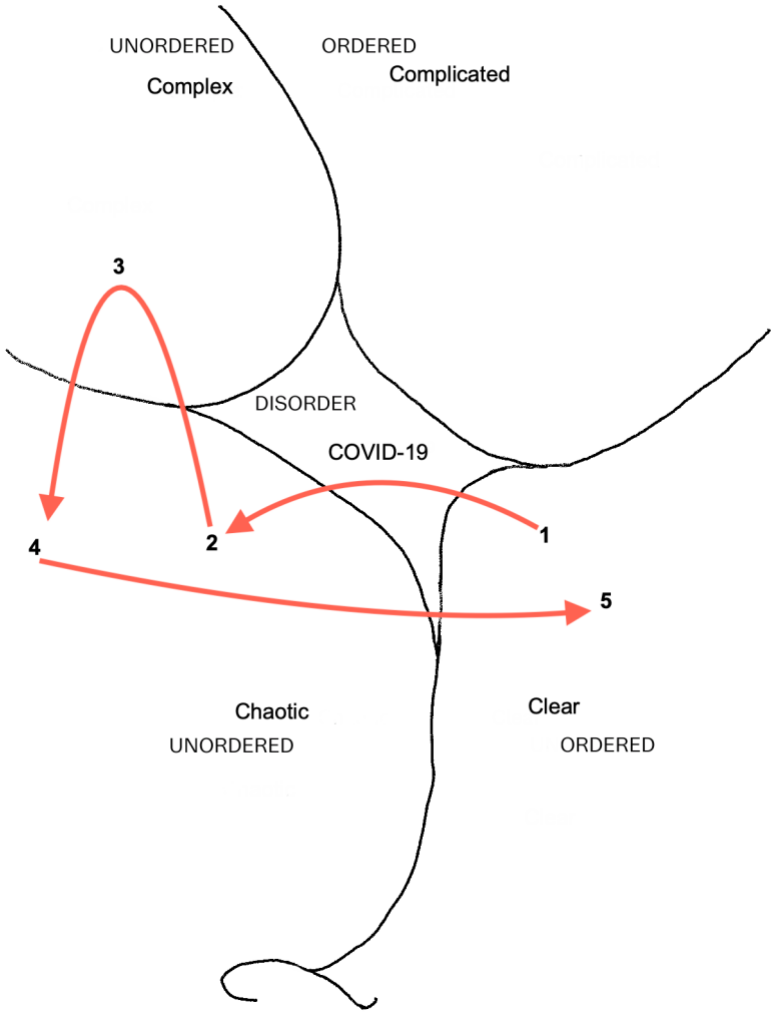


When considering communication with students, Figure 4, the response about Pre-COVID-19 times, was, "I set up Google Classroom and then never used it" (1). This is in the Clear Domain. During COVID-19, this changed. Casault said, (they) "Had to learn Google Classroom to communicate with the students" (2). This was during COVID-19 and is shown in the Chaos Domain. Casault used YouTube (3) to learn how to use Google Classroom effectively

(4). Post COVID-19 Casault has found that communication with students can be summed up this way, "The first thing that they do when they come in my room, they look at the lesson today. Working through Google Suite and having everything shared from, like syllabi to textbooks, to lesson plans. Kept that" (5).

Figure 5

Casault's Communication with Parents



In Pre-COVID-19 times, Figure 5 shows communication with parents often occurred via SchoolZone or phone call (1). This was recognized as a best practice at the time and was in the Clear Domain. During COVID-19, the usual environment of the classroom, where much of the

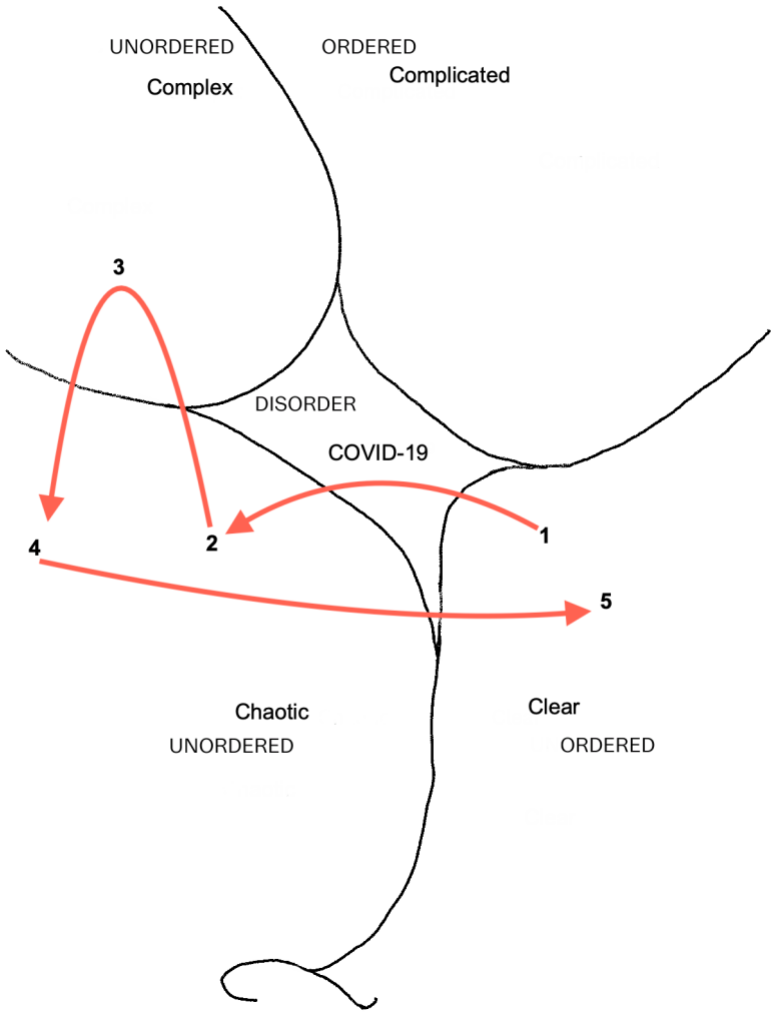
communication was done in person, changed. Teacher's understanding of the classroom environment had changed. They grasped it in a new way. Casault discusses communication in pre-COVID-19 times this way: "SchoolZone was the platform for communication with parents".

During COVID-19, communication was more common in Google Classroom (2), partly because teachers were using Google Classroom every day. Also, teachers were not working in the school and therefore did not have a school phone to use when calling home. This was in the Chaotic Domain. After Casault learned to use GoogleClassroom effectively through YouTube videos (3), Casault said that "everything was transparent" about expectations and assignments that were presented through Google Classroom (4). Google Classroom was initially intended to facilitate the delivery of lessons. However, when the parents have access to everything in Google Classroom, it becomes another method of communication with the parent. When the parents have full access to the lessons, assignments, the included links to the syllabus and with all assignments date-stamped, there is no question of what has been done and what was assigned. This level of transparency between teacher and parent provides the parent with a non-curated view of how the student is doing in the class. This then reduces the need for extraneous communication to the parent because every parent can see exactly what should be done for class work, the assignments, and how it relates to the course with the links to the syllabus. Communicating with the parents by repurposing Google Classroom to be used as a method of communication in addition to its designed purpose of a vehicle for classroom information delivery is an exaptive practice. The transparency makes the student more accountable, to both the teacher and parent, for their activity. Communication is no longer an email or a phone call home, rather, it is an ongoing process. In Post-COVID-19 times (5), the only critique Casault has

received from a parent is that students might be confused by seeing more than one way to solve a math problem. This change has been retained.

Figure 6

The Change in Helle's Google Classroom



In fact, communication overlays many other topics that the teachers identified as changed because of COVID-19. Teaching is an art form that requires careful navigation of the communication channels among teachers, parents, and students. Figure 6 shows the change in Helle's Google Classroom. Helle found that they used Google Classroom for only one specialized class that required electronics during pre-COVID-19 (1). During COVID-19, Google

Classroom was “great for reminding students of deadlines” (2). By teaching online during COVID-19, teachers learned how to save and reuse parts of the work that they had done. Helle learned how to store the Google Slides from year to year for presentation of their lessons on Google Classroom (3). This learning was done through online searching. Capturing repeatable parts of instruction for future use was done throughout the online teaching time. The storage of projects ideas (4) has provided the students with more instantaneous access to the assignments in Post COVID-19 times. Post COVID-19 Helle uses Google Classroom differently. Helle says, “The first day of school ... I can have the whole year mapped out for them (the student). It has been amazing in bridging that gap in communication” (5). This is also an example of the overlap of communication and organization. “I’m finding parent-teacher interviews are becoming a lot less like my kid is doing how well or how poorly? There’re just no surprises”. This exaptive change has been kept.

Figure 7

Hunt's Use of Google Classroom

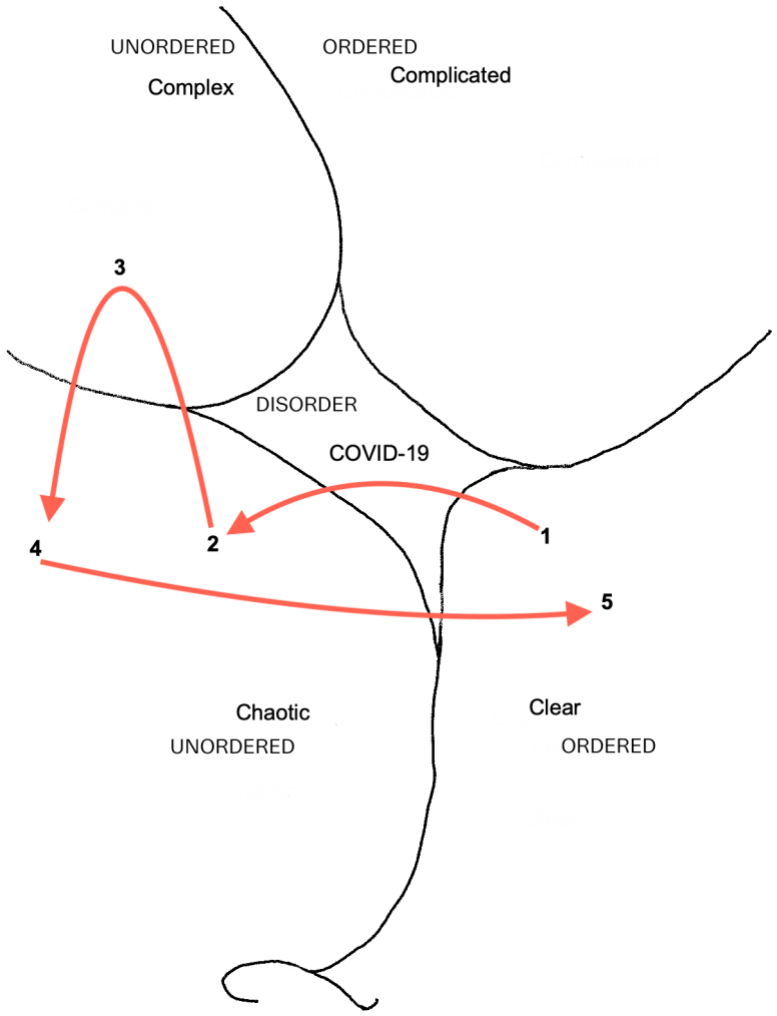


Figure 7 shows how students' have helped shape the teacher's use of Google Classroom. In pre-COVID-19 times, Hunt used Google Classroom when students were writing a composition. Pre-COVID-19, Hunt would want "them (the student) to add their document to Google Classroom (1) so that I could provide feedback". Hunt has previous technology training (2). Hunt is able to share a document with each student in the class (3) so the students can receive feedback and are accountable for their work (4). Moving into post-COVID-19 times,

students “send me a message in Classroom. I’m buzzed. If they send an email, they have to wait until I check my email. Now they will send a message ‘Can you take a look at this’. They are shy. They don’t want to get up (in front of the class)” (5).

Figure 8

Helle’s Use of a Specialty Website

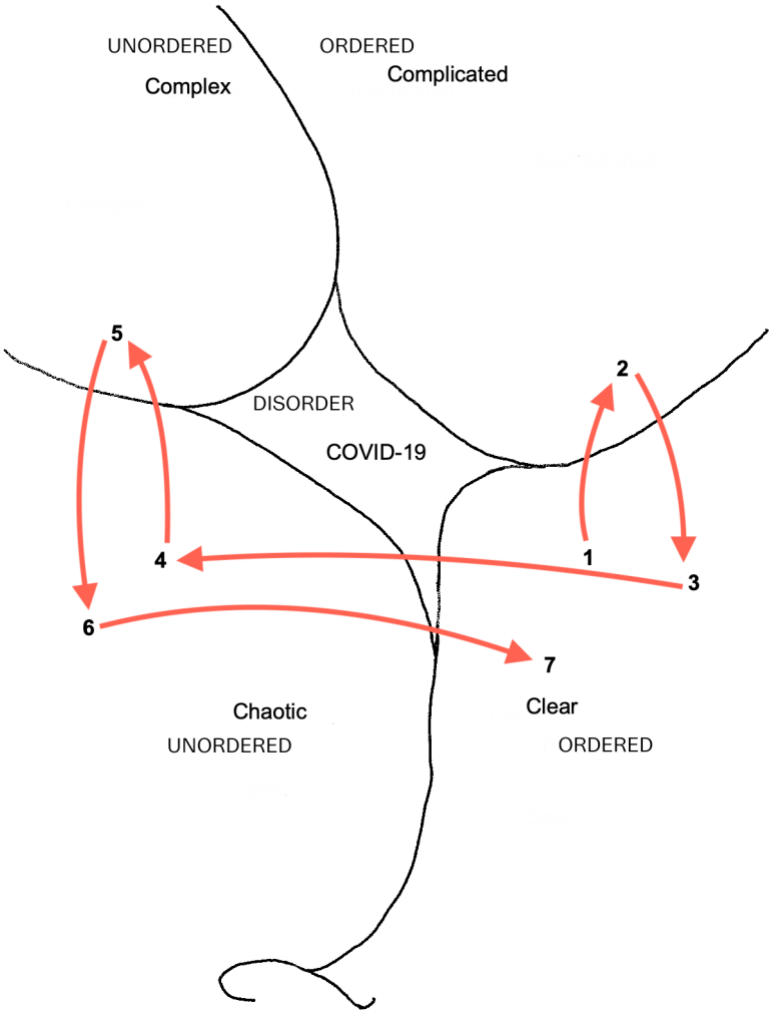


Figure 8 shows Helle’s search for ideas diagrammed in the Cynefin Framework. Pre-COVID-19, Helle would search the Internet for project ideas. Beginning the search moves the teacher from the Clear Domain (1) to the Complicated Domain (2) where they looked for advice

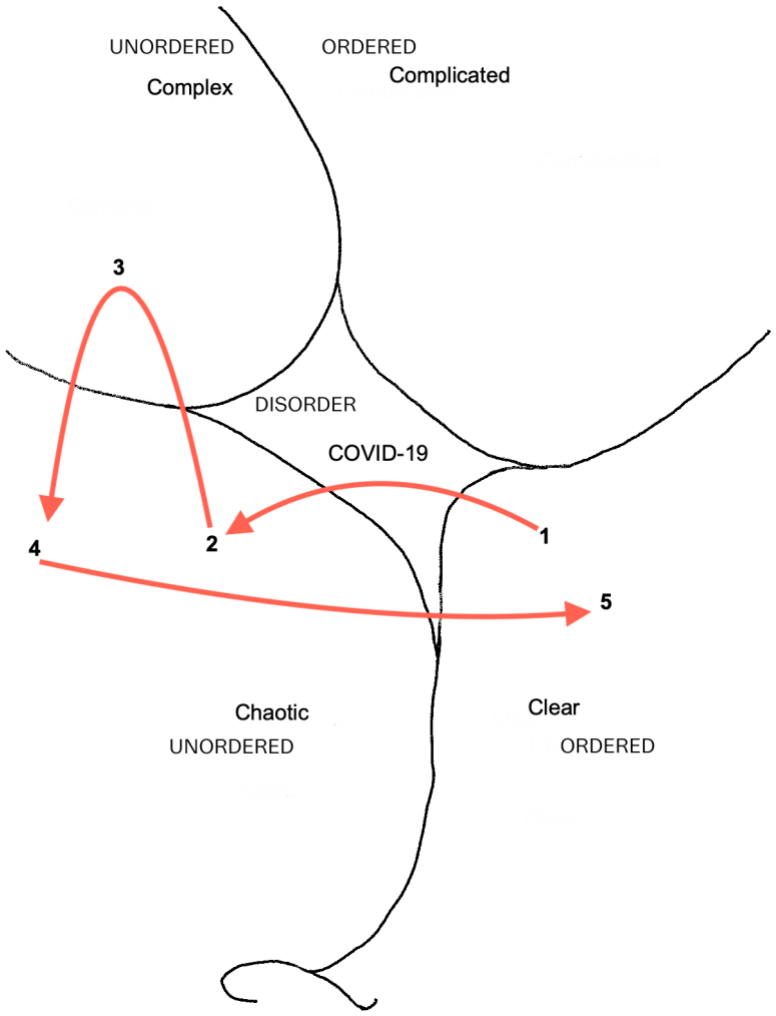
from experts. In this search some, but not all, of the websites were secure meaning that a search of the website would be different for a member of the community than for the public. After finding a website with project ideas, exploring the website showed there are different levels of accessibility and security. There may be different permissions for viewing within the community. Some results of the search, may be visible to everyone while some are only visible to an exclusive group. Using the website for project ideas is in the Clear Domain (3). During COVID-19, teachers used this website to view their student's assignments. This was when teaching passed through Disorder and into the Chaotic Domain (4). After seeing other projects on the website, Helle repurposed the website to be an assignment drop (5). This is a repurposing of the original intention of the website. The assignments remain on the website for pre-approved family and friends to see (6). Post-COVID-19, Helle uses the website like a cabinet to house former students' work, each to be used as an exemplar for new assignments (7). This has been retained as best practice in Clear Domain post-COVID-19.

Teachers became very adept at searching for ideas and information on YouTube or by using Google. When thinking about the Cynefin Framework, the transition between Chaotic Domain and the Complex Domain is described as a bridge being built each time. YouTube, Google and Communities of Practice became that bridge during COVID-19. Post COVID-19 Google Classroom is still used. Teachers provide not only assignments in Google Classroom but also supplemental material and links to the syllabus for each class, an upshot of which was clarifying communication channels with students and families with each use.

Storage

Figure 9

Allen's Paper to Digital Storage



Allen's paper to digital storage transformation is shown in Figure 9. Prior to COVID-19, storage of teaching materials, quizzes and tests were mostly kept in hard copy (1). Sometimes these were in binders or sometimes they were kept in filing cabinets. Allen says, "Being able to take something, because a lot of my stuff was paper, and scanning it into Google Classroom (2). No big deal". The process of producing digital copy from the physical paper copy was learned. There were a few methods to complete this task (3). All the methods required some work on the

part of the teacher, examples of these methods varied due to available technologies which shifted throughout the course of online teaching and isolation legislation (4). Post-COVID-19 the teacher uses the method of creating a scan that is easiest (5).

Figure 10

Hunt's Binders to Digital Storage

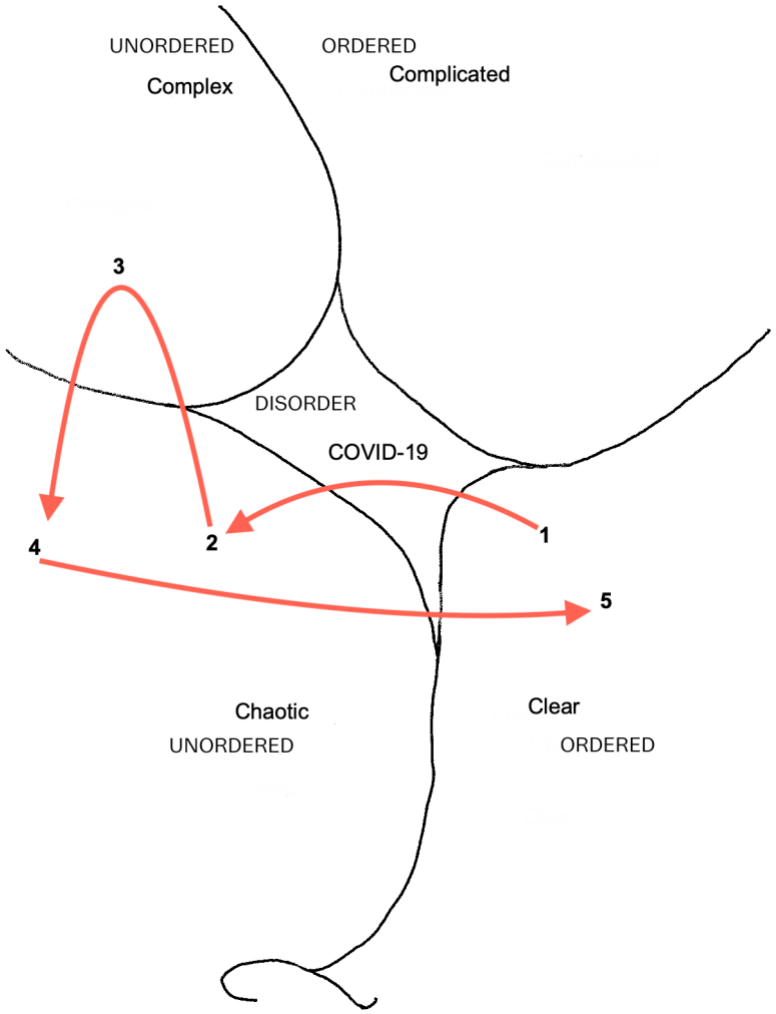


Figure 10 shows Hunt's journey. Post-COVID-19 Hunt is almost paperless (5). Hunt has a "whole shelf of binders behind me, that I haven't picked up in three years (1). Hunt digitized most of their material as it was needed during COVID-19 pandemic (2). Everything is in Google

Drive after being used during the pandemic (3). Everything's digital (4). If I need to print it for them, I print it, but unless I have an old key in a binder, I don't go to the binders" (5).

Figure 11

Corriveau's Binders to Google Drive

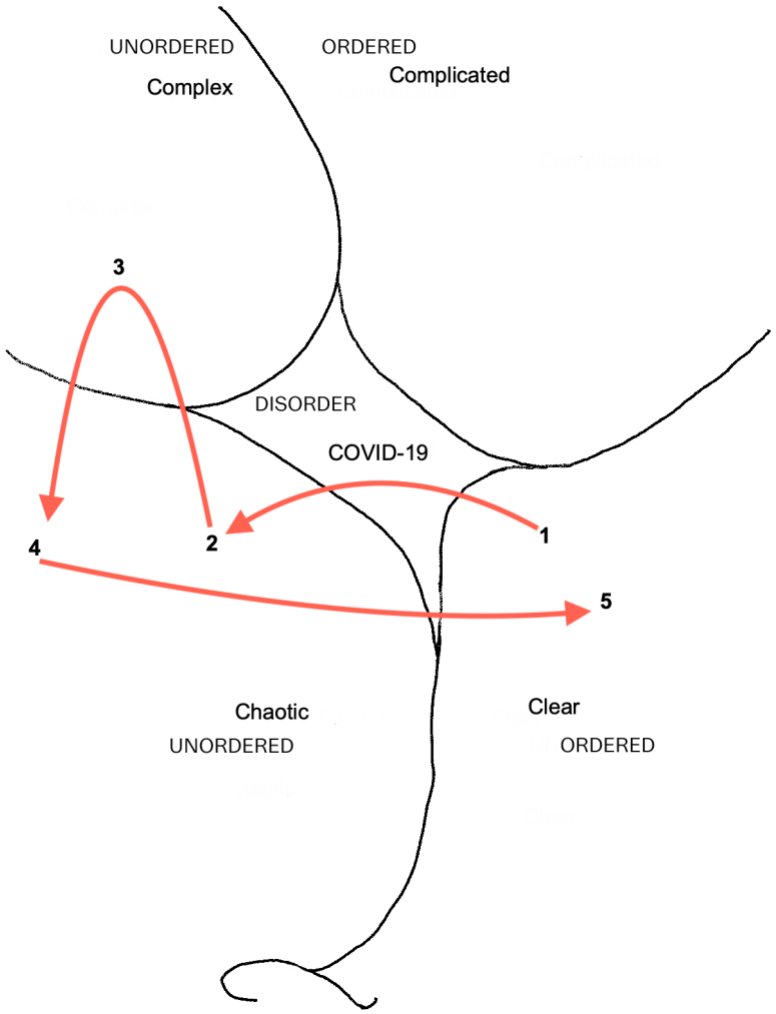


Figure 11 shows the progression of Corriveau's Binders to Google Drive. Corriveau said pre-COVID-19, "I teach three different maths so I have three binders on my desk" (1). During COVID-19, they said, "It's Google Drive 7, 8, and 9 (2). That's my filing cabinet". Google Drive has become, "A place to add supplementary material that I used while teaching during COVID (3) and I still use it now. For Corriveau, those videos are all saved and you can reuse them, so

same with the notes on the iPad" (4). Google Drive holds not just the question sets and the exams, it houses the related links, videos, and supplemental resources (5) used in the program.

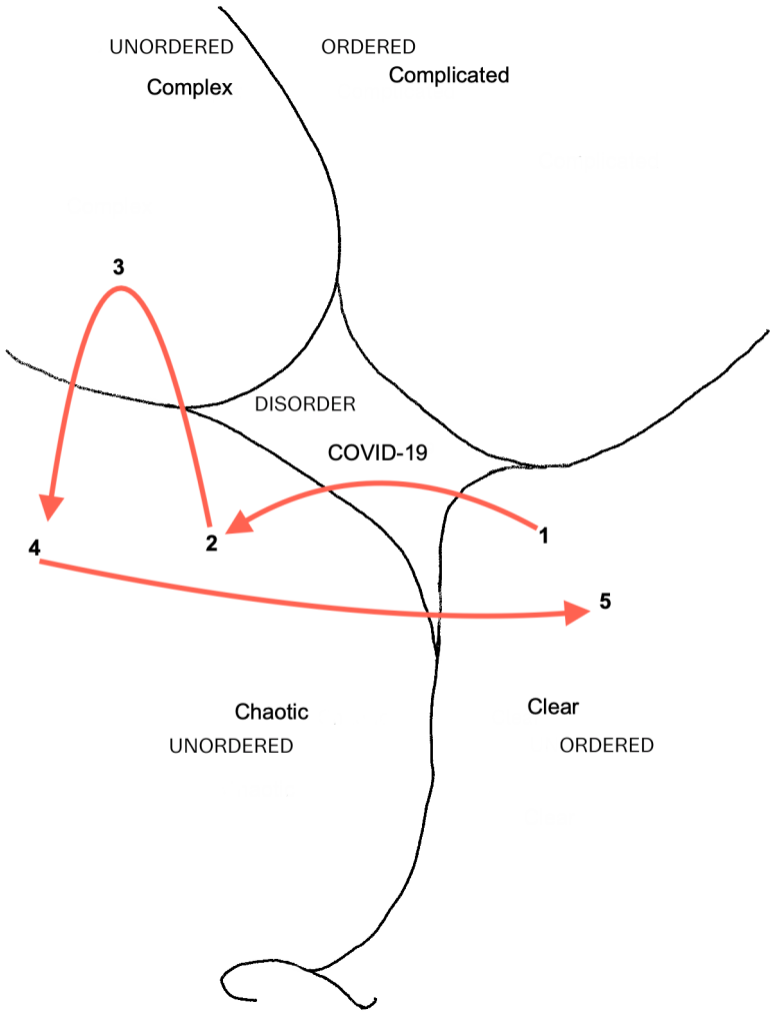
Prior to COVID-19, some teachers had their own Google Drive where they stored teaching materials. Several teachers stored their teaching materials in binders and file folders. These printed materials were less useful in their physical form during online teaching because the distribution of these materials was by necessity digital. By the end of COVID-19 online teaching, numerous teachers had converted much of their materials into virtual documents even if they use hard copies in their classrooms today.

Teaching and knowledge management

Resource organization

Figure 12

Casault's Change From Physical to Digital Resources



The interchange of physical and digital storage occurred rapidly. Figure 12 shows the progression of Casault's change from physical to digital resources. The topic of storage overlaps with organization, but the topics are sufficiently different to be discussed separately. Pre-COVID-19, Casault used Google to organize their resources (1). This meant that although the information was shared with the students, it was not shared on the Google platform. During

COVID-19, for Casault, classes had both asynchronous and synchronous components. The students had access to the lesson plan slides and instructions on Google Slides before class (2). These functioned as a textbook in which the student could read ahead. The slides also included supplemental videos and performance tasks for assignments that were found on the internet (3). As part of the students' daily work, when they had questions, the questions could be answered during the synchronous time (4). Post-COVID-19, Casault has "everything organized in Google Suite (5). Google Classroom has links to my Google website. Google Sites enables you to put hyperlinks in and list assignments. I have links to online textbook versions. I would be working about five days ahead so students could look at it ahead of time if they wanted to. I would hyperlink the documents and they would be read only because the student knows that when it is assigned that it will be through Google Classroom and they get their own copy. It's kept me organized, and the kids organized."

In pre-COVID-19 times, many teachers did not use Google Classroom to its full extent. When emergency online teaching was announced, teachers scrambled to have a system ready to provide lessons reliably to students. During COVID-19, Google Classroom was a common platform for teachers to use. For most teachers, this meant scanning paper copies of course material to make them digitally accessible and to find videos or create videos to go with the curriculum to be delivered. As they were able, teachers made Google Slides on how to complete discrete tasks and included these as part of their lessons. During post-COVID-19, teachers have found that Google Classroom can be repurposed for organization to work like a specific filing cabinet. Each topic in the curriculum is in a separate folder and not only does that folder contain what would have originally been paper but also all the video demonstrations, all the laboratory information and all the exams, projects, worksheets and a multitude of other information for the

topic. Google Classroom has changed from a vehicle to present information, to an ideal organizational tool for teachers. This is a repurposing of the intent of Google Classroom and, therefore, is an exaptive process.

During pre-COVID-19 times, assignment deadlines might be written on the board or given to the class orally. Students might choose to remember the deadline, they might record the date in a daytimer, or they might look at the whiteboard for an assignment reminder every class. During COVID-19, every assignment was submitted through Google Classroom. Some schools limited teachers to assignments only once per week in each subject area. This decreased the number of assignments to track and the variety of ways they could be handed in—only on Google Classroom. This would be considered by Kalyuga (2007) as a decrease in extraneous cognitive load for the student. Post-COVID-19, numerous teachers continue to make assignments available through Google Classroom, and in this case Google Classroom has been repurposed to be an online daytimer.

Figure 13

Helle's Process of Digitizing Exemplars

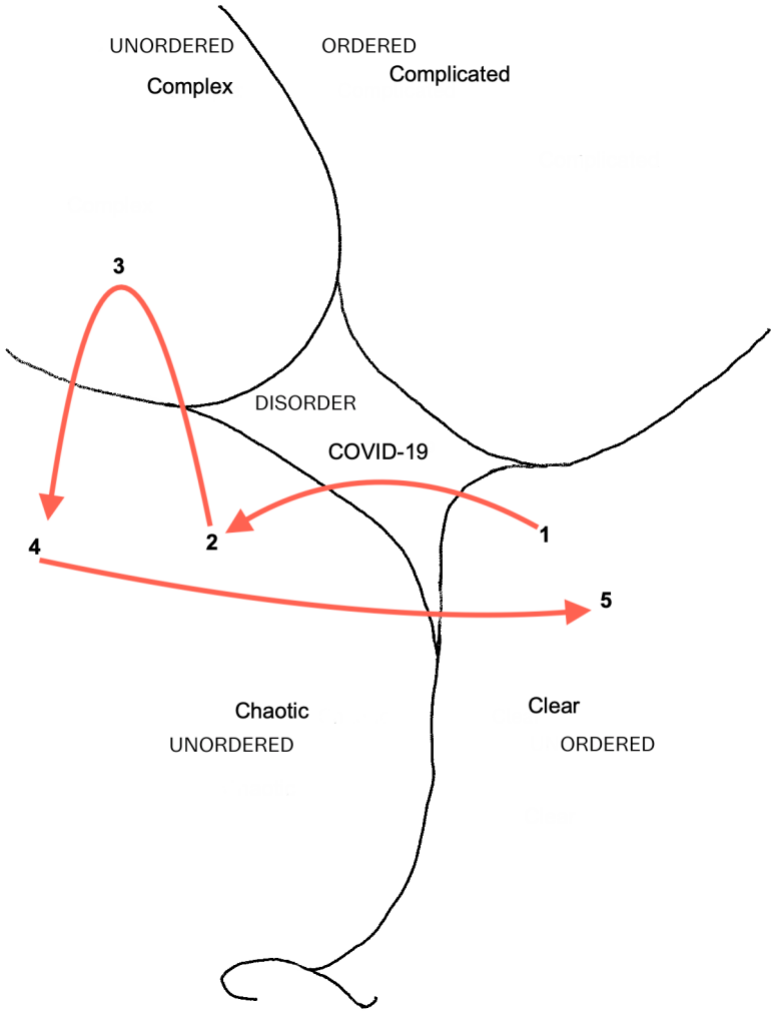


Figure 13 traces Helle's paper to digital progress through the Cynefin Framework. Pre-COVID-19, much of the organization of teaching material was the organization of physical items. Helle said, "There was one binder for the class and it was passed around" (1). During COVID-19, these physical items were transformed into digital ones (2), "I had to have a Google Slide presentation (3) to accompany my lessons. I had to digitize everything that I had and then upload it to Google Classroom, which is amazing because I can rely on that from year to year" (4). Post-COVID-19, "The kids bring their Chromebooks everyday so they all have access to all

the procedures right at their fingertips in their Google Classroom"(5). Pre-digitization of the materials there was a limitation as to what could be housed by the teacher as an exemplar due to space constraints, with digitization some of these constraints were erased.

The teacher can set each student up in a private digital gallery space to which the students or parents can invite other people to view the child's art. This provides an opportunity for friends and family who are not in the immediate geographic area to participate in the student's education. In Post-COVID-19 times, the teacher retains the student assignment submissions to the website. The exaptive innovation that the teacher has made is that the teacher uses the website as a gallery to house former students' work (5), each of which can be used as an exemplar for new assignments.

In pre-COVID-19 times, most of the organization of teaching material was the organization of physical items and many teachers did not use Google Classroom. During COVID-19, materials are sorted into classes, units and lessons and many become digital and were housed on a platform such as Google Classroom. Post COVID-19, the organizational structure of platforms such as Google Classroom is in place and teachers can find the material when they need it.

Assessment

Figure 14

Casault's Adoption of Performance Tasks for Exams

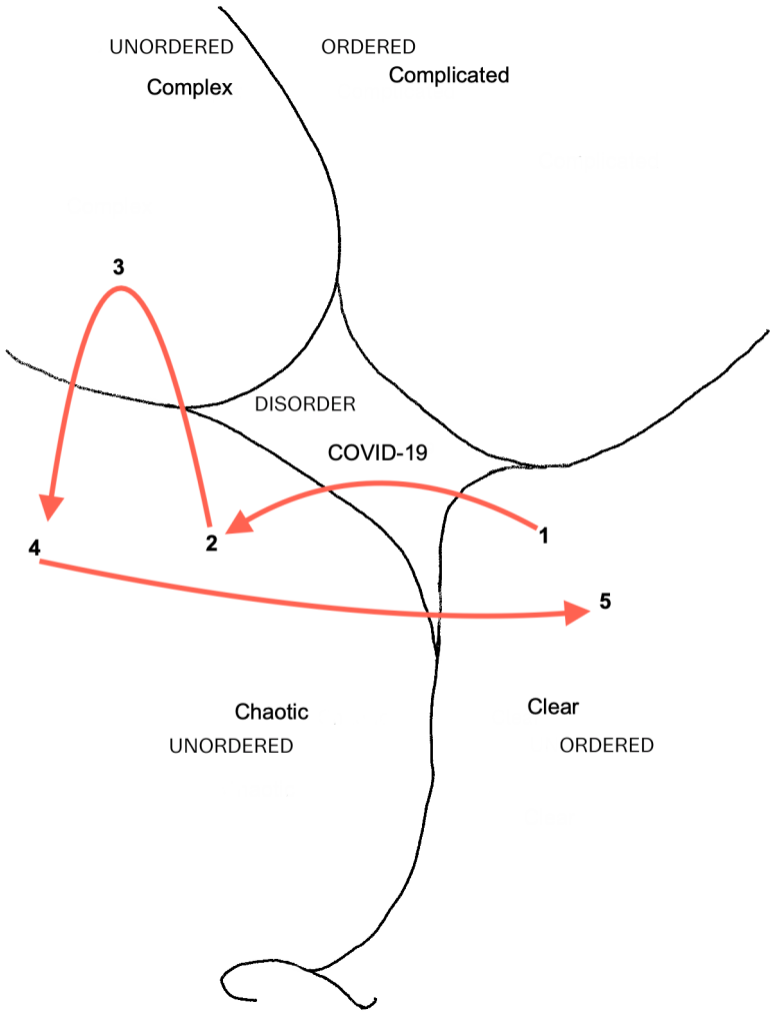


Figure 14 shows Casault's change in assessment tracked through the Cynefin Framework. Teachers have preferences for grading and assessment. Pre-COVID-19 teachers might have accepted assignments online or in-person. Assessments might be written or oral (1). Figure 13 identifies one path to an additional type of assessment. During COVID-19, teachers who had assessed student work only by having the student write on paper had to find a new method (2).

During COVID-19, Casault gave little value to tests “because of the necessary policing. We don’t have the technology out there for monitoring students while they’re taking quizzes”.

Mathematics is typically assessed by giving written quizzes and exams. During emergency online teaching, it became difficult to deliver assessments that were equitable to all students. Every student had different access to the Internet and different home conditions. This situation resulted in the teacher switching from traditional mathematics assessment methods to use performance-based assessments (3). An Internet search engine was used to find performance task assessments in mathematics and then that teacher determined those tasks that could be repurposed to be delivered, solved, and reported virtually (4). A performance assessment in mathematics is often a real-life problem where the student must use the mathematics that have been taught recently. It can show that the student understands how to apply the mathematical concepts and is an example of an exaptive process. In doing this, the teacher moved from the Chaotic Domain to the Complex Domain and back to the Chaotic Domain. The teacher retained performance-based assessments in their in-person teaching and used the performance-based assessment to replace some quizzes in the classroom (5). Post-COVID-19 performance tasks have replaced some quizzes. Performance tasks have moved to the Clear Domain or the domain of best practice.

Figure 15

A Future Look at Bettenson's Assessment

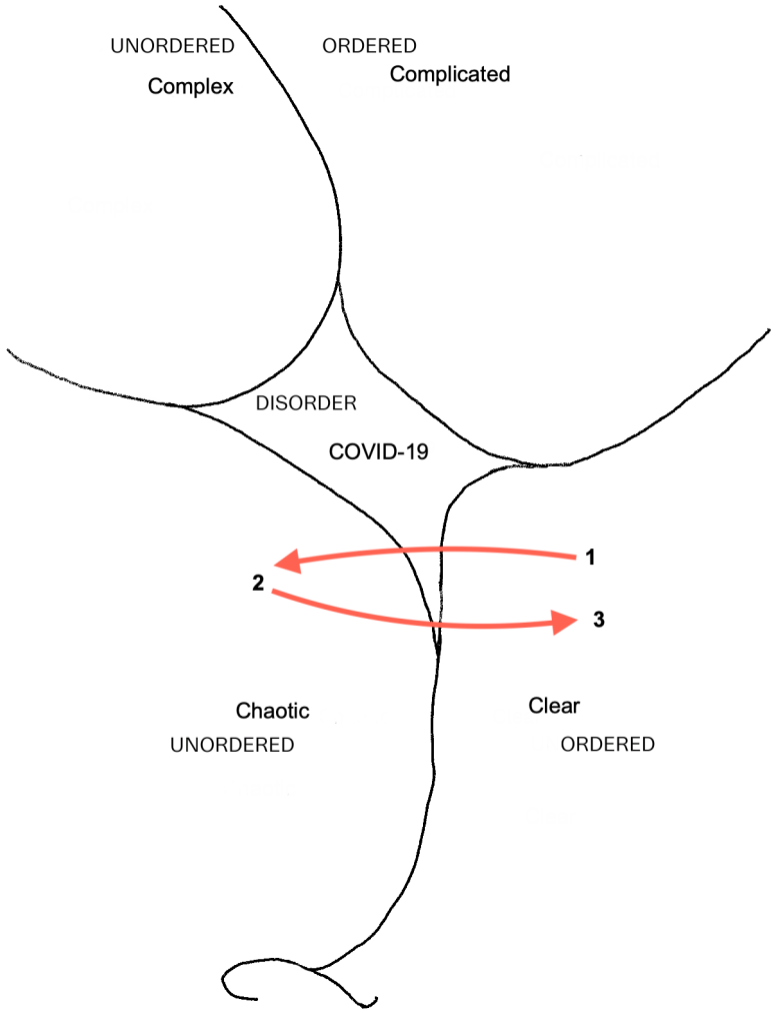


Figure 15 shows a not yet executed potential change in Bettenson's assessment. Prior to COVID-19 exams were given in person and were multiple choice or short answer. Bettenson gave "Grade 12 Social Studies a test. Just let me know when you want it and I will roll it out to you and release it. You have so much time to finish it". The test was the same, just delivered in a different format (2). Post-COVID-19, exams are very similar to Pre-COVID-19 times.

Bettenson, during COVID-19, found that "when diplomas were optional, 75% of the students wrote. They felt they had lost a lot and that their grad might not be normal. It was a rite

of passage". Looking forward, Bettenson would like to provide a recording of exams for students who need the exam read to them (3). The proposed change in assessment shows potential growth in the future.

Figure 16

Uses of Flipgrid

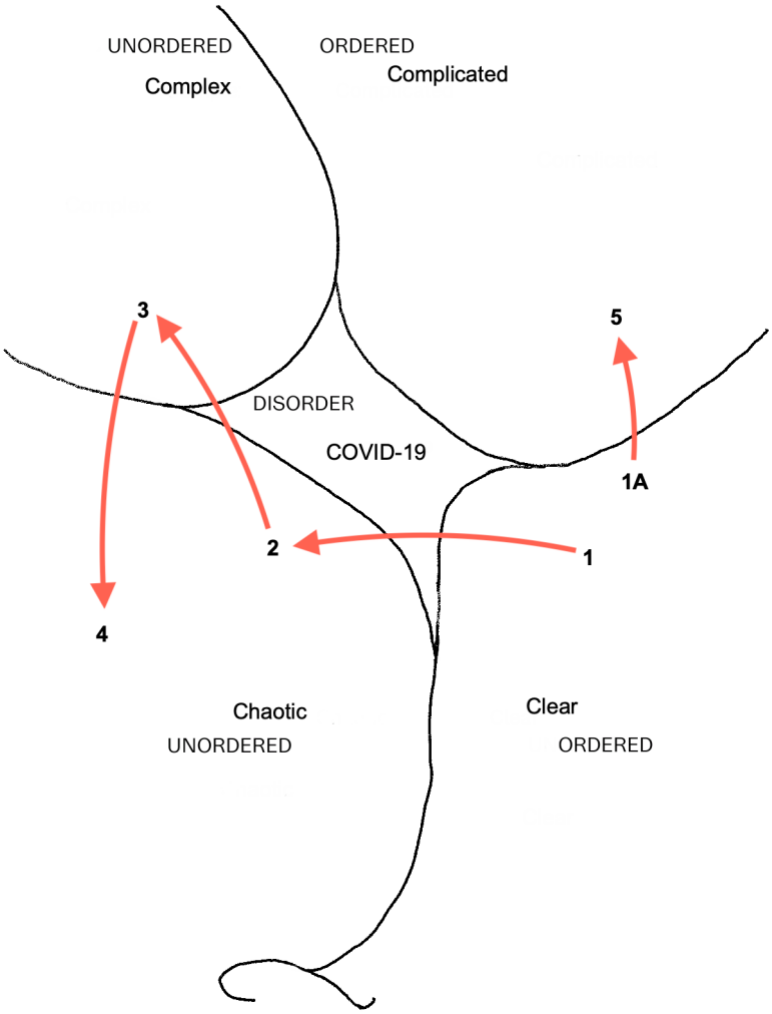


Figure 16 shows two teachers use of Flipgrid. Prior to COVID-19, Allan used traditional methods of assessment (1). During COVID-19 traditional methods of assessment such as direct observation of physical skills were difficult (2). Allan said, "It really did feel kind of creepy and an invasion of their privacy" when the teacher observed during a GoogleMeet. Allen found that,

during COVID-19, students were willing to make videos for assessment using FlipGrid (3). Post-COVID-19, “I (Allen) would say something about FlipGrid, they (the students) would say ‘We’re so done with FlipGrid’” (4).

Post-COVID-19, Corriveau uses video for formative assessment this way:

"I give them a question and they have to respond with their work so they’ll talk to the camera (1A). A lot of them are more tech savvy than me. They’ll either have their phone and they’ll be videoing from it as they are writing or others will just have their paper and hold it up after and show me, but they walk me through step by step. It is just a completion mark" (6).

Pre-COVID-19, in-person evaluations were sometimes conducted via a small video produced and then posted via Flipgrid. This was in the Clear Domain. During COVID-19, numerous samples of course work were recorded and posted via Flipgrid. This was in the Chaotic Domain. The students had two significantly different responses to using Flipgrid for evaluation after a return to in-person teaching.

Post-COVID-19 (1), in the Clear Domain, a teacher requested videos be posted via Flipgrid to show an understanding of a concept. Although the students had produced videos before for similar summative assessments, the students’ responses were “We’re so done with that”. The teacher honored the request from the students and accepted the assignment in a different format. Flipgrid was not retained as a summative assessment tool.

Post-COVID-19 (1A), a teacher requested a short one-minute video that demonstrates an understanding of a mathematics concept to be recorded and posted via Flipgrid. This work is for completion only with no grade assigned. The students complied and the use of Flipgrid was retained. This is in the Clear Domain.

Although the two Post-COVID-19 responses appear to be different responses to similar situations, the assignments and situations are in fact very different. Response 1 is an assessment of learning and Response 1A is an assessment for learning. Stefanescu (2001) identified the first step in any evaluation, as identifying the intention of the evaluation, which involves specifying the purpose and the modality, or form, of that evaluation. The purposes are different in these two cases. During COVID-19, numerous tasks and assignments were graded as complete or incomplete, such as a video of yourself performing a task or a picture of the cake you had baked to show the final product. This is still the process in some online schools. Students videoing themselves participating in or completing a task was a fairly equitable method of evaluation during COVID-19.

In post COVID-19 times, producing a video to demonstrate learning is a two-part process 1) making the video with all relevant information and 2) making that video in the constraints of time and space of the form in addition to writing the paragraphs or delivering an oral presentation on the topic. Students consider the preparation for the video and realize that the paragraphs they would have to memorize for the short video could be submitted as paragraphs. It is significant that the students called a halt to the use of technology and that the teacher was wise enough to acknowledge their choice.

With the mathematics homework, the students were asked to video themselves completing one question they were doing for homework and to talk through the steps. If all the students can complete this task, the teacher can feel confident that the students understand the instructions to that date. The students understand that this information could also be gained by the teacher walking to each student's desk and asking the student to complete a problem.

Exams were written on paper during pre-COVID-19, and therefore marking was often done by hand. An exception to this was the use of a Scantron sheet, which could be marked by a reader or by hand. When exams moved to online responses, the marking became digital. Google Forms and ZipGrade became commonplace for multiple-choice exams. SmarterMarks is also a common choice by teachers.

Dow used Google forms for exams. They prepared "five to six versions. Sometimes just shuffled the questions, sometimes change the variables".

In Pre-COVID-19 times, many teachers gave written quizzes or exams in mathematics (1). During COVID-19, some teachers gave virtual quizzes and exams instead of paper copies (2). This meant that sometimes the teacher produced multiple variations of the exam (3). When the exams were delivered in Google Forms (4), the multiple-choice portions of the exams were marked immediately upon submission back to the teacher. In Post-COVID-19 times, teachers might use multiple iterations of the same quiz or exam. This is simplified by programs such as SmarterMarks (5), which will randomize multiple choice answers and make substitutions in multiple choice answers, so there are a variety of questions testing the same topic. Many teachers have retained the randomization of questions or of answers within a question.

Lesson Delivery

To recognize the message of technology associated with delivering school classes online, we must recognize the change of scale of technology use and the change in pattern that was introduced into the lives of teachers and students. Casault used little technology in pre-COVID-19 times. Their technology use was limited to VHS, DVD and some virtual reality. During COVID-19 using "Google Meet for Physed felt creepy and an invasion of their privacy". Casault later used Flipgrid where "the students would take these cool, funny short videos where they'd

be meeting up with friends.”. This technology is Flipgrid. Post-COVID-19, Casault suggests students use “Google Read and Write- This is how you can use it to edit some of your work. Listen to it. Put it in a different accent. Hear what you’re saying.” Casault often goes "online to watch the news".

During COVID-19, materials were sorted into classes, units and lessons and many became digital. Corriveau found during COVID-19 that some parts of the curriculum were time consuming to prepare to present online. Corriveau “now look(s) forward to teaching those units because I know I have some many resources at my fingertips”.

Pre-COVID-19 teachers had students take notes on the instruction they were receiving (1). This is in the Clear Domain or the domain of best practice. During COVID-19 online teaching, teachers posted videos in Google Classroom of themselves or of someone else teaching the topic (2). This was in the Chaotic Domain. The teacher repurposes the video, which is usually used to capture a special moment in time, to provide instruction. This takes the use of the video to Complex Domain (3), repurposing it, or using the exaptive process, and then using it back in the Chaotic Domain for delivery of instruction (4). During post-COVID-19, the teacher posts a picture every day of the work shown on the board to accompany the slides regarding the lesson. This action is in the Clear Domain (5).

In post-COVID-19 teaching times, the uploaded pictures of a classroom’s whiteboard replaced the video posted in COVID-19 times as the instructional material provided in Google Classroom. These were instructions for the student to review. The teacher repurposed their whiteboard demonstrations to replace the external videos provided in Emergency online teaching times. Uploading the photo in Google Classroom helped to provide equal instruction to all students, as students who were absent would have access to the same material as those who were

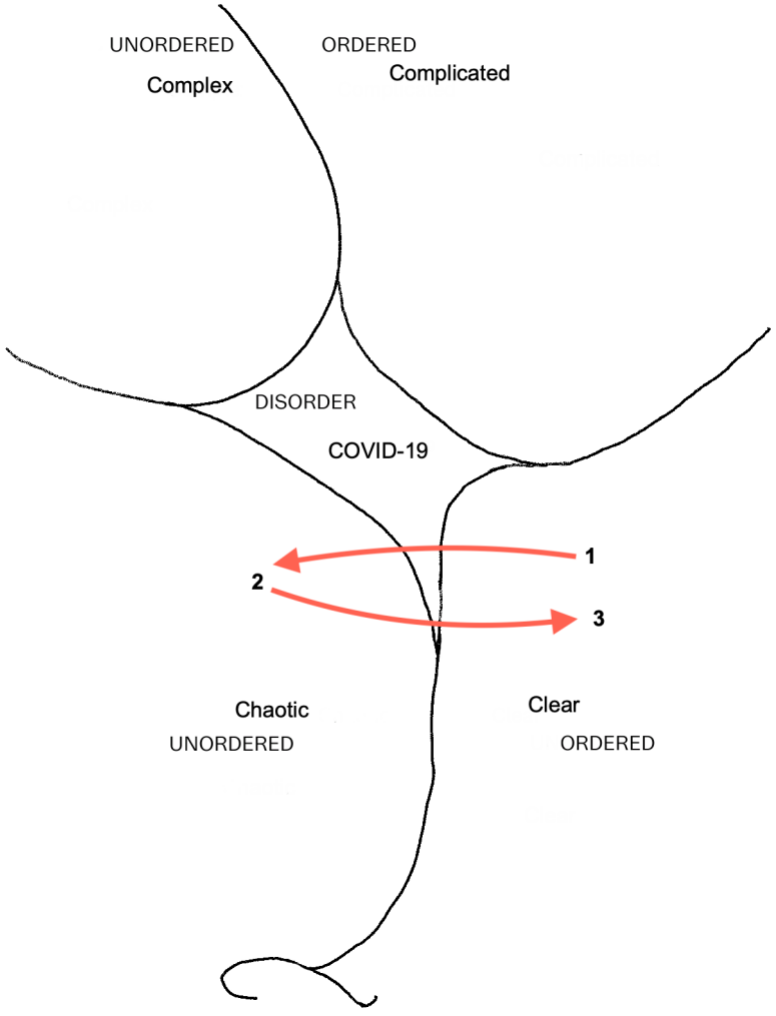
present. The pictures reflected the transparency of the instruction in the classroom without the teacher needing to produce or find a video for every activity. A photo is often a representation of people or places or important events. Here, a quick photo is a literal snapshot in time that records the lesson of the day. It has replaced the need for the teacher to either find or record a video for every instruction period.

Teachers as innovators

Gamification

Figure 17

Uses of Gamification



The classroom is often the group of people the student is most engaged with. During COVID-19, this became more apparent. Gamification may be introduced to promote student engagement, introduce a sense of play, engage with the curriculum, or complement and extend the curriculum. Prior to COVID-19, Corriveau used iPads and QR code scanners around the school for technologically gamified scavenger hunts with curricular outcomes (1). While Pre-COVID-19, Hunt used Kahoot! Post-COVID-19, Hunt continues to use gamification by including Gimkit for the gamification of studying. “They (the students) love it because they actually sit there and need to know the right answers to be able to snap everybody out of existence. … I always ask at the end of a class that we’ve given them -Is there one term that you know now that you didn’t know before we started to play”?.

Dow said that “there’re lots of online games that I used during COVID-19. Anything with games online- they love it and they’re willing to play those games. I would say they seem to really enjoy that part of it and anything you can make into a game or somehow gamify it, they seem to be attracted, which I get it because like they’re all really into ... video games. They connect through video games (2) and COVID definitely made them connect that way as well”.

In the during and post COVID-19 times, the online group game has created a community of learners. Even though the students have avatars for anonymity, the community aspect is apparent when the teacher refers to the student wanting to “freeze” someone or “snap everybody out of existence”. A community of learners is usually found in the classroom, however, these learners also have a digital group persona and also exist in an online environment (3). These students are active participants in this online community of learners. Nadeem and Blumenstein (2021) argue that student presence needs to include participatory engagement and not just

attendance. Play and group work are two ways to build this community. This activity has been retained to help keep the students engaged in the learning community.

Community of practice

At the beginning of emergency online teaching, teachers scrambled for ideas to improve their teaching and to support the students. Participation was high in various Communities of Practice, but the organization of these communities was low. Pre-COVID-19, Casault attended Professional Development offered by the division. During COVID-19 Casault used a combination of guidance provided by the division and personal experience form taking online classes. They also began using YouTube for ideas and methods. Post-COVID-19, Casault continued using YouTube.

Helle identified that learning to use technology during COVID-19 happened through internet searching. Post-COVID-19, the teachers in Helle's subject area in the division, met as a faculty and started a shared Google Drive specific to their subject. Post COVID-19, the organizational structure is in place and teachers can easily access the material when they need it.

Ulla and Perales (2021) referred to a Community of Practice as a group of people who share an interest, learning, knowledge and practice. Teachers often seek help for any situation from within their workplace. This is usually the school at which they teach, and the teachers with whom they teach. These are the people who are often familiar with the resources there are to work with. However, during COVID-19, the community of practice became larger when teachers across the world were seeking help for similar problems.

Access and establishment of Communities of Practice varies between teachers and division. Pre-COVID-19 Hunt followed groups on Facebook or Instagram to learn about technology. While during COVID-19, Hunt communicated with their teaching staff. Pre-

COVID-19 Bettenson went to their teaching staff first; whereas during COVID-19, this changed to Googling and YouTube searches.

In-person teachers, who access a Community of Practice, are considered to be centered in the Clear Domain, which is an ordered ontology and is what existed prior to the COVID-19 pandemic being declared. The declaration of the pandemic moved the time frame into Disorder which changed again when the school boards declared emergency online learning. This took the situation to the Chaotic Domain, where the procedure is Act-Sense-Respond. Where Act is to deliver the lesson; Sense is to seek for a better way; and, Respond is to seek out information from the Community of Practice.

In the Clear Domain, the domain of best practice, delivering a lesson is done by observing the pattern of sense, categorize and respond. However, in the Chaotic Domain, delivering a lesson is completed by act, sense, and respond. During the time between lessons, the response is to seek information from the Community of Practice. When the usual community of practice cannot be reached, the request for help must be made to a larger community. This becomes a different group of teachers on social media. It is an exaptive process because social media such as Facebook and Twitter are considered to be social media but in fact they were used as a Community of Practice.

Other parts of the Internet also became part of the community of practice. Prior to COVID-19, teachers would seek help from fellow staff members. Numerous schools had a teacher assigned to do part time technology help, or a technology person was shared between a few schools to provide help. These people seem to be universally approachable and well liked. While this is likely not true in all Alberta schools, it was definitely true of the feelings of the teachers the researcher interviewed. This is an example of a school operating in the Clear

Domain with best practices. When teachers needed immediate help with technology during the COVID-19 pandemic, the technology-help people had often been seconded to central office. This removed the technology support people from the teachers' direct access. This occurred at the same time that teachers were moving their instruction online. Teachers were in the Chaotic Domain during the online teaching where the process is to act, sense, and respond.

To improve their practice, teachers turned to YouTube, which is an online video and social media platform. There are several teachers or ex-teachers who record education related videos or technology use videos and upload them to YouTube. These videos can be watched at any hour of the day or night and have the additional benefit that a teacher can view them privately, masking the need to admit that you did not know how to do something. Although the original use of YouTube was a social media platform, teachers are now using it to extend their community of practice to various specialists in the field they are searching. They have repurposed YouTube from a site to watch videos, or its original purpose as a dating site, to a site that substitutes for their staff members as a Community of Practice. This is an exaptive process of repurposing an activity that has been retained in the Post COVID-19 era.

Pre-COVID-19, teachers in specialty subjects such as fine arts or industrial education would meet other subject area specialists at Conventions or Professional Development days. During COVID-19, these specialty meetings became virtual and the sharing of project ideas also became virtual. A shared Google Drive became the resource library with examples of projects and sets of instructions for their completion. In Post-COVID-19 times, the shared Google Drive is retained as a valuable resource. This is the repurposing of Google Drive to be a large, virtual Community of Practice.

During COVID-19, when almost everyone was online, and no one was in the physical school building, new methods of connection became important. These often occurred via Google Meet or Zoom, but more important than the virtual meeting was the passing of knowledge between teachers about how to teach some concepts in a virtual space. Teachers shared these ideas and eventually they coalesced into communal Google Drives. The broader school or division wide subject specific Google Drive was born. The Google Drive functions as a resource library, which is complete with projects and instruction sets.

Teachers as learners

During emergency online teaching, administration often formally paired members of staff to work together. Teachers team taught to there was someone else to talk to and engage with to keep the lesson interesting.

> Bettenson noted that: "technology took a lot away from the process of teaching and what I mean is it's that human contact, it's how to connect. It's how to connect. It's to have the kids present, because just because they say they're in your class, we learned that because the bandwidth is easier if they turn off their video, and that's great, except then you don't know that they are even there".

Hunt mentioned that during COVID-19, being in front of the camera meant you were on screen all the time unless you muted the camera, which leads the students to think you are not there. The solution that was devised was to create an additional breakout room with only the teacher in it. The teachers could still monitor the requests for help and it would appear that the teacher was helping other students while, in fact, they were in their individual breakout room.

Hunt often records a video of the lesson if they are going to be away. This helps the supply teacher. Hunt keeps the video for future use if the student needs to review the lesson.

Bettenson recalled an incident post COVID-19, when the schools were in but people were isolating if ill or exposed. Teachers would be out of the classroom with a substitute in the room to cover those classrooms which were not isolating. That pushed the comfort level of technology use. The teacher could post all the material in Google Classroom, have a Google Meet with the substitute teacher and could be potentially present via computer for any problems that arose in the non-isolating classrooms.

Pre-COVID-19, teachers taught using a variety of methods, most of which were very effective and acceptable. This occurred in the Clear Domain, or the domain of best practice. During the COVID-19 pandemic, the teaching and learning situation plunged into confusion or the ontology of disorder. The school boards declared that school would continue with online learning and this imposed restriction results in (unorder) and the Chaotic Domain. During this time, some teachers delivered their lessons as a flipped classroom. This is in the Chaotic Domain. Post COVID-19, some teachers retained a very specific length of time to teach. Although this was not a flipped classroom, the teacher was very cognizant of the student's time in the classroom. This became best practice in the Clear Domain.

During COVID-19 online emergency teaching, a teacher changed their pedagogy so that their students would have access to teaching, support videos, and assignments before they came to class. The students could either watch the videos during the synchronous time and then complete the assignments, or they could come to class after watching the videos and use the synchronous time to ask questions or receive clarification on the work assigned. After COVID-19, when this teacher returned to the in-person class, they felt they should limit the instructional time so that the students had time to attempt the assigned work associated with the lesson. This resulted in the teacher setting their watch timer for fifteen minutes while they delivered

instruction. After fifteen minutes, the teacher would either take pictures of the whiteboard work used as an explanation of the topic, or, if required, ask the students' permission for time to complete the explanation and then take pictures to post in Google Classroom. The teacher intentionally retained the longer period of time for the students to work in class.

Looking at this through the Cynefin Framework in pre-COVID-19 times, the teacher was guided by the bell to begin and end the lesson. During COVID-19 emergency online teaching, the teacher structured their class so students could work on questions or complete the videos that housed the information teaching the lesson of the day or ask questions about the lesson they had worked through. In post-COVID-19 times, the teacher repurposed the watch timer to be the classroom bell; it signaled the end of formal instruction. This shorter time of instruction would allow the student to have a predetermined amount of time to work on the questions following the instruction and the opportunity to interact with the teacher for questions the student still had about the topic. The predictability of the timing of the class meant the student had time to ask questions after the teacher provided instructions.

Supply Teaching

In pre-COVID-19 times, supply teachers were often left with written notes to use as supply teacher plans. During COVID-19, most teachers delivered their lessons through a platform such as Google Classroom and many of those teachers would have a video to either provide the instruction for the lesson or a video to support the instruction for the lesson. In post-COVID-19 times, the delivery of lessons has mostly returned to in-person instruction but the video, PowerPoint, or screencast set of slides remains as a supplemental support often left for the supply teachers. With this additional support in the classroom, it is easier for the teacher to feel confident that the students will receive great uninterrupted instruction.

Additional Thoughts

Teachers reported being able to deliver special events in an online situation and still be able to keep the spirit of the event. This skill was not taken back to the classroom for general use but is retained for those occasions when a student might not be able to attend a time, such as graduation or a scholarship presentation.

McLuhan et al. (1977) from *City as Classroom,* "Remember figure and ground are not categories: they are tools that will help you to discover the structure and properties of situations."

One teacher described themselves as not using a ton of technology but that they were no longer afraid to try different technologies. The use of technology in their career has spanned from paper to Google Classroom. COVID-19 had forced the use of technology. The teacher felt that as a result of this required use of technology that they had changed. Looking at McLuhan's treatment of figure and ground, it becomes easy to see what has happened to this teacher and perhaps all teachers of this time.

A simple explanation of figure and ground is to imagine a piece of plywood lying flat on a section of green lawn. When the plywood is removed after a month's time, there is still an almost plywood colored image on the green lawn. Although the wood is gone, the impression it left on the green lawn remains. When a teacher has used more technology than is generally accepted to be required in a classroom and, during such unusual times as the COVID-19 pandemic, the use of technology leaves a mark on them, like the plywood left on the lawn. The teachers are forever changed. The figure of the technology can be removed from teaching, but the teacher remembers how it felt.

Pre-COVID-19 most of the technology support came from within the school. During COVID-19, technology support was moved to central office. Post COVID-19, technology

support is often in central office. Many staff members turn to other staff or students for support with technology. Technology use is being driven by the times, not necessarily by its effectiveness.

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Appendices

Appendix A

Recruiting Email

Subject line: Participants Wanted: How has COVID-19 changed your technology use?
Dear Graduate Students, Teaching Assistants and Research Assistants:

- Were you teaching in person (in Alberta in a K–12 school) prior to the COVID-19 pandemic being declared in March of 2020?
- Did you participate in online teaching as a result of the COVID-19 pandemic?
- Are you/have you returned to the in-person classroom?

If you have answered YES to these three questions you are invited to participate in a study entitled "Alberta teachers' innovations in classroom practice arising from use of technology in online learning as a result of COVID-19" (Pro00116666) being conducted by me, Darlene Bakker, a Masters student at the University of Alberta. This research is being completed as a part of requirements of my M.Ed. in Secondary Education through the Faculty of Education.

Participation is being limited to Alberta teachers who were involved in all three teaching situations so that developments in their pedagogy can be examined. Participation will entail one virtual interview on Zoom of about a one-half hour, the audio of which will be recorded. This interview will provide you with a great opportunity to reflect on your change in practice over this time. If you or someone you know meet these three criteria please contact me at:

dbakker@ualberta.ca

Thanks for your consideration. Darlene Bakker

Appendix B

Snowball Participant Information Email

Dear Mx. _____:

This email is being forwarded to you because you have been identified as a teacher who has taught pre-COVID-19, online during COVID-19 and then again in the in-person classroom. I am a graduate student in the Faculty of Education at the University of Alberta and my research area is technology. I am writing to solicit your participation in a research project investigating how your use of technology has changed in your in-person classroom as a result of teaching online during the pandemic. The purpose of the research is to document these innovative changes and share the changes with other in-service or pre-service teachers.

Your time commitment will be a thirty (30) minute semi-structured interview that will be completed online via Zoom. The interview will take place at your convenience and will be recorded.

Your participation in this research is entirely voluntary. You may opt out of the study at any time until we end the interview. In the event that you withdraw consent for participation before the end of the interview, the data collected to that point will be discarded and not included in the data set. After that point, I will integrate all data collected and will not be able to remove data specific to you from the aggregated data.

The data from this research may be used in future research publications and/or presented at conferences. Research reports might include direct quotations made by you, but a pseudonym will be used instead of your name. Other identifying information (e.g. school, class, and/or students) will also be omitted when results are made public. I will assign and use pseudonyms in my analysis of the data. All data for this study will be kept for a minimum of five years following the completion of the research project. Data will be kept in an encrypted file on my

password-protected computer. A master list matching names to specific files will be stored in this file. This master list will be destroyed once the data have been coded and analyzed. These measures will help ensure your privacy and maintain confidentiality.

Your consent to participate in this study would be greatly appreciated. If you are willing to participate, please sign the attached consent form and contact me at dbakker@ualberta.ca.

The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at reoffice@ualberta.ca. This office is independent of the researchers. The title for this study is "Alberta teachers' innovations in classroom practice arising from use of technology in online learning as a result of COVID-19" (Pro00116666).

Thank you for considering this request. If you have any further questions regarding this study, please do not hesitate to contact me or my supervisor at the emails below.

Ms. Darlene Bakker	Dr. Catherine Adams
dbakker@ualberta.ca	caadams@ualberta.ca
University of Alberta	University of Alberta
Edmonton, Alberta T6G 2G5	Edmonton, Alberta T6G 2G5

Appendix C

Teacher Consent Form

Alberta teachers' innovations in classroom practice arising from use of technology in online learning as a result of COVID-19

Participant Consent Form (Pro00116666)

Date: _____

Please read the brief outline of the research project below before completing the Consent to Participate section.

Current Research Project

This research project is to be completed as part of the requirements for a Master of Education (MEd) degree and the raw data collected will be accessed only by the Principal Investigator and her supervisor.

The aim of this research project is to investigate the change in technology use in a K–12 classroom as a result of teaching online during COVID-19. As such, the research questions are as follows:

Question: What new digital online technology practices did teachers learn during the COVID-19 pandemic and plan to or have taken back to their in-person classrooms?

Sub-question: How has a teacher's perception of their use of digital technology for teaching changed from pre-pandemic instruction to emergency online teaching.

This research will have implications for discussions regarding teachers' use, and perceptions of use, of technology in the classroom.

Consent to Participate

I consent to allow the following data to be used for future presentations and publications:

I have read and understand the details in the **Participant Information Letter** and consent to participate in this research project:

_____ _____

Signature of Participant Name of Participant

Please keep a copy of the information letter for your records. A copy of your signed consent form will also be provided to you.

If you have any questions or would like more information about this research project, please contact Darlene Bakker at dbakker@ualberta.ca.

If you have any questions or concerns about your rights as a participant, or how this study is being conducted, you may contact the Research Ethics Office at reoffice@ualberta.ca. This office has no affiliation with the study investigators.

Appendix D

Interview Script

Section I Pre-Pandemic Teaching Practices

This first section is to establish how you used digital technology in your teaching practice before the onset of the COVID-19 pandemic. Is it alright to continue the interview?

1. As a teacher in your Pre-Pandemic classroom, what digital technology did you use as a teacher prior to COVID-19. This might include digital technology such as the internet, a personal website, Google classroom or other learning management system, Zip grade for marking, Voice Thread, Interactive White Boards, document camera, Chromebooks, Tablets, phones, FlipGrid, ClassDojo, Seesaw or other e-portfolio, Notability, Google read and write, Lexia for ELL students, Minecraft, Google Street View or other.

2. Please give one descriptive example of how you used technology in the classroom that you believe was helpful for your students, was especially innovative, or in some way filled an important need in your classroom—prior to COVID-19?

3. Who or what was your source of help for your technology ideas and implementation? For example, did you use the internet, or a technology support person, a friend, or did you find some other way?

4. Why did you choose that source of help, for example were they convenient, experts, patient or some other reason?

Section II Pandemic Teaching Practices

The next section is about Pandemic Teaching Practices (March 2020–June 2021): This section asks about your technology use as a teacher during the pandemic, from March of 2020 until June of 2021. Is it alright to continue the interview?

5. Thinking about your technology use from March of 2020 until June of 2021, please give an example of how technology use has changed in your classroom.

6. Please provide examples, if possible, of how the specific technology has benefited you or your students.

7. Who or what was your source of help for your technology ideas and implementation? Did you use the internet, a technology support person, a friend or some other method?

8. Why did you choose that source of help? For example, were they convenient, experts, patient, or was there some other reason?

9. Do you have a second example you would be willing to share?

Section III Current Teaching Practices

Current Teaching Practices: This last section is about your technology use any time after June, 2021 and includes ways that you anticipate using technology in your classroom or innovative changes to your classroom practice and technology use as a result of the COVID-19 pandemic. Is it alright to continue the interview?

10. Of the new technologies that you used during the pandemic, which are you particularly proud of learning and are planning to continue using? Please provide an example.

11. Please describe how you plan to use this new technology in your in-person classroom OR have already begun to use this technology in your classroom? What makes this technology particularly useful to you as a teacher?

12. Who or what was your source of help for your technology ideas and implementation? Did you use the internet, a technology support person, a friend or some other method?

13. Why did you choose that source of help, for example were they convenient, experts, patient, or some other reason?

14. Do you have a second example you would be willing to share?

15. Is there anything else you would like to tell me about technology, teaching, and COVID-19?

    Is it alright for me to use this interview as data?