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Learners' Perspectives on ARCH + STEM: Integration of Archaeology and Indigenous Knowledges with Western Knowledges of STEM

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Abstract: It is often the case that the integration of archaeology and Indigenous knowledges with science, technology, engineering, and mathematics (STEM) concepts, practices, and processes is missing in school-based contexts, which limits learners' perspectives of STEM. This study examined how an afterschool program focused on the intersection of STEM and the field of archaeology and Indigenous knowledges developed and/or enhanced middle school learners' perspective of (a) Indigenous people; (b) the field of archaeology; and (c) STEM concepts, practices, and processes. Data were collected through 15 focus group interviews held approximately six weeks after the program's conclusion. The results demonstrated that learners gained a new perspective of STEM, integrating Indigenous and Western perspectives; gained an understanding of archaeology and archaeological concepts; and made connections between STEM concepts embedded in the program and those within and outside of their school experience. Based on the results, we contend that the integration of alternative knowledges and ways of being and seeing the world within nonformal learning environments has the potential to diminish differences and/or tensions between Indigenous and Western knowledges and perspectives of STEM, as well as support archaeology as an approach to facilitating the learning and application of STEM concepts, practices, and processes.

Keywords: afterschool program; archaeology; Indigenous knowledges; middle school learners; STEM perceptions; third space

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1. Introduction

What is science? What is mathematics? What might be an integrated approach to science, technology, engineering, and mathematics (STEM) teaching and learning? The answer to these questions is dependent on one's culture, experiences, and worldview. In particular parts of the world, such as the U.S. and Canada, the responses to these questions are more often based in current Western assumptions, epistemologies (i.e., what counts as knowledge), and axiologies (i.e., what is valued), as opposed to Indigenous epistemologies and axiologies [1–3]. On one hand, an Indigenous perspective of STEM is focused on relationships and a way of seeing and being with nature, as it offers us gifts and teachings. For example, a circle is reflected in the round trees, the four seasons, the cycle of life, and our round eyes, or a pinecone is composed of spirals and sequences as visible in the Fibonacci sequence [4]. Meanwhile, the Western perspective is focused on teaching concepts (e.g., circle is a round plane figure) to develop individuals who are able to address global concerns, such as environmental and economic issues, through technological and scientific innovations and advances [5]. The Western perspective of STEM is often concerned with combating the low number of historically excluded groups (e.g., gender-fluid, Blacks, persons with disabilities) who obtain a degree and career in a STEM field [6,7] as opposed to forming a reciprocal relationship with the living world of STEM.

Similarly, the field of archaeology may not be recognized as a STEM field, but as a social science with a focus on the people, cultures, and societies of the past [8,9]. However, there are others that contend that the field of archaeology utilizes the application of methodologies and approaches from the natural and physical sciences [10,11]; thus, highlighting a tension within the field of archaeology. Additionally, archaeology is not a discipline often taught as part of learners' school curriculum, as some narrowly believe that archaeology is taught as part of other subjects (e.g., World History), while others believe that the field of archaeology is only relevant for studying the deep past [12]. More recently, there has been an argument for archaeology to be integrated within STEM disciplines for K-12 learners [12–14]. Again, this highlights a tension as to whether archaeology should be integrated in the school curriculum and the curriculum beyond history, into subjects in the STEM fields such as science. As challenged by Rahm [15], "Archaeology does not simply belong into a history or social studies course, but deserves to be developed further through a STEM education and informal content lens" (p. 209).

As such, as argued by others [4,12,15–17], we see value in exploring the integration of archaeology and Indigenous knowledges with STEM concepts, practices, and processes. This paper focuses on a novel afterschool program for middle school learners that integrated Western STEM concepts, practices, and processes privileged in school standards with both archaeological and Indigenous concepts, practices, and processes, as grounded in STEM disciplines. We refer to this as ARCH + STEM, as archaeology in this context integrated and highlighted both Indigenous knowledges and approaches into STEM and Western knowledges and methodologies into STEM. In this paper, we asked, how might an afterschool program focused on the intersection of STEM and the field of archaeology and Indigenous knowledges develop and/or enhance middle school learners' perspective of (a) Indigenous people; (b) the field of archaeology; and (c) STEM concepts, practices, and processes, if at all? Through our study, we addressed Colaninno's [18] call for research regarding the integration of archaeological concepts and current STEM concepts and practices. We highlight the ways in which the youth made sense of their participation and experiences within the afterschool program, and argue for the inclusion of archaeology and Indigenous knowledges within nonformal STEM learning environments for non-Indigenous learners. Canevez et al. [19] referred to this approach as indigenization and noted that the benefits to this approach include enhancing learning outcomes and diminishing the power imbalance of knowledge and ways of viewing STEM between different communities such as Western and Indigenous communities.

2. Relevant Literature

Below we present scholarship grounded within formal and nonformal learning environments, and as aligned with the above stated research question, namely: (a) Indigenous programs, curriculum, and activities; (b) archaeology programs and activities; and (c) learners' perspective of STEM after participation in a nonformal STEM program. In some cases, relevant literature aligned with the research question was sparse.

2.1. Indigenous Programs, Curriculum, and Activities

Scholarship regarding the integration of Indigenous knowledges and Western knowledges around STEM concepts and practices within both formal and nonformal learning environments highlights positive outcomes for Indigenous and non-Indigenous learners and educators [4,17]. As an example of this integration, Beatty et al. [16] discussed the creation and implementation of three lessons centered on teaching learners how to loom, as common within the Algonquin culture of Pikwàkanagàn, and on developing mathematical concepts grounded in Western standards. As another example, Miller et al. [20] highlighted the integration of STEM content within the Indigenous game of snow snakes, in which participants in the game throw a carved piece of wood (i.e., snow snake) down a constructed ice track. The one who throws the furthest snow snake is deemed the winner.

First, this approach to integrating Indigenous knowledges into STEM education highlights an understanding of STEM concepts through the practices and processes of mathematics and/or science [16,20–23]. For instance, through participating in the looming lessons discussed above, elementary learners engaged with multiplicative thinking, patterning, spatial reasoning, and number sense [16]. In calculating the number of black and blue beads needed to create a bracelet with an arrow design, one learner, Dan used mathematical strategies such as "making 10" and compensation (e.g., 11 + 9 is the same as 10 + 10, as Dan took 1 from 11 and added to 9). This illustrates Dan's facility with numbers. Learners in this study also engaged in patterns beyond repeating patterns that are more typical in standards for their grade level (e.g., ABC). They also were able to see relationships between multiple patterns that extend horizontally, vertically, and diagonally, to construct the pattern of the entire bracelet. As another example, Babbit et al. [21] found a statistically significant difference in learners' knowledge of mathematics and computing concepts when engaged in Adinkira programming language lessons, as compared to learners who engaged with a more well-known mathematical program, Geogebra.

A second positive outcome was exemplified by Eglash and Bennett [22], who noted an increase in learners' STEM interest after engaging in a web-based program involving the cultural, and mathematical, content of braiding cornrows. Third, learners may experience a positive shift in their identity as a STEM learner through engaging in the practices and processes of science and mathematics through an Indigenous perspective [1,24]. Lastly, integration of the two knowledges and perspectives may promote high levels of engagement and collaboration among young learners [23] and family members [24], particularly through the use of storytelling.

2.2. Archaeology Programs and Activities

Literature regarding archaeological programs and activities for young learners are more often integrated into social studies education [25,26] than STEM disciplines [12,18], and facilitated by archaeologists as opposed to teachers due to lack of training and professional learning opportunities [12]. Similar to above, the integration of archaeological concepts within different disciplines has a positive impact on learners. Research highlights an increased understanding of archaeological concepts [26–28], career awareness of archaeologists [25], and the personal responsibility for protecting archaeological sites and cultural preservation practices [29,30]. For example, Henderson and Levstik [27] conducted interviews with 29 students three to four years after their archaeological experience, including classroom instruction and excavation-lab work. As stated by the researchers, the "in-depth archaeological study clearly has considerable sticking power" (p. 510). Students understood the importance of artifacts in understanding the past, including how observations of material culture allow archaeologists an opportunity to construct more complete interpretations.

As another example, sixth-grade students gained insights into the day-to-day professional duties of archaeologists, such as the time and effort needed to study material culture and the location of excavation sites, after participating in a program called Think Like an Archaeologist [25]. As noted by Ducady et al. [25], exposure to archaeologists and their careers may lead some students to consider the field of archaeology as a career path, as their prior knowledge of the field was, most likely, only grounded in movies and television. Research has also highlighted how exposure to archaeological concepts may lead to an increase in a learner's interest in and excitement about archaeology [27], active investment in archaeological tasks [26], and use of appropriate terminology [30].

2.3. Learners' Perspective of STEM

Nonformal learning environments are often framed as a way to support and enhance children's development as STEM learners, as situated in formal or classroom-based learning environments [31–33], such as an increase in career awareness and career interest in a STEM field [34,35] or developing learners' identity as an engineer [36,37]. Prior research has also

examined how nonformal learning environments shift learners' perceptions and attitudes towards STEM [33,38].

In general, results from recent research found a positive shift in learners' perceptions and attitudes towards STEM disciplines and careers at the completion of their engagement in a STEM-focused program in an out-of-school context [35,39–43]. For example, Baran et al. [35] examined the impact of an afterschool program designed to engage forty 10–12-year-old learners in hands-on STEM problem-based activities. Over the course of five days, the program had a significant impact on students' positive attitudes toward STEM, particularly in their attitudes towards the personal and social implications of STEM and their attitudes towards science and engineering disciplines (as opposed to mathematics and technology subject areas). As another example, Vela et al. [43] saw a statistically significant increase in secondary students' perceptions of STEM careers at the conclusion of a one-week STEM camp. In particular, their perceptions of science had the strongest association with learners' positive perceptions of STEM careers. As such, it could be argued that nonformal STEM-focused learning environments can combat the negative perceptions towards STEM disciplines that are prevalent in middle and high school learners [44,45].

Additionally, prior scholarship has highlighted how nonformal learning environments with a STEM-focus have supported learners in making connections to their schoolwork and daily lives [35,40,46]. Learners in the study by Baran and colleagues [35] expressed how the activities in the STEM program helped them to succeed in STEM-related exams and homework assignments, and in their potential success in the upcoming year. Furthermore, learners conveyed an understanding of how STEM subjects are a component of their day-to-day lives. In the study by Wade-Jaimes et al. [46], fifth-grade students made connections between experiences in a STEM club and activities in their home environment (e.g., playing with Legos), as well as between the STEM club and their science class (e.g., experiments).

3. Theoretical Grounding

This study was grounded in the third space, which has been utilized in a variety of educational research studies, such as examining an educator's tensions within a hybrid making space [47], analyzing the different kinds of funds of knowledge that students use within their science class [48], discussing an urban teacher residency program and collaboration between a university and public schools [49], and investigating the integration of Pikwàkanagàn's looming practices into an elementary math class [16]. As an example, Gutiérrez and colleagues [50] examined an afterschool computer club, *Las Redes*, as a formal–nonformal learning environment (or hybrid space) that included and privileged students' knowledge of home and students' knowledge of school, which are often dissimilar to one another. In other words, as conceptualized by Gutiérrez [51], the afterschool program represented a third space, where dissimilar scripts—"the formal and informal, the official and unofficial spaces of the learning environment—intersect, creating the potential for authentic interaction and a shift in the social organization of learning and what counts as knowledge" (p. 152). Through this theoretical lens, Gutiérrez et al. [50] highlighted the program as a transformational place for meaning-making, collaboration, and student agency.

But what is third space? Moje et al. [52] described third space as the negotiation and integration of two alternative and/or competing spaces—a first space, which may include the Discourses or rules/norms (e.g., ways of knowing and talking) of an individual's home and community, and a second space that may include the Discourses or rules/norms of an institution, such as a school. The use of "Big D" Discourse, as opposed to "little d" discourse, is intentional. Discourse includes the ways that people act, behave, talk, dress, etc. that is socially and historically accepted as a certain "kind of person" [53]. Consider the following as an illustrative example. In a school setting, it is often a norm that students have to raise their hands before speaking or answering a question, but in their home environments, they can answer without having to raise their hands or they can playfully interrupt a sibling. In a third space, such as in an afterschool program, it may be the case that educators and students develop a new approach to answering a question or getting

one's attention such as color-coded cue cards (e.g., purple = "I got this."; orange = "Don't call on me yet, I need more think time."). But as simple as this may sound, a third space is much more complex than this, as it is often multi-voiced and polycontextual [51,54–56]. As synthesized by Moje et al. [52], there are at least three perspectives of third space: (a) a bridge from marginalized knowledges and Discourses to institutional and academic knowledges and Discourses, as a way to promote the learning of concepts and processes; (b) a navigational space where an individual crosses a physical and social boundary as a way of generating new knowledges and Discourses; and (c) an "in-between" space where different and competing cultural, social, and epistemological frameworks come into "play" to challenge, resist, and reshape dominant structures and Discourses.

In the present study, third space is conceptualized as a hybrid space that integrates Indigenous knowledges of STEM concepts, and practices with Western knowledge regarding STEM concepts, practices, and processes. Similarly, third space in this study is conceptualized as the integration of archaeological concepts, more often taught in out-of-school environments, with the STEM concepts prioritized in school environments. We contend that through the integration of alternative knowledges and ways of being and seeing the world, this afterschool program has the potential to transform middle school learners' understanding of STEM, archaeology, and/or Indigenous knowledges [50,51]. Additionally, the afterschool program was situated within a formal–nonformal learning environment, in which ways of acting, behaving, and talking are often at odds with one another [57].

4. Methods

4.1. Context

The afterschool program was designed to advance middle school learners' knowledge of STEM through informal sessions based on archaeology and Indigenous perspectives. The educational team developed curricular modules, each based on an aspect of archaeology or Indigenous knowledges that were grounded in STEM specific disciplines, such as life sciences, technology, physics, mathematics, and ecology, and in some instances, connected to age-level standards, such as use of the Pythagorean Theorem.

Archaeologists, along with undergraduate and graduate assistants, implemented the afterschool program in three rural middle schools (grades 6–8). Each program involved two to three hours of informal activities per week for 10 weeks. Enrollments ranged from 7 to 16 youths per session. Each afterschool lesson included inquiry-based activities. Through active learning and hands-on exercises, the youth observed and analyzed data related to each topic. Topics and activities included: artifact identification/classification, field surveying, stone tool replication and use, faunal (animal bone) analysis, flora (plant) analysis, cordage (rope) making, spear throwing with an atlatl, wampum making (shell beads), landscape analysis, hypothesis testing, typologies, and storytelling (learning about a culture from oral tradition).

In addition, the modules were created to build learners' STEM practices and processes (e.g., observation, hypothesis testing). More specifically, the modules built towards a final project aimed at developing and applying the research and analytical skills through a research project framed within a STEM-related archaeological or Indigenous perspective. Around week six, learners formed groups and developed hypotheses that framed their research about how Indigenous people prior to European contact used tools, acquired and prepared food, and used landscape resources. Experiments included testing what size stone tool cuts leather better; what method is best for making cordage and how much weight can it support; and what variables make an atlatl (a wooden spear throwing device) more effective for distance throwing (e.g., type of atlatl, person's height, dart length, person's arm length, throwing style). As a specific example, in the third semester of the afterschool program, three learners experimented with two tools made from materials commonly used by Indigenous peoples: stone (i.e., flakes) and animal bone. They asked whether stone or bone worked better to scrape and cut raw food materials (e.g., carrots). Their hypothesis

was that stone would be better at scraping and cutting the raw food because it was stronger and sharper than animal bone pieces.

Additionally, an important aspect of the program was including traditional Indigenous knowledge as it relates to science and the environment. The afterschool program centered on precontact Indigenous lifeways. Therefore, a Haudenosaunee Clan Mother, a Faithkeeper (and wampum maker), and a storyteller presented to the learners and grounded our lessons within an Indigenous perspective that highlighted respect for the land we all live on today [58] and for Indigenous knowledge of life sciences. For instance, the importance of the environment was highlighted by one of our Indigenous guests, who discussed the current impact of pollution on a lake that was and is vitally important to their community. They further shared their technological and traditional ecological knowledge (TEK) through oral tradition and storytelling [59,60]. Indigenous educators recited the Thanksgiving Address in their own language. This address highlights the close connection between nature and everything in it and their culture today and in the past. They also presented on how wampum (or shell bead) belts are made and their cultural significance; the process of making cordage from dogbane; and how all parts of a deer are used to make necessary items.

In connection with the social studies curriculum of the state, learners are required to study Indigenous people and their cultures in the fourth grade. In this curriculum, adolescents are taught about specific Indigenous Nations, and the ways in which each Indigenous Nation interacted with their environment. In studying these topics, learners examined the location of Indigenous Nations; compared and contrasted the traditions, roles, and customs of regional Indigenous Nations; and identified the continued contribution of these communities to today's society. Outside of these topics, adolescents are not required to learn more about Indigenous peoples and their cultures in the classroom.

4.2. Participants

We conducted the program in three public middle schools in rural areas within the same county, located in the Northeastern region of the U.S. In spring 2021 and fall 2021, the afterschool program took place in Windy School District, which serves approximately 1489 children within a 110-square-mile radius (see Table 1). The student population in the district (as of 2021) is mostly White (91%), with 52% identified as economically disadvantaged. The graduation rate is 86% [61]. In fall 2021, spring 2022, and fall 2022, the afterschool program was implemented in Wiley Point School District. The district serves about 1355 youth living within a 114-square-mile radius. Students are mostly White (96%), 58% are identified as economically disadvantaged, and the graduation rate is 79% [61]. We ran the program in a third school district, Happy Valley, only once, in spring 2022. This district serves approximately 601 youth living within a 91-square-mile radius. The graduation rate is 87%; 95% of the students are white; and 66% are identified as economically disadvantaged [61]. The schools offered a snack and late bus transportation was provided in most cases [62].

Table 1. Overview of afterschool program.

Session	School Name (Pseudonyms)	Schedule	# of Leaners
Spring 2021	Windy	2 days/week; 1.5 h each	16
Fall 2021	Windy	2 days/week; 1.0 h each	15
Fall 2021	Wiley Point	1 day/week; 2 h	15
Spring 2022	Wiley Point	1 day/week; 2 h	7
Spring 2022	Happy Valley	1 day/week; 2 h	14
Fall 2022	Wiley Point	1 day/week; 2 h	12

We recruited youth participants in collaboration with the three middle schools. School administrators sent information about the program electronically and/or physically to

parents/guardians of students in grades 6–8. Over the six sessions at the three schools, we worked with 79 learners, with 43 providing consent and assent to be a part of the research study. Of the 43 youths participating in the research, 25 (~58%) were in 6th grade, 9 (~21%) in 7th grade, and 9 (~21%) in 8th grade. In addition, three participants (~7%) self-identified as non-binary, one (~2%) as trans male, 17 (~40%) as female, and 18 (~42%) as male. Four participants (~9%) preferred not to self-identify their gender. Lastly, the majority of our participants self-identified as White (n = 32, 74%). Five (~12%) participants self-identified as two or more races, two (~5%) identified as Asian, two (~5%) identified as Black, and two preferred not to self-identify.

4.3. Data Source

To address the research question, the research team collected data regarding learners' experiences in the program through a series of informal focus group interviews. The use of focus groups was purposeful, as they create a more natural environment, one where learners in the group influence each other [63]. Moreover, learners may feel more inclined to share their responses when surrounded by supportive peers [64]. Semi-structured focus group interviews were conducted in small groups of two to five learners by grade level. Not everyone that provided consent was part of the focus group interviews, as they were absent or chose not to participate. These interviews were conducted approximately six weeks after the conclusion of the afterschool program, during the learners' lunch period, and lasted approximately 30 min. A member of the research team conducted four focus groups at Windy Middle School in June 2021; two groups at Windy Middle School and four focus groups at Wiley Point in January 2022; two focus group at Wiley Point Middle School and two focus groups at Happy Valley Middle School in June 2022; and one focus group at Wiley Point Middle School in February 2023. This amounted to 15 focus group interviews over the course of the afterschool program. During the interview, learners were asked five to six questions. Questions asked during interviews included (a) What did you learn about archaeology? (b) What did you learn about Indigenous peoples and their culture that might have shifted your understanding of science, technology, engineering, and math? How is this similar to and/or different from what you might learn in school? and (c) What do you remember about your experience in the program? Each of these interviews was then transcribed verbatim for later analysis.

4.4. Data Analysis

To begin the analysis, each researcher individually read through the interview transcripts. When reading, the researchers looked for common ideas and threads across interviews that addressed each component of the research question. Once this process was complete, the research team met to discuss their insights. One commonality noted by all of the researchers was that learners stated how the afterschool program was similar to and/or different from school. While the language each researcher used when describing a thread differed, generally they focused on the same concept. For example, each researcher highlighted how the learners made connections between Indigenous peoples' ways of living and STEM concepts. Author J described this as an "impression of the lives of Indigenous people (previous and new)". Author L named this as "Indigenous life & STEM", and Author A detailed this as "How they live/function in the current and in the past; respect for environment—medicine, fish, make baskets (cordage), flintknapping, etc.; some in terms of math and science (and how their ways of living may be similar and/or different from our own)".

In the event that one member of the research team described a thread that was uncommon across interviews and/or different from other researchers, the team discussed the thread and decided to either keep and/or omit. For instance, the thread—shared experiences or ways of living (e.g., tapping maple trees, hunting)—was not included, as this was only mentioned by three students, each in a different focus group, and was not a statement or thread taken up by other learners in the focus group. In addition, there was at least one instance in which a member of the research team noted a theme that the others

did not; that is, archaeology as a possible profession. After some discussion, we decided to keep this theme, as there was enough evidence in the interview data to support this.

From this process, we developed common themes or ideas for each part of the research question. As an example, for how the program enhanced learners' perspective of STEM, four themes were developed from the analysis of the interview data, namely connections to what they do in school, application and exploration of concepts dissimilar to school, STEM through a different perspective, and learning new STEM concepts. The last part of our analysis included each research team member going back through the transcripts and picking out quotes that exemplified each of the themes.

5. Results

In the results, we utilize exemplary and direct quotes from middle school learners to highlight how the afterschool program developed and/or enhanced the middle school learners' perspective of (a) Indigenous people; (b) the field of archaeology; and (c) STEM concepts, practices, and processes. Middle school learners in this study created the pseudonyms that are utilized throughout this section. Additionally, different modules are described throughout to add context and meaning to the results.

5.1. Indigenous Peoples

There are several ways in which the ARCH + STEM program enhanced learners' perspective of Indigenous peoples. First, some of the learners made connections between their own lives and the lives of Indigenous peoples; and in some cases, connections between the present (their own lives) and the past (the lives of Indigenous peoples). The following are two examples from Leonardo.

> Leonardo: They [Indigenous peoples] could make a net and have rocks that hold down the net in a river, so when the water is flowing and the fish are coming, they could can just trap the fish in the nets. You can still trap fish in nets today.
>
> Amber: Okay. Are there any other connections that you can think of?
>
> Leonardo: Yeah, Indigenous people used an atlatl 'cause it helped kill their prey easier and we still hunt today, just not with an atlatl.

These thoughts were also shared by Steve, who noted, "we're doing that atlatl thing, that was something they [Indigenous peoples] used to do." Both Steve and Leonardo were able to connect aspects of their lives, some of which they had been exposed to in the afterschool program, with the lives of Indigenous peoples. In this case, they both made connections between throwing an atlatl and the way in which Indigenous peoples hunted for their food. An atlatl is a stick or short pole in which the end of a dart is inserted into a wood or bone hook. The use of an atlatl allows for the dart to be thrown farther and with more force than if thrown only by hand.

Second, a few of the middle school learners expressed an enhanced sense and knowledge of how Indigenous peoples interacted with their environment.

> Amber: What did you learn about Indigenous peoples and their culture?
>
> George: We learned how they hunted and how they used the environment around them to their benefit, and how they treated the environment around them.
>
> Kit-Kat: Yeah, they just took advantage of their resources, and used everything that they were like presented to. They didn't waste anything, and they used everything that they had to the max.

Broadly speaking, in this example, George and Kit-Kat highlight an ecological perspective of how Indigenous peoples interacted with nature as a way of living. However, of note in this example is how Indigenous peoples were spoken of as if they lived in the past, as if they currently do not take advantage of their resources and have a relationship with their environment. As a more specific example of this ecological understanding, a student Lion Birch Tree commented on how Indigenous peoples used every part of a deer.

Specifically, "they [Indigenous people] used the brains of a deer to make oil to make their clothes softer".

Third, when asked if the afterschool program shifted their understanding of different cultures, one learner, Elisea said yes. She stated that she is now "more understanding [of] some of the traditions". Elisea also noticed similarities between her traditions and the traditions of Indigenous peoples, namely that she has "Thanksgiving with [her] family every year", which is similar to how Indigenous peoples recite the Thanksgiving Address before all meetings, gatherings, and ceremonies "with their tribe". Like Elisea, many other learners in the afterschool program found a new understanding and/or knowledge of Indigenous peoples and their traditions. As another example, one speaker, a storyteller, shared the Haudenosaunee Creation Story, a story that describes the creation of the world, and the role of Sky Woman in its creation. For example, as stated by Cacey, "For me, one of my more interesting things, just something I found interesting was the Indigenous person that came up to tell the tales and the stories. Sky Woman definitely stood out to me". For Cacey, this oral tradition was a highlight of his experience in the afterschool program (i.e., "more interesting things"). Similarly, for Timothy, this story was situated in contrast to his own culture and religious beliefs, but one that allowed him to be appreciative of different perspectives; "I have a little bit different culture. I go to church, I do all that. So, hearing about the sky people and the sky dome kind of opened up new thinking for me".

A fourth way in which the program enhanced learners' perspective of Indigenous peoples is that some middle school learners described STEM, and ways to utilize STEM, as a way in to understanding some aspects of both Indigenous and Western knowledges. For others, their perception of STEM through a Western viewpoint was situated as different from, or at least varied from, an Indigenous perspective of STEM. A popular example of the former was the use of an atlatl to throw a dart.

> Kit-Kat: When we were doing the atlatl, we didn't really think about science, we were just like having fun, just throwing them. We weren't really thinking about the science behind it.
>
> Amber: When did you realize that you were doing science?
>
> Kit-Kat: After a few tries, I realized that I put force on it, and that's when I realized that was like science.

As highlighted in this example, the use of the atlatl, a tool common to Indigenous peoples, was an application of the science concept of force. The scientific knowledge was "hidden" in the learners' embodiment, in that they mirrored the actions of Indigenous peoples. Consider another example from Elisea and Selena:

> Elisea: I don't picture them using a tube with green liquid in it and doing all that science experiment stuff, I see them like trying to...
>
> Selena: She did talk about how they make their own medicine, so I thought like they have to combine different herbs and plants.
>
> Elisea: Exactly.
>
> Selena: All different things to make their own medicine and stuff so that is science in a way.

In this example, Elisea and Selena co-constructed how the science of medicine, while common to both Indigenous and Western ways of living, may also be different, as the Western approach to this was situated in an experimental lab setting (e.g., "tube with green liquid").

While, the connection of science concepts was more common than other STEM disciplines, engineering was another discipline for which learners saw a relationship between the two perspectives and knowledges. Timothy gave an example of engineering grounded in his research project with two of his peers:

Because we had to engineer our tools. We took raw bone from an animal and we sharpened it into tools that you can use to cut things. That's like, if you just took a random

bone and took the bone that we had, our bone would excel compared to the regular bone, 'cause of how much engineering we did on that to make it as sharp as we could.

Similar to the quote by Kit-Kat, Timothy described how their actions engineering a tool embodied that of Indigenous peoples. Hannah too shifted her idea of engineering to embrace both Indigenous and Western knowledges. "When you think about engineering, you will immediately think of electronic stuff, gears, anything that has to do with something bigger. But now that I think about it, engineering could also... could be tracking those little stone weapons".

For George and Cacey, STEM concepts and processes were different between Western and Indigenous knowledges. As stated by George, "They [Indigenous peoples] just have this different angle on how they look at things in life". Cacey agreed. "[O]ur two cultures are scientifically and mathematically different". Technology, and the development of tablets, was one example in which Cacey situated the two perspectives as differently. "I mean right now in biology this year, we learned that you're able to edit your DNA. This is around the culture in cities and what the rest of the world is centering around. We're going into new technology. This tablet right here, we're making this". Cacey's example seems grounded in a Western perspective, the promotion of technological and scientific innovations and advances (OECD, 2019), as opposed to considering how in the past Indigenous peoples' lives were also grounded in science. Conversely, Akina noted how Indigenous people "used math and science in a practical manner", while as a learner in school, they "have to learn so many stupid things". As such, differences between the two knowledges were less common than similarities.

5.2. Field of Archaeology

Through their participation in the afterschool program, middle school learners' assumptions and perceptions of archaeologists and the field of archaeology changed. It is not unfounded that learners' previous knowledge may have been informed by popular movies and television shows such as the American film franchise "Indiana Jones" [25,65–67]. These films followed a fictional professor of archaeology, Dr. Henry Walton (i.e., Indiana Jones), who traveled the world rescuing artifacts from individuals with villainous intentions [68]. For instance, Elisea stated that she "thought archaeology was just based off like profit". She believed that archaeologists make money by selling the artifacts they excavated. Through the afterschool activities, Elisea was able to "learn more about it [archaeology]". This idea of finding artifacts and unknown objects was a common thread amongst the middle school learners. Another adolescent, Selena, also shared her preconceived notions about archaeology; "Before I came, I thought an archaeologist was just someone that digs up dinosaur bones... I thought I was gonna see dinosaur bones and went like, 'Oh, really?'" Again, this belief and eventual surprise, highlights an original lack of knowledge about the field of archaeology and the exact jobs an archaeologist performs. For Hannah, she noted how finding artifacts may be difficult, as some objects "often decay depending on the material it's made out of".

Moreover, some middle school learners showcased an enhanced knowledge of archaeology and its related concepts. Mark stated: "That it [archaeology] was not about everything in the past, it was just people . . . And it's not just digging". Another learner, Tracy, also had the same understanding of archaeology. In her focus group interview, Tracy stated that archaeology "wasn't digging up bones, it was about people from the past". This emphasis on people is different from a focus on digging up artifacts as these artifacts are a "mystery until you collect all the pieces" to tell a story (Hannah).

Along with building learners' foundational knowledge of archaeology, the program developed some learners' initial interest in the field. As stated by James, "I really like digging up and trying to find fossils and like figure out where certain people lived at certain time periods and it just really interests me now". Similarly, for Jaquiline, her interest not only grew through the program, but she was able to connect with her dad as he once worked as an archaeologist: "I kind of wanted to see what it was like, so I could talk to him

[dad] about it. And I also thought it was cool. I liked learning more about archaeology and I liked looking more at the artifacts". For Danielle, the afterschool experience confirmed her choice to pursue a career as an archaeologist.

> Danielle: At first, I did wanna be an archaeologist, and this was finally where I could learn what it was actually like to be one, to see if I actually wanted to be one.
>
> Amber: So now do you think you might wanna be one [an archaeologist]?
>
> Danielle: Yeah.

5.3. STEM Concepts, Practices, and Processes

Through their experience in the afterschool program, the middle school learners articulated how the STEM concepts embedded in the afterschool program were similar to STEM concepts in their school experience. Consider the following example from Cillion:

Well, for Mr. Starch's class we are learning about fossilization with animals and we're learning about like different structures, bone structures . . . And basically, he taught us relative dating. Relative dating is the process... It's like the process of ordering them. But oldest is on bottom. Like if you had kids and basically, it'd be bottom for the oldest, middle for the middle child and then top for the youngest.

In this excerpt, Cillion made a connection between STEM concepts he was exposed to in school, and in the afterschool program. In the afterschool program, educators discussed the dating techniques used by archaeologists. The law of superposition (oldest strata are at the bottom of an undisturbed stratigraphic sequence) is one common method of relative dating used in archaeology. As another example, Hannah did not see a distinction in math concepts between the two learning environments. For her, "math is math. Math doesn't change much . . . as you use math in real life". Moreover, learners in the program might not have been aware they were using similar STEM concepts, skills, and practices during the afterschool program. One adolescent, Doug, claimed as much in his focus group interview. He stated that "we don't even realize we're using it [the concepts]". When probed for examples, Doug mentioned an activity he participated in during the program, where the adolescents created and compared different graphs and charts. He noted that, as learners, they "didn't even realize it was math".

Conversely, for other learners, the afterschool program was different through their application and exploration of STEM concepts and practices. For example, Greg noted that he learned "more basic types" of these STEM concepts in school, but that it was the "way that we were using it [STEM concepts} that was new. In other words, STEM concepts within the afterschool program may have been considered "new" to some of these learners, due to the way in which the adolescents interacted and/or applied these concepts. This sentiment was also expressed by Cacey who said that "instead of just learning about it [math and science], we're actually applying it; rather than just sitting in a classroom and reviewing for a test." Cacey cited the aforementioned atlatl activity as evidence. When asked to explain his answer, Cacey stated:

> . . . 'cause instead of just, "Here a carrot on a piece of paper, take a ruler, measure it, how long is it?" We're actually being able to throw something, learn that what we're doing involves levers, and then being able to measure that distance.

Other adolescent interviewees agreed with Cacey's point. For Kit-Kat, this was expressed as a strength, in that they were learning different ways to apply math and science concepts: "In school, we just learn about how to use it in everyday life, and then we just get quizzed on it. And then in the archaeology, we learn how people years ago used it and how it was originally made. So, we learn two different ways of how math and science were used".

Beyond allowing for opportunities to interact with and apply STEM concepts, the afterschool program afforded the learners opportunities to explore STEM concepts, practices, and processes. This was expressed by Munesco:

> So, I think it's kind of different from school because school teaches us in like the first part and just figure it out. But in the club, we get in a group and we kind of

put it out in the first part. Then we all come back in the middle of it, then figure out what our plan is after we did all the work.

We interpreted this statement to indicate that the afterschool program encouraged learners to work together and explore STEM concepts, and to then share their thinking within a whole group setting. This is in contrast to school where they are taught a concept and then are left to figure it out on their own. Ell noted a specific example of exploration: "In the bone identification, they [educators] barely helped us and we had to go around and find those. I liked trying to find it on my own. I learned more about the bones themselves." This statement highlights how exploration supported Ell's foundational understanding of a STEM concept not part of a school curriculum; namely, how to examine and identify animal remains (i.e., bones) from an archaeological site.

6. Discussion

This paper focused on a novel afterschool program for middle school learners that integrated Western STEM concepts, practices, and processes privileged in school standards with both archaeological and Indigenous concepts, practices, and processes (i.e., ARCH + STEM). We argue for the inclusion of archaeology and Indigenous knowledges within nonformal STEM learning environments for non-Indigenous learners, as our results highlight how the program developed and/or enhanced middle school learners' perspective of (a) Indigenous people; (b) the field of archaeology; and (c) STEM concepts, practices, and processes.

First, the ARCH + STEM program resulted in middle school learners discovering connections and the relevancy of Indigenous peoples' traditions and ways of living to their own. We contend that taking the perspective of another culture was an unexpected result, as learners at this age may not engage in historical perspective taking, beyond a superficial and restricted level [69,70], nor recognize that others' perceptions may differ from their own [71]. However, a significant concern raised in this study is that some students seemed to refer to Indigenous people in the past tense, despite the fact that three Indigenous people presented to the learners during each program. As an example, Steve noted, "we're doing that atlatl thing, that was something they [Indigenous peoples] used to do." Or Leonardo, who said: "Yeah, Indigenous people used an atlatl 'cause it helped kill their prey easier and we still hunt today, just not with an atlatl." While Steve and Leonardo connected aspects of their lives, some of which they had been exposed to in the afterschool program, with the lives of Indigenous peoples, there was no connection to Indigenous people and Indigenous knowledge today. As educators and researchers, we are deeply concerned with the learners' inaccurate positionality of Indigenous people as relegated to the past and the ethical concerns that raises. As stated by one of our Indigenous speakers, history books used in schools also position Indigenous communities as people of the past. Similarly, in a content analysis of K-12 standards in the U.S., Shear and colleagues [72] found that Indigenous peoples were situated within a pre-1900 context and "directed students to see Indigenous Peoples as a long since forgotten episode in the country's development" (p. 89). Math and science standards and curriculum are also void of Indigenous knowledge systems [73,74]. Future programs will have to address this unforeseen issue, in terms of how contemporary Indigenous people are positioned and perceived by learners throughout the program. We further contend that such future research lies within deep reflection of our individual and collective selves as educators and researchers within nonformal programs (e.g., self-study) and how we position Indigenous peoples through our language and intercultural collaborations [75].

It was also the case that a few learners also gained a new perspective of STEM, in that they began to construct a foundational connection between Indigenous perspectives of STEM and Western perspectives of STEM. Through the lens of third space [52], learners bridged Indigenous peoples' knowledges and Discourses to institutional and academic knowledges and Discourses of Western societies that may be considered at odds with one another [1–3]. This finding adds to prior scholarship—observations by Beatty et al. [16] and survey/test by Babbit et al. [21]—that documented Indigenous and non-Indigenous learn-

ers' understanding of STEM concepts through the integration of Indigenous knowledges and Western knowledges of STEM concepts and practices. In this study, learners retained their newfound perspective of STEM approximately six weeks after the conclusion of the afterschool program. Learners' association of the two perspectives may also have implications for their interest/development of STEM [22], identity as a STEM learner [1], and levels of STEM engagement [23]. Future research on ARCH + STEM afterschool programs should attend to this scant research, as it was also the case that other learners considered their perception of STEM through a Western viewpoint that differed from the Indigenous viewpoint of STEM. How might nonformal programs support young learners in seeing value in and appreciate both Western and Indigenous perspectives of STEM? Second, similar to prior research, learners in the study gained an understanding of archaeological concepts [27,28], as well as an awareness of what archaeologists do in their careers [25]. We conjecture that this shift in understanding was due to their prior knowledge as informed by popular movies and television shows [66,67] and limited exposure to archaeological concepts in school [18]. It was also the case that some learners developed and/or maintained an initial interest in the field [27]. Prior research has illustrated how interest in a particular field (e.g., math and science) influences one's degree and career choices [76–78]. Therefore, it is possible that learners in this program will pursue and obtain a degree and career as an archaeologist. Furthermore, unlike the integration of Indigenous and Western perspectives of STEM, learners did not make explicit connections between archaeological concepts and STEM concepts. This is not to preclude the argument for integrating archaeology within STEM disciplines for K-12 learners [13,14]. Future research studies should continue to explore how to support learners in developing an understanding of STEM concepts through archaeology. We contend that considering an embodied approach to analyzing video data [79] of learners' actions and behaviors may shed light on the intersectionality or third space of archaeology and STEM.

Third, learners articulated how the STEM concepts embedded in the afterschool program were similar to the STEM concepts in their school experience. Researchers such as Baran et al. [35] and Wade-Jaimes et al. [46] found similar results; however, their research was not grounded in STEM concepts, practices, and processes through an archaeological and Indigenous perspective (i.e., ARCH + STEM). As expected, the learners' viewpoints were grounded in a Western perspective of STEM, which informs what is taught within STEM subjects in schools throughout the U.S. On the other hand, learners articulated how the ARCH + STEM program was different from their school experience, as they were provided opportunities to apply and explore STEM concepts, practices, and/or processes; whereas in school, some learners expressed being limited and constrained. This highlights the value and importance of third space opportunities for youth. Additionally, the afterschool program promoted skills (e.g., collaboration) aligned with the 21st century skill framework [80]; learners developed skills to prepare them for their future work environments.

Based on the results, we contend that the integration of alternative knowledges and ways of being, and seeing the world within nonformal learning environments (e.g., ARCH + STEM), has the potential to transform middle school learners' perception of STEM, archaeology, and/or Indigenous knowledges. As articulated by learners in this study, such a program has the potential to diminish differences and/or tensions between Indigenous and Western knowledges and perspectives of STEM [2], as well as support archaeology as an approach to facilitating the learning and application of STEM concepts, practices, and processes [15]. As stated by Cajete [81], "teaching and learning is about thinking differently, beginning in places, knowledge, and contexts where Indigenous and Western ways of knowing, being, and doing can circulate together; letting go; and paying close attention to what emerges" (p. 144).

Beyond the future research studies identified above, the research team sees value in examining the impact of the ARCH + STEM program with Indigenous middle school learners, as well as families in the local area (see [24] for an example). We encourage educators and researchers across the STEM learning ecosystem to implement and/or adapt

the modules within the ARCH + STEM afterschool program by visiting the following website: https://archaeolessons.com/ (accessed on 23 April 2023), Archaeology in Rural Schools and Communities, and to examine various constructs (e.g., identity development, interests, beliefs), as there is limited research at the intersection of archaeology, Indigenous knowledges, and STEM concepts as informed by Western perspectives. Similar to the research by Henderson and Levstik [27], who interviewed learners three to four years after their experience in an archaeology program, future research should consider the "sticking power" of such programs.

7. Conclusions

This novel afterschool program for middle school learners focused on the intersection of archaeology and STEM, as taught within an Indigenous perspective of STEM (i.e., Third Space; Moje et al., 2004). The central goal was to answer how the program developed and/or enhanced middle school learners' perspective of (a) Indigenous people; (b) the field of archaeology; and (c) STEM concepts, practices and processes, if at all. Group interviews with learners demonstrated that learners unexpectedly discovered connections between their own lives and the traditions of Indigenous peoples. The integration of Indigenous and Western perspectives of STEM resulted in some learners gaining a new perspective of STEM.

In terms of archaeology, learners acquired an understanding of broad archaeological concepts and what is entailed in an archaeological career. For some, they developed a new interest in the field, while for others their interest was maintained or heightened. Learners were also able to see connections between the STEM concepts embedded in the afterschool program and those that were presented in their school experience. However, learners noted that the ARCH + STEM program differed from their school experience, in that they were applying and exploring STEM concepts, practices, and/or processes. The afterschool program allowed them to move beyond the limits and constraints imposed by the formal school structure. We maintain that through a Third Space, the integration of alternative knowledges within nonformal learning environments may diminish differences/tensions between Indigenous and Western knowledges and perspectives of STEM, and support archaeology as an approach for learning STEM concepts, practices, and processes.

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