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CURIOSITY-DRIVEN, INQUIRY-BASED SCIENCE PROJECTS BRIDGE FACE-TO-FACE AND ONLINE LEARNING FORMATS DURING COVID-19: A TEACHER'S COMMUNITY OF INQUIRY

Carol Rees
Thompson Rivers University

Hannah Allen
Thompson Rivers University

Morgan Whitehouse
School District No. 73 (B.C.)

Naowarat (Ann) Cheeptham
Thompson Rivers University

Michelle Harrison
Thompson Rivers University

Elizabeth DeVries
School District No. 73 (B.C.)

Grady Sjokvist
School District No. 73 (B.C.)

Christine MIller
Thompson Rivers University

ABSTRACT

This paper is a report on a year-long action research project with a Community of Inquiry where a group of teachers from across primary, secondary, and tertiary contexts were developing and implementing student-centered, curiosity-driven, inquiry-based science projects to bridge face-to-face and online learning contexts and support their students' engagement in learning during the COVID-19 pandemic. We followed the teachers through two research cycles to investigate their driving question: "How can we best support our students' learning in blended learning environments through Curiosity-Driven, Inquiry-Based Science Education?" We report on their ideas, successes, and challenges as they created and implemented eighteen projects. In the first cycle of inquiry in fall 2020, the teachers met online to discuss plans, they implemented their plans with their classes, and they met online to reflect on their projects and share resources. In the second cycle of inquiry in spring 2021, the teachers met online again for further planning, implementation, and reflection. We recorded all online meetings, collected resources that teachers shared, and conducted thematic analysis. Findings indicated the primary focus for the teachers were: which education technology methods to use; the importance of supporting their students' voices to discuss their work at all stages of their projects; coming up with appropriate means of assessment of their students' projects; supporting their students in their developing research and problem-solving skills; and supporting their students to reflect on their learning. This study is significant because it demonstrates the creativity and innovation of a group of teachers in their efforts to support their students' engagement and learning through

Curiosity-Driven, Inquiry-Based Science Education during the Covid-19 pandemic. The teachers' projects have been shared on an Open Education Resource.

KEY WORDS: Blended learning; Community of Inquiry; COVID-19 pandemic; Curiosity-driven projects; Inquiry-based science pedagogy;

INTRODUCTION

The impact of the COVID-19 pandemic on education was devastating. In the spring of 2020 most nations (146 countries) had to close educational institutions, impacting over 60% of students worldwide, i.e., more than one billion students, (UNESCO, 2020). Efforts were made globally to maintain students' education online (e.g., Huang et al., 2020; Reich et al., 2020). However, media reports in Canada (as in other countries) indicated that teachers and parents of school-aged students had grave difficulties engaging students' interest in learning online (e.g., Wong, 2020). In the local school district of the authors of this article, we noted some teachers had successes in bridging face-to-face and online learning using Curiosity-Driven, Inquiry-Based science projects in a blended learning approach that combined online learning with hands-on activities.

Inquiry-based science education in the context of this study refers to the ways of observing, thinking, investigating, and validating that scientists use (AAAS, 1993). Students have opportunities to practice scientific inquiry experiences that ''…denote forms of engagement that have a …resemblance with what scientists … do in their daily work'' (Hsu et al., 2009, p. 481). Students initiate, plan, and conduct open-ended investigations in which the teacher has not planned the answer (Pizzini et al., 1991). Curiosity is used as a driver for inquiry-based science education (Lindholm, 2018). Curiosity is "characterized by the joy of discovery and the motivation to seek answers" (Shah et al., 2018, p. 380). Curiosity is associated with the kind of wonder that can ignite interest and awaken students' imagination (Egan et al., 2014). To draw attention to the importance of beginning with students' curiosity, we use the term Curiosity-Driven, Inquiry-Based Science Education (CDIBSE) to describe the pedagogical approach that teachers used in this study.

Teachers in our study (from elementary and secondary schools) had arrived at this pedagogical approach from a variety of backgrounds including Masters of Education, International Baccalaureate teaching, and professional development in inquiry-based science education, offered by the school district. At our university, there were faculty using similar approaches with their university students. We decided to bring teachers and faculty together to investigate and learn from their successes in an online Community of Inquiry (Garrison et al., 2010). Teachers and faculty could share ideas that were not only valuable for them at their grade level but could also inform, and be informed by the knowledge of those who teach at different levels of schooling. We applied for and received funding for a year-long research project and in this paper, we describe this study and its outcomes.

We chose an action research approach because we were supporting the teachers and faculty in creating knowledge about their own practice (McNiff & Whitehead, 2010). They were a group of practitioners "[studying their] own work to understand it better [and] to try to make systemic improvement to it" (Sullivan et al., 2016, p. 25). We worked together to design opportunities for cycles of inquiry where they could utilize a continuous approach of acting, reflecting, and acting again in new ways supported by each other and by the research team (McNiff & Whitehead, 2010). As researchers, our role was to facilitate for the teachers and faculty, work in the background organizing meetings, record and transcribe discussions, collect written reports to develop their ideas and resources and share these through an Open Education Resource (OER). Ultimately, through this work we wanted to support teachers of both school-aged and university students to conduct CDIBSE projects with their students in a blended learning environment that brought together hands-on activities (conducted at home or close to home) and online communication.

Specifically, this action research project aimed to support teachers and university science faculty to investigate the following driving question: "How can we best support our students' learning in blended learning environments through Curiosity-Driven, Inquiry-Based Science Education?"

Literature Review

The closure of schools during the COVID-19 pandemic raised significant challenges for educators. At the same time, it offered opportunities to rethink educational norms and creatively address students' learning needs through remote means (Zhao & Watterston, 2021). In this literature review, we first share studies that describe some of the ways that teachers and faculty used remote strategies to engage their students in learning science during COVID-19, including complete online learning and blended learning. In the second section of the literature review, we turn to the approach used by teachers in our study: Curiosity-Driven, Inquiry-Based science education. We explain what we mean by Curiosity-driven, Inquiry-Based science education and then we take some time to justify the value of the practice, since there has recently been some controversy in the literature. Next, we explain what we mean by using this approach in a blended learning format.

Remote Learning: Complete Online Learning and Blended Learning

During the COVID-19 pandemic, most teachers of science had to shift their practice to complete online learning with no opportunity for hands-on learning. Teachers did their best to use creative means to engage students' interest (e.g., Croce & Firestone, 2020; Deak et al., 2021; Edyburn, 2021). For example, Callaghan et al. (2021) shared details on the virtual implementation of an inquiry-based STEM program for secondary students called *Discovery* that made use of online discussion boards, video conferencing, gamified labs, and Labster simulations. Similarly, Trust and Whalen (2021) reported on K-12 educators use of Google Apps, online videos, and learning management systems to support their students in the move from face-to-face to emergency remote teaching. In the context of higher education, virtual field activities, open education resources, and digital portfolios were presented as options for satisfying the unique demands of online course delivery (Lowes et al., 2020).

Rather than going completely online, some teachers and faculty had opportunities for a blended learning approach that combined online learning with hands-on activities (e.g., Atwa et al., 2022; Ng, 2022). In these examples, the hands-on components were considered to be essential because of the nature of the learning needed. Ng et al. (2022) reported on an aviation program, where they designed an alternative blended learning approach. They altered the activities in their program from face-to-face to online and they included flight simulation activities that were essential to the learning of the students. Atwa et al. (2022) described how the students and teachers in their location attended campus and clinical training settings in person and their learning was augmented with the theoretical component being delivered online. It is this combination of practical hands-on activities and online learning that the teachers in our study were using in their Curiosity-Driven, Inquiry-Based science education projects. In the next section, we first review some of the literature around Curiosity-Driven, Inquiry-Based science education. We then discuss the controversy in the literature and justify the value of this approach to science education. Finally, we describe how the teachers in our study used Curiosity-Driven, Inquiry-Based science education in blended learning formats.

Curiosity-Driven, Inquiry-Based Science Education

As explained in the introduction, Inquiry-based science education in the context of this study refers to the particular ways of observing, thinking, investigating, and validating that scientists use (AAAS, 1993). Bell et al. (2005) propose levels of inquiry. At one level, confirmation inquiry occurs when the teacher provides the research question, a plan for the students to follow, and the specific outcome that the students are required to find. In structured inquiry, the teacher provides the question and the procedure and students have some freedom to find the answer. In guided inquiry, the teacher poses the question but allows the students more freedom on arriving at an answer. In open science inquiry, students initiate, plan, and conduct open-ended investigations where the teacher has not planned the answer (Pizzini et al., 1991). Such inquiries are sometimes termed ‘”student-led’’ because they follow the students' own questions (Bell et al., 2005). Inquiry-based science education aligns with the curricular competencies for science education in the curriculum in British Columbia in Canada where this study took place (BC curriculum, 2015). It is one of the recommended approaches deriving from Indigenous' perspectives because it is experiential, recognizes the value of group processes, and supports a variety of learning styles (FNESC, 2016). It also aligns with recommendations for culturally responsive teaching (Brown, 2017) and differentiated instruction (Llewellyn, 2010) because it allows students to have a voice and a choice in their own inquiries for their own learning.

As previously stated, in this study, curiosity is used as a driver for inquiry-based science education (Lindholm, 2018). Curiosity is "characterized by the joy of discovery and the motivation to seek answers" (Shah et al., 2018, p. 380). Curiosity is associated with the kind of wonder that can ignite interest and awaken students' imagination (Egan et al., 2014). To describe how scientific inquiries in this study derived from students' curiosity, we use the term Curiosity-Driven, Inquiry-Based science education (CDIBSE) to describe the projects that teachers were doing in our study. In terms of learning theory, CDIBSE is aligned with the philosophical position of John Dewey (1938), who proposed that it is through their own experiences that students generate the ideas that drive their learning. It is also aligned with constructivist ideas of learning (Piaget, 1970) that focus on learning by doing and sociocultural learning theory (Vygotsky, 1978), which emphasizes the importance of learning in a sociocultural environment supported by teachers and peers.

The Value of Inquiry-Based Science Education

A wealth of research across decades indicates that when it is appropriately supported by teachers, inquiry-based science education increases student interest, motivation and engagement in science (Aditomo & Klieme, 2020; Anderson, 2002; Furtak et al., 2012; Kang & Keinonen, 2018; Lazonder & Harmsen, 2016; Minner et al., 2010). However, a plethora of recent studies of PISA 2015 results have suggested that the inquiry-based science education approach contributes negatively to students developing science literacy (e.g., Cairns & Areepattamannil, 2019; Oliver et al., 2021). Using a variety of statistical methods, these studies have compared students' self-reported frequency of experiences with inquiry-based science education in the questionnaire part of the PISA results, with their science literacy scores on the main PISA test. More specifically, the studies have shown that students who achieve the highest scores in the science literacy test have the lowest self-reported frequencies of inquiry-based science education. Concomitantly, students who self-report the highest frequencies of inquiry-based science education achieve the lowest scores on the science literacy examination. These findings have led to recent recommendations that teachers should use inquiry-based science education approaches in moderation (Cairns, 2019). We take the opposing view shared in counter-arguments in support of inquiry-based science education (e.g., Sjøberg, 2018) and agree with those who suggest a more measured approach to interpreting PISA results (Rutkowski & Rutkowski, 2016). We are aligned with Sjøberg (2018) when he reminds us that the PISA test cannot measure the importance of inquiry-based science education for students' science skill acquisition, as well as engagement, curiosity and enthusiasm for science learning. Sjøberg (2018) states:

> A written (or digital) test like PISA can hardly measure the skills and competencies acquired in experimental work in a lab or on an excursion; neither can it capture the kind of interest, curiosity and enthusiasm that may be the result of argumentation, inquiry, and the search for solutions to questions that the students have formulated themselves. (p. 200)

Therefore, although on the one hand there are recommendations in the literature for reduced use of inquiry-based science education in curricula due to the findings from studies of PISA 2015 (e.g., Cairns, 2019), there are also calls for an increase in its use. Cremin et al. (2015) and Cremin and Chappell (2021) identify inquiry-based science education as a creative pedagogy, a pedagogy which supports the development of students' creativity, creative thinking, and capacity for innovation. Global organizations such as the OECD have identified these capacities as much needed for life in the 21st century (Vincent-Lancrin et al., 2019). It is interesting to note that currently the OECD is working on methods of assessing students' creativity and creative thinking so that these capacities can be included in future PISA tests (PISA 2021: Creative thinking framework). In the next section of this paper, we describe the use of CDIBSE projects in blended learning formats to engage students in our context during the COVID-19 pandemic.

Curiosity-Driven, Inquiry-Based Science Education in Our Context

The CDIBSE projects described by teachers and faculty in our study were quite diverse, but all used a blended learning approach that incorporated a hands-on component augmented by an online component. In one case, when schools closed in March 2021, the teacher of a grade 11 physics class delivered materials to students in their homes so that they could build model electric cars. The teacher then engaged with the students remotely through Google Classroom and supported them to conduct CDIBSE projects using their cars and their curiosity as a starting point. In the context of their projects, students learned about Newton's laws of motion and the concepts of power and efficiency. The teacher invited an engineer to meet the students online and the students presented their findings, demonstrated, and explained their projects.

In another case, when universities were closed though 2021 and 2022, a professor who would normally have taken their class on a field trip instead sent the class members to explore an outdoor environment on their own, following health recommendations during COVID-19, using approaches they learned about online and following their own curiosity. Through remote means the professor supported the students to share their discoveries online. Further descriptions of 18 projects that teachers conducted with their students have been shared through an OER that is available online (Rees et al., 2022). In the next section of this paper, we share the action research methodology, research design and methods that we used in our study.

Methodology

Action Research (AR) was introduced by Kurt Lewin in the 1930s as an approach for researchers to help people conduct studies in their own localities and bring about social change (Lewin, 1946). In the teaching profession, AR can allow practitioners to build theories or models for best practice through a systematic process of cycles of self-reflection, planning, implementing, observing and reflecting (McTaggart, 1991). AR was our chosen methodology for this study because we were facilitating a group of teachers and faculty who shared concerns that were, in the words of McTaggart, "immediate, pedagogical and reflexive" (McTaggart, quoted in Wicks, Reason & Bradbury, 2008, p. 21). Through this research we aimed to support our colleagues to generate their own theories about what worked and why it worked, as well as what didn't work and why it did not (McNiff, 2017).

This action research study aimed to support participants in an on-going basis and addressing their driving question; "How can we best support our students' learning in blended learning environments through Curiosity-Driven, Inquiry-Based Science Education?" Ultimately, our aim was to support teachers in researching their successes and sharing their ideas and the projects they created. We wanted to make these findings accessible to all teachers through an OER that could support others to do CDIBSE in blended learning formats, and engage more students' interest and support their learning during and following the COVID-19 pandemic.

Research Design

To support our group of teachers and university faculty working on their driving question (i.e., How can we best support our students' learning in blended learning environments through Curiosity Driven, Inquiry-Based science education?), we used an educational community of inquiry (COI) model. According to Garrison and Akyol (2017),

> An educational community of inquiry [COI] is a group of individuals who collaboratively engage in purposeful critical discourse and reflection to construct personal meaning and confirm mutual understanding. There is both independence and interaction (co-regulation) in a community of inquiry [COI]. (p. 106)

Using a three-pronged approach that constitutes the overlapping presences social, cognitive and teaching (Figure 1), the COI was designed to help establish learning conditions that promote collaborative discovery and co-creation of knowledge (Bozkurt, 2019). Based on the work of John Dewey, COIs follow a constructivist perspective of learning that focuses on the notion that higher-order and critical learning and reflection occurs when participants are engaged in collaborative discourse and reconstruction of experience (Garrison & Akyol, 2017).

There are two important considerations for the structure of the COI in this AR study. One is that collaborative groups were vertical as well as horizontal (Trabona et al., 2019), meaning that we brought together representative teachers from across grade levels to meet with post-secondary faculty (vertical collaboration), as well as within levels (horizontal collaboration). This grouping is important so that teachers share ideas that are not only valuable for them at their own grade level but also inform, and are informed by, the knowledge of teachers who teach at the levels below and above. The second is that the COI must be small enough and membership consistent enough to facilitate online discussions and allow building of social presence over the course of the year (Akcaoglu & Lee, 2016).

Our design for this year-long action research project was to facilitate COIs through two cycles of action research on their driving question, where each cycle included Zoom meetings of COIs for planning of projects, teachers and university faculty implementing projects with their students, and follow-up reflection meetings of COIs on Zoom.

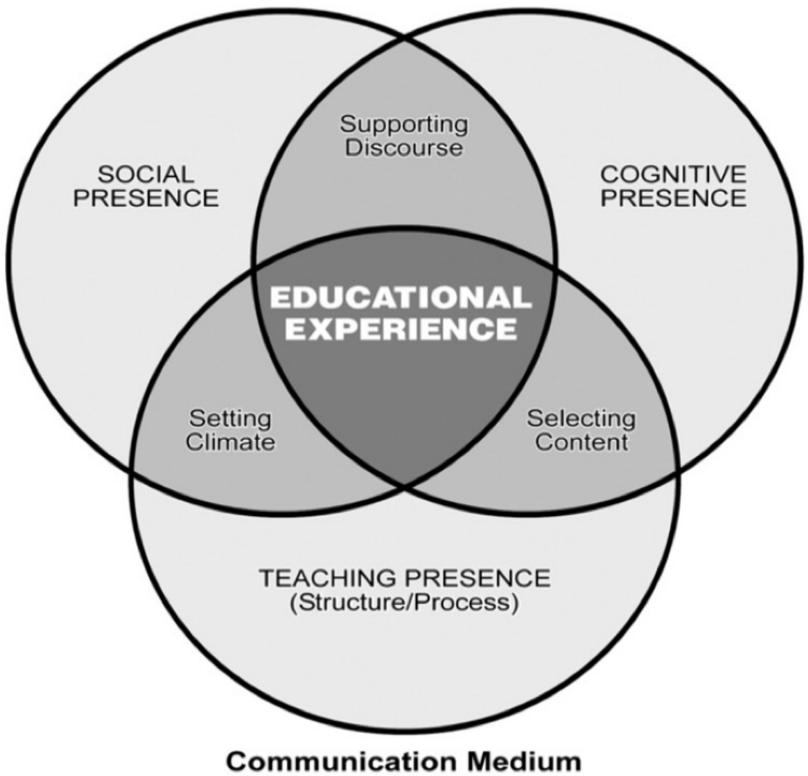

Figure 1. *The Community of Inquiry framework. Reproduced from Garrison et al. (2010).*

Our research design allowed data from the first research cycle to be analyzed by the research team and findings provided to COI participants in time for their second cycle of discussion, planning, implementation, and reflection, so that in the second cycle, ideas and resources from the first cycle could be developed and refined. The COIs online Zoom meetings were followed by online support through a secure text-based platform called Mattermost. Throughout the project, Mattermost was used as an online platform for sharing text-based information. Mattermost is a secure, open-source, online chat service similar to Microsoft Teams. We used Mattermost to support COIs to share resources and text-based planning documents. The reason why we chose Mattermost was to allow sharing between teachers and faculty who belonged to different institutional domains from a technology standpoint.

In the first cycle, planning in October 2020 was followed by one month of implementation in November where teachers put their ideas into practice with their students. Teachers then engaged in reflection meetings on Zoom in December 2020. Planning and reflection meetings were facilitated by our research team. Meeting recordings were transcribed at the end of the first cycle, and Mattermost communications and shared documents were collected. Between the first and second cycle, in December 2020 and January 2021, researchers analyzed data to bring back their findings for the first planning meeting of the second cycle. The second cycle consisted of planning meetings in March 2021, implementation with students in April 2021, and reflection meetings in May 2021. Finally, from May to October 2021, the research team worked on data analysis and the creation of an OER that shares the projects of the teachers (Rees et al., 2022).

Timeline

The timing of events that occurred throughout this year-long study is as follows:

Jun 2020 – Oct 2020: Preparation. Research ethics proposal and approval; recruitment of participants.

Oct 2020 – Jan 2021: Cycle 1. In October 2020: Planning meeting for COIs online discussions in two groups (recorded). In November 2020: Implementation – teacher participants from COIs conduct CDIBSE projects with students. In December 2020: Reflection meetings for COIs (recorded). Reflection and sharing on their projects and sharing resources on Mattermost. The research team collected these, as well as videos of the meetings and the online communication. In January 2021: Transcription and data analysis from Cycle 1 to bring findings back to participants for Cycle 2.

Feb 2021 – Apr 2021: Cycle 2. In February 2021: Planning meeting (recorded) (teachers have new classes, new students). COIs received from the research team the results of data analysis from Cycle 1. The COIs discussed and made plans for Cycle 2 for teachers' new classes for semester II. In March 2021: Implementation – COI teachers implement their CDIBSE projects with students. In April 2021: Reflection meeting for COIs (recorded). Reflection and sharing.

May 2021 - Oct 2021. Research team worked on transcription and data analysis, developed model and created an OER (Rees et al., 2022).

Context

This study took place in a small city in British Columbia during the COVID-19 pandemic. It brought together a team of researchers from the local university and local school district. The team applied for and received a SSHRC Partnership Engage grant in 2021. The grant allowed us to hire graduate student research assistants and work to support teachers to come together in the online COIs as described in the previous section. Research team members, including graduate student research assistants, met prior to the meetings of COIs to plan the COI meetings. We facilitated discussions, arranging the participants into two groups for their meetings based on times they could be present. Discussions were held on Zoom and recordings were collected. We transcribed and collated data and used NVivo to support thematic analysis (described in the data analysis section).

Participants
Following research ethics board (REB) approval, teachers and faculty were invited through recruitment posters and direct invitation. Fourteen teachers (middle and high school) and three university science faculty were recruited (Table 1). Table 1 shares participants' grade levels as well as number of years of teaching. By bringing together elementary teachers, secondary teachers and university faculty, we could support teachers learning within their own level and across levels (Trabona et al., 2019). Our seven-member research team also facilitated and engaged in the COI discussions and worked on projects in their own contexts. We asked participants whether they would like to use their own name or a pseudonym. Some participants chose to use their own name and others a pseudonym and we followed their requests.

Table 1
Research Participant Attributes

Participant (pseudonym)	Grade Level	Years Teaching	Familiarity with Inquiry-Based Learning 1=not familiar, 3=somewhat familiar, 5=very familiar	Familiarity with Technology 1=not familiar, 3=somewhat familiar, 5=very familiar
Brandy	7-12	13	3	4
Courtney	7-12	9	2	2
Chris	7-12	7	2	4
Jenn	7-12	20	3	4
Kim	7-12	1	3	4
Monica	7-12	20	3	2
Selma	7-12	15	3	5
Grady	7-12	22	4	4
Amanda	4-7	4	3	4
Hilary	4-7	35	3	3
Laura	4-7	6	2	3
Lisa	4-7	18	4	4
Melody	4-7	15	5	4
Sharmane	4-7	22	4	4
Lyn	Post-secondary	34	4	3
Nancy	Post-secondary	30	3	4
Tory	Post-secondary	8	4	3

Data Collection
Data for this Action Research project included transcripts of Zoom recordings from our COI meetings as well as content from participants' projects shared on Mattermost, as indicated in the

timeline. In each cycle of action research, there were four 90 minute Zoom sessions. As indicated in the timeline, in Action Research cycle one there were two COI planning meetings in October and two COI reflection meetings in December on Zoom and these were recorded and transcribed. As indicated in the timeline, there were two COI planning meetings on Zoom in March and two reflection meetings on Zoom in May in cycle two of the Action Research. These Zoom meetings were recorded and transcribed. Data collected from Mattermost included the developing plans for the CDIBSE projects shared throughout Action Research cycle 1 from October to December and throughout cycle 2 from March to May. The contents of the projects as they were developing were first shared on Mattermost and later developed for OER publication on Wordpress (Rees et al., 2022). There were 18 projects published in total.

Data Analysis

We used thematic analysis (Braun & Clarke, 2006) to analyze data using NVivo software. We followed the six phases of analysis as described by Braun and Clarke (2006), shown in Figure 2**.** We immersed ourselves in the transcripts and projects collected to familiarize ourselves with the data (Braun & Clarke, 2006). As the research progressed, open coding was used to creates codes and develop themes. We used an open inductive approach, identifying passages in the transcript data relevant to developing codes. We worked through the data coding passages in the transcripts and developed themes by collating codes and collapsing subthemes into larger overarching themes.

Phase	Description of the process
1. Familiarising yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking in the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells; generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Figure 2. *Phases of data analysis (modified from Braun & Clarke, 2006)*

We analyzed data similarly to identify the particular codes to focus on. This approach helped us to identify themes, which were underlying concepts that connected items (codes) together. Thematic analysis of cycle one data took place in January and February. We brought the developing themes to COIs in the planning meeting for cycle two in March. Participants reflected on the developing themes and used this knowledge in their planning for their projects that they were designing to implement in April. Finally, we brought our analyses together to produce a mind map (see Figure 3; Braun & Clarke, 2006) or thematic network (Attride-Stirling, 2001).

Trustworthiness

Member checking (Candela, 2019) and inter-rater reliability (Armstrong et al., 1997) were used to enhance trustworthiness. Findings from the first COI cycle were presented to participants for them to consider during their second COI cycle. While analyzing data, members of the research team compared codes and emerging themes on a regular basis in order to establish consistency.

FINDINGS

In this section of the paper, we present the themes elucidated from our data analysis in response to the research question. Themes and sub-themes are shown in Figure 3. Themes are presented under five main headings: (1) using education technology; (2) the importance of student discussion; (3) appropriate assessment methods; (4) students' developing research and problem-solving skills; and (5) the importance of student reflection.

Throughout the findings section, we share quotes from our participants relevant to each theme. We bring these themes together to form a model for conducting CDIBSE projects in blended learning environments, based on this study.

Using Education Technology

The first theme concerns ways to use technology to support CDIBSE projects in blended learning formats, during the COVID-19 pandemic. Tools and topics that came up included using video conferencing, bringing students together through online means to share the work they were doing offline, sharing across platforms, reducing interruptions, online advancements, and supporting Indigenous connections.

During the pandemic, the teachers in our study employed video conferencing programs like Zoom to bring guest speakers into their class during both face-to-face classes and online classes. Teachers mentioned that guests can be very important for helping students understand the real-life relevance of their learning. Normally there would be many visitors to classrooms, but during the COVID-19 pandemic, alternative arrangements needed to be created. Even when face-to-face classes resumed, guests were not permitted to come into school buildings. One teacher explained how she brought a scientist from the observatory to the class using Zoom:

> And I had one of the scientists from the observatory to come in as our guest audience member. So he zoomed in and answered questions from the kids. So actually, for the unit, they really stepped up their game because they had somebody from the observatory come in. (Kim)

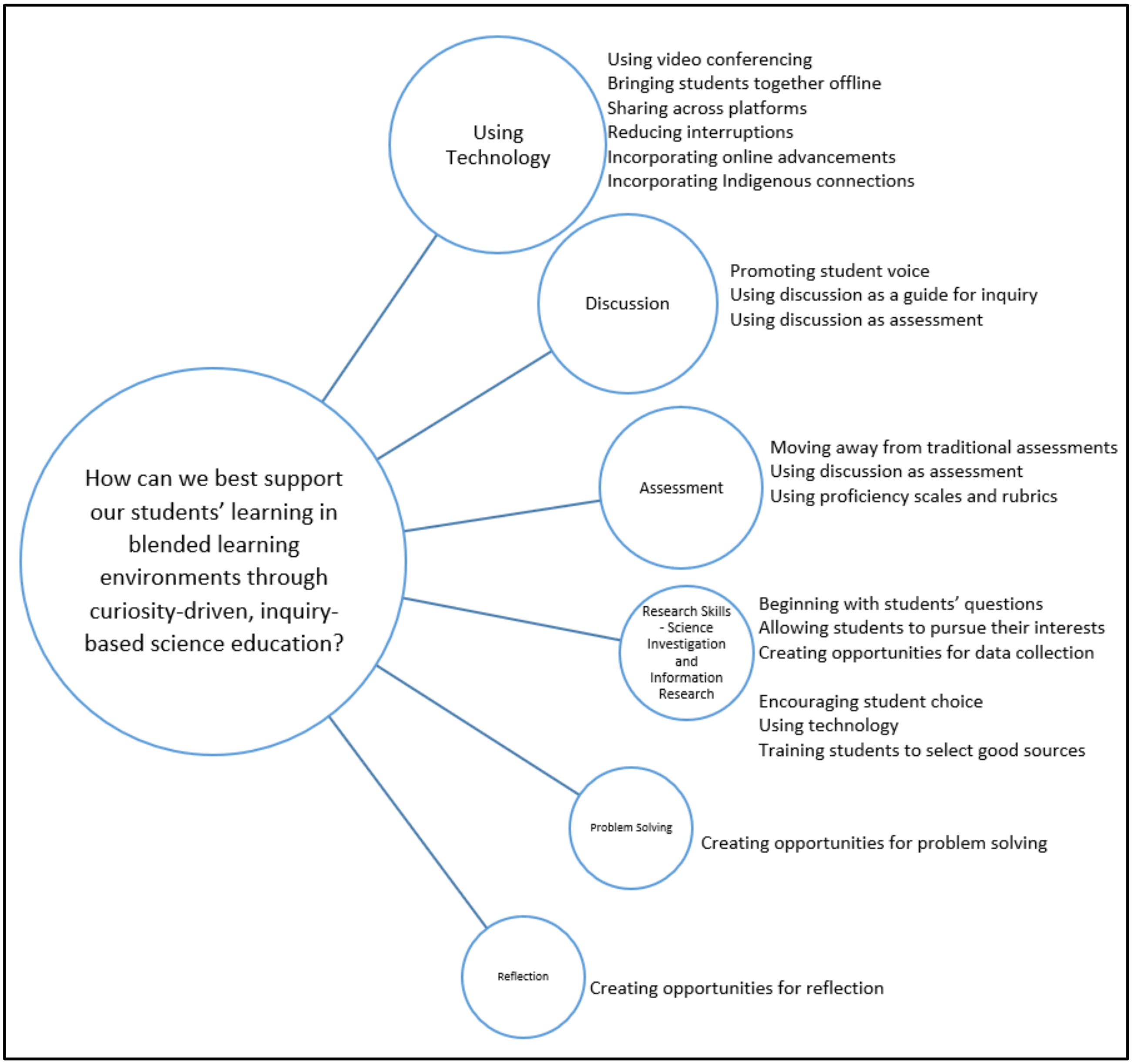

Figure 3. *Key Themes and Subthemes Emerging from this Study*

Guest lecturers acted as important resources for students' learning by answering questions and leading unique inquiry-based activities. For example, one teacher shared how she invited a guest into the class to give a "how-to" presentation on infographics. Following the presentation, students were able to take the lessons they had learned about font, color, size, and organization and apply them to an inquiry poster project investigating household chemicals. These examples are indicative of the efforts teachers made in discovering new tools for interacting within online spaces and connecting students with outside professionals who offered unique perspectives and opportunities.

Teachers also described how they used technology to bring students together online to share the work they were doing offline or in field settings. When students were attending school or university from home, for instance, teachers incorporated technology as a tool to share inquiry projects. One example of this occurred when a university biology professor who would normally have gone out in the field with her class assigned a project that required students to independently collect field samples, and then use an application called *iNaturalist* to discuss what they had found with others:

> And so I developed an alternative where students could go out on their own and follow the directions for the project themselves. And I used iNaturalist. So iNaturalist, just to give you a very brief overview, you can use your phone to take pictures of something, upload them, and then the community of people that are interested in that taxonomic group help you ID. So all of a sudden my students had access not just to me, but to the entire world of people that are interested in this species that we find. (Lyn)

Another university professor explained how she added hands-on 'kitchen' labs for her students to do at home with products they could buy locally: "For biology I had my students actually buy chicken thighs and dissect them. And then look at epithelial tissue, muscle tissue, connective tissue…" (Christine). She then described how she brought her students together online to share their discoveries. Both of these examples illustrate how educators brought learners together in an online forum to discuss hands-on inquiry projects they were doing offline.

Furthermore, teachers in our study explained that they used online platforms to share and collaborate with other teachers during the pandemic. This was particularly important for interactions between K-12 teachers and university educators, as the platforms employed by school districts and universities are often different. To bypass this, teachers and educators in our COI used an open-source website called Mattermost to share learning resources and ideas for projects. Mattermost pages created by the research team acted as a space for participants to post links, receive feedback, and assist one another with technical difficulties:

> So basically what Mattermost does is like Slack, but it's an open source version that we can run. And the reason that we thought about this piece of technology is that it allows TRU and non-TRU people in and it's pretty lightweight. So what we're hoping that you'll be able to do is use it to share resources and then work in your small groups. (Michelle)

While Mattermost was used to connect with other educators, teachers also commented on the ways that online learning platforms helped them in their own teaching. Learning management systems such as Moodle and Google Classroom, for instance, were seen to be beneficial for assignment organization and student access. Teachers explained how they used Google Classroom when they were online and found it equally helpful when they returned to face-to-face teaching. One teacher noted that she regularly directed students to "go back and look at the instructions" on Google Classroom as they often misplaced their paper copies (Amanda).

Within their conversations in the COI, teachers spoke about how they used technology to appropriately address interruptions that arose when their classes moved from face-to-face to online learning. With technology, students attending school from home could video chat with their teachers and gain access to their assignments. This served to lessen disruptions for teachers and made it possible for learners to continue their inquiry work when they were not able to come into class:

> So during class, I could just turn on Google Meet so the student who could not join was able to attend during our class time. It was interesting for me because I would talk to the class and then I would talk to my computer. And the student (or students) who was at home could talk back. And we have this little mini discussion. And at other times where the class had been talking about a topic, I could just connect them with a different group, and then they could have a conversation. So, it actually worked really well, having that technology in the class and having that Google Suite has come in handy regularly. (Selma)

In these examples, technology was not only used to facilitate conversations between students and their teacher, it also allowed students to collaborate with one another on their projects.

Another important point discussed was the opportunity to incorporate advanced resources that only exist digitally. For example, one professor drew attention to a resource on the NASA website that offers students the chance to drive a rover around the surface of Mars. Another teacher spoke about giving students virtual tours of her parents' beehive using videoconferencing:

> I'm a beekeeper, my parents are beekeepers and so last May, I went with my smartphone and hosted a Zoom session and held my phone in the hive so the kids could see inside my parents' hive. (Elizabeth)

Both of these examples illuminate the ways in which technology can be integrated in CDIBSE projects to provide students with enriching experiences that augment their learning.

Finally, teachers also used technology to support Indigenous connections in students' inquiry learning. One teacher shared a project that combined "the Indigenous idea of finding out about your local plants and what grows in your backyard" (Kim) with a plant identification app. Another teacher created an inquiry project that gave students the opportunity to collect a variety of local, traditional plants during a nature walk led by the school district Aboriginal Resource Teacher. Following the nature walk, students visited a website called First Voices to "identify the common, Secwepemc, and scientific names of the plants" (Courtney).

The Importance of Student Discussion

Our participants identified discussion as a fundamental part of the CDIBSE process, expressing the need to keep discussion going whether the class was held face-to-face or online. Within their conversations, teachers viewed discussion as a means of promoting student voice, as a guide for different stages of inquiry, as a way to connect students during the pandemic, and as an assessment tool for projects.

Teachers emphasized how important it was for students to talk to one another and ask meaningful questions during inquiry projects. One teacher noted that their favorite part of these projects was the "conversations between the students when they're asking each other questions about the project, why they chose that, what difficulties they ran into and listening to the kids talking to each other" (Grady). Speaking to an assignment where students had the opportunity to showcase the work they had done in a gallery style, a research team member observed the excitement students had when discussing their inquiry work with their peers:

> So the way they had their gallery walk set up, the kids who were there presenting, were presenting to other kids from the other projects […] what was super exciting for them was telling their friends - this is what we researched, okay, well, we're coming over to see yours but this was really cool. (Carol)

When students were given the chance to engage in discussions with one another while sharing their projects, their voices and interests were promoted. It is important to note, however, that teachers mentioned it was more difficult to support students to take part in discussions online. One teacher shared that bringing in an expert online and asking students to tell them about their projects helped with this issue. Another teacher expressed that using text-based tools like Padlet, Pear Deck, and Google Forms encouraged students to express their voice.

When considering the different steps involved in CDIBSE, teachers noted that discussions among students should occur frequently. They reflected on the significance of adding discussion into all phases of inquiry to move projects forward and facilitate collaboration between learners:

> So, we thought you really need to consciously put discussion in at all the key steps during the inquiry process. Once you develop the question and they come up with a skeleton framework of what they're going to be inquiring on; Big Stop. Now it's time to talk. Having these discussions throughout is really what's guiding the process. The teacher and the students are facilitating each other in their inquiries. The whole class is involved helping other groups develop their inquiries as well. (Brandy)

As identified here, discussion was used as a guide for teachers and learners during inquiry projects, allowing them to stay on track and support one another's work. Students were able to share their wonderings as they arose and support each other in the direction of class inquiries.

Discussion as a pathway to student collaboration was advised in general contexts as well. Through discussion, students were able to experience feelings of connectedness with their peers. This was especially important during the period where students were able to return to in-person learning, but were required to isolate from others in their school:

> They like to be sharing ideas with each other. And that piece, especially during COVID, has been really important in my classroom because I feel like they're segregated from the rest of the school, especially out in the portable. So they're really needing that connection with each other and being part of the same cohort, it's really the only connections they're allowed to have right now. (Laura)

Teachers also recognized how discussion in inquiry projects was well-suited for collaboration in online learning environments:

> And then I realized that perhaps the type of inquiry project I have running with the grade sevens, because it more relies on connecting, and conversing with people and learning about other people's experiences, that perhaps it would actually lend itself well to an online format. (Melody)

Incorporating opportunities for discussion into inquiry projects was an important choice teachers made to support students' connections throughout the isolation and uncertainty of the COVID-19 pandemic as well.

Discussion was seen as a meaningful method of assessment for CDIBSE. Teachers in our study described how they used discussion to gauge where students were at in their understanding, rather than employing traditional evaluations like quizzes:

> And we thought the best way to actually do assessment throughout is through the discussion. So we said, after each step, we have a discussion between groups about where they're at and get feedback and they can do a reflection afterwards. And based on that, we can see where they're at in terms of their questioning, in terms of their analyzing, and so on. (Brandy)

Teachers found that opting for discussion as a form of assessment in inquiry led to richer conversations between students. When the pressure of testing was removed, students felt more comfortable engaging in deeper discussions and communicating their individual interests.

Appropriate Assessment Methods

During conversations in the COI, teachers spoke extensively about assessment methods throughout the transition from face-to-face and online learning. Finding appropriate and creative ways to assess CDIBSE within fluctuating educational environments was a significant challenge faced by K-12 teachers and university instructors alike. Participants in our study drew attention to the importance of moving away from traditional assessments, discussion as a form of assessment, and utilizing proficiency scales and rubrics.

Teachers in our study mentioned the need to move away from traditional methods of evaluation like tests and quizzes. They alluded to students' tendency to be resistant or hesitant toward these traditional evaluations and explained that enjoyment and engagement increased when alternative options were presented. For instance, one teacher explained how students became more invested in a project upon discovering assessment was not going to be quiz or test based:

> Students were surprised. One student said: "You mean all I have to do is ask a question, read about it, and then tell you what my question was and that's it?" I answered, "Yes! that's it. I'm not tricking you." (Chris)

Teachers spoke in favor of using differentiated assessment tools and allowing students to have a voice in what they preferred to be assessed on. Giving students this choice was seen as a path to supporting students' diverse learning strengths:

> The same topic can be covered but students can access it through different ways. And I wonder if that might give students more motivation because they might say, "Oh I really like to draw or I really like to be in nature." And I wonder if that might really work for those students who struggle with writing or a test. (Selma)

Allowing students to choose their own assessment pieces rather than assigning one quiz or test to all of them was seen as beneficial for sparking interest, increasing motivation, and encouraging involvement. Offering differentiated assessments was often necessary for blended learning environments, as what was feasible in a face-to-face context might not work online. For assessing developing skills in CDIBSE, teachers described how conversations between students were indicative of skills such as collaborating with one another. Others spoke about the option of storytelling as a unique and engaging means of assessing students. One teacher commented that "the buy-in is huge" when students have the opportunity to consider what stories they can share rather than what assignment they have to do (Monica). Others shared how creating space for discussion and storytelling within assessment promoted student voice and encouraged learners to think about their work in a different way. In online environments, teachers supported students' discussion and stories by using applications designed for conversing and sharing information, such as Flipgrid.

Teachers in our study spoke a great deal about using proficiency scales and rubrics for assessing CDIBSE, citing benefits that included more room for teacher judgment and an increased focus on student growth:

> I found the proficiency scale to be really liberating quite honestly. I felt like proficiency scales gave me license to use my teacher judgment and say, "OK, right now, you are doing exactly what I would expect a grade six student to do with this type of information or with this type of material." (Sharmane)

Another teacher commented: "We were asking 'How far along this continuum are you?' It has changed my perspective because it's always about growth. You're somewhere on that continuum" (Chris). As rubrics were often created by the teachers themselves, many opportunities for creativity and adaptation arose. For instance, one teacher described designing a rubric centered on the different phases of a growing tree, while another spoke about creating a rubric that concentrated on big ideas and student-friendly language. In this way, proficiency scales and rubrics became flexible, productive assessment methods that could be adapted to support students' changing needs throughout the transitions between face-to-face and online learning.

Developing Research Skills and Problem Solving

Designing and carrying out science investigations in blended learning environments undoubtedly came with several challenges that required teachers to be flexible and creative in their approaches to CDIBSE. Teachers talked about the importance of starting with students' questions, allowing students to pursue their own interests, and incorporating independent data collection.

When reflecting on the projects they had completed or planned to complete, teachers in our study described designing science investigations around students' questions which could be revealed face-to-face or through online applications like Zoom, Padlet, or Google Forms. Regardless of whether they were face-to-face or online, this practice tapped into students' curiosity and provided a way for projects to progress forward:

> What I want to do for this inquiry curiosity-driven learning, is I actually want to focus it on Space because my kids have been having some really interesting questions about Space. And I think there will be a lot of wonderings and that we can build a more individual quest. (Sharmane)

Asking driving questions provided a topic or 'Big Idea' around which students could pose their own questions. Teachers spoke of the ways that they used driving questions as a starting point for engaging learners in hands-on science investigations, whether they be achieved in-person or from students' homes and communicated through online means. As more and more questions were posed, students were encouraged to be inventive in their thinking:

> We've been talking a lot about how nutrients help us with our energy. What I was thinking for a driving question would be, "How can I redesign my school lunch to meet my body's needs?" So I want the kids to think about, how, if it's a practice, how can we use this information practically, what are the possible outcomes of it? What are the effects? (Lisa)

Positioning questions as the driving force behind science investigations ensured that projects remained open to new directions of inquiry while providing boundaries. This flexibility was key to consider during transitions between blended learning environments.

According to teachers' conversations in our COI, experiments directed by students' interests were an essential component of CDIBSE. One teacher spoke about the advantages of allowing a student to openly design and execute his own investigation:

> [The student] was a piano player, but he was actually interested in becoming a piano tuner. And he did an investigation on the relationship between the frequency of a piano string and the tension in the wire. And he was able to get a nice relationship on a graph and get the results out of that experiment that could lead to career options for him […] When they can choose any topic and then find something scientific about that to investigate, those are the best projects that I get out of my students. (Grady)

As seen in this scenario, casting a wide net for students to investigate within had positive repercussions for creativity and professional growth. At the same time, it framed inquiry projects as something that can be achieved beyond physical classroom spaces, including students' homes.

Blended learning environments offered opportunities for students to collect their own data, which, teachers asserted, helped students to become involved in all processes of science investigations, rather than just the reporting stage. This was particularly relevant when students were conducting their experiments from home and sharing their work with their teacher and peers through online communication tools. One professor shared a project she designed that required students to find and identify plants within their local ecosystems:

> I told them to find three gymnosperms, three angiosperms and make some field notes to identify each. Then take a moment to enjoy where they were. Look around to see what kind of ecosystem it was. Even if was an urban area, they could think about the question "How do you feel about that place?" (Tory)

This project, which was communicated and evaluated online through Moodle, helped students connect with their surroundings through data collection and place-based learning. By supporting students to safely venture into nearby spaces such as parks or forests to gather physical samples for use in science investigations, teachers made experiential inquiry projects possible during COVID-19.

The process of researching information is a fundamental stage in CDIBSE, and teachers and faculty shared the strategies they incorporated to help students be successful in face-to-face and online environments. These strategies included letting students choose the information they wanted to research, utilizing interactive technology, and encouraging proper selection of sources.

Teachers highlighted the importance of providing voice and choice in information research assignments. By remaining open to new ideas, teachers catered to the diverse interests of their students to keep content engaging. Instead of telling students what to research, teachers introduced a particular subject area and allowed students to explore different directions. For example, one teacher explained:

> I have a project going on in my grade 6-7 class. Instead of doing space and the planets, by just providing information, I just threw a project right at them and said, look at anything that has to do with space exploration and create a timeline for me with at least six events. And they're making these really cool digital timelines. (Amanda)

During the pandemic when universities closed, students were often living miles apart in their hometowns while learning online. Allowing students to choose their own research material was critical. One professor described a statistics project where students' gathered data about any aspect of their choice about their hometowns:

> First of all, they made a graph with data about their hometown. They got data of interest to them from Stats Canada, or from the university library, or they got data from every place under the sun related to their home. For example, frequency of men and women, frequency of people in different age groups. The amount of snow per month if they were skiers. Then they made a postcard with their data and mailed it to me. (Nancy)

This project creatively accounted for the logistics of online learning while also giving students the opportunity to search for and share the information they considered interesting about their hometowns.

Teachers also shared how they used technology to support students in the process of researching information. By incorporating technology in CDIBSE, teachers provided unique and compelling approaches to researching information on a variety of different topics. For example, one teacher spoke about a chemistry project where students had to "make a QR code that linked so they could snap their phones and go to a YouTube, or some sort of internet video to watch a crazy chemistry experiment" (Kim). Another teacher described an earth science project that required students to research volcanoes and "use Google Maps to pin and locate all of the events that have happened in their lifetime" (Jenn). In addition to these online programs, teachers also recommended digital textbooks with interactive links students could use to explore further information. A few teachers specified a science techbook resource they were using in their classes to introduce students to inquiry projects. These techbooks were particularly well-suited for online learning, as they are designed to immerse students in engaging 3D learning content accessible from their computers.

Teachers indicated the need to teach students to discern between good and bad sources while gathering research information. This need emerged from the challenges students faced when using google search results to explore their inquiry questions:

> Being able to actually use our critical thinking and look at the results that we're getting because they're actually results, they're not answers, right? So being able to go through the process of reading and understanding the bits and pieces is challenging as well. (Elizabeth)

To work through this challenge and support their students' CDIBSE projects, some teachers guided students to choose one source to begin with and only progress to others after deciding whether the first source answered their question or gave them new questions to consider. Others spoke of curating specific sources for their students to select from in order to steer them in positive directions and minimize the risk of becoming lost in the research. These were important strategies when dealing with the abundance of information available to students through online learning platforms.

Teachers described their efforts to show students that problem-solving was an integral component of inquiry projects. Discovering challenges that hindered progress or forced students to change directions or begin again were not to be seen as failures, teachers emphasized, but rather part of the learning process:

> We thought it's really important to make it very explicit to the students that failing a bit can be part of the process of inquiry. Everything's not going to work out and you're going to come across roadblocks and stumble a bit. And that's the whole reason why we're doing it together. (Brandy)

Framing roadblocks in a positive fashion enhanced students' experiences and sparked their drive to continue. Indeed, many teachers designed inquiry projects around problems that students needed to solve. One teacher described an inquiry project where students were required to use a variety of simple machines to approach the question: "How am I going to get this heavy box of books onto the top shelf" (Hilary). This project lent itself well to students working at home and connecting with the teacher and the rest of the class through video conferencing. Other teachers spoke about how impressed they were upon witnessing students brainstorm solutions to problems in their inquiry projects that they had not been able to foresee. In both cases, problem-solving was positioned as a defining aspect of CDIBSE, and as a way to support students in handling the unexpected issues that arose within blended learning environments.

The Importance of Students' Reflection
Teachers indicated that reflection should be integrated in inquiry work as a method of getting students to think deeply and critically about their learning experiences and that these reflections could be shared online in blended learning situations. One professor explained how she did this with her students:

> They made reflections on these nature writings in their field journals. And they also learned to make careful, close accurate observations of the field themselves. And I expect them twice a semester to distill meaning from those experiences. They had to hand in what I call a field reflection or free write and we read it and they shared it. (Lyn)

Some teachers also discussed beginning their inquiry projects with a group reflection in an effort to approach complex subjects like sustainability. This allowed teachers to gauge where students were at in their understanding while encouraging collaboration and communication between peers. Group reflections like these were also beneficial in that they could be completed with online platforms like Padlet. Thus, whether implemented at the start, end, or midway through inquiry projects, reflection was used by teachers to guide students in CDIBSE.

SUMMARY
Our purpose in this action research study was to support teachers and faculty to address their driving question: "How can we best support our students' learning in blended learning environments through Curiosity-Driven, Inquiry-Based science education?" By collating the themes that they brought forward in two cycles of action research, we were able to develop a rough model that answers this research question (Figure 4).

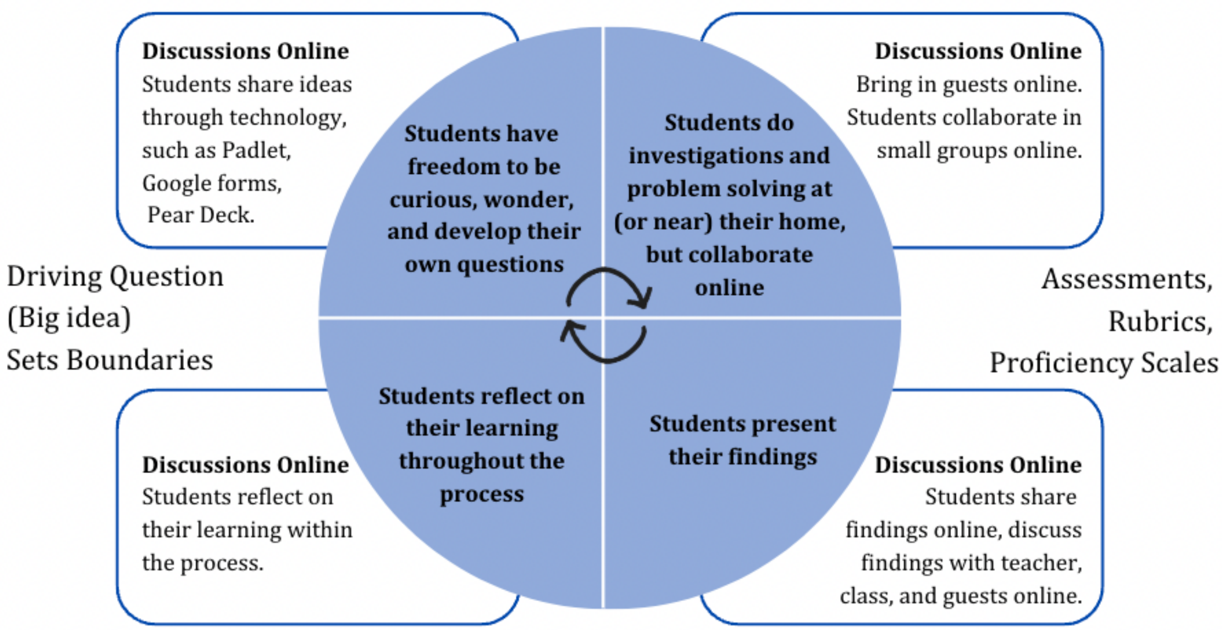

Figure 4. *A rough model for Curiosity-Driven, Inquiry-Based Science Education in blended learning environments (developed from our findings)*

Teachers and faculty identified the elements of CDIBSE that, for them, must be preserved during a blended learning environment. Figure 3 collates these ideas to create a rough model of the teachers' ideas for CDIBSE projects in blended learning environments. Our participants mentioned that a driving question around a big idea provides boundaries for students' investigations. This agrees with literature on best practice for science inquiry and project-based learning (Marx et al., 1997). Our participants talked about the fundamental importance of beginning with students' curiosity and their own questions and how discussions must be continued in blended learning formats and can be conducted online. The importance of beginning with students' curiosity has been talked about in the literature (e.g., Egan, 2014; Lindholm, 2018) and throughout this paper. Participants talked about it being imperative that there were opportunities for discussion at all stages of the inquiry process, not just at beginning stages. Similar recommendations about discussion at all stages have been made in the literature (e.g., Bjønness & Kolstø, 2015; Rees & Roth, 2019). At the investigation stage, students could develop their projects at home or close to home through field work, they could conduct online research at home through their phone or computer and in some cases, they could use materials delivered by the teacher, most importantly students' could collaborate online. This aligned with the blended learning methods described in the literature review (Atwa et al., 2022; Ng et al., 2022). At this stage, discussions online were important for supporting students' doing their projects. These were facilitated by both the teacher and collaborative groups. In addition, students could make contact online with guests who had expertise in their areas of interest. The value of bringing in guests online has also been established in the literature (Fulton, 2020). In the next stage, students could present their learning online through videoconferencing with the teacher, students and guests, and submit reports through online means. Such means of sharing learning online aligns with recommendations from the literature concerning online learning (e.g., Gillett-Swan, 2017). Finally, students' needed opportunities for reflection on their learning through online discussion with the teacher and their peers. Similar recommendations have been made in the 5E model of inquiry-based science education (Duran & Duran, 2004). With regard to assessment, teachers and faculty advocated moving away from quizzes and tests to using rubrics and proficiency scales, and these could be used for formative or summative assessment. Again, this agrees with recommendations in the literature for assessment of inquiry-based learning (e.g., Straits & Wilke, 2002).

Prior research has indicated the importance of integrating technology in CDIBSE during the COVID-19 pandemic. The inquiry-based STEM program, *Discovery*, for example, utilized virtual labs, video conferencing, and online data sharing to successfully engage learners when in-person laboratory activities were suspended (Callaghan et al., 2021). Other research examining novel approaches in post-pandemic STEM education similarly suggests that virtual labs can be used by educators to improve inquiry learning (Deak et al., 2021). Moreover, Lowes et al. (2020) recommended further forms of technology that could be used to promote interactive online activities, which included virtual field trips, simulated activities, and open education projects. These examples are closely connected to the approaches of teachers in our study, such as in the case of giving bee-hive tours over Zoom and exploring the surface of Mars using rover videos.

We believe our research extends the literature by focusing specifically on blended learning environments. Teachers and faculty can support students at their home locations to do practical hands-on, curiosity-driven, investigations, whether they be fieldwork, kitchen science investigations or investigations using equipment delivered by the teacher. Through online means, they can provide avenues for much needed discussion at all stages.

The COVID-19 pandemic challenged the rule that students and teacher must remain in the same location and encouraged educators to create new models of online and blended learning, like the one proposed here. Zhao and Watterston (2021) proposed a model that resonated with us as well, which they described as follows: "students receive instructions from online resources or synchronous meetings, conduct inquiry, create products individually or within small groups, and make presentations in large class synchronous meetings" (p. 9). In Canada, similar project designs were adopted to facilitate science education during the transition to online learning during COVID-19. For instance, McMaster University experimented with sending students physics and biology lab kits to complete from home (Lowes et al., 2020), while other students were encouraged to use their local surroundings for investigations that could subsequently be shared via virtual discussions with peers. Thus, in our study, and in the literature, education technology not only permits CDIBSE projects to continue, but provides opportunities for creativity and innovation that extends this approach.

Previous research on student-centered learning has shown that allowing students to design their own questions and direct their own investigations is critical for the learning of scientific inquiry skills (Hodson, 2014). By allowing students to choose their own topics, questions, and assessment methods while completing CDIBSE projects, teachers promoted a number of significant benefits recognized in prior literature on inquiry-based science education, including increased student motivation and engagement (Aditomo & Klieme, 2020; Anderson, 2002; Furtak et al., 2012; Kang & Keinonen, 2018; Lazonder & Harmsen, 2016; Minner et al., 2010; Lazonder & Harmsen, 2016).

Moreover, the commitment to student-centered learning maintained by teachers in our study aligns well with recommendations for education in a post-COVID-19 society. According to Zhao and Watterston's (2021) exploration of the educational changes needed after the pandemic, they advocate that students should be permitted to have a choice over the content they would like to learn and the directions they would like to follow without the hindrance of pre-determined curriculum. At the same time, pedagogy should be adapted to focus on "student-initiated explorations of solutions to authentic and significant problems" (p. 8) in order to help learners to develop the skills needed to manage unknown future challenges. Teachers in our study facilitated such explorations by giving students the ability to initiate their own inquiry work and select their own research directions.

As described in the literature review, the abrupt shift to online instruction at the beginning of the pandemic resulted in many assessment challenges for educators that have been described by other researchers. These challenges include lack time, experience, and student participation (Middleton, 2020). In our study, teachers approached these challenges by remaining flexible, moving away from tests and quizzes, creating their own rubrics and scales, and allowing students to choose their own assessment methods. In doing so, they catered to the diverse interests of their students and improved engagement while learning online.

When face-to-face learning was no longer permitted, experiential learning activities that engaged students within their communities were especially hard hit (Lowes et al., 2020). Taking this into account, it was interesting to discover the projects that teachers in our study created to combine independent work in the field with digital communication tools. Prior research has indicated the importance of experiential learning in real-world environments (Favaloro et al., 2019; Kolb & Kolb, 2017; Savage et al., 2015). Merging individual CDIBSE projects with collaborative sharing apps and websites, however, appears to be a new area of study. In our COI, teachers shared a number of experiential projects that allowed students to complete hands-on investigations and form connections to local spaces and ecosystems. Following their investigations, students were instructed to convey findings with their teachers, peers, and outside professionals using applications like iNaturalist and Moodle. These projects creatively responded to the confines of online and blended learning while supporting active participation in CDIBSE throughout the COVID-19 pandemic.

Conclusion

Despite the challenges raised by the COVID-19 pandemic, teachers in our study showed exceptional creativity and innovation in their efforts to support their students through CDIBSE in blended learning environments. At a period of heightened stress and busyness, these teachers went beyond simple solutions and chose instead to design unique and advanced projects to immerse learners in an engaging combination of online and face-to-face activities. Through sharing these processes in the COI, we found that teachers made use of educational technology, discussion, assessment, and research to assist student learning during a time of crisis. Findings that emerged from conversations in the COI were used by teachers to extend and improve their own teaching, and to share widely with other educators through a freely accessible OER (Rees et al., 2022).

This was an Action Research project and critical reflection on the outcomes of the study is an essential element (McNiff & Whitehead, 2010). In reflecting on these experiences, participants in our study commented on the extreme difficulties that were presented by the COVID-19 pandemic for educators and for students. The isolation experienced by students brought about mental anguish (Waddell et al., 2020), and in 2023, the effects are still unfolding. This study was conducted completely online. The discussions between researchers and participants in the Community of Inquiry occurred through videoconferencing, resources were shared through an online platform, and we never had a chance to get together in person. To this day, there are members of our group who have never met in person. In conducting this research, there were times when technology failed us, and we were presented with challenging barriers to continuing our research. For example, we were almost shut down when the school district could no longer allow the teachers the release time that the grant was paying for because they were so short of on-call teachers. We problem solved by supporting teachers in COI meetings after school. In ways, the COIs served as supportive environments for teachers and provided a positive avenue during difficult times. We learned a lot together about how to make science learning engaging for our students through Curiosity-Driven, Inquiry-Based Science Education projects in blended learning environments. Teachers talked about how their students constantly surprised them and they learned so much from them. We end this paper with a quote from one of our professor-participants that sums this up so well:

> I think that, if there is any gift of COVID, the gift for me is that it has upended many of the things that I always thought were right and true. And when there's no other possibility you make do with what you have and sometimes the make-dos are better than you could have imagined. (Lyn)

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Biographical note:

Dr. Carol Rees is a Professor Emerita at Thompson Rivers University in BC. She is currently lecturing in Ireland at Maynooth University and at Marino Institute of Education.

Hannah Allen completed her Masters' in Education at Thompson Rivers University and is now an Instructional Designer. Hannah was the primary research assistant on the project. She supported the team, produced the Open Education resource and with Carol, she co-authored this paper.

Morgan Whitehouse is a master of education student at Thompson Rivers University. At the time of the project, she was Science Education Coordinator at SD#73 and the lead in the partnership between researchers and teachers at SD#73. She was a collaborator on the project and she contributed greatly to the project at all stages.

Dr. Naowarat (Ann) Cheeptham is a professor of microbiology at Thompson Rivers University. She was a co-applicant on the grant application for this project and she contributed significantly to the organization of the Community of Inquiry meetings and the Open Education Resource.

Dr. Michelle Harrison is Senior Instructional Designer and Assistant Professor at Thompson Rivers University. She was a co-applicant on the grant application for this project and she contributed significantly to the project design, the Open Education Resource design, and the Community of Inquiry meetings.

Elizabeth DeVries is the education technology coordinator at SD#73. She was a collaborator on the project, and she contributed significantly to the Community of Inquiry meetings.

Grady Sjokvist is a physics teacher at SD#73 and an instructor in the STEM program at Thompson Rivers University. He was a collaborator on the project and he contributed significantly to the Community of Inquiry meetings and the Open Education Resource.

Christine Miller is a senior lecturer at Thompson Rivers University. She was a collaborator on the project and she contributed significantly to the Community of Inquiry meetings.