Integrating Literature into STEM to Promote Inclusivity and Foster Holistic, Transdisciplinary

Learning Environments

by

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Abstract

The goal of this study is to examine the integration of literature, defined as any form of short or long fiction and/or non-fiction, or poetry, into secondary STEM (science, technology, engineering, and mathematics) classes in British Columbia, Canada. The data were collected through interviews with nine secondary STEM subject teachers and focus on teachers' perceptions of the effects of including literature, what/how literature has been included, and the perceived barriers to doing so. Interviews were conducted online via Zoom and coded using NVivo software.

A review of the literature demonstrates that integrating literature into STEM can be appealing to a broad range of students and teachers and can help to engage students with a variety of interests, perspectives, and backgrounds. Literature can facilitate the inclusion of a variety of perspectives (i.e., Indigenous ways of knowing). The arts, including the literary arts, are a part of STEAM education, which focuses on interdisciplinary or transdisciplinary approaches to education. Furthermore, due to its multiple disciplinary nature, literature can present opportunities for students to learn holistically and help them to better understand the context of the content they are studying. Interview data suggest that literature can also help to make lessons memorable, build community within the classroom, and create opportunities for students and teachers to authentically represent themselves and the subject matter. Through exploration via a variety of educational approaches, students may be better able to find a pathway to engage with a subject.

Participants in this study described several barriers they have faced in choosing to integrate literature in STEM classes, including time constraints, locating appropriate literary

material, and managing the expectations of students, colleagues, administrators, and parents. However, the participants in this study all stated that they would continue to include literature in their classes in the future, despite the perceived barriers, and offered advice for teachers who may not yet have attempted to do so. The participants also found that student reactions to literature in STEM classes is generally positive, and they described some ways in which their assessment practices may change when integrating literature (i.e., marking holistically or using rubrics).

Lay Summary

This study looks at the effects of including literature (short or long fiction and/or non-fiction, and/or poetry) in secondary STEM classes in British Columbia, Canada. When teachers include literature in their classes, it can help a wide range of students become interested and connect to the subject. Literature can help more students feel included and can be a way to introduce information and views from other cultures and perspectives. It can also help all students understand how their learning is relevant and how it fits into the big picture in a memorable way. Although there can be some challenges, such as time constraints, trouble finding appropriate resources, or difficulty in managing expectations, the teachers involved in this study expressed that the positive outcomes they saw were worth the effort.

Preface

This study required an ethics review by UBC's Behavioural Research Ethics Board (BREB approval H20-03956). I created the proposal, conducted all interviews, analyzed the data, and did the writing in consultation with Dr. Penney Clark (supervisor) and Dr. Susan Gerofsky (committee member).

Table of Contents

List of Abbreviations

STEM: Science Technology Engineering Math

STEAM: Science Technology Engineering Art Math

STREAM: Science Technology Reading Engineering Art Math

Tchr. A-I: Refers to study participants (see section 3.3.1)

Glossary of Terms

Bernard C. K. Choi and Anita W. P. Pak (2006) offer the following definitions; the three terms, multidisciplinarity, interdisciplinarity, and transdisciplinarity, "refer to the involvement of multiple disciplines to varying degrees on the same continuum" (p. 351).

- "*Multidisciplinarity* draws on knowledge from different disciplines but stays within the boundaries of those fields

- *Interdisciplinarity* analyzes, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole

- *Transdisciplinarity* integrates the natural, social and health sciences in a humanities context, and in so doing, transcends each of their traditional boundaries" (Choi & Pak, 2006, p. 359)

They suggest that "for the more general situation, the term 'multiple disciplinary' should be used when the level/nature of involvement of multiple disciplines is unknown or unspecified" (Choi & Pak, 2006, p. 359). I will follow their recommendation for this paper.

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And thank you to my friend Dana MacDonald, for encouraging, listening, and offering advice.

Chapter 1: Introduction

One afternoon, shortly before I started graduate school, I was driving while listening to CBC radio and happened upon a discussion about calculus. The show's guest, Steven Strogatz (McDonald, 2019), was an author who is passionate about mathematics and had written a book about seeing calculus in the world around us (*Infinite Powers: How Calculus Reveals the Secrets of the Universe)*. Given that I am a language arts teacher and avid reader, my curiosity was sparked in a way that had never occurred during high school math classes. It sounded like a great foundation for a project: students could examine how "mathematics interweaves with the fabric of the Earth," as David Jardine would suggest (1990, p. 112). Perhaps students could use the skills acquired in their language arts classes to interpret their findings in calculus. Students could possibly understand math in a different way, potentially increasing their perception of the relevance in their studies, and perhaps drawing a different type of student into the concepts. It is also possible that a fresh, integrative perspective could escalate student engagement for those who might not normally consider math class a favourite.

However, the potential benefits of integrating literature need not be limited to mathematics; in the current BC Curriculum, communication is one of the core competencies and the government recognizes that "literacy... [is] fundamental to all learning" and should be "applied in all areas" (Government of British Columbia, 2020). We have an opportunity to use literature in an effort to refocus learning around themes and relevant inquiry questions, as opposed to framing education by subject matter siloes. Thus, a multiple disciplinary approach to learning and the integration of literature beyond language arts classes could be used as a step towards creating a more holistic curriculum.

1.1   Positionality

I have been a language arts teacher at the secondary level for fifteen years, and as such, I have used a wide variety of literature in my own lessons. I have first-hand experience with holistic approaches using literature as a connector through literature circles and science fiction. I understand the power of literature and its ability to transcend subject boundaries. For example, I taught environmental sustainability in English 12 using a multi-modal approach; my classes examined the topic through documentaries and scientific writing, as well as through poetry, fiction, and art. I have been able to introduce literature from a variety of perspectives, particularly that of Indigenous authors, in an effort to help students from a variety of cultural backgrounds to see themselves represented. As a person with a settler background, I seek to learn and understand more about Indigenous peoples and how I can contribute to decolonizing educational approaches and frameworks, while helping to create inclusive, non-hierarchical classrooms.

I know that for many students, literature is engaging and offers a way to connect to the world around them. Even for myself, reading literature introduces me to new ideas that spark my interest and compel me to seek further information and perspectives on a topic that may not have seemed interesting in previous contexts. I've started to see this effect in my young daughter through the questions she asks while we are reading together: For instance, "why do fireflies light up?" during *James and the Giant Peach* (Dahl, 1996) and "why is there no gravity in space?" during *Charlie and the Great Glass Elevator* (Dahl, 2001). Her inquiry offers an opportunity to explore new topics and she is more engaged because she is the one who initially asked the question. Integrating literature provides readers with a chance to understand the complexities of situations that they would never otherwise have the opportunity to experience. I

have never taught any STEM classes, but I am interested in exploring whether the experiences I have had in language arts classes, particularly with the use of literature, are transferable and equally beneficial in those environments as well.

1.2   Research Questions

My research focuses on the results, and potential benefits, of including literature in STEM (science, technology, engineering, and mathematics) classes. Therefore, I needed to begin by looking at how teachers are already approaching the integration of literature into STEM subjects. By hearing about what teachers have tried, I can gain an understanding of what works effectively as well as what support teachers may need in order to initially try this concept. My research questions are as follows:

- How do BC teachers describe their use of literature in STEM classes?

- What do BC teachers perceive as the effects of integrating literature into STEM subjects?

- What do BC teachers perceive as the barriers to integrating literature and STEM?

- What are the implications of this research for the integration of literature into STEM subjects?

Chapter 2: Review of Literature

2.1   Fragmented Learning and Relevance in STEM Education

The majority of BC public secondary school education is completed in "profound disintegration" with subjects taught independently from one another by different teachers (Jardine, 1990, p. 109). When learning is fragmented through the division of "knowledge into subjects, units, and lessons," students may lose the ability to find the connection between their school work and the realities outside of their classrooms; consequently, students might not be able to "see the relationship between... subjects, the relationship between facts within a subject, or the relevance of the subject to life," and the real purpose of education is lost (Miller, 2019, p.6). William E. Doll, Jr. recommends "connect[ing] each discipline to the larger culture in which it appears" because the "richness of a curriculum is largely sacrificed by over-specification" (Noddings, 2019, pp. 176-177). Doll (2003/2012d) also explains that "discrete facts in and of themselves are quite useless" and it is only when "facts [are] embedded in a matrix of relationships" that they allow for real understanding to occur as well as the development of knowledge (as cited in Zhang, 2019, p. 34). While all subjects suffer from "compartmentalization and standardization" (Miller, 2019, p.5), according to Camilla Schreiner and Svein Sjoberg's (2005) research, "the lack of relevance of the [science and technology] curriculum is seen as one of the greatest barriers for good learning", and contributes to "low interest... and lack of motivation for pursuing the subject in... higher education" (p. 2). Their study found that despite having a positive outlook on science and technology, many students are less likely to pursue a career in those fields than in areas unrelated to STEM.

Students can easily become disinterested when faced with teacher-centric teaching methods and fragmented information (Flynn & Hardman, 2019; Grey, 2013; Hatch, 2018; Klassen & Klassen, 2014; Schreiner & Sjoberg, 2005). When "STEM is decontextualized from real life", learners may not be able to understand the relevance of content they are learning, which may lead to disengagement (Banack, 2018, p. 46). By erasing the borders between subjects, students may be better able to see the "interrelatedness, interdependency, or interconnectedness" in all subjects which could help them become well-rounded, well-prepared individuals (Jardine, 1990, p. 110). Similarly, John P. Miller (2019) argues that there are "three basic principles in holistic education: balance, inclusion, and connection" and that the aim should be to "help the student find a sense of purpose in life" (p. 9). Moreover, students have lived experiences and interests that are unique to each individual. Teachers can help increase student engagement by allowing and encouraging idiosyncrasies and independent thought through transdisciplinary projects in the classroom (Henriksen, 2014; Herro et al., 2016). Conversely, when student voices are not heard or they cannot identify the relevance of what they are learning, students can display "a variety of behaviours such as disengagement, [and] class disruption or the search for a more personally relevant education outside school" (McGregor, 2009, p. 347). Multiple disciplinary education may enable students to discover the world around them and explore paths of personal interest in a relevant and contextual way, without being confined to a single subject matter at a time.

2.2   STEM or STEAM?

One vision of integrated learning is STEAM (science, technology, engineering, arts, and math), and "paradoxically, as arts electives continue to be eliminated first in budgetary belt-tightening, and as parents continue to dissuade their children from majoring in art, the arts are

being recognized as essential to innovation" (Wynn & Harris, 2012, p. 42). STEAM education emphasizes the connection between subjects that were previously seen as unrelated (Guyotte et al., 2015). Although the A in STEAM represents Art, that category is not limited to visual art and design, but encompasses language arts and humanities as well: "STEM disciplines can benefit from an artistic infusion that connects disciplines in ways that are powerful and motivating for learning" (Henriksen, 2014, p. 4). Furthermore, STEAM education must go beyond the narrow view of simply adding arts to existing STEM curricula and actually re-envision the way we approach STEM education (Henriksen, 2017; Jolly, 2014). The arts in STEAM are not a superfluous add-on, they are of "equal importance" (Wynn & Harris, 2012, p. 42). Toni Wynn & Juliette Harris (2012) assert that with an integrated STEAM approach, "art students [can] become better technicians and conceptual thinkers... while science students [can] become more imaginative and innovative" (p. 47). STEM can be "made more complete through its relationship with the arts" and their unification can help "to make science learning more authentic and engaging" (Braund & Reiss, 2019, p. 221). Thus, STEAM education can be beneficial for a wide range of learners.

STEAM offers an alternative to fragmentation in education and strives to develop life-long learners (Helfferich et al., 2014; Yakman & Lee, 2012). STEAM education acknowledges that students have a variety of interests and strengths, and that an integrative approach can make subjects more broadly accessible. For example, students who feel uncomfortable in STEM classes may feel very comfortable in language arts classes, so for those students, literature may help them better connect with the subject matter (Vardell & Wong, 2015; Wynn & Harris, 2012). In STEAM, there is an expectation that students will approach tasks in different ways and, consequently, they may find a variety of methods to demonstrate their learning. There is also an

emphasis on contextually-based, experiential learning (Guyotte et al., 2015; Jolly, 2014). Martin Braund and Michael J. Reiss (2019) explain that "a STEAM approach constantly reiterates the importance of a local, relevant problem to solve, drawing in the arts and humanities as well as STEM content as a natural consequence of researching and communicating solutions" (p. 226). Moreover, "the hands-on, creative aspect" is embedded in integrative STEAM projects where students are working towards "creating a broader, deeper understanding" of each subject and their interactions (Helfferich et al., 2014, p. 2).

Punya Mishra, Matthew J. Koehler, and Danah Henriksen (2011) describe "seven cognitive tools" that cross the boundaries between subjects and form the basis of "trans-disciplinary knowledge": "perceiving, patterning, abstracting, embodied thinking, modeling, play, and synthesizing" (p. 24). In school, these tools help to build a bridge between subjects because they are useful in all disciplines for "integrat[ing] different solutions, viewpoints, or perspectives", and allow students to "creatively move across multiple disciplines, to cross-pollinate ideas between domains" (Mishra et al., 2011, p. 24). Rather than focusing on content, emphasis is on the procedures and knowledge structures that transcend disciplinary cells; the attention is on developing skills rather than memorizing facts. Content is learned through exploration and discovery in a less restricted way. Many of those same cognitive tools are relevant during the study of literature, which is rarely limited to one subject. For example, writers and poets "rely on their knowledge of linguistic patterns and structures" when "dream[ing] up a new story [or] poem", but patterning is also important for architects during the design process, as well as musicians, mathematicians, and many others (Mishra et al., 2011, p. 25). Modelling these skills through literature studies could equip students with a more in-depth understanding of how to apply those same tools to discovering the world around them and

making connections. Therefore, a creative, integrative approach to education can help to develop well-rounded students who can transfer their skills, think critically, and innovate in a variety of environments (Braun & Reiss, 2019; Marmon, 2019).

2.3 Indigenous Ways of Knowing and STEM

The disparity between learning in context and traditional schooling has been especially pronounced in the Eurocentric education offered here in Canada. Annamarie Hatcher, Cheryl Bartlett, Albert Marshall, and Murdena Marshall (2009) explain that "Western Sciences emphasize knowledge that is compartmentalized into disciplines" (p. 151). Furthermore, in our current system, there is a tendency for skills to be unrelated to context (Munroe et al., 2013). In Canada, we are now striving to decolonize our educational system which "will require a shift in perspective and action" (Howard & Kern, 2019, p. 1144). Thus, it is the responsibility of "scientists and educators to acknowledge... that the dominant western paradigm is not the only way to engage in science" (Howard & Kern, 2019, pp. 1135-1136). Although the inclusion of Indigenous knowledge in the curriculum is a step forward, making space for an integrated framework based on context would be an appropriate follow-up. Marie Battiste (2005) asserts that our current Eurocentric system "confines education to a narrow view of the world" and that a more holistic approach is more in line with traditional Indigenous educational values (p. 12). Historically, Indigenous education was relevant because the learning was reflective of what happened around the learner. Therefore, the process of decolonization necessitates an understanding that, for those who wish to continue traditional practices, the knowledge that Indigenous peoples "pass on to their children comes through daily living" and "seasonal activities particular to place" and, thus, is intrinsically linked to context (Battiste, 2017, p. 171). International organizations, such as the United Nations Educational, Scientific and Cultural

Organization (UNESCO) and the International Council for Science (ICSU), also recognize the need to combine and mix subject matter in order to better reflect the needs of Indigenous learners globally (Battiste, 2005). Deirdre Helfferich, Jan Dawe, Zachary Meyers, and Nancy Tarnai (2014) promote an approach where classes meld "technology, art, and science with traditional place-based narratives" because "by studying a specific site through a story... students gain a deeper appreciation of, and sense of connection to, their local landscape" (p. 8).

Four Arrows & Miller (2019) argue that Indigenous education is actually the foundation of the current holistic education movement and that the two approaches have many overlapping ideas, such as interconnectedness between people and the earth. Because a "holistic curriculum is based on the principles of connection, balance and inclusion", Hatcher (2012) argues that it is imperative to "[create] a community within a classroom and between the class and the community outside the school" with the teacher acting as a "facilitator who can guide the educational process without dominating" (pp. 352-354). Furthermore, an Indigenous approach to education blends STEM and arts-based learning (Hatcher, 2012). However, Cornel Pewewardy (2002) also explains that "although some research may identify patterns of learning among" Indigenous peoples, "a wide variety of individual differences have been identified" (p. 23); thus, we must be cautious in generalizing about large groups of individuals. Furthermore, in the same way that the arts cannot simply be added into STEM education without a re-design of the curriculum (Henriksen, 2017; Jolly, 2014), integrating Indigenous knowledge cannot be an "*add and stir* method of cultural topics" and requires fundamental change (Battiste & Henderson, 2009, p. 15). Stavros Georgios Stavrou & Dianne Miller (2017) also point out that teachers generally "only includ[e] a token amount of traditional Indigenous knowledge in – but not

integrated with – school science" which is not effective in creating an inclusive and holistic learning environment (p. 105).

Indigenous learners are less likely than non-Indigenous students to pursue STEM education, and subsequently, careers in STEM fields (Aikenhead & Elliott, 2010; Stavrou & Miller, 2017). This "disparity in education" can occur for many reasons, including circumstances of "racism at the institutional, social, political, and educational levels", and is not limited to "cultural differences in learning styles" (Stavrou & Miller, 2017, pp. 97, 100). However, "culturally relevant... curricula [can] connect the student with their heritage" and provide a "bridge between his or her world on the reserve… or in the community and the different world that may... exist in the school" (Pewewardy, 2002, p. 30). When STEM education is not inclusive, students may resist, disconnect or become marginalized (Aikenhead & Elliott, 2010; Snively & Williams, 2008). However, feeling represented and being visible in the STEM curriculum can help Indigenous students to connect to STEM subjects (Pewewardy, 2012; Snively & Williams, 2008; Stavrou & Miller, 2017). The data generated by a five-year study of students in British Columbia suggest that when there is a commitment to integrate Indigenous content and perspectives, there is a positive effect on Indigenous student achievement at school (Richards et al., 2008). Indigenous content includes "the integration and revitalization of Indigenous histories, experiences, values, knowledge, and localized content in the curriculum", which can help to decolonize STEM curricula and may allow students who are often marginalized to feel represented (Stavrou & Miller, 2017, p. 98).

The concept of Two-Eyed Seeing involves incorporating Indigenous knowledge and Western STEM learning in a mutually beneficial fashion (Aikenhead & Elliott, 2010; Hatcher et al., 2009; Munroe et al., 2013). Hatcher et al. (2009) explain that "in the Mi'kmaq language,

Toqwa'tu'kl Kjijitaqnn (Integrative Science) means bringing knowledges together" and that

"Two-Eyed Seeing intentionally and respectfully brings together… different ways of knowing"

(p. 146). Science literacy can involve looking at subjects through more than one lens in a way

that "affirms Aboriginal science knowledge" while it "establishes and supports... cross-cultural

science teaching" (Snively & Williams, 2008, p. 129). Thus, an "Integrative Science" approach

to STEM education "incorporates a more holistic mindset and is transcultural as well as

multidisciplinary, multidirectional, and multisensory, with the total environment as the

laboratory" (Hatcher et al., 2009, p. 146). Elizabeth Ann Munroe et al. (2013) assert that

combining Indigenous knowledge and 21st century learning, which emphasizes "critical thinking,

creativity, collaboration and communication," could realistically "benefit all learners" (p. 319).

Similarly, in Robin Wall Kimmerer's (2013) view, "science and traditional knowledge" enhance

one another; therefore, "we see the world more fully when we use both", because then "the

beauty of one is illuminated by the radiance of the other" (pp. 46-47). Unfortunately, there are

limited options for curricular materials designed to support secondary teachers in creating a

holistic learning environment (Hatcher et al., 2009). However, studying literature in STEM

classes has the potential to help fill that gap.

2.4   Integrating Literature into STEM Education

The incorporation of literature could be a starting point for a more holistic approach to

STEM education. John Jerrim and Gemma Moss (2019) assert that "the ability to read is a

fundamental life skill, which is critical to participating effectively within both society and the

workplace" (p. 181). Literature can include fiction and non-fiction novels and stories, as well as

poetry, and "books do not have to be taught or read in their entirety" to be a meaningful addition;

in any class, "books can offer stories, tidbits to make lectures more captivating, [and] poetry

[can] add beauty and wonder to the topics in a curriculum" (Kane, 2020, pp. 3, 86). Literature is not limited to a single subject and can therefore be easily used as a starting point to help students understand the real-world implications of what they are learning in class. Stories can be a bridge between students and the concepts and theories they are trying to learn (Flynn & Hardman, 2019; Klassen & Klassen, 2014). In addition, reading "widely and deeply" builds students' "background knowledge and ability to comprehend the course content" (Kane, 2020, p. 6). Furthermore, "real world problems are not solved with discrete and decontextualized facts", so a holistic, literature-based approach to education allows students to see the bigger picture in learning (Henriksen et al., 2015, p. 458).

In literature, poetry can often be overlooked; however, it can serve as a powerful resource for STEM education (Farlow, 2017; Helfferich et al., 2014; Kane, 2020; Vardell, 2019; Vardell & Wong, 2015). Although STEM and poetry may be viewed as "antithetical" to many, ultimately, these fields have a common goal: they attempt to develop our "understanding [of] how human beings fit into the world" (Major, 2011, p. xv). Mathematics, in particular, is often "presented as a wholly abstract discipline, devoid... of human emotions... and artistic expression"; however, this approach does not allow students to experience the "abstract beauty of mathematical ways of knowing" which can be explored through the arts (Gerofsky, 2019, p. 58). Sylvia Vardell (2019) argues that "we can connect thematic poetry collections with those same topics" in STEM classes in an effort to create deep, meaningful connections for the students (p. 100). Poetry can be particularly impactful for "students, who are used to texting, tweeting, and engaging in short-form communication" as they "can find the same powerful conciseness and focus in poetry" (Vardell, 2019, p. 101). Additionally, Sharon Kane (2020)

suggests that poetry can lead to long-lasting learning through meaningful and memorable connections and, therefore, deserves specific consideration in STEM classes.

Philosopher Martha Nussbaum (2010) emphasizes the importance of literature in democratic societies and how critical it is for the development of empathy in humans. The arts, and literature specifically, can create scenarios where students must see the world through another point of view (Kane, 2020; Magee et al., 2019; Mishra et al., 2011; Nussbaum, 2010). It allows readers to see others as more than "just a body", which is particularly important for scientists and people working in STEM fields (Nussbaum, 2010, p. 102). Jennifer Boger (as cited in Galloway, 2021) suggests that employing a cross-curricular approach to ethical discussions is important because often the groups that are "building tech", for example, are not the same groups who are "asking questions about impacts and ramifications of tech", and there is a perception that "it's not one's job to consider the other"; however, if STEM can be "unsilo[ed]", there would be "more crossover so that the people building [tech] can talk to the people who are passionate about the implications of it and vice versa" (para. 46). Literature, especially science fiction, could offer all STEM students opportunities to contemplate ethical questions and extrapolate potential outcomes (I will discuss science fiction further in section 2.5).

Paula A. Magee, Aimee Lee Govett, and Jane H. Leeth (2019) also suggest that using non-fiction literature helps "students develop a sense of social consciousness and empathy" (p. 126). Literature can promote the development of empathy through "bring[ing] students in contact with issues of gender, race, ethnicity, and cross-cultural experience and understanding" (Nussbaum, 2010, p. 108). Students who do not normally see themselves or their cultures represented in the STEM curriculum can feel that classmates respect their culture and take an interest in it through the integration of culture-specific literature (Nussbaum, 2010). Similarly,

Kane (2020) states that one of the many benefits of reading is empathy and that "informational books can promote science... literacy" as well as an "understanding of many different cultures and people" (p. 29). It is important for a teacher not only to accept diversity, but to affirm and normalize it in the classroom; therefore, a teacher who includes a variety of reading selections (ie., representing various cultures, backgrounds, and experiences) helps to make "the classroom into a safe haven where differences are recognized as resources and assets that can add richness and vibrancy" (Lieber, 2009, p. 95). Thus, the integration of literature can be a tool for promoting inclusivity and respect for diversity in the classroom. Moreover, narratives can also "[humanize] science through the use of history" and "make it clear that scientists do not work in isolation", hence supporting the concept of collaboration which is integral in STEM (Flynn & Hardman, 2019, pp. 133-134).

Arguably, a student's interest in the subject matter is one of the most influential factors in education, which is also associated with long-term memory retention (Klassen & Klassen, 2014). What is taught in a curriculum, although important, is not the only factor to consider; Nel Noddings (2017) asserts that "how those subjects are taught, how they connect to the personal interests and talents of the students who study them, and how skillfully they are laid out against the whole continuum of human experience" deserves equal consideration (p. 203). Furthermore, "repress[ing] interest... weaken[s] intellectual curiosity and alertness... [and] suppress[es] initiative" (Dewey, 2017, pp. 38-39). Therefore, variety in instructional techniques and perspectives can be important when attempting to connect the subject matter to a wide range of learners. Literature is one way to allow the "reader or listener" to process "the story both emotionally and cognitively"; thus, "the primary vehicles" for science instruction should be "the science story, hands-on activities, and social interaction" (Klassen & Klassen, 2014, pp. 134,

147). Integrating arts "leads to more motivated, engaged, and effective disciplinary learning in STEM areas" (Henrikson, 2014, p. 2). Danah Henriksen (2014) describes a previous winner of the National Teacher of the Year award (in the United States), and explains that his "arts-based approach has meant better science achievement scores, but also that his students are more excited about science" as well as "more motivated and curious" (p. 4). Not all students respond positively to traditional STEM teaching; therefore, in order to capture the interest of a variety of learners, a multiple disciplinary approach can be very effective.

Additionally, Hanke Korpershoek, Hans Kuyper, and Greetje van der Werf (2014) establish a connection between reading skills and achievements in math classes; their findings suggest that incorporating reading comprehension in STEM classes could aid creative thinking, problem solving, and following instructions, among other benefits. Stanley J. Farlow (2017) also notes a connection between reading and math skills, as well as an increased engagement in math. There is evidence that "students who are taught mathematics with connections to storytelling become better problem solvers for problems related to the real world" (Farlow, 2017, p. 581). Peter MacMillan, Catherine McGregor, and Barbara Old (2005) describe an overarching belief among students that math is "culturally neutral" although this is not the reality (as cited in Stavrou & Miller, 2017, p. 105); the "lack of cultural relevance in teaching mathematics" could be contributing to "Indigenous students' lower achievement" and disengagement in math classes (p. 111). Thus, integrating mathematics-related literature involving a variety of cultures could help to create a more inclusive environment for students who do not see themselves represented in the curriculum. Furthermore, "there is some hesitation to infuse... language tasks into science and mathematics" despite the "recognition that numeracy and science literacy involves communications to inform others and persuade people" (Yore et al., 2003, p. 2003).

15

Several articles discuss the importance of writing in science or STEM classes (Emerson, 2019; Norris & Phillips, 2003; Strube, 1996; Yore et al., 2003). Successful scientists are able to communicate effectively in a variety of forms: "oral and written communication and the processes of speaking, listening, writing, and reading are highly valued within the scientific community" (Yore et al., 2003, p. 693). In order to teach science literacy, science curricula must include text (Norris & Phillips, 2003). However, STEM educators may need to be convinced that integrating writing and language arts skills is a legitimate and effective method of developing science literacy (Yore et al., 2003). Lisa Emerson (2019) expresses frustration at her students' inability to see the relationship between written communications and STEM, as well as the connection to life beyond the classroom. As a result, she argues that "we must revise our elementary and high school science curricula to include authentic opportunities to develop writing skills and to embed positive writing-related attitudes and beliefs in our K-12 students" (Emerson, 2019, p. 177). In his article, Paul Strube (1996) describes the Australian National Chemistry Week (ANCW) short story competition that blended narrative writing and chemistry. The goal of the competition was to "show the possibility of using science knowledge as a component of the stories we tell each other everyday, rather than as something confined to a laboratory or industrial process" in the hope that through writing, science would become more relevant and meaningful (Strube, 1996, p. 248). Arguably, it is difficult to teach effective writing skills without incorporating and examining examples or samples. Therefore, the integration of literature would have a positive impact on students' writing ability in STEM classes, which could include scientific reports among other styles of writing, thereby offering students some variety in how they could communicate their learning.

2.5   Science Fiction and STEM Education

Although there are many forms of literature, and there can be a place for all of them in STEAM education, an easy starting point for teachers could be science fiction. Science fiction is founded on science and math principles. According to Charles L. Adler (2014), "accomplished" science fiction writers often have an understanding of the following areas: "basic physics, chemistry, biology, astrophysics, history (modern and ancient), sociology, and military tactics" (p. 2). Therefore, science fiction is an ideal resource for examining subjects from an integrative perspective. STEAM learning promotes experiential activities, but they may not always be possible; time and resource constraints can limit what teachers are able to manage in class. However, science fiction can allow students to experience science concepts in a new way as well as inspire discussion and reflection on complex, real-world problems (Cavanaugh, 2002). Therefore, the use of science fiction in STEM classes can increase student engagement and build interest (Cavanaugh, 2002; Kane, 2020; Knippels et al., 2009). Moreover, science fiction can help to "bridge the gap between real science and school science" by allowing students to see the concepts they are learning used practically (Nunan & Homer, 1981, p. 317). Students are able to use their imaginations to go beyond what is possible, escaping the constraints of the real world, while opening the door for some truly creative and innovative thinking (Bucher & Manning, 2001; Kane, 2020).

Science fiction reminds readers that science is neither devoid of politics nor context. Its analysis can provide a starting point for students to reflect on "how science affects individuals as social beings" as well as how science is "shaped by social factors and responds to social change" (Nunan & Homer, 1981, pp. 317, 327). Students will have the opportunity to look at science in a human, interconnected way as opposed to striving for neutrality and being disconnected from the

real-world applications of the knowledge they are learning. This shift may be useful in captivating a broader spectrum of student, drawn into seeing science from a different perspective. As this genre looks at STEM through a more social, human lens, it can provide opportunities for the inclusion of a variety of voices and cultures. Specifically, there are many examples of science fiction novels by Indigenous authors that would very easily start conversations about indigeneity in a science context (ex. *The Marrow Thieves*, by C. Dimaline). Although STEM teachers should not be limited to science fiction, this genre can be a good fit, and natural starting point, for those who wish to introduce literature into STEAM curricula.

2.6   Literature Circles in STEM Classes

One possible method for integrating literature in STEM classes is literature circles. Literature circles offer a technique for studying literature collaboratively in any class as they are simply "small, peer-led discussion groups whose members have chosen to read the same story, poem, article, or book" (Daniels, 2002, p. 2). In fact, Harvey Daniels (2002) proposes that the name may have been a "mistake" as it "implies that the structure works only for fiction and only in reading or language arts classes" when, in reality, any class can benefit (p. 200). Teachers can easily experiment with using this technique by scheduling discussions around existing class structures, such as lectures or experiments, and they can test out this method for a few weeks without much change to the units that they would normally do. Alan Colburn (2010) suggests that literature circles could be an effective addition to STEM classes, particularly in units where there are not as many opportunities for hands-on learning.

Essentially, literature circles can broaden students' understanding of science and increase engagement (Calmer & Straits, 2014; Colburn, 2010; Magee et al., 2019; Straits, 2007; Straits & Nichols, 2006). "Students learn best when they can connect abstract ideas to real events" and

view concepts from a variety of perspectives (Magee et al., 2019, p. 126). Therefore, when

"selecting books to use, it is beneficial if the topic(s) covered in the text parallel concepts taught

in class" (Straits, 2007, p. 35). Although reading selections should be relevant to the topic, they

should also be interesting, relevant to the students, appropriate, and accessible (Magee et al.,

2019). Having students choose their reading material from a list of options provided by the

teacher, as well as a choice of assessment options can help increase engagement (Daniels, 2002;

Magee et al., 2019; Straits, 2007). Additionally, collaboration and discussion enhance learning,

but, in order for these methods to be effective, students need some freedom (Grey, 2013).

Conversations allow students the freedom and responsibility to explore areas of interest within

the text in an organic way. When a teacher first introduces this method, students are given

specific roles which help to teach them how to communicate and create meaningful discussions

with peers; over time, these scaffolds are removed once students have a better understanding of

how to participate and moderate discussions themselves (Daniels, 2002). Therefore, to keep the

focus on students, literature circles necessitate that teachers become facilitators and allow

participants to explore and discover topics through inquiry (Calmer & Straits, 2014; Daniels,

2002; Newton, 2017).

2.7   Barriers to the Integration of Literature in STEM

Emerson (2019) argues that literacy integration in STEM subjects has not been widely

adopted because "years of professional development have failed to shift STEM teachers' own

entrenched negative literacy-related attitudes and beliefs", which then get passed onto the

students, and also "because literacy remains tangential to definitions of science in schools" (p.

177). Further research into the reluctance of STEM teachers towards arts or literature integration

would help to determine a method to get more teachers to participate in a new mode of

instruction. The reality is that "if science teachers continue to show little concern for text, see reading as merely a tool to get to science, or see reading as unimportant, then they are likely to reinforce this... view" with their students (Norris & Phillips, 2003, p. 230). Therefore, the more we can find ways to create supportive environments and resources for teachers who want to explore an integrative approach to STEM education, the more likely there will be a lasting shift in the way we approach curriculum development, thereby creating a more inclusive, holistic way of learning that can address a diverse student body.

Assessment expectations could also be a challenge for teachers who are used to quantitative forms of assessment, such as tests and quizzes. In contrast, the humanities and arts tend to include more opportunities for qualitative assessment, including rubrics and self-assessment. Working holistically differs from traditional education in both its efforts to bring subjects together by working on projects through a multiple disciplinary lens, and also its challenge in not being easily "controlled or planned"; thus, the curriculum "cannot be delivered equally to students" (Yakman & Lee, 2012, p. 1078). Not all students will exit the class with the exact same knowledge, especially as a teacher introduces more choice and flexibility to explore personal interests, and that can be a challenge for teachers who expect to assess via tests. "Legitimiz[ing] multiple models of excellence" is way of recognizing that there are many different types of learners and a plethora of paths to success (Noddings, 2017, p. 200). Unfortunately, teachers may feel "that young people are incapable of making reasonable decisions" and it is this assumption that makes educators wary of incorporating freedom, choice, and curiosity into classes (Grey, 2013, p. 59). When there is an over-reliance on testing and an increase in standardization, it becomes "hard to defend the big chunks of time that good activities like lit circles require" (Daniels, 2002, p. 11). In opposition to a Neoliberal agenda, literature

circles, for example, are not efficient, they do not prepare students for tests, they cannot be

objectively assessed, and they will not directly help students get a job (Kumar, 2019). However,

that does not mean that integrating literature is not beneficial, just that it requires an examination

of the purpose of education and what type of learning we are trying to encourage, while being

open to including qualitative assessment strategies.

Chapter 3: Methodology

3.1   Theoretical Framework

Context and connections affect understanding; as Doll explains, "all reality is the reality of relationships, which is always in process" (as cited in Zhang, 2019, p. 33). I hold a relativist/subjectivist perspective: a view of education founded on relationships and the understanding that "people are complex, their social systems are complex, their morals and values and where they come from are complex" (O'Leary, 2017, p. 7). This perspective may explain why I am so interested in an authentic, holistic approach to education; in order to fully understand, a student needs to be able to see the big picture as well as their place in it.

Furthermore, education should be a dynamic experience, shifting to accommodate the varying needs and interests of learners; not "determinate" and not totally "preset before teachers and students have met" (Noddings, 2019, p. 178). The process of learning is important for both student and teacher, and I believe that "the process and the goal... are one and the same" (Dewey, 2017, p. 37). My classes are respectful and non-hierarchical, where elements of choice are embedded into projects and assignments, even assessment. As a teacher, I strive to facilitate and assist, not "to impose certain ideas or to form certain habits" (Dewey, 2017, p. 36). Students are natural learners and I want to encourage their "wonder, curiosity, and imagination" (Fenstermacher, 2000, p. 7). Thus, I tend to favour activities where students can take responsibility for their learning and pursue topics of personal interest, like literature circles.

Not only do I want my students to be aware of the big picture, but I want them to strive to improve the situation for themselves and for others. For students to be participants in the "public space", there needs to be a "cultivation of citizenship"; they will need to "be able to listen

attentively, hear views that contrast with [their] own, and be prepared to accept adjudication and compromise", skills which require guidance, practice, and the development of empathy (Fenstermacher, 2000, p. 6). Thus, students need to think critically about how their actions affect not only themselves, but the people and the world around them. Studying literature can offer students the opportunity to understand the way their learning fits in with other subjects, as well as their own connections to the course content and their peers.

3.2   Study Overview

In education, there can be a disconnect between theory and practice. Although I have attempted to explore the possibilities, and potential benefits, of literature and STEM, the published literature has only provided a narrow view of teacher perspectives on this topic. I wanted to discover what some teachers are actually doing in their classrooms to offer a holistic perspective and engage students through literature, as well as why other teachers may not make that same choice. Therefore, I examined the integration of literature in STEM subjects through a qualitative study using a phenomenological approach. Phenomenology is based on gathering and interpreting subjective description because "in a socially constructed, intersubjective world, our direct awareness is the only thing we can really know, since all knowing depends on individual perceptions" (O'Leary, 2017, p. 149). Through this lens, I hoped to better understand the lived experience of STEM teachers, as well as what effects their choices and feelings, in regards to literature, have on themselves and their students (O'Leary, 2017). I also wanted to identify any barriers, real or perceived, or hesitations towards adopting a more holistic approach to STEM education.

3.3 Locating Interview Subjects

I created a set of criteria to determine if a teacher was appropriate for this study. Specifically, I sought secondary school STEM teachers (any type of science class, digital media or technology, math, etc.) in British Columbia, Canada, who have included any form of literature (fiction, non-fiction, short, long, poetry, etc.) in their classes. I did not exclude retired teachers or teachers currently working in another setting. Also, I was open to speaking with teachers who may have tried including literature at one point, but no longer do.

In order to locate interview participants, I began by reaching out to former colleagues. I also posted on social media (ie., Facebook – see Appendix A). I primarily used a volunteer sampling method; although I tried to use a snowball sampling strategy as well, that was not successful (O'Leary, 2017). Online searches included trying to locate specialized programs involving STEM and literature or STEAM, as well as private schools with those specialties. I contacted the relevant Provincial Specialist Associations in BC (Science, Technology, and Mathematics) and also searched their websites and publications (e.g., *Vector*, the journal published by The British Columbia Association of Mathematics Teachers, or BCAMT) for any references to literature. Furthermore, I used the Government of BC website to locate contact information for each school district. I targeted staff members with district position titles that included innovation, or science, math, and technology support, for example, as I thought they may have a broader knowledge of what is happening in their district, as well as potentially having connections to a multitude of teachers. When I located a person who I thought might fit my research criteria, I would send an initial recruitment email (see Appendix B). Many of the people I emailed responded that they would forward my information to their colleagues.

3.3.1   *Participants*

Nine teachers volunteered to participate in this study. All of the participants teach or taught secondary school in BC, and all but one teach or taught in the public education system. One of the teachers is based in a rural setting while the rest of the teachers I interviewed teach in more urban spaces. The basic demographic information that I collected for each participant is as follows:

- Teacher A studied English and Spanish at university, and now teaches Spanish, English, and Computer Studies. This teacher has been teaching for 7 years, using literature from the beginning.

- Teacher B studied Mandarin, Linguistics, and math at university, and taught mostly English and math at secondary schools for 10 years. This teacher now teaches in a post-secondary setting.

- Teacher C studied biology, chemistry, and math at university, and currently works in an urban private school. This person has been teaching math and science for 9 years and has included some literature over the past 7 years.

- Teacher D studied math and social studies at university. They have been teaching math for 38 years and have included literature in classes since they started.

- Teacher E studied engineering, physics and math at university, and now teaches math, physics, science, and French, and has used literature since they started teaching.

- Teacher F studied biology, earth science, environmental education, and Spanish at university, and then taught science, biology, earth science, and English at secondary schools for 3 years as well as many years teaching in settings outside of traditional classrooms – they did not include literature while teaching secondary school often;

however, they included literature more frequently throughout their teaching in other settings. This teacher now teaches in a post-secondary setting.

- Teacher G studied history and geography at university and has been teaching computer science and social studies for 11 years at a rural secondary school. This teacher also teaches in an academy with a flexible schedule geared towards students interested in media, arts, and technology.

- Teacher H studied geology and earth & space science at university, and now teaches science, math, and earth science. This person has been teaching for 18 years and began incorporating literature in classes about 8 years ago.

- Teacher I studied physics at university, and now teaches math, physics, and science (also information technology in the past). They have been teaching for 23 years and have used literature since they started.

3.4 Interview Structure

I had originally intended to conduct interviews in person; however, that was not possible due to the Covid-19 pandemic. Increased safety measures meant that in-person interactions had to be discontinued and physical distancing upheld. Over the past year, I have communicated via several digital programs, such as Zoom, MS Teams, Go To Meeting, and Facetime; it took time for me to feel comfortable talking to others online, especially when I could see myself speaking. The shift to online communication for work, schooling, and socializing has made many people more familiar with digital communication and, as a result, discomfort speaking with others online is likely less of a barrier since the start of the Covid-19 restrictions. Although I could not get a sense of the full body language of the interviewee, I was still able to see gestures and facial expressions; however, I did find that not being able to make eye contact was challenging at first.

26

Researchers have documented positive experiences using synchronous digital communication programs, such as Skype, for their interviews (Iacono et al, 2016; Janghorban et al., 2014). Not only are these programs useful when interviewing in person is not possible, they do offer some advantages.

There are several benefits to conducting interviews digitally. For example, researchers do not need to find an interview location, which can be costly, unfamiliar, uncomfortable, or noisy, allowing each participant to remain in the comfort of their home (or chosen location), which can also be more environmentally friendly. Further benefits of online interviewing include being able to see non-verbal cues and facial expressions (unlike during phone interviews), to record interviews easily, and to increase accessibility for a wider range of participants. Moreover, when an interview is done in a person's home, they may have access to artefacts, photos, and videos that they would not have brought to an interview; for example, two of my interviewees used the chat feature to send me links and poems, and another was able to show me a book that they had used in their classroom. Valeria Lo Iacono, Paul Symonds, and David H. K. Brown (2016) found that people tended to talk longer when they were in their own space, doing an interview online. The interviews I conducted ranged from 25 minutes to 1.25 hours (my initial estimate for interview length was 30-45 minutes).

One concern for researchers is that not everyone has access to quality internet and a computer, which can hinder the democratization of research and limit potential participants. The teachers that I spoke with had no difficulty accessing and using the technology; however, there were several times while I was interviewing when I would experience unstable internet connections, which was frustrating for both parties. Iacono et al. (2016) also suggest that interviews on sensitive subjects might be better in-person because there can be some distrust of

software and technical issues which can create a break in intimacy. I used Zoom for my interviews and, currently, UBC has its own Zoom license and cloud storage; although Zoom is an American company, my data will be stored in Canada. Another concern is that conducting an interview in a person's home could violate their privacy by inadvertently disclosing something in the background. Due to the increase in online research, UBC has outlined a list of security measures for researchers, including allowing individuals to turn off their camera (if possible), using a nickname when signing in (to protect identity), and introducing a password. Zoom also offers filters to hide a participant's background in an effort to protect privacy. Using technologies owned by third parties and where/how data are stored can also be a concern: one of my participants had privacy concerns about using Zoom, so we conducted a telephone interview instead and I made a recording with a device that was not web-enabled.

3.5 Data Collection

I conducted one interview with each of my nine participants. The interviews were semistandardized: although I had a list of questions prepared ahead of time (see Appendix C), I allowed myself the flexibility to seek further clarification or details as I saw fit (Berg, 2004). Demographic questions included university preparation, number of years as a secondary teacher, and area(s) of specialization.

I had planned to record interviews while taking notes; however, I found note-taking distracting and I felt rude looking down to write because, online, my interviewee could not see what I was doing. I transcribed and coded the interviews immediately, as opposed to waiting to do them all at once at the end, which helped me to start identifying connections throughout the research process.

As I was studying human subjects, I was required to seek ethics approval from the UBC

Behavioural Research Ethics Board (BREB) and completed the Tri-Council Policy Statement:

Ethical Conduct for Research Involving Humans Course on Research Ethics (TCPS 2: CORE) in

preparation (BREB approval H20-03956). I did not and do not foresee any risks for the

participants in my study. All of my interview subjects are secondary and post-secondary teachers

who voluntarily consented; I hold no position of authority over the interviewees.

Roksana Janghorban, Robab Latifnejad Roudsari, and Ali Taghipour (2014) found that

there are no extra ethical issues when making the switch from in-person to digital interviews and

consent can be gained via email ahead of time. Furthermore, participants can easily withdraw

their consent, if they choose, by simply pressing a button to cut off communication (Janghorban

et al. 2014). The teachers I interviewed expressed no difficulty in reading, signing, and returning

the consent form (see Appendix D) digitally prior to our interview. At the start, I reminded the

teachers that they were being recorded; however, Zoom also notifies parties as they sign in.

3.6   Transcription

For the first three interviews, I did the transcription entirely myself. The first interview

was done by phone and all subsequent interviews were via Zoom. I had originally intended to do

partial transcriptions; however, as I was creating early transcriptions, I found myself questioning

what eventually would be useful or irrelevant, and, as a result, I ended up doing full

transcriptions of each interview. The focus of my research is on the content as opposed to the

linguistic choices of the speaker, so I focused on what was said and I left out most pauses,

gestures, and expressions of emotion, unless they seemed particularly important.

I initially thought I needed to make a transcript myself as part of the analysis. Steiner

Kvale (2007) indicates that transcription can be a useful process: "researchers who transcribe

their own interviews will learn much about their own interviewing style" and it can be a starting

point for analysis (p. 4). I also knew that Zoom's transcription would not be 100% accurate.

However, after completing three full transcriptions, I realized that my reluctance to accept a

Zoom transcription was a mistake: fixing a partially-accurate transcript was much less time-

consuming and I was still able to reflect on the content, perhaps even more so since I did not

have to listen closely to individual words while continually stopping to type.

In order for Zoom to make a transcription, I had to enable the auto-transcription feature,

which shows up on screen as captions. When each interview was finished, I copied the closed

caption file and pasted it into a word document. Because the Zoom transcription is not totally

accurate (around 70-80% accuracy), I would listen to the recording of the interview while

checking the transcript for errors and making corrections. The transcript that Zoom makes is

broken into time chunks, and both the audio/video and the transcript can be uploaded directly to

NVivo and coded directly. If an interviewer does not enable auto-transcription prior to the

interview, it cannot be done afterwards. At that point, the only option, besides doing the entire

transcription oneself, is to pay for Zoom's transcription services.

3.7   Coding: Traditional (by hand) vs. Using NVivo

As this was my first experience coding and analyzing data, I thought it would be

beneficial to try both traditionally (by hand) and digitally to see what felt most comfortable to

me. Coding means tagging a key word or concept so that others of the same type can be

identified and marked as being in the same category, which is key to content analysis and

grounded theory (Kvale, 2007). I coded my first interview by hand and, as per Saldana's (2016)

suggestion, I widened the right margin on my transcript to accommodate notes and codes, and

then printed out a copy. I started by circling words and phrases that stood out as potential In

Vivo codes, which I wrote in the right margin. Then, I read through the interview again and did "line-by-line coding", which Kathy Charmaz and Robert Thornberg (2020) assert "forces the researcher to take a fresh look at the data, compare fragments of these data, and ask analytic questions about them" (p.3). My goal, through grounded theory, is to understand my "research participants' experiences and perspectives" while "constructing new concepts that explicate what is happening" (Charmaz & Thornberg, 2020, p.3). The researcher must look at meaning beyond what is said or unsaid, and seek to identify relationships through interpretations (Kvale, 2007).

I attended a workshop on NVivo through the UBC library to familiarize myself with the software and to see if it would be a fit for my research. There are also many short videos on YouTube and I watched several to help me with specific parts, such as creating new nodes. Although doing the coding by hand was more straightforward and the researcher is not restricted by software limitations or complications, I do see the organizational potential of the software, particularly once I got a system in place. Because I had already coded one interview, I was able to look at the codes I had already generated; therefore, I started by entering those as nodes (codes). Then I grouped some of the nodes as parent-child hierarchies to try to organize myself a little more.

Digital analysis tools, such as NVivo, can be somewhat restrictive for researchers who prefer a non-linear, relational, or a more visual or kinesthetic approach: there is less space for ambiguity and data can become de-contextualized (Maher et al., 2018). However, I did not feel restricted by NVivo and felt that the software mirrored what I would have done with pen and paper had that been my only option. I like being able to see a list of my nodes as I am coding, and NVivo makes it easy to highlight sections and then assign as many codes as I feel is appropriate for that section. NVivo also offers the benefit of being able to code oral interviews

directly. I did try to code the audio transcript of one of the interviews, but I felt lost without being able to see the words. Although NVivo has many features far beyond what I will be needing for this particular research project, once I understood the basics, I found it to be a useful tool. Software can help manage and sort a lot a data efficiently while creating a data trail, which is important for demonstrating rigour in qualitative studies (Maher et al., 2018). Furthermore, my research is portable and I can easily do searches, and create coded memos for myself.

3.8   Data Analysis

After gathering data through interviews, I "explore[d] commonalities and divergences in the experience" of STEM teachers and their views on integrating literature in STEM classes (O'Leary, 2017, p. 151). I coded recurring themes and identified patterns, then used the data to draw conclusions (Berg, 2004). Through my data analysis, my goal was to reflect on the general experience of teachers integrating literature into secondary STEM classes and how that may be transferable to the larger body of STEM teachers in BC. Furthermore, the data collected reflect some of the barriers that teachers face when contemplating including literature in their classes as well as why a teacher may persist despite the challenges.

3.9   Study Limitations

My research relies on teachers' self-reported perceptions as my data collection was limited to interviews and the data reflect the unique, lived experiences of those teachers with whom I spoke. I also limited my interviews to secondary STEM teachers who have experience using literary resources in their classrooms already; therefore, the data will not reflect the views of teachers who have chosen not to include literature in their classes or teachers who plan to incorporate literature in the future. Limiting the teachers involved in my research allowed me to focus on the commonalities among that particular set of educators.

I received several responses from districts and teachers indicating that due to the Covid-19 pandemic restrictions, many teachers were already overburdened and unlikely to participate in my study. Although I was aiming for ten interview participants, I was only able to locate nine teachers who were willing to be interviewed.

For this study, I did not seek information from students, parents, or administrators. Therefore, in discussing student reactions, as well as parent, student, and administrative expectations, I am relaying the teachers' perceptions of reactions and expectations.

Chapter 4: Findings

4.1 Reasons to Include Literature in STEM

When I asked the teachers about why they feel compelled to include literature in their STEM classes, they had a variety of answers. All of the teachers responded that they would like to continue using literature in their classes in the future, either in the same capacity or attempt to do so more often. Several teachers indicated an interest in trying some new ways of incorporating literature, provided they can work through their particular barriers.

4.1.1 The Art/STEM Divide

The most frequently cited reason for including literature in STEM classes is that it can help to engage diverse styles of learners and appeal to a broad range of personalities. Many of the teachers recognized that their classrooms were comprised of students with varying interests and abilities; therefore, creating opportunities for all types of learners could help more students become interested in the subject matter and find space where they feel comfortable. For students where "math… [doesn't] feel like their thing", adding literature can be "just… another pathway in" and could "[give] a different feel" to the course (Tchr. C). For certain math students, including literature "gives them meaning for being in the course, because for the most part, the language of numeracy and numbers really is kind of hard for them", thereby helping more students to better understand and connect with the course material (Tchr. H). Literature can provide students with another way to explore STEM and offer new ways to communicate their observations and findings. Fundamentally, incorporating different styles of literature can increase inclusivity as it can be "enriching" and can "speak to everybody, from the not-so-good at math to the very-good-at-math", or for any of the STEM fields (Tchr. D).

Several teachers expressed frustration at the separation between the arts and sciences in our educational system: "our society has segmented people into thinking that you're either a poet or a scientist, and if you look back in history, that's not true" (Tchr. I). This separation, as well as the pressure in STEM to specialize, can leave some learners "feel[ing] incomplete or unfulfilled because they haven't explored some aspects of themselves" (Tchr. F). Some teachers reflected on when they were in secondary school themselves and how their own interests were not always represented in the subjects they were taking, and how they are now trying to reach learners like they themselves had once been. One teacher explained that "by continually bringing literature in, it allows [them] to keep pushing at that divide" between arts and sciences by "saying, okay, the stories being told over here, the stories being told over here, it might… sound different, it might appear different, but we can also see commonalities in our stories" (Tchr. F). In this way, students don't have to choose between arts and sciences, and can feel free to explore subjects in ways that feel organic to them.

Three of the teachers also discussed the benefits of incorporating student choice into assignments involving literature, which allows students the capacity to include their own interests in their studies. One teacher mentioned students reacting positively to a literature-based assignment because the content "was student-driven, so it [was] based on their interests" (Tchr. A). Another explained that "some kids don't like to read novels", so finding non-fiction literature relating to the class content could help students find new, and potentially engaging, reading possibilities (Tchr. E). Moreover, by providing flexibility and choice, teachers can try to "use the stories that [the students are] already interested in to fuel the other learning" and increase engagement in the curricular content (Tchr. G).

4.1.2 Contextualization, Holistic Learning & STEM

The next most frequent reasons to include literature in STEM classes are increasing contextual relevance and creating opportunities for holistic learning. Effective teaching helps students understand what they are learning and why. Although skills and content are important, without an understanding of how those lessons relate to one another, as well as to a broader context beyond siloed classes, they ultimately may not be useful to students. Including literature can help "wid[en] the scope" (Tchr. C) to allow students to see where the content they are learning fits into the big picture, which can help "bring the math to life" (Tchr. D). Teacher H explained that "just teaching the course work wasn't getting into the students' realm of their life. And having a good narrative to go along with what they're learning really helps them kind of connect to the stuff more". Literature is inherently connected and multi-faceted, and thus can become a lynchpin for bringing a variety of subjects together:

> Literature itself is interdisciplinary, right? It's not just a book, it's a book about, often about history and time periods, but it's also about people and morality and group dynamics and how to relate to each other. And it's also art, it's also a creation, right? And how do you create things? You need STEM stuff, right?... It's real. (Tchr. G)

Therefore, the inclusion of literature can help to highlight the connections between subjects. Another teacher expressed frustration when students wouldn't use "appropriate paragraph structure" on assignments; students couldn't understand why that mattered to a science teacher, because it was not an English class (Tchr. I). That teacher would explain to the students, "it's a communication thing. You learned English in order to communicate. And it's the same thing in math: we learn math in order to solve problems that often occur somewhere else" (Tchr. I). Including literature can help to create a bridge between subjects:

[The students] start to see math more holistically… quite a lot of them start to see math as something more relevant to their lives and more beautiful. And, and sometimes… we'd be working on a puzzle or a word problem or some kind of math problem in class and they would connect it with what we'd been doing with literature. So there was kind of a way of contextualizing mathematics in some meaningful way with something that they really liked. Because I think too often math is just seen as decontextualized, like you just keep being shown a technique and then you apply it and then another technique and you have no idea where they all come from or what they're really for, just, you just get good at following instructions. (Tchr. B)

In this way, students have another way to connect their learning to realistic scenarios and prompt conversations relating to context and critical thinking.

Many of the teachers also want to help their teaching align with the way they perceive their subjects outside of schools: "The world is not chopped up into these little segmented pieces where after an hour and 15 minutes, the bell goes and you suddenly change topics" (Tchr. I). Incorporating literature can help foster a multiple disciplinary perspective through the blending of subjects and approaches.

4.1.3   Improving Critical Thinking and Literacy Skills

Critical thinking skills go beyond solely learning content and memorizing facts and extend to how content can be used in various situations or how it can change based on context. For example, critical thinking and problem solving are fundamental skills in computer coding. One of the technology teachers explained that in "STEAM or STREAM [the R stands for reading] what's so important for the kids to learn about is the resiliency and the problem-solving skills" and "that having literature as part of [the lessons] further strengthens their ability to think

critically" (Tchr. A). Furthermore, the narrative structure and storytelling are both integral in video game development; therefore, incorporating language arts in technology-based classes can "contribut[e] to the quality of games that are produced" by students (Tchr. A). Learners also need to be able to think critically when assessing new information and while doing research. As opposed to presenting information to the students, "if they're reading something, then at least they're going through… some kind of information extraction" (Tchr. C). Encouraging the development of literacy skills, as well as critical thinking and problem solving, may also help encourage students to become lifelong learners. When empowered with these learning skills, students may begin to understand that they have the control and ability to seek knowledge independently in areas of interest, which could affect their understanding of themselves as learners, especially once they finish with formalized education.

4.1.4   Including Diverse Points of View

Through literature, teachers can introduce perspectives that may not be as common in STEM classes, such as underrepresented groups or female perspectives. I had originally thought this would be a more prominent reason for teachers wishing to include literature; however, only three of the teachers mentioned this as a motivator.

Two teachers advocated for integrating literature as a way of including Indigenous perspectives in STEM classes, as well as a potential starting point for discussions around Indigeneity and STEM. Incorporating "Indigenous knowledge and perspectives" into every grade level and curricular area is an integral part of the current BC Curriculum (Government of British Columbia, 2020). For Teacher I, including literature in STEM helps to reinforce a fundamental belief: "that math is for everyone and science is for everyone". Additionally, this teacher is conscious that "the colonial view of how to teach is chopping things up into all these little

separate pieces that are all taught separately" and uses literature to help reinforce the connections between subjects (Tchr. I). Teacher E suggested that including Indigenous literature in STEM can help all students understand that there are multiple "way[s] of understanding the world around [them]". These two teachers are attempting to incorporate Indigenous Ways of Knowing, history, and culture through the use of literature.

Two of the teachers also mentioned that literature could be used to include female perspectives, which can help women and girls feel included in STEM subjects. One of the teachers "ha[s] a really strong interest in bringing in other voices" because of the "male-dominated background" and perception of their subject area (Tchr. I). Another teacher sourced some new books on female mathematicians in history; the teacher found it was eye-opening for the students "to realize that a lot of math actually was created by more than just old guys in robes" (Tchr. H). Women and Indigenous peoples are both underrepresented in STEM fields; by having opportunities to see themselves represented in a STEM context, a more diverse group of people may be able to visualize themselves in those fields and find a place where they can excel.

Incorporating literature in STEM classes can also help those students who may not normally be drawn to STEM to feel seen and find a place within related fields; this could include students who feel a stronger connection to the arts. Specifically, for students "who [are] very language-oriented and story-oriented", including literature in STEM can allow "them a way in" without feeling "excluded"; they can see the subject as "warm and close and human" and relatable, instead of perceiving the subject "as something kind of cold and distant" (Tchr. B). It can also help all students "at least understand that there's people in the world who do see" differently from themselves, and that it is beneficial when "some people have… different perspectives, in order to make all the great things that we have" (Tchr. I). One assignment where

students need to examine lesser-known scientists to discover relatable qualities and funny stories, can help remind students that scientists are humans, as opposed to "icons", when, in reality, "anybody can be a scientist, you don't have to fit a certain mold"; however, that may be hard for students to see when classes are siloed and their skills are not perceived as being transferable (Tchr. I).

4.1.5 *Making Lessons Memorable*

One of the teachers mentioned trying to help give students a little story that they could easily remember so they would have something to share with others, for example, during a dinnertime conversation. This teacher recognizes that calculations may be hard to talk about, but stories and facts are more shareable. Stories not only make the learning relevant, but they help students remember where concepts fit in the big picture. It is integration that "makes things come alive and kids… and people and humans love stories and different types of stories. It's the best way to remember stuff" (Tchr. G). Furthermore, introducing multiple ways of understanding a concept allows more students to find a way of connecting to the material in a memorable way. For example, one teacher's goal in math is to get students "tuned into this kind of patterning thing, which is really what being mathematical is about. You start to notice patterns and you abstract them a little bit and sort of see where else you find that same pattern" (Tchr. B). Therefore, connecting the learning to the world outside of the classroom can help students to extend and apply their learning in a meaningful way. Moreover, introducing authentic, easily-sourced learning materials can be an important step in developing lifelong learning:

> So, the idea about getting outside of textbooks reminds [the students] that when they're in spaces where textbooks don't exist anymore, learning is still happening. So, you need to show them those places that are right in front of their noses… anything that gets you

outside the classroom and reminds you that this doesn't just happen when you're sitting at

a desk or in a school, it can happen, walking down the street. (Tchr. I)

Although learning is not limited to a school setting, schools can help students understand the

value of exploration, observation, and making connections through integrated, contextual

lessons, which, hopefully, will help set students up to seek learning opportunities throughout

their lives.

4.1.6   *Authenticity*

Being authentic as a teacher and creating authentic assignments were both mentioned as

reasons to include literature in STEM classes. For instance, teachers who like reading or writing

poetry will likely feel more comfortable including that element in their classes, as well as seek

opportunities to do so, because that is a part of their authentic selves. In order to build

relationships with students, "teachers have to learn who [they] are as a teacher and bring that into

[their] teaching" (Tchr. F). By incorporating their own interests, teachers can show more of

themselves to their students. Some of the teachers I spoke with mentioned their own enjoyment

of literature as a reason to include certain texts, for example, novels or stories that they had

enjoyed when they were students themselves. When a teacher finds an engaging piece of

literature and brings that in to share with the students, their excitement about the material can be

infectious; therefore, a teacher who brings in material that they themselves are interested in may

have a better chance of engaging students. In contrast, relying solely on literature provided

through a textbook could leave students feeling disconnected:

often on a textbook page they're trying to fit it in with the space requirements and… it

just has that more canned or packaged feeling because it's all been uniform, right? It's not

like when you go out and find a more authentic voice; it's been processed in order to fit

into the textbook (Tchr. I)

Students "can smell inauthentic from a mile away" and, consequently, assignments with more

realistic elements can be engaging (Tchr. G). For example, Teacher G described a group of

students working hard to create a theatre set because theirs might be the one chosen for the play;

the students were motivated to do their best because of the implications of the public seeing their

work.

For some people, the literary arts can offer another authentic perspective or way of

understanding the course content. There is never just one way to approach a topic and different

students will feel engaged through different pathways. Whereas some students may enjoy more

fact-based or computational lessons, others may feel motivated to learn by an appreciation of

beauty or a feeling of a personal connection. One of the teachers explained the unique

understandings that students can have after being inspired by the inclusion of literature:

When I include literature, it's because it makes me feel good, or it makes me feel in ways

that connect to the learning, that connect to those that I'm learning with. And I feel that

that's somewhat contagious, that once I legitimize it, and they see how others respond to

it and how it makes them feel, then they become more comfortable and confident in

incorporating literature, or whatever it might be, music or art or whatever it is that

inspires sensual learning in ways that [don't] necessarily always get satiated in curricular-

based learning. (Tchr. F)

Literature can help students connect to the course material in a variety of ways that are not

necessarily limited to learning within a classroom environment. One teacher explained their own

experience as a student working with a teacher who had a more holistic approach, including

incorporating literature in a mathematics class:

> And all of a sudden I could connect mathematics with everything else, it wasn't just a
> little fun logic game, but for what purpose? It suddenly connected with the meaning of
> life and with beautiful patterns, and all kinds of things that I really loved; it connected
> with music, it connected with language… math is also really connected with the literary
> world and the artistic world and it's often not seen by people… I wanted to reach those
> kids who were sort of like I had been in high school. Who were, you know, I liked
> science too, but I wasn't, like, a complete science, you know, fanatic. But, I love the arts,
> and…mathematics is sort of a structuring for the arts… I wanted to reach those kids who
> might be able to see things that way. (Tchr. B)

There are infinite iterations of personalities, and teachers cannot expect all students to feel

engagement in the same way, or for the same reasons. For students who may feel inspired by

aesthetics, or wordplay, or storytelling, including a variety of literary elements into lessons can

help them gain a foothold in the subject matter. It can also validate students who are interested in

a subject, but perhaps do not feel engaged through a more traditional approach. Furthermore, this

inclusion can help reinforce that it is acceptable to learn in any way that feels authentic to the

learner.

4.1.7   Building Community

Incorporating language arts can help students make personal connections to topics as well

as with fellow students. For Teacher F, "using literature and other types of art" can help to

connect learners: they explain, "I share bits of me, people share bits of them, and together we

form a community of learners and that community of learners, I feel, allows us to do better work

around whatever our subject might be". Working on developing positive relationships within classroom communities can help to foster trust and it can help "build relationships with people in important ways… because it makes connections that are not superficial connections, that are deeper connections" (Tchr. F). Studying literature can promote critical thinking and reflection, as well as presenting views that may challenge previously held ideas.

In my own teaching, I have seen literature circles have a positive effect on classroom community. Students get to know each other through conversation because literature not only allows them to discuss the content, but also their personal reactions and connections. After reading together, they have an understanding that links them. The ability for literature to connect to one's personal life, often prompts readers to open up and share stories of their own. One of my favourite aspects of teaching literature was that I could learn so much about my students organically through discussion. I also had opportunities to share about myself and my own life in ways that felt natural and meaningful to the conversation, not forced or awkward.

4.1.8   What Was Not Mentioned?

No teachers mentioned using literature to discuss ethical questions related to their subject areas. In STEM fields, the impacts of new technologies and discoveries, as well as ethical implications need to be considered; new developments occur continually, and rather than considering solely what is possible, people working in STEM fields must think about whether new developments will have a positive effect for humanity and the environment. Often, choices can be complex and significant. Fictional narratives where students can imagine real or hypothetical situations from a variety of viewpoints, or non-fiction texts where students can examine historical implications could be particularly useful in starting conversations about ethics in STEM.

4.2   Student Reactions

Overall, the teachers in this study perceived that their students reacted positively to the inclusion of literature in STEM classes. Negative reactions seemed to arise when teachers deviated from expectations and this can stem from fear, usually that marks would be negatively affected. Students who enjoy, and are successful in, a more traditional STEM classroom may not want to change that format because it is working for them. Therefore, some teachers may feel it is too challenging to convince students to accept new styles of lessons or assignments, and not push to make changes, especially when there are significant barriers. However, maintaining the status quo could keep one type of student engaged while another type of student remains disengaged. In this case, embedding choice in lessons that include literature, as well as in assessment, may help to further engage all learners and make STEM classes more inclusive. Furthermore, a more holistic assessment approach could help to reassure students and allow more freedom for exploration.

For the students who ask, "why am I learning this right now?" or "when am I going to need this in real life", holistic learning, perhaps through the integration of literature, can help them to discover the answers to these questions through finding "the connections themselves to real life things" (Tchr. I). Students can feel a sense of ownership over their learning, which may help to spark internal motivation. A feeling of success and connection can also help to imbue "a sense of pride" in students, which they may not have experienced previously in STEM classes (Tchr. B).

4.3   Barriers

4.3.1   Time Constraints

A lack (or perceived lack) of time was cited most frequently as a barrier to including

literature in STEM classes. Several teachers explained that they were overburdened the last year

and a half specifically due to the changes in teaching brought about during the Covid-19

pandemic, including moving education online, creating hybrid online/in person formats, and

adopting a quarter system[1] in some cases. One teacher discussed a lack of time dedicated to

collaboration, as well as the lack of preparation time in the semester system[2] (as teachers only

have preparation time during half of the year), that both contribute to teachers feeling reluctant to

try new methods in their classrooms.

Most teachers have a very limited amount of time with their classes and may feel like

they are "stealing time from [the students'] learning the material, like the curriculum material" if

they stray from the direct instruction of concepts (Tchr. H); another referred to "trade offs"

because a teacher must make a "choice" to "giv[e] some time to whatever the resource is" that

they choose to include (Tchr. C). One teacher suggested thinking about the inclusion of literature

"as good glue, as opposed to just putting more stuff in" (Tchr. H). That particular teacher (H)

would include articles for the students to discuss in a holistic way, where they could explore how

the details learned in class fit with a broader examination and understanding of the subject.

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[1] A quarter system in a secondary school in BC would consist of students taking two classes per quarter, for a total of eight possible classes during the school year.
[2] A semester system in a secondary school in BC would consist of students taking four classes per half of the year, with eight classes in a full course load.

The time constraints of having siloed blocks can also impact what a teacher is able to attempt with their classes. The teacher with the flexible schedule discussed being able to assign larger projects and assignments:

> Every day this week, we spent an hour just getting our camera gear set up to shoot,
> right?... The films they're making are exceptional, like really, really good high school
> films. But it's, like, we're moving fast… it takes time to, like, set up microphones and
> block out shots and smooth lights and set all these things up and run electrical and tape it
> all down and, like, it's just so time consuming. And a regular timetable, we'd just be, like,
> hopeless, hopeless to try and do that. (Tchr. G)

In order to provide the students with the freedom to create, that particular program eliminated siloed blocks and runs a full-day, full-semester program for students consisting of four courses. Teacher G explained that they need the "flexibility to just work the schedule however [they] need to work it… it allows [them] to do these really messy, creative projects that a timetable just, just wouldn't."

Teacher H is conscious of the pressure that students are under due to frequent assignments in other classes and, therefore, hesitates to include more complex projects in an attempt not to overburden students. Due to the separation of subjects, multiple projects assigned in multiple courses could be overwhelming for students. Perhaps if teachers worked together to integrate subjects, a single project could be used to evaluate criteria from more than one subject area.

4.3.2   *Finding Appropriate Literary Material*

It also takes time to find literature to include that is appropriate for the subject matter and students' varying abilities. Incorporating articles can "sometimes [take] some extra support"

because the writing "can be kind of technical" (Tchr. C). Three of the teachers (Tchrs. C, H, & I) described struggling to locate appropriate literature to include in STEM classes. Using reading material at the wrong reading level for the students then increases the amount of time a teacher needs to dedicate to the lesson. Inappropriate reading material could also contribute to student frustration. Scientific articles can be relevant and contemporary, but the language level can be too high for the grade level of the content. Although textbook articles may be an appropriate reading level, these can feel dated and inauthentic:

> Kids relate to stuff if it's more like from a clip from a movie or, or somebody's story in a book. It's a little bit, has more human content in it, than a textbook does, even when it's really well laid-out because sometimes you can have a little snippet in a textbook that actually is well done. But, because it's in the textbook somehow it kind of feels more packaged and less real. (Tchr. I)

Being able to easily share current, relevant resources with like-minded teachers could reduce the time barrier. However, there needs to be content created and available that appeals to students at appropriate reading levels in order for teachers to be able to incorporate it into their classes.

4.3.3 Expectations

Several of the teachers explained that the expectations of students, parents, colleagues, and administrators can be a barrier to including literature in STEM classes. The expectations or beliefs that people have in respect to what should occur in a STEM classroom can contribute to the fear of trying new approaches in general and, in this instance, of incorporating literature. For example, one teacher explained how plagiarism was rampant during the first few attempts at a literature-based project. It took that teacher persevering through several cycles of classes to develop an assignment where the students were not able to easily plagiarize. Another teacher

explained that assigning a literature-based research project garnered pushback from several parents: they complained that the students should be focused on math, not social studies as they perceived the assignment to be. Not every teacher who encounters resistance will persevere; for many, it may seem easier to conform their teaching to the expectations placed upon them.

New teachers can find themselves in a more vulnerable position as they have not yet had time to establish themselves as professionals and have not had time to accrue seniority towards gaining continuing contracts of employment (in the public education system). Furthermore, the confidence that comes with experience can allow teachers to take more risks, as well as to be able to more clearly define and communicate their motivations to the students:

> You get a few [students] who [ask]… 'Why are we doing this?' but you're always going to get that. Overall, though, I think, as the years have gone by especially, I've become more capable of explaining that idea of context, that, in reality, there's no such thing as math class and English class, and that we do need to see how things exist in context, not by taking things out of their context all the time. (Tchr. I)

Several teachers expressed that it was more difficult to integrate literature as a new teacher or that they didn't attempt using literature until later in their careers. New teachers may be simply trying to survive their new job without getting overwhelmed. One teacher encountered pushback from students, parents, and an administrator, when incorporating literature circles early in their career:

> [The students] were really worried because some of them had, they'd done very well by the old-fashioned system, where you didn't do literature in math class, and they were really worried that they were going to get marked down because they weren't, you know, maybe they weren't as good at English literature or whatever their preconception was… I

49

never ran into anything like that later and I guess I established a reputation in the school

and in the district, you know, 'she's the one who does math projects' and the kids always

do, like, really, really well on the math projects and I could really see that their insights

were developing through this work too. (Tchr. B)

An established reputation in a school can help future students build trust and open-mindedness

when assignments differ from previously held expectations. Incorporating literature can also

necessitate a change in assessment practices or in the way that a teacher communicates desired

outcomes.

4.4 Assessment Adaptations

The teachers that I spoke to highlighted some of the adaptations they needed to make to

their assessment strategies when they include literature in STEM classes. Generally, these

teachers approach assessment when incorporating literature more holistically. However, it can

take some time to find a way to approach new ways of assessing and outlining expectations for

students:

I definitely had more difficulty figuring out how to do assessments of some of these

things and I've also realized that one of the fun things is recognizing that just because you

have students do something doesn't mean you have to give them a mark for it, right? …

your criteria and your expectations are that they engage in the material, and that they

come out with something new and they're able to express it. Like, that could be the goal.

And if they've done it, then it's just a check, 'yes, this has been accomplished'. I'm not

going to judge them and rank them based on, you know, my view because the whole

point was I wanted them to go out and explore and learn about an inventor or a creator or

come up with a story or just, you know, discover something new that they thought was

interesting. It's not a place for me to put a value judgment and a mark on it, in this case.

So a number of the things that I've done in that case I haven't necessarily gone at with a

mark in mind because I wanted it to be more, more of a space for them to explore. (Tchr.

I)

More than one teacher mentioned that it can be valuable to think deeply about what their desired

goals and outcomes are for the students, as those may differ from a more traditional approach.

Assessment can also include more conversation, both with the students as well as with their

parents:

So, like at the midpoint, we have the kids host a parent interview that's basically a job

interview with their parents and us. And they show off… 'here's what we've done here's

where I'm going. Here's what I need to work on next. Here's what I'm proud of. Here's

what I slipped up on'... So, assessment becomes a lot more, like, focused on the actual

work and less focused on numbers. Again, a luxury of our structure where we have kids

for that period of time. (Tchr. G)

Because of the flexible nature of that particular program, Teacher G is also able to use a single

project as assessment for multiple class subjects, which can allow students to go more deeply

into the learning.

Teacher H began using rubrics to assess a literature-based project because the methods

they had previously been using (mainly tests and quizzes) did not seem to work in that context.

They explained that in their experience "the students at the top always ask, 'how do I go further

or what, what can I do to do more?'" (Tchr. H). In this case, rubrics can help to clarify

expectations, especially when the marking is not based on simply achieving a correct answer.

Now, that teacher finds themselves "think[ing] with the more holistic lens… want[ing] to see

thought pattern" and using rubrics can help with assessing in a more holistic way (Tchr. H).

Rubrics can also be helpful for teachers who wish to grade literature-based assignments.

Other teachers choose not to grade or mark explicitly when they include literature; these teachers may be looking for comprehension or participation, or think of the assignment as part of a work habit mark. One teacher views including literature as "enrichment, it's for fun" and it can offer students another "way to express themselves" (Tchr. D). Teacher D added, "not everything has to be for marks, sometimes we just do it for fun… I don't punish [the students] if they choose not to do" the assignment.

4.5   Areas of Teacher Study and Their Impact on the Inclusion (or Avoidance) of Literature

Several of the teachers had studied a field outside of STEM during their university education (most often language arts, history, foreign languages, or philosophy). Teacher A, who also teaches English and Spanish, explains how a foundation in language education can impact STEM teaching:

> My training is primarily in languages, in Spanish and English, and literature is inherent in those areas, so whenever I introduce something new, that's my base, that's my foundation. So, I think about drawing on the concepts that I've learned from my English and Spanish training.

For teachers who have taught English before, the approaches that are common in that field can "[come] in handy for the math classes also" (Tchr. D). Other teachers expressed a personal interest in literature currently and/or as a child which has inspired their use of literature in their classrooms.

Three of the teachers (Tchrs. C, H, & I) whose university education focused primarily on STEM, seemed to express more hesitation towards including literature. Teacher H saw the potential to connect an assignment they had done to poetry. However, that person did not feel like they had the background knowledge to be able to create that type of assignment:

> To write poetry and stuff I think you have to kind of really know the material, then kind of get into it as well. So that would be a little bit tougher. I'm not sure how I could approach that one, that might be collaboration with somebody to figure out what to do, right?" (Tchr. H)

Another teacher (Tchr. I) wanted to incorporate some literature into their math classes, but hesitated because they were unsure what reading level would be appropriate for the students, particularly those learning English as an additional language. Again, this teacher theorized that collaborating with a teacher familiar with language arts could be helpful in this situation. However, interdisciplinary collaboration requires effort to find a collaborator with the desired skills, similar goals, and compatible schedules.

Two of the teachers (Tchrs. A & C) speculated that teachers with a language arts background might be more likely to feel comfortable incorporating literature into their STEM classes. Another theory could be that teachers who have studied broadly may be more likely to see the connections between subjects in a holistic way.

4.6   How Literature is Located

The teachers I spoke with used a variety of methods to locate literature for use in the classroom. Some teachers would read for their own personal interest and include texts, or portions of texts, that they enjoy, or texts that they remembered enjoying when they were a student themselves. By including literature that they find interesting personally, a teacher can

share their passion for the subject matter with their students in an authentic way. Other teachers would collaborate with colleagues or seek help from the school librarian in order to find appropriate literature. The school library can offer teachers a way to access a variety of literature more cost-effectively as the burden to purchase texts does not fall solely on the department. Several teachers would simply do an online search for the topic that they wished to cover, and use digital articles with their students. Teacher B mentioned that they became "alert" to any sort of literary connections to their subject, and another (Tchr. I) described the challenge of finding an appropriate piece of literature and then having to keep it in mind until the time it was applicable to the course content.

Several teachers spoke of the value in having students find or choose the literature to be included based on interest. Two of the technology teachers (Tchrs. A & G) described including literature of the students' choosing. Teacher G explained how culturally-relevant stories become inherent in the students' lives and how teachers can connect familiar stories to lessons and assignments:

> We've done a lot of stuff on *Marvel* and *The Avengers* because for the kids in our program a couple years ago… *Iron Man* was the first film that they remember seeing and it was, like, the end of that Avengers story arc, and it was, like, it was their whole lives, right? It was literally their whole life. So how do we ignore that? So… that's the resource that we're going to use, the text we're going to do, and then we'll teach hero's journey with the Avengers story.

Encouraging students to have input in the literature included, either through locating an interesting source themselves through the library or choosing the text that they find most appealing from a selection can be an effective way of increasing student engagement.

4.7   Ways of Including Literature into STEM

The study participants included a variety of literary styles in their classes (see Table 1). They also described a number of ways in which literature can be incorporated into STEM classes.

4.7.1   Non-Fiction (Articles, Biographies, Current Events, & Historical Accounts)

Several teachers described incorporating biographical and/or historical projects in their courses, which necessitate locating and referencing non-fiction literature; for example, several teachers described assigning a research project where students choose and research a scientist or mathematician. Studying the history within a subject area can help to contextualize the learning and reinforce the human element in the understandings we have today. Teachers also sought articles from digital and print sources to share with their classes in an effort to provide context to the learning and integrate contemporary perspectives. After students have read or listened to an article, they can discuss as a class or in smaller groups. A teacher could also use a portion of a text if they feel like the language might be overwhelming for students.

Table 1

The types of literature included by each participant

	Types of literature included							
Teacher	Non-Fiction (current events)	Non-Fiction (historical accounts)	Non-Fiction (biography, memoir, autobiography)	Fiction (novels & graphic novels)	Fiction (short stories and/or children's books)	Poetry	Song Lyrics	Theatre & Scripts
A					X	X	X	
B				X	X	X		X
C	X							X
D				X		X	X	X
E	X	X	X	X	X			
F		X	X	X	X	X		
G	X	X	X	X	X			X
H	X	X	X					
I	X	X	X		X			

4.7.2 Fiction (Short Stories, Novels, & Graphic Novels)

Teacher D mentioned that "even at the senior grades", "kids love being read to". This teacher will "spread [a novel] out so they [are reading] a little bit every week" (Tchr. D). Teachers who incorporate fiction do so in a variety of ways: for example, literature circles, independent reading, and the teacher reading aloud. Novels were not always used in full; reading excerpts does not require as much time and may be less daunting for teachers initially wishing to try including fiction. Teacher B was able to incorporate literature circles with limited copies of

novels, by having groups of students share and read together, then they would take on roles for literature circles. They would arrange the chairs in small groups and "one person might be the discussion leader, one person would come up with some questions, one person might be doing a synopsis," and so on. Two math teachers (B & D) mentioned using the novel *The Number Devil: A Mathematical Adventure*, by H. M. Enzensberger with their classes. *The Number Devil* is a novel about a little boy who is frustrated with his math class at school, and dreams about a number devil who explains math principles to him while he sleeps. The novel consists of twelve chapters, each representing a different dream about a different mathematical concept. Other examples of novels that teachers B & D have used include *Flatland*, by E. A. Abbott, *Alice's Adventures in Wonderland & Through the Looking Glass*, by L. Carroll, and *A Wrinkle in Time*, by M. L'Engle, all of which offer narratives with mathematical components.

Teacher G has used *1984*, by G. Orwell, and *Harry Potter*, by J. K. Rowling, as well as graphic novels, in teaching media and technology in combination with language arts; assignments can prompt students to think about how they could visually represent aspects of the literature using technology. This teacher (G) has also had students examine the storytelling in video games as a novel study. The same elements that teachers highlight in novels, such as characters, plot, and setting, are present in video games, and students could reflect on how "interactivity with the reader [can] affect their ability to understand and interpret and feel emotion from the story" (Tchr. G).

4.7.3   *Poetry and Song Lyrics*

Poetry can be a way of incorporating beauty and wonder into STEM classes, helping students to see the concepts through a different lens. Some teachers who include poetry also ask students to write their own, and, in this case, poems can be studied as inspiration or as a model

for students' self-expression. For example, a teacher could ask students to "use a mathematical structure to write a poem" (Tchr. B). One teacher uses limericks in math class, either getting students to write their own or providing the first couple of lines for them to finish, because they have "such an easy pattern to follow" (Tchr. D). In digital media, Teacher A used song lyrics and concrete poetry to help students visually represent mood. Conversely, language arts teachers could examine language patterns and structures within poems through a mathematical lens.

4.7.4   Theatre (Scripts & Performing Arts)

Teacher C described their experience working with an art teacher to have math students create scale models of sets for a play. For set design, students needed to look closely as the text to make appropriate choices, and then use mathematical skills for scale, as well as technical skills for those sets that become functional. Students can use their literary skills to create scripts from novels or short stories, and their technical skills to turn them into films or video games. Teacher B challenged students to recreate *The Number Devil* as a script and had students perform their sections to the class, finding that after students completed the assignment, "pretty much everybody got what was in their chapter". Yet another teacher (Tchr. D) created musicals with their students, changing popular song lyrics to reflect mathematical lessons and creating an entire performance with singing, dancing, and acting. Although Teacher D loved creating the scripts and songs, they did not enjoy directing; therefore, collaborative relationships, for example with a drama teacher, could help these types of projects come to fruition. These types of assignments can help to engage students who are interested in the performing arts or perhaps those who prefer more movement incorporated into their learning.

4.8   Advice

The teachers I interviewed would all recommend using literature in STEM classes. Although fear was not one of the specific barriers that teachers mentioned during the interviews, it was a fairly consistent theme when giving advice, prompting me to feel that the fear of trying something new is actually a significant barrier to teachers attempting to include literature for the first time. It is also important that literature is truly integrated as opposed to being simply a "hook", which can "[diminish] the literature": when teachers use it to draw students in before they get "to the real stuff and the important stuff", this can reduce the addition of literature to "a type of tokenism" (Tchr. F).

Several of the teachers would advise that teachers "start small". Teachers attempting to integrate literature into a STEM class for the first time may want to try with a lesson, rather than a whole unit, or perhaps a poem rather than a novel. Whatever resource a teacher chooses, it is beneficial if the integration does not feel forced and connects to the course content in a meaningful way. Additionally, teachers may want to find other educators with similar interests, if possible; they could share resources as well as offer new ideas and support. Teachers should also think critically about what they want their students to learn and why, which can help to clarify the purpose for integrating literature for both the teacher and their students. Furthermore, offering choices that appeal to students' interests, can help to increase student engagement. I have included a list of the advice given by the study participants (see Appendix E).

Chapter 5: Conclusion

During our interview, Teacher G described understanding and enjoying their subject's content while struggling to explain to students its importance. It was through reading as an adult that this individual began to appreciate the relevance of a multiple disciplinary approach; they likened this connectivity to mushrooms that send out shoots in all directions in search of a good place to grow, which is "what literature in a subject and a science will do" (Tchr. G). This mushroom metaphor reminded me of Kimmerer's (2013) description of lichens:

> a lichen is not one being, but two: a fungus and an alga. These partners are as different as could be and yet are joined in a symbiosis so close that their union becomes a wholly new organism…These ancients carry teachings in the ways that they live. They remind us of the enduring power that arises from mutualism, from the sharing of gifts carried by each species (p. 269, 275).

Perhaps lichens can also be used as a metaphor for the relationship between the literary arts and STEM. It is through joining both subject areas that each can be fully explored, experienced, and appreciated. STEAM education and multiple disciplinarity can help to highlight the mutually beneficial relationship between the arts, including the literary arts, and STEM. This unification, or reunification, can also allow all types of students to find a place within STEAM where they feel engaged. Thus, incorporating a variety of approaches can help learners find a way into STEM and internalize the concepts in a way that feels compelling and meaningful (Braund & Reiss, 2019).

By listening to the experiences of STEM teachers, I have gained a more thorough understanding of the benefits as well as some of the challenges that STEM teachers face when considering or attempting the use of literature in their classes. A lack of time, as well as

challenges in locating appropriate resources, can discourage teachers from trying new lesson ideas or teaching methods; these barriers can affect any teacher, and are not limited to teachers in STEM subjects. Additionally, a STEM teacher may have a negative view of integrating literature or may not see its relevance to their class or subject, which could affect how their students perceive more holistic approaches in future classes (Emerson, 2019; Norris & Phillips, 2003). Straying from preconceived notions and expectations around STEM education, from educators, administrators, students, and parents, could potentially lead to stressful situations and difficult conversations. However, the teachers that I interviewed all seemed to believe that striving to overcome these barriers is worthwhile, and that the perceived benefits of including literature outweigh the challenges.

In the compartmentalized educational environment in most BC secondary schools, the integration of literature in STEM classes has many potential rewards. Integrating literature in STEM can help to foster inclusivity in two ways. First, including literature in secondary STEM classes can appeal to students who are interested in language arts and help them to feel a connection with STEM curricula (Vardell & Wong, 2015; Wynn & Harris, 2012). Not all students will be engaged in the same way; thus, teachers can broaden the appeal of STEM classes by incorporating a variety of instructional approaches and assignments. Second, literature can offer variety in perspectives and cultural representations, which can help students to feel represented in the curriculum and can also contribute to the development of empathy (Kane, 2020; Nussbaum, 2010). The current BC curriculum specifies that Indigenous knowledge and perspectives be included in all subject areas (Government of British Columbia, 2020); holistic approaches to education, which literature can help to foster, are generally more consistent with Indigenous world views (Battiste, 2005). Furthermore, current holistic and transdisciplinary

approaches to education originate from and overlap with Indigenous ways of knowing (Four Arrows & Miller, 2019).

Whereas curricular fragmentation can lead to disengagement, holistic approaches in STEM classes can help to highlight content relevance and contextualize learning (Banack, 2018; Flynn & Hardman, 2019; Grey, 2013; Hatch, 2018; Klassen & Klassen, 2014; Schreiner & Sjoberg, 2005). Literature is rarely limited to one subject matter, and thus, can be a useful tool for exploring context and helping students to see connections. STEAM is a more transdisciplinary approach to a traditional STEM education, and the A includes language arts, as well as visual art and design (Henriksen, 2014). Blending the arts and STEM can help to engage a broader range of student, while offering learners a chance to understand the commonalities between these areas and develop skills that can be beneficial for any subject (Braund & Reiss, 2019; Mishra et al., 2011). For instance, the arts are an integral component of innovation within STEM fields (Wynn & Harris, 2012). STEAM may also help teachers feel that they are representing their subject matter authentically, in a way that more closely resembles their perception of the content in real life.

Furthermore, teachers can help to make lessons more memorable by helping students to make connections to themselves and highlighting the contextual relevance of class content. Other potential benefits of including literature in STEM classes may include helping to foster a sense of community within a classroom and improving critical thinking skills. Moreover, the use of literature can offer teachers another way to express themselves and integrate their own authentic interests and passions into the classes they teach.

5.1   Implications

Choi & Pak (2006) assert that the spectrum of multiple disciplinarity is a continuum. Although transdisciplinarity may be one goal, multidisciplinarity or interdisciplinarity can also increase the connectivity between subjects and help students to better understand context; they may also be more easily achievable within the current timetable structure in BC secondary schools. Teachers who may be interested, but nervous, about attempting to integrate literature into their STEM classes can follow the advice given by the participants of this study and start slowly. They might try an excerpt, a poem or a short article, for example, for one lesson. Also, like any new teaching method, using literature can take some practice and perseverance; seeking feedback and suggestions from the students could be one way to rethink and refine assignments over time. Teachers could also benefit from being open-minded, especially in regards to assessment. Furthermore, literature is only one tool in holistic, STEAM-based education, and can be blended with many other approaches, such as visual art and hands-on experiments.

There were several teachers who expressed a desire to integrate literature, but who struggled with how to do so effectively. The inclusion of holistic approaches, as well as multiple disciplinary assignments and instruction, could be useful for student teachers who may not have experienced this style of education as students themselves; multiple disciplinarity in their own university course work may help to highlight the possibilities and potential benefits. Moreover, being able to see how other teachers are successfully integrating literature, through modelling opportunities or professional development, could also help more teachers feel comfortable making an attempt in their own classrooms. Finding time or opportunities for cross-curricular collaborations could also make STEAM learning more possible and integrated in school communities; teachers, like students, have a wide variety of interests and skills, and coming

63

together to combine resources could be mutually beneficial, as well as offering a positive, real-life model of STEAM for students to see. Teachers could display the value of holistic learning, as well as contextualization, by showing students how their own differences are assets, and that they can flourish by working together.

Having the support of school districts and administration could make multiple disciplinary connections more likely and more sustainable. For example, collaboration time for teachers can be built into a school timetable. Although it can be more challenging without specifically-designated collaboration time, Teacher G suggested that, for teachers who want to find opportunities to work with others, they could look at their school timetable and identify potential collaborators by looking at who else is teaching a course at the same time. If that other person is open to a collaboration, the two classes could join together for an interdisciplinary project, for example. Combining two classes may necessitate finding an appropriate space that could accommodate a larger number of students; locations like the library or gymnasium could work, if those rooms were available at the right time. Some schools have classrooms designed for collaboration that can accommodate larger groups by opening sliding walls. However, in order for those shared classrooms to work for multiple disciplinary learning, the relationship between the collaborators would likely need to be established before timetabling and would necessitate the assistance of the administrator creating the timetable, so that the right classes share a removable wall at the right time.

5.2 Further Research

Future research could involve classroom observations as well as student surveys/interviews to assess the impact of literature integration in STEM classes on student engagement. Another opportunity for further research in this area could include a case study of a

64

teacher integrating literature into a STEM class for the first time. This type of study could look at overcoming barriers as well as student expectations, reactions, and feedback. Furthermore, an examination of the use of literature while studying ethics could yield data about what effect that can have on students' understanding and perception of ethical quandaries in STEM fields.

References

Abbott, E. A. (2010). *Flatland*. Cambridge University Press.

Adler, C. L. (2014). *Wizards, aliens, and starships: Physics and math in fantasy and science fiction*. Princeton University Press. https://www-jstor-org.ezproxy.library.ubc.ca/stable/j.ctt5hhs58.3

Aikenhead, G., & Elliott, D. (2010). An emerging decolonizing science education in Canada. *Canadian Journal of Science, Mathematics and Technology Education, 10*(4), 321-338. DOI: 10.1080/14926156.2010.524967

Banack, H. (2018). Where STEM binds, and ST(eee)M flows: A case for the *where* in STEM discourse and practice. *Critical Education, 9*(16), 41-66. file:///C:/Users/lrcun/Downloads/186262-Article%20Text-197290-3-10-20181004%20(1).pdf

Battiste, M. (2005). Indigenous knowledge: Foundations for First Nations. *World Indigenous Nations Higher Education Consortium-WINHEC Journal*. https://www2.viu.ca/integratedplanning/documents/IndegenousKnowledgePaperbyMarieBattistecopy.pdf

Battiste, M. (2017). *Decolonizing education: Nourishing the learning spirit*. Purich. http://ezproxy.library.ubc.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=1498008&site=ehost-live&scope=site&ebv=EB&ppid=pp_2

Battiste, M., & Henderson, J. Y. (2009). Naturalizing Indigenous knowledge in Eurocentric education. *Canadian Journal of Native Education, 32*(1), 5-18,129-130. http://ezproxy.library.ubc.ca/login?url=https://search-proquest-com.ezproxy.library.ubc.ca/docview/755262421?accountid=14656

Berg, B. L. (2004). *Qualitative research methods for the social sciences* (2nd edition). Pearson

    Education.

Braund, M. & Reiss, M. J. (2019). The 'great divide': How the arts contribute to science and

    science education. *Canadian Journal of Science, Mathematics and Technology*

    Education, 19(3), 219-236. DOI: 10.1007/s42330-019-00057-7

Bucher, K. T., & Manning, M. L. (2001). Taming the alien genre: Bringing science fiction into

    the classroom. *The ALAN Review, 28*(2), 41. https://doi.org/10.21061/alan.v28i2.a.9

Calmer, J., & Straits, W. (2014). Reading to understand anatomy: A literature circle approach.

    The American Biology Teacher, 76(9), 622-625. https://www-jstor-

    org.ezproxy.library.ubc.ca/stable/10.1525/abt.2014.76.9.9

Carroll, L. (1949). *Alice's adventures in Wonderland, and Through the looking glass*. Harper.

Cavanaugh, T. (2002). Science fiction and science education. *Science Scope, 25*(6), 64-69.

    http://tinyurl.com/ybcc3ptk

Charmaz, K., & Thornberg, R. (2020). The pursuit of quality in grounded theory. *Qualitative*

    Research in Psychology (ahead-of-print), 1-23. DOI: 10.1080/14780887.2020.1780357

Choi, B. C. K., & Pak, A. W. P. (2006). Multidisciplinarity, interdisciplinarity and

    transdisciplinarity in health research, services, education and policy: 1. Definitions,

    objectives, and evidence of effectiveness. *Clinical and Investigative Medicine, 29*(6),

    351-364. https://go.exlibris.link/wHHz4wcL

Colburn, A. (2010). The prepared practitioner. *The Science Teacher, 77*(3), 8.

    http://tinyurl.com/ybutkfe9

Dahl, R. (1996). *James and the giant peach.* Knopf.

Dahl, R. (2001). *Charlie and the great glass elevator.* Knopf.

Daniels, H. (2002). *Literature circles: Voice and choice in book clubs & reading groups* (2ⁿᵈ

    edition). Stenhouse.

Dewey, J. (2017). My pedagogic creed. In D. J. Flinders & S. J. Thornton (Eds.), *The curriculum*

    studies reader (5ᵗʰ ed., pp. 197-205). Routledge.

Dimaline, C. (2017). *The marrow thieves*. Dancing Cat Books.

Emerson, L. (2019). "I'm not a writer": Shaping the literacy-related attitudes and beliefs of

    students and teachers in STEM disciplines. In V. Prain, & B. Hand (Eds.), *Theorizing the*

    future of science education research (pp. 169-187). Springer International.

Enzensberger, H. M. (1997). *The number devil: A mathematical adventure*. Henry Holt.

Farlow, S. J. (2017). Writing and storytelling as an aid in learning math. *EURASIA Journal of*

    *Mathematics, Science and Technology Education, 14(*2), 579-584. DOI:

    10.12973/ejmste/76960

Fenstermacher, G.D. (2000, July). *What is the difference between the North Star and Northfield?*

    How educational goals and ideals become confused. Invited presentation to the Summer

    Institute of School Superintendents, Macinak, MI, United States.

Flynn, S., & Hardman, M. (2019). The use of interactive fiction to promote conceptual change in

    science: A forceful adventure. *Science & Education, 28*, 127–152.

    https://doi.org/10.1007/s11191-019-00032-6

Four Arrows, & Miller, J. (2019). To name the world: A dialogue about holistic and Indigenous

    education. In J. Miller's *The holistic curriculum* (3ʳᵈ edition) (pp. 219-235). University of

    Toronto Press. http://tinyurl.com/y46hg83q

Galloway, M. (Host). (2021, June 11). Ethical questions around neural implant technology with

    guests Ning Jiang and Jennifer Boger [Audio podcast episode]. In *The Current*. CBC

Radio Canada. https://www.cbc.ca/radio/thecurrent/the-current-for-june-11-2021-
1.6061963/friday-june-11-2021-full-transcript-1.6062779

Gerofsky, S. (2019). Approaching the history of mathematics via the performing arts: Kepler: A
''renaissance folk play'' in verse. *The Mathematical Intelligencer, 41*(1), 57-66. DOI:
10.1007/s00283-018-9818-2

Glesne, C. (1999). *Becoming qualitative researchers: An introduction* (2nd edition). Addison
Wesley Longman.

Gray, P. (2013). *Free to learn: Why unleashing the instinct to play will make our children
happier, more self-reliant, and better students for life*. Basic Books.

Guyotte, K. W., Sochacka, N. W., Costantino, T. E., Walther, J., & Kellam, N. N. (2015).
STEAM as social practice: Cultivating creativity in transdisciplinary spaces. *Art
Education, 67*(6), 12-19. DOI: 10.1080/00043125.2014.11519293

Hatch, J. (2018). Building better science teachers. *Nature (London), 562*(7725), S2-S4.
https://dx.doi.org/10.1038/d41586-018-06830-2

Hatcher, A. (2012). Building cultural bridges with Aboriginal learners and their 'classmates' for
transformative environmental education. *Journal of Environmental Studies and Sciences,
2*(4), 346-356. DOI: 10.1007/s13412-012-0088-6

Hatcher, A., Bartlett, C., Marshall, A., & Marshall, M. (2009). Two-eyed seeing in the classroom
environment: Concepts, approaches, and challenges. *Canadian Journal of Science,
Mathematics and Technology Education, 9*(3), 141-153. DOI:
10.1080/14926150903118342

Helfferich, D., Dawe, J., Meyers, Z., & Tarnai, N. (2014). *STEAMpower: Inspiring students,
teachers, and the public*. The Agricultural and Forestry Experiment Station (University of

Alaska Fairbanks). file:///home/chronos/u-

bb4dfc0df1016273fbef37d1773a91722b3c9f60/MyFiles/Downloads/MP_2014-13.pdf

Henriksen, D. (2014). Full STEAM ahead: Creativity in excellent STEM teaching practices. *The*

STEAM Journal, 1(2), 1-9. DOI: 10.5642/steam.20140102.15

Henriksen, D. (2017). Creating STEAM with design thinking: Beyond STEM and arts

integration. *The STEAM Journal, 3*(1), 1-11. DOI: 10.5642/steam.20170301.11

Henriksen, D., Mishra, P., & Mehta, R. (2015). Novel, effective, whole: Toward a new

framework for evaluations of creative products. *Journal of Technology and Teacher*

Education, 23(3), 455-478. https://www.researchgate.net/publication/281069484

Herro, D., Quigley, C., & Dsouza, N. (2016). STEAM enacted: A case study exploring middle

school teachers implementing STEAM instructional practices. *Journal of Computers in*

Mathematics and Science Teaching, 35(4), 319-342. http://tinyurl.com/y5rskfuj

Howard, M. A., & Kern, A. L. (2019). Conceptions of wayfinding: Decolonizing science

education in pursuit of Native American success. *Cultural Studies of Science Education,*

14, 1135–1148. https://doi.org/10.1007/s11422-018-9889-6

Iacono, V. L., Symonds, P., & Brown, D. H. K. (2016). Skype as a tool for qualitative research

interviews. *Sociological Research Online, 21*(2), 103-117. DOI:

https://dx.doi.org/10.5153/sro.3952.

Janghorban, R., Roudsari, R. L., & Taghipour, A. (2014). Skype interviewing: The new

generation of online synchronous interview in qualitative research. *International Journal*

of Qualitative Studies on Health and Well-being, 9(1), 1-3. DOI: 10.3402/qhw.v9.24152.

Jardine, D. (1990). To dwell with a boundless heart: On the integrated curriculum and the

recovery of the earth. *Journal of Curriculum and Supervision, 5*(2), 107-119.

Jerrim, J., & Moss, G. (2019). The link between fiction and teenagers' reading skills: International evidence from the OECD PISA study. *British Educational Research Journal, 45*(1), 181-200. DOI: 10.1002/berj.3498

Jolly, A. (2014, November 18). *STEM vs. STEAM: Do the arts belong?* Education Week: Teacher. https://www.edweek.org/tm/articles/2014/11/18/ctq-jolly-stem-vs-steam.html

Kane, S. (2020). *Integrating literature in the disciplines: Enhancing adolescent learning and literacy* (2nd ed.). Routledge, Taylor & Francis Group.

Kimmerer, R. W. (2013). *Braiding sweetgrass: Indigenous wisdom, scientific knowledge, and the teachings of plants*. Milkweed Editions.

Klassen, S., & Klassen, C. F. (2014). The role of interest in learning science through stories. *Interchange, 45*(3-4), 133–151. DOI: 10.1007/s10780-014-9224-4

Knippels, M.-C. P. J., Severiens, S. E., & Klop, T. (2009). Education through fiction: Acquiring opinion-forming skills in the context of genomics. *International Journal of Science Education, 31*(15), 2057-2083. DOI: 10.1080/09500690802345888

Korpershoek, H., Kuyper, H., & van der Werf, G. (2014). The relationship between students' math and reading ability and their mathematics, physics, and chemistry examination grades in secondary education. *International Journal of Science and Math Education, 13*(5), 1013-1037. https://doi-org.ezproxy.library.ubc.ca/10.1007/s10763-014-9534-0

Kumar, A. (2019). The menace of neoliberal education reforms: Where capitalism, behaviourism, and positivism meet. In A. Kumar (Ed.), *Curriculum in international contexts: Understanding colonial, ideological, and neoliberal influences* (pp. 235-268). Springer International. DOI: 10.1007/978-3-030-01983-9

Kvale, S. (2007). *Doing interviews*. SAGE. https://tinyurl.com/y8lmwxlc

L'Engle, M. (1962). *A wrinkle in time.* Ariel Books.

Lieber, C. M. (2009). *Making learning real: Reaching and engaging all learners in secondary classrooms*. Educators for Social Responsibility.

McDonald, B. (Host). (2019, May 24). No, really, calculus can be beautiful and this mathematician will tell you why, with guest Steven Strogatz [Audio podcast episode]. In *Quirks and Quarks.* CBC Radio Canada. https://www.cbc.ca/radio/quirks/may-25-sharks-on-a-bird-diet-fossils-of-fungus-lifelike-machines-and-more-1.5147055/no-really-calculus-can-be-beautiful-and-this-mathematician-will-tell-you-why-1.5147060

McGregor, G. (2009). Educating for (whose) success? Schooling in an age of neoliberalism. *British Journal of Sociology of Education*, *30*(3), 345–358. DOI: 10.1080/01425690902812620

Magee, P.A., Govett, A.L., & Leeth, J. H. (2019). Using nonfiction texts and literature circles to rethink science learning. In C. Tai, R. M. Moran, L. Robertson, K. Keith, & H. Hong, (Eds.), *Handbook of Research on Science Literacy Integration in Classroom Environments* (pp. 124-140). Information Science Reference.

Maher, C., Hadfield, M., Hutchings, M., & de Eyto, A. (2018). Ensuring rigor in qualitative data analysis: A design research approach to coding combining NVivo with traditional material methods. *International Journal of Qualitative Methods, 17*(1), 1-13. DOI: https://dx.doi.org/10.1177/1609406918786362

Major, A. (2011). *Intersecting sets: A poet looks at science*. University of Alberta Press. https://tinyurl.com/y4uwga39

Marmon, M. (2019). The emergence of the creativity in STEM: Fostering an alternative approach for science, technology, engineering, and mathematics instruction through the

use of the arts. In M. S. Khine, & S. Areepattamannil (Eds.), *STEAM Education: Theory and Practice* (pp. 101-116). Springer Nature Switzerland AG.

Miller, J. P. (2019). *The holistic curriculum* (3rd edition). University of Toronto Press. http://tinyurl.com/y46hg83q

Mishra, P., Koehler, M. J., & Henriksen, D. (2011). The seven trans-disciplinary habits of mind: Extending the TPACK framework towards 21st century learning. *Educational Technology, 51*(2), 22-28. http://www.jstor.com/stable/44429913

Munroe, E. A., Borden, L. L., Orr, A. M., Toney, D., & Meader, J. (2013). Decolonizing aboriginal education in the 21st century. *McGill Journal of Education (Online), 48*(2), 317-337. http://ezproxy.library.ubc.ca/login?url=https://search-proquest-com.ezproxy.library.ubc.ca/docview/1461735131?accountid=14656

Newton, N. (2017). *Math problem solving in action: Getting students to love word problems, grades 3-5.* Routledge. DOI: 10.4324/9781315465050-9

Noddings, N. (2017). The false promise of the paideia: A critical review of *The Paideia Proposal*. In D. J. Flinders & S. J. Thornton (Eds.), *The curriculum studies reader* (5th ed., pp. 197-205). Routledge.

Noddings, N. (2019). Post-modern curriculum: Reviving the vision. In M. Quinn (Ed.), *Complexifying curriculum studies: Reflections on the generative and generous gifts of William E. Doll, Jr.* (pp. 29-37). Routledge. DOI: 10.4324/9781315151212

Norris, S. P., & Phillips, L. M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science Education, 87*(2), 224-240. DOI: 10.1002/sce.10066

Nunan, E. E., & Homer, D. (1981). Science, science fiction, and a radical science education

    (science, science-fiction et éducation scientifique "de gauche"). *Science Fiction Studies,*

    8(3), 311-330. http://www.jstor.com/stable/4239438

Nussbaum, M. (2010). *Not for profit: Why democracy needs the humanities*. Princeton

    University Press. http://www.jstor.com/stable/j.ctvc77dh6.11

O'Leary, Z. (2017). *The essential guide to doing your research project*. Sage.

Orwell, G. (1996). *1984.* Chelsea House.

Pewewardy, C. (2002). Learning styles of American Indian/Alaska Native students: A review of

    the literature and implications for practice. *Journal of American Indian Education, 41*(3),

    22-56. http://www.jstor.com/stable/24398583

Province of British Columbia. (2020). *New curriculum info.* BC's New Curriculum.

    https://curriculum.gov.bc.ca/curriculum/overview

    https://curriculum.gov.bc.ca/curriculum/overview#indigenous

Richards, J., Hove, J., & Afolabi, K. (2008). Understanding the aboriginal/non-aboriginal gap in

    student performance: Lessons from British Columbia. *C.D. Howe Institute – Commentary*

    No. 276. http://tinyurl.com/yxvoq89e

Rowling, J. K. (2018). *Harry Potter: The complete series*. Scholastic.

Saldana, J. (2016). *The coding manual for qualitative researchers*. SAGE.

Schreiner, C., & Sjoberg, S. (2005). How do learners in different cultures relate to science and

    technology? *Asia-Pacific Forum on Science Learning and Teaching, 6*(2), Foreward.

    https://www.researchgate.net/publication/26453386

Snively, G. J., & Williams, L. B. (2008). "Coming to know: Weaving aboriginal and western science knowledge, language, and literacy into the science classroom. *L1-educational studies in language and literature, 8*(1), 109-133. http://tinyurl.com/y32mlha5

Stavrou, S. G., & Miller, D. (2017). Miscalculations: Decolonizing and anti-oppressive discourses in Indigenous mathematics education. *Canadian Journal of Education / Revue Canadienne de l'éducation , 40*(3), 92-122. https://www.jstor.org/stable/10.2307/90014773

Straits, W. (2007). A literature-circles approach to understanding science as a human endeavor. *Science Scope, 31* (2), 32-36. https://www.jstor.org/stable/43181227

Straits, W., & Nichols, S. (2006). Literature circles for science. *Science and Children, 44* (3), 52-55. Retrieved from http://ezproxy.library.ubc.ca/login?url=https://search-proquest-com.ezproxy.library.ubc.ca/docview/236904244?accountid=14656

Strogatz, S. (2019). *Infinite powers: How calculus reveals the secrets of the universe.* Houghton Mifflin Harcourt.

Strube, P. (1996). Chemistry and narrative: Short stories and school chemistry. *Research in Science Education, 26*(2), 247-25. DOI: 10.1007/BF02356435

Vardell, S. (2019). Exploring the global landscape through digital poetry. *English Journal, 108*(4), 100-102. http://tinyurl.com/y4hkvfz7

Vardell, S., & Wong, J. (2015). The symbiosis of science and poetry. *Children & Libraries, 13*(1), 15-18. DOI: 10.5860/cal.13n1.15

Wynn, T., & Harris, J. (2012) Toward a STEM + arts curriculum: Creating the teacher team. *Art Education, 65*(5), 42-47. DOI: 10.1080/00043125.2012.11519191

Yakman, G., & Lee, H. (2012). Exploring the exemplary STEAM education in the US as a

    practical educational framework for Korea. *Korean Journal of Science Education, 32*(6),

    1072–1086. https://doi.org/10.14697/JKASE.2012.32.6.1072

Yore, L., Bisanz, G. L., & Hand, B. M. (2003). Examining the literacy component of science

    literacy: 25 years of language arts and science research. *International Journal of Science*

    Education, 25(6), 689-725. DOI: 10.1080/09500690305018

Zhang, H. (2019). Toward the reenchantment of curriculum: A study on William Doll's post-

    modern curriculum theory. In M. Quinn (Ed.), *Complexifying curriculum studies:*

    Reflections on the generative and generous gifts of William E. Doll, Jr. (pp. 29-37).

    Routledge. DOI: 10.4324/9781315151212

Appendix A

Recruitment social media post

Hi Friends!

I'm looking for teachers who fit the following criteria: Secondary school STEM teachers (any type of science class, digital media or technology, math, etc.) in BC who have included literature (any form - fiction, non-fiction, short, long, poetry, etc.) in their classes. This person may or may not be currently teaching, and they may have tried including literature at one point, but no longer do.

My name is Lindsay Cunningham, and I'm a teacher. I'm currently doing an M.A. in the Department of Curriculum and Pedagogy at UBC. In short, I'm interested in a holistic approach to education and exploring how literature can be a part of that. I'll be doing interviews as part of the research for my graduate thesis.

If you or someone you know is interested in doing one 30-45 minute interview with me via Zoom or phone, please contact me (or share my email!)

If you choose to comment on this post or "like" it, you will be publicly identified with the study. Dr. Penney Clark is the Principal Investigator of this study (Integrating literature into STEM to promote inclusivity and create holistic, transdisciplinary learning environments).

Appendix B

Initial Contact email

Dear _____

Short description of how I located this person and why I think they might be interested. Currently, I'm doing an M.A. in the Department of Curriculum and Pedagogy at UBC. In short, I'm interested in a holistic, transdisciplinary approach to education and exploring how literature can be a part of that. I'll be doing interviews as part of the research for my graduate thesis.

I'm looking for teachers who fit my research criteria: Secondary school STEM teachers (any type of science class, digital media or technology, math, etc.) in BC who have included literature (any form - fiction, non-fiction, short, long, poetry, etc.) in their classes. This person may or may not be currently teaching, and they may have tried including literature at one point, but no longer do.

If you would be interested in doing one 30-45 minute interview with me via Zoom or phone, please let me know. I've attached the consent form if you'd like a little more information. I'd also be happy to talk to you if you have any questions.

Dr. Penney Clark is the Principal Investigator of this study and you may contact her if you have questions or concerns.

Best,
Lindsay Cunningham

Appendix C

Interview Questions

- How long have you been a secondary teacher?
- What was your area of study at university?
- What are your areas of specialization in teaching?
- How long have you been using literature (apart from textbooks) in your classes?
- What made you decide to integrate literature into your classes?
- What types of literature do you use in your classes? Could you please provide some examples?
    - How did you locate the resources that you use?
- Could you give me some specific examples of how you integrate literature into your classes?
- How has this approach affected the way you assess your students?
- In your view, in what ways does integrating literature affect your students?
    - How did/do students react to this approach?
- Did you face any challenges in deciding to integrate literature into your class(es)? Please explain.
- How have parents, administration, colleagues reacted to this approach?
- Will you continue to integrate literature in your courses in the future?
    - Why? Or Why not?
- What advice would you give to another teacher who wanted to try integrating literature in STEM classes?
- Is there anything you'd like to add that we didn't cover?

Appendix D

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

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

Tel: 604 -822 -5337
Fax: 604 -822 -4714
www.edcp.educ.ubc.ca

Consent Form

Date:

Re: Integrating literature into STEM to promote inclusivity and create holistic, transdisciplinary

learning environments.

Principal Investigator: Dr. Penney Clark, Professor
Department of Curriculum and Pedagogy
University of British Columbia

Co-Investigator: Dr. Susan Gerofsky, Associate Professor
Department of Curriculum and Pedagogy
University of British Columbia

Co-Investigator: Lindsay Cunningham
Graduate student (M.A.)
Department of Curriculum and Pedagogy
University of British Columbia

Purpose: This study will look at why and how STEM teachers in BC are using literature in
secondary school classes, what barriers (real or perceived) they may have encountered when
trying to integrate literature, as well as discovering possible solutions to overcoming those
barriers. This research will form part of my graduate thesis, which is a public document, and may
also be published in journal articles and books.

Study Procedures: I (Lindsay Cunningham) will interview you once. The interview will last approximately 45 minutes. You can choose to refrain from answering any questions on topics that you prefer not to discuss and you can withdraw your participation at any time. All interviews will take place online via Zoom or by phone. Please log into Zoom using a nickname or substitute name. You may turn off your camera if you wish. Interviews will be recorded, with permission, and later fully or partially transcribed. I may also take notes during the interviews.

Confidentiality: Your privacy will be respected. All digital files and recordings, as well as transcripts, will be encrypted and kept on a password-protected computer. Any written notes will be destroyed once they are copied online. I will not include names or places of work in the transcripts.

Potential Risks: I am not aware of any potential risks to interviewees.

Potential Benefits: I do not think taking part in this study will help you. However, in the future, others may benefit from what we learn in this study. This research may contribute to the understanding of STEM instruction in BC. I would be pleased to send you the final results of the study upon its completion via email.

Payment: You will not be paid for participating in this study.

Contact for Information about the study: If you have any questions or concerns about the study, you may contact Dr. Penney Clark.

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

Participant's Consent: I understand that my participation in this study is voluntary and that I may refuse to answer any questions or withdraw from the study at any time without consequences.

My signature below indicates that I have a copy of this consent form for my own records. My signature below indicates that I consent to participate in this study and to allow my information to be used for the purposes of this study.

Please indicate in the box below if you would like to receive a copy of the results of the study upon their completion. If so, please provide an email address.

☐ I would like a copy of the results of this study upon their completion.
Email address _____

Subject Signature _____
Date:_____

Subject's name (please print clearly)_ _____

Ethics ID# H20-03956
Version February 22, 2021

Appendix E

List of Advice

The following is a list of advice that the interview participants suggested for teachers wanting to try incorporating literature in STEM classes in the future:

- "Use literature – it brings the math to life" (Tchr. D).

- "Do it, don't hesitate. Just go for it" (Tchr. D).

- "Listen to what the kids are listening to and go from there. Because I'm not really listening to what they're listening to anymore, but at the time I was doing the musicals. I was listening to what they were listening to so I was listening to Lady Gaga and Katy Perry and, and others other things. So I was able to use the songs that they knew rather than just rely on my old stuff." (Tchr. D)

- "Why not? It's just nice to find something that's, like, when you're doing something like this, I think it's nice if it's something that fits in really well and doesn't feel forced, I guess. Something that's, like, very related in some way to what you're working on. Like, it could be related to the science, to the content, I guess, because there's lots of that, or maybe just some, like cultural connotation." (Tchr. C)

- "I think it's really about digging into your own reasonings for one: What is it you want students to learn? Why do you want them to learn it? How do you want them to, inspire them to be lifelong learners?" (Tchr. I).

- "Talk to people who've done it already and find some good things. You're going to need to find your own stuff in the end to make something that's passionate, like speaks to your own passions, but also share and, and collaborate and create" (Tchr. I).

- "I would say don't be afraid. Try different things out. And, just don't be afraid." (Tchr. A)

- "I would say start small. Start with one project maybe with one grade or two grades and just do it, like make it low stakes. Integrate it with a topic, so, for example, you know, if you can connect it with a curricular topic at the start" (Tchr. B).

- "Don't make it too daunting on yourself or for your classes, but then if you do it one year, the next year the kids will come in and say 'can we do that poetry thing that you did with the kids last year?' You have a reputation, it passes among the kids and the parents, the community knows what's happening in your classroom" (Tchr. B).

- "I recommend that teachers connect… you have to have a bit of courage to, kind of, take something half-baked, not perfectly perfect, you worked out, but be open to what the kids will bring to it, and they will bring you new things and you'll understand it better and they'll be thrilled" (Tchr. B).

- "Be brave. It's one of the seven grandfather teachings from the Anishinaabe peoples. And I really feel that it captures a sentiment in ways that I haven't heard in western sort of motivations, where we're like, 'be confident, trust yourself' that, that brave piece of it, I think is unique… And if we want to incorporate literature, if we want to do something different, that doesn't seem mainstream, then we need that sense of bravery" (Tchr. F).

- "Find your people and surround yourself with good people because, you know, you might get knocked, people might criticize you and say this isn't what we do here or this isn't

relevant for this topic and, you know, you might need nourishment at certain points" (Tchr. F).

- "Start small and, like, give the kids the freedom to do it and… you'll never look back" (Tchr. G).

- "Find good stories… Find out what kids are into, your kids are into, because it's different building to building, and, like, use the stories that they're already interested in to fuel the other learning" (Tchr. G).

- "Keep it small to begin with" (Tchr. H).

- "I think the longer the project goes, the worse it's going to get for you. Check ins. You need check ins… you need to check in every day or so" (Tchr. H).

- "Go for it!" (Tchr. E).