Exploring Art and Science Integration in an Afterschool Program

by

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Abstract

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Science, technology, engineering, arts and math (STEAM) education integrates science with art, presenting a unique and interesting opportunity to increase accessibility in science for learners. This case study examines an afterschool program grounded in art and science integration. Specifically, I studied the goals of the program, its implementation and the student experience (thinking, feeling and doing) as they participated in the program. My findings suggest that these programs can be powerful methods to nurture scientific literacy, creativity and emotional development in learners. To do so, this program made connections between disciplines and beyond, integrated holistic teaching and learning practices, and continually adapted programming while also responding to challenges. The program is therefore specially suited to engage the heads, hands and hearts of learners, and can make an important contribution to their learning and development. To conclude, I provide some recommendations for STEAM implementation in both formal and informal learning settings.
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CHAPTER 1: INTRODUCTION

From STEM to STEAM: Integrating Art and Science

For countless generations, human beings have used science, technology, engineering and mathematics in efforts to explain, to impose order on and take advantage of the world that exists around them. In some cases this has led to remarkable feats of engineering, medical breakthroughs or more efficient technology, which many would argue have impacted human civilization for the better. On the other hand, scientific pursuit and exploration have also been known to have dire and sometimes fatal consequences, particularly if we consider the anthropogenic impacts of climate change or the development and use of the atomic bomb. In either case, the seemingly innate desire of the human race to want to know and do more, to constantly push boundaries and to live ‘better’, longer and more efficiently suggests that the disciplines of science, technology, engineering and math (also known as the STEM fields) will have an ever present influence on our lives and society at large.

One of the most prevalent arguments for STEM education today comes from the potential contribution and influence of STEM on global economic competitiveness (Land, 2013; FedDev Ontario, 2010). For this reason, there has been a large push in certain North American and European nations towards STEM Education in K-12 settings and beyond, aiming to generate skilled STEM workers that can contribute creative and competitive ideas and fuel further economic growth. As Land (2013) notes, “Many professionals hold the belief that by focusing these key [STEM] areas, the students of tomorrow will propel our global competiveness forward through the development of innovative ideas” (p. 547). STEM Education is therefore seen as the primary method to ensure future economic sustainable growth.
This movement has become of particular interest in the United States, where, as Daughtery (2013) suggests:

The rationale for increased emphasis in STEM education is driven largely by lackluster national assessments of PK-12 students over the last decade or two. These assessments continue to indicate that the United States is failing to compete with other countries when it comes to student performance and interest in STEM subject areas. (p. 10)

Even in Canada in recent years, STEM based initiatives have been implemented, with the hope of “addressing the ability of young people to meet future labour market needs by developing the next generation of STEM leaders to fuel business innovation” (FedDev Ontario, 2010). The decrease in performance and number of STEM graduates and a growing desire for innovation to fuel economic competition and growth and environmental sustainability have become a major economic concern in countries around the world.

Beyond the need to create more STEM professionals, there is a mounting question regarding whether STEM graduates possess the competencies necessary to contribute to innovation, productivity and sustainability in the post-modern economy. It has been suggested, in fact, that STEM skills alone are insufficient and should be used in combination with communication, teamwork, entrepreneurship, art and creative design skills (Council of Canadian Academies, 2015). It is therefore important to consider not only how to nurture learner skills in these areas, but also how to do so in a way that increases both interest and performance in STEM fields. To do so, involves taking a critical look at modern science education and STEM as they exist, and to consider how they can evolve to meet these needs in the future.

Some scholars have suggested that modern science education, and STEM by extension,
place an incredible emphasis on students’ ability “to quickly comprehend large amounts of abstract, decontextualized knowledge (e.g., as laws, theories and functions of inventions) that often are rapidly transmitted to them in school science” (Bencze, 2010, p. 296). This is consistent with what is expected in the present knowledge economy fueled on intellectual capital, which “requires relatively few people to create knowledge” (Lash, 2002 cited in Bencze 2010, p. 295) and “much larger classes of workers [to] carry out most of the labour” (Bencze, 2010, 296). This model of science education creates a barrier to access and opportunity for a large number of learners, and in doing so, not only “squelches children’s innate curiosity about natural phenomena”, but also neglects to “provid[e] other students with so much as a minimal level of scientific competence” (Jones, 1997, p. 665). Perhaps the most troubling consequence of this model of science education and STEM is that “Students in most schools and in urban centers in particular are presented with a view that serves to legitimize the existing social order since change, conflict, and men and women as creators as well as receivers of values and institutions are systematically neglected” (Apple, 2004, p. 95). In summary, this model of schooling not only denies the rights of some students to participate, but does so in a way that legitimizes the hegemonic perspective that the ability to ‘create knowledge’ or serve as ‘intellectual capital’ should rest in the hands of the privileged few.

In addition to its focus on abstract knowledge, modern science education and STEM continues to place emphasis on the traditional positivist vision of scientific inquiry. According to this view, “scientific work is tacitly always linked with accepted standards of validity and is seen (and taught) as always subject to empirical verification with no outside influences, either personal or political” (Apple, 2004, p. 83). This highly objective vision of science attempts to remove the element of human influence, denying that science can be imbued with value or offer up more than
one perspective on a given phenomenon. The rigidity of a positivist vision of science education could also be responsible for both the low performance and lack of interest in STEM courses. In these cases, “science students are expected to construct scientific concepts meaningfully even when those concepts conflict with indigenous norms, values, beliefs, expectations, and conventional actions of students’ life-worlds” (Aikenhead, 1997; Cobern, 1996; Jegede & Okebukola, 1991 cited in Aikenhead & Jegede, 1999, p. 270). In other words, learners are expected to understand and rationalize learning in science from a positivist perspective, regardless of their prior experience, personal needs, background, interest or values. STEM education, implemented without consideration of these factors and “without ethical grounding, remains self-serving and hegemonic” (Steele, Brew & Beatty, 2012, p. 129). This presents a conflict that can be troubling for learners, who then might “invent ways to avoid constructing scientific knowledge, or … conveniently store the constructed scientific knowledge in their minds out of harm’s way from interfering with their life-world experiences” (Aikenhead & Jegede, 1999, p. 270). This serves as another means of selecting students out of learning in science. When the structure of the discipline cannot be negotiated with reality as experienced by learners, many simply disengage and/or opt out of pursuing science or STEM studies, choosing instead to pursue more relevant, engaging and personally fulfilling alternatives in the humanities, arts or social sciences.

It can be argued, that a STEM approach to science education, if implemented according to a purely positivist model aimed at using abstract knowledge to train ‘elite’ science specialists, encourages rigorous selection and perpetuates hegemony. As a consequence, fewer learners might continue with science education or engage in creative ways. If however, STEM is also used as a strategy to nurture scientific literacy, and to empower learners to make responsible decisions
and become active citizens, science education may become more accessible and meaningful to a greater number to today’s learners. As Hodson (2003) notes:

> The purpose of such an education is to enable young citizens to look critically at the society we have, and the values that sustain it, and to ask what can and should be changed in order to achieve a more socially just democracy and to ensure more environmentally sustainable lifestyles. (p. 654)

Learners, through their commitment to informed and active citizenship, can therefore participate in a process of social reconstruction (Hodson, 2003). Each individual has an innate right to contribute to this process. STEM educators therefore “cannot deprive certain members of our society the tools to make good decisions based on their race, class or level of access” (Marrero, Gunning & Germain-Williams, 2014, p. 2), as may be the case with the dominant economic model of STEM education. Using STEM as a means to open up access in science for all learners permits the exploration of “many untapped talents”, and encourages “more diverse research and knowledge [to] be shared, for the betterment of all” (Marrero et al., 2014, p. 2).

It seems that science education and STEM as an extension, are indeed in need of a reconceptualization. The present positivist model, focusing on the selection of a few ‘elite’ learners is, in my view, illogical and unjust. If the purpose of STEM education is not only to generate more skilled STEM professionals, but also to nurture scientific literacy and responsible citizenship, then science education and STEM must be remodeled in ways that welcome and meet the needs of more diverse groups of learners. This is vital to creating a more accessible and just learning experience in science for all students, to encourage more students to participate and to nurture a passion for scientific studies. Integrating science with art may be one interesting strategy toward rethinking STEM education in terms of meeting the imperative for accessible and
equitable opportunities for learning in science. This modified version of STEM, known as STEAM (science, technology, engineering, arts and math), has been proposed and explored by Bequette and Bequette (2012), Daugherty (2013), Guyotte, Sochacka, Costantino, Walther and Kellam (2014), Land (2013), Madden, Baxter, Beauchamp, Bouchard, Habermas, Huff, Pearon and Plague (2013), and Wynn and Harris (2012) to name a few. As Land (2013) suggests, “Adding the arts into the STEM equation can re-invigorate the platform, providing not only an interesting approach, but also opportunities for the self-expression and personal connection new generations crave” (p. 548). The idea of adding the arts into STEM was intriguing to me. Ultimately, it led me to explore a specific example of STEAM education in an afterschool program.

The case under study was an afterschool program in a large Canadian city, uniquely grounded in art and science integration. This particular case offered a unique and interesting opportunity to explore an example of STEAM programming in action and to engage with instructors and learners to explore why there is an interest in this type of integration, and how this integration is both executed and experienced. More specifically, through this case I explored the goals of the art-science program and the specific type of content integration and teaching and learning strategies implemented. I considered factors or challenges that would influence the implementation of the program, and explored instructor/teacher perspectives, and the student experience including, what they think, feel and do, as they participated in the program. I spent two and a half months at this site, visiting weekly. I conducted interviews with the two program facilitators and nine students enrolled in the program, wrote-copious field notes as a participant observer, and collected documents and artifacts. As a result, this investigation has provided insight into the potential of STEAM education in informal, but also formal learning settings.
Research Questions

In this study, I explored three related questions, which served as the foundation for this research project:

• What are the goals/objectives of an after-school program which specializes in the integration of art and science?

• How is an afterschool program, specializing in the cross-curricular integration of art and science implemented? What factors or challenges experienced by educators influenced the way the program was implemented?

• What are the experiences of students in an afterschool program which specializes in the integration of art and science?

In the next section, I describe my journey as a science student and now science educator, and how through these experiences, I became passionate about accessibility in science education. I also briefly describe the origin of my interest in the arts and why this exploration of them in an informal setting was particularly appealing to me.

The Journey From Student to Science Teacher to Artist

As a science student and science educator I have observed learners disengage with studies in science first-hand on multiple occasions. In high school, as I progressed through the senior grades, I began to notice that class sizes in science were shrinking around me. It always interested me that my Grade 12 university preparation chemistry class only had fifteen students in it, when there were approximately 500 students in my grade. I also remember being troubled when a close friend expressed that she no longer wanted to pursue studies in chemistry due to the frustration
and anxiety it caused her. I remember that she cited the volume and abstract nature of the material being some of her most pressing concerns. It baffled me that a motivated student with a clear interest in science and strong study skills felt that she was being denied the experience to truly engage. This is not a unique phenomenon to my experience, as often, “the sheer number of products [facts, theories, laws, etc.] in curricula can compel teachers to cover them so rapidly and with few opportunities for application in personally meaningful contexts that many students are left confused and only capable of rote learning” (Jenkins, 2000 cited in Bencze & Carter, 2011, p. 655). This conversation with my friend has stayed with me for years, and I do believe was one of the factors that encouraged me to become a science educator, to complete this thesis and to contribute to research in science education that aims to make science accessible to all learners.

As I began my career as a science teacher, I experienced more and more instances of student disillusionment with science. In my many conversations with learners, I have observed a significant number of them lack both the motivation and interest in pursuing scientific study. Students cite various reasons for these attitudes, claiming that science is irrelevant to their daily lives or future careers or that they do not possess the skills or ‘smarts’ to be successful. Their comments are echoed in the President’s Council of Advisors on Science and Technology report (2010, p. 43) that states: “students conclude early on that STEM subjects are boring, too difficult, or unwelcoming”. Regardless of the reasons student cite, I have always found these conversations heartbreaking, particularly because I pursued science education as a means to share my enthusiasm and wonder of science with young people and to hopefully spark that same passion in them.

As a result of my experiences as both a teacher and a student, I have become very aware that for some learners, school science is fundamentally inaccessible. With that in mind, however,
I have been eager to learn about and attempt different strategies, which might open doors for learners in science. One of the strategies I am particularly interested in is the transition of STEM education to STEAM. As Land (2013) notes, integrating the arts with science, technology engineering and mathematics, may be a powerful way to ‘reinvigorate’ STEM and nurture student engagement. Interestingly, I have seen evidence of this in science lessons and assignments where I have purposefully integrated an artistic element. For example, in a Grade 9 general science class, after having explored the concept of the carbon cycle, I asked learners to create a type of story-board that represented the flow of carbon through the natural environment (or to “tell the story of a carbon atom” from the perspective of the atom). Students were asked to identify five potential steps of the carbon cycle, in sequence, writing out a brief sentence for each. To accompany their sentences, learners were to create a diagram or flow-chart to visualize the movement of carbon they described. Some of the complete assignments that I received were outstanding, particularly those where students embraced the opportunity to be creative. In fact, in some cases, I noticed that the students whose story-boards were the most artistic were generally those that were more hesitant to participate in class. I saw this experience as having been a positive way of getting learners to use the skills they already possessed in a scientific setting and to make a personal connection to science. Hopefully, it helped to affirm that all learners have a place in the science classroom.

In consideration of these kinds of experiences, I oriented the following research study towards exploring STEAM education. I conducted a case study in an afterschool program that focuses exclusively on the integration of art and science content. Through this case, I explored some of the potential goals and implementation strategies of STEAM programming and took a detailed look at the student experience of STEAM. I chose to explore this particular case in an
informal setting, because I have come to appreciate that as a science student and teacher, it was not until my adulthood, in environments outside of the formal classroom, that I was able to build an appreciation and enthusiasm for creating visual art. In these environments, where there was a potential to explore and discover, there was no expectation to compare ones work to others and no emphasis on grades, I was able to actually find my inner artist, a discovery that I admit has been an incredibly soul affirming experience. It is my hope that through this study and the exploration of art and science integration in informal learning settings, that other learners will be able to recognize and embrace both the artist and scientist that exist within them, and in doing so find new pathways into science.

Thesis Overview

This thesis has seven chapters. In the next section (Chapter 2) I outline the theoretical framework of the study, as supported by academic literature. This framework will provide relevant background and context to the study and also scaffold the analysis and findings. This discussion will begin with an introduction to STEM education, its purpose and the needs it meets in society. This will be followed by an exploration of creativity in education, particularly the possibility to foster creativity through the integration of art and science. STEAM education will be introduced as a means to accomplish this integration in practice. Some of the principles of Whole Child Education will be explored and serve as the lenses through which findings of this study are interpreted. The discussion will conclude with a look at informal education, particularly after-school programs, and the possibilities they hold for supporting STEAM education.

Chapter 3 provides an outline of the methodology of the study, including a description of the interpretivist or constructivist framework used to structure the case study and interpret it’s
findings. This includes a detailed discussion of the research design, including the data collection and analysis strategies that were used. Chapters 4, 5 and 6 address each research question respectively, while Chapter 7 concludes the discussion by considering the significance of the study and providing a few recommendations and extensions which may help to further develop understanding in art and science integration as interest in it and evidence to support it continues to grow.
CHAPTER 2: LITERATURE REVIEW

STEM (Science, Technology, Engineering and Math) Education

Recently the field of STEM education has grown in prominence in countries around the world. STEM, which refers to science, technology, engineering and mathematics, is an example of a cross-disciplinary, collaborative understanding of these fields (Duggar, 2010; Guyotte et al., 2014). This approach typically involves “taking subjects that have previously been taught in isolation and weaving them into an integrated curriculum” (Guyotte et al., 2014, p. 12). In doing so, STEM “offers students a chance to make sense of the integrated world we live in rather than learning fragmented bits and pieces of knowledge and practices about it” (Duggar, 2010, p. 2). In a sense, STEM has the potential to provide learners with a more realistic and holistic conception of how these disciplines operate and influence their lives.

The push for STEM education in recent decades has found traction in the mounting concern that countries around the globe are not producing enough competent STEM professionals to keep their economies growing and to continue innovating. Interestingly, this concern is not a novel one, particularly in the United States. Some scholars have argued that:

The modern STEM crisis can be traced to the 1950s when there was a perceived threat to U.S. economic and homeland security by the launch of Sputnik, and fear that the Soviet Union was annually producing almost twice as many more scientists and engineers than the United States (Stevenson, 2013, p. 135).

The heart of this issue remains the same; “if the U.S. is to compete with other nations, … children [students] must be well-versed in 21st century workforce skills related to STEM education” (Daugherty, 2013, p. 10). This concern is compounded by the facts that students in the U.S. are not performing as well in STEM subject areas, there is a lack of student interest in
STEM fields (Daugherty, 2013) and that skilled and passionate STEM workers are choosing to work in other nations (Duggar, 2010).

The Canadian context for the push in STEM education is similar to that in the United States, with the exception that Canadian students ‘perform relatively well’ on standardized math and science assessments (Council of Canadian Academies, 2015). A 2012 report from the House of Commons Standing Committee on Human Resources, Skills and Social Development and the Status of Persons with Disabilities (HUMA) outlined several STEM occupations that project a large number of job openings in the coming years. In response to this shortage, the report claims that “without a steady and important rate of students graduating in the STEM professions, the science and technological industries will suffer along with the whole economy” (Standing Committee on Human Resources, Skills and Social Development and the Status of Persons with Disabilities [HUMA], 2012, p. 14) and recommends not only “that the Government of Canada continue to fund programs to increase enrolment and graduation rates” but to also “increase collaboration between academia and [STEM] industries … to ensure that curricula are more relevant and meet the needs of these industries” (HUMA, 2012, p. 16).

The push for STEM Education in Canada, on behalf of “governments, policy-makers, educators, and business leaders” is intended to “maximize their economic competitiveness and productivity” while also “fulfill[ing] labour market demands and promot[ing] innovation” (Council of Canadian Academies, 2015, xii). It is interesting to note, however, that despite these employment and innovation concerns, an Expert Panel on STEM Skills for the Future in their 2015 report note that they “found no evidence of a current imbalance between the demand for and supply of STEM skills at the national labour market level” (Council of Canadian Academies, 2015, xiii). Regardless of this finding, the report maintains, “investments in STEM literacy are
crucial for developing a skilled society that is prepared to respond to an uncertain future” (Council of Canadian Academies, 2015, xiii) and therefore still valuable and indeed necessary.

As an integrated model of curricula, STEM learning attempts to nurture and develop a ‘skilled society’ by placing emphasis on specific areas of student learning, which include, but are not limited to “probing, making connections, investigating, questioning, [and] communicating” (Amgen Canada Inc. and Let’s Talk Science, 2012, p. 14). These skills are particularly significant because they not only play a role in the development of “analytical, curious and critical thinkers” (Amgen Canada Inc. and Let’s Talk Science, 2012, p. 5), but they also advance the STEM fields and “provide individuals with options in uncertain labour markets” (Council of Canadian Academies, 2015, p. xiii). It is important to note however, that STEM skills, although an asset in the evolving knowledge economy are not the only skills that learners will need to be successful in the working world and in their daily lives. Skills in “leadership, creativity, adaptability, and entrepreneurial ability may be required to maximize the impact of STEM skills” (Council of Canadian Academies, 2015, xvii).

Perhaps it is most important to consider that through participation in STEM programming, students can be presented with opportunities to nurture their scientific literacy. The definition of scientific literacy is quite contentious. As Hodson (2003) notes:

While some see scientific literacy as the capacity to read newspaper and magazine articles about scientific and technological matters with a reasonable level of understanding, others see it as being in possession of the knowledge, skills and attitudes essential to a career as a professional scientist, engineer or technician. (p. 646)

Still others maintain that scientific literacy requires a much broader definition that integrates ideas of citizenship and democracy, including “informed decision making; the ability to analyze,
synthesize, and evaluate information; nature of science (NOS) perspectives; the coupling of science, ethics, and moral reasoning; and agency” (Pedretti & Nazir, 2010, p. 604). Scientific literacy, for the purpose of this research study will be conceived as a combination of all these ideas. It is important to note however, that all learners, regardless of whether they decide to pursue a STEM profession or not, have the right to a science education that nurtures this critical literacy. This is imperative to preparing learners for their informed and active participation in a world that is ever changing and increasingly complex. Hodson (2003) describes the fundamental need for scientific literacy best when he states:

What is clear is that ordinary citizens will increasingly be asked to make judgements about matters underpinned by science knowledge or technological capability, but overlaid with much wider considerations. Those without a basic understanding of the ways in which science and technology are impacted by, and impact upon, the physical and the sociopolitical environment will be effectively disempowered and susceptible to being seriously misled in exercising their rights within a democratic, technologically-dependent society. (p. 650)

As contemporary problems continue to become more complex, informed and creative solutions will be required to address them effectively and efficiently. If STEM adheres to a purely positive notion of science and focuses exclusively on the creation of ‘elite’ subject specialists, it may do so at the expense of nurturing a critical scientific literacy for all learners. It is for these reasons that many are calling for an evolved definition of STEM, known as STEAM, which integrates art into the scientific, technological, engineering and math dialogue, accommodates a wider breadth and depth of skills and places explicit focus on creativity, while also ensuring all students have access to learning that can nurture their scientific literacy, thus preparing learners to become
more informed and active citizens.

The next section will outline the role and importance of creativity in education. It will introduce the potential for art and science integration to facilitate a nurturing of that creativity, through STEAM education.

**Fostering Creativity - The Potential Merger of Art and Science through STEAM**

**Creativity in Education**

Although there are different conceptions of the meaning of creativity, a fairly simple understanding rests in the difference between divergent and convergent thinking. Madden et al. (2013) note “Convergent thinking is following a process to reach one solution to a problem, whereas divergent thinking involves exploring many possible solutions to a problem. Programs designed to foster creativity often focus on teaching students strategies to promote divergent thinking” (p. 542). This is not to suggest however that divergent or creative thinking is a fully unrestrained process that considers an infinite number of solutions to a problem. In the process of solving any problem, there are always factors that must be considered that determine whether a particular solution is realistic and viable. In the case of divergent thinking and the creative process, there are four factors to consider that I have converted into questions. Each question is discussed below.

The first question in the process of creative thinking asks, *does this solution or idea involve imagination?*, where imagination is defined as “the process of generating something original: providing an alternative to the expected, the conventional, or the routine” (National Advisory Committee on Creative and Cultural Education [NACCCE], 1999, p. 31). The second question asks *does this solution or idea have a purpose?* This question prompts an individual to
consider the overall objective or central problem being addressed (NACCCE, 1999). The third question asks, *is the solution or idea original?* Although similar to the first, this question probes at the degree of originality rather than the process of imagination. It requires an individual to consider whether the solution or idea is “original in relation to their own previous work and output”, “original in relation to their peer group” and/or “original in terms of anyone’s previous output in a particular field”, historically (NACCCE, 1999, p. 32). The final question asks, *is the solution or idea of value?* In other words, this question considers whether the solution or idea is “effective, useful, enjoyable, satisfying, valid, tenable” (NACCCE, 1999, p. 33). Only when these four questions have been carefully addressed are the potential ideas, revealed through processes of divergent or creative thinking, potentially constructive and viable.

How then can classroom teachers and educators engage learners in this creative and ultimately, reflective process? Put most simply, “Teaching for creativity involves teaching creatively” (NACCCE, 1999, p. 103). This rather abstract concept has been divided into three much more manageable tasks, “encourage[y] young people to believe in their creative potential, to engage their sense of possibility and to give them the confidence to try” [emphasis added], to “help young people to discover [identify] their own creative strengths” [emphasis added] and to help foster creativity through the development of certain skills and abilities, such as curiosity (NACCCE, 1999, p. 104). Fulfilling these three tasks, might help establish a “relationship of trust” in the learning environment and consequently help to improve learner “self-confidence, independence of mind, and the capacity to think for oneself” (NACCCE, 1999, p. 106).

It is important to note that traditionally, creativity may have been exclusively considered to reside within the domain of the arts, or possessed by a small, elite group of individuals with
particular talents (NACCCE, 1999). For the purposes of this research, creativity will be considered democratically, that is that “all people are capable of creative achievement in some area of activity, provided the conditions are right and they have acquired the relevant knowledge and skills” (NACCCE, 1999, p. 29). In addition, the role or potential of creativity will stretch beyond the arts and into other areas of learning, where creativity and skills in other areas such as literacy and numeracy are seen as “complementary abilities, not opposing objectives” (NACCCE, 1999, p. 13). With this cross-disciplinary understanding of creativity in mind, it is of interest to explore how seemingly unrelated disciplines such as art and science can work together to nurture creativity and take a more holistic approach to learning.

**Art and Science**

There has recently been some interest in looking at the disciplines of science and the visual arts to determine whether, by working together they can enhance learner creativity and perhaps performance in both subjects. On the surface, this may seem unusual, particularly if one considers these two disciplines to be, at their core, opposed to one another. For example, “science is considered to be dealing with objective, universal truth”, whereas art “deals with the notion of “the beautiful” as the personal, sensual, and emotional expression of humanity” in much more subjective terms (Erez, 2001, p. 7). Despite this seemingly irreconcilable difference\(^1\), through careful consideration of both disciplines, it becomes clear that “Employing artistic sensibilities in STEM practices is more an affinity of shared values than an appropriation” from either discipline.

\(^1\) The notion of science as objective, and universal truth has been challenged through Nature of Science (NOS) perspectives, which suggest that science as a pursuit is subjective, includes bias, requires imagination, and is conducted within a social-cultural context.
(Wynn & Harris, 2012, p.43). These ‘shared values’ include a similar purpose, type of thinking, model of inquiry or design and set of skills, values and dispositions. These similarities will each be individually discussed.

At a fundamental level, both scientists and artists seek to achieve a similar goal or purpose. As Craciun (2012) notes, “Artists, but also scientists, study materials, humans, phenomena or cultures to gain a deeper understanding in order to model and transform the information into something that can be given back to the population in a different form” (p. 94). In essence, both scientists and artists seek to understand phenomena that exist around them and to capture that understanding in a way that can be shared with others. Just as a photographer, who through capturing a unique moment in time seeks to understand and share their understanding of a certain phenomena, a scientist uses their understanding of specific natural phenomena to generate new discoveries, which are shared with vast populations.

In addition to purpose, the types of mental activity used in either discipline are also similar. Traditionally, scientific inquiry was thought to exclusively involve processes of analysis (including justification and evaluation of ideas), whereas artistic inquiry involved the process of synthesis (including generation or creation of ideas) (Erez, 2001, p. 8). This distinction is most evident in science education, which usually is oriented toward “the justification process” or ‘analysis’ of known theories (Erez, 2001, p. 8). Erez (2001) notes, however, that “the process of discovery in science…[resembles] that of artistic creation”, requiring “a synthetic approach that employs direct and holistic perception through intuition” (p. 8). The process of scientific inquiry is therefore just as much a process of analysis as it is a process of synthesis. Conversely, art also involves a level of critique, which “resembles the process of justification” and analysis (Erez, 2001, p. 8). It is therefore evident that the thought processes traditionally thought to belong to
one discipline or another, actually exist in both.

Art and science are also similar in their models of inquiry and design. In science this has particular relevance to the field of engineering, where design is generally thought to be characterized by the following steps:

- Considering the problem and challenges that need to be solved,
- Considering the benefits and drawbacks of different ideas and material choices,
- Coming up with one or several design options,
- Conveying raw data as prototypes,
- Testing and evaluating the usefulness of prototypes (Bequette & Bequette, 2012, p. 44).

Through these steps (which may not always be so linear), engineers are able to create useful tools for use across society. Interestingly, a similar process is explored in art classrooms when discussing creative design. Vande Zande, Warnock, Nikoomanesh and Dexter (2014) have summarized this process into six steps, including defining a design problem, investigating or researching the problem, developing ideas and brainstorming, creating and testing prototypes, presenting the final solution and evaluating and revising based on constructive critique. A comparison of both processes reveals that they mirror one another very closely.

In addition to these evident similarities, both art and science require a similar set of values, skills and dispositions from their workers. For example, one common trait is “aesthetic appreciation” or “awareness”, which means to “respond to the sensory or formal qualities of an experience: to such qualities as harmony, tone, line, symmetry and colour” (NACCCE, 1999, p. 83). This type of ‘awareness’ can be very significant to the form and function of the final products created through art or engineering design. Merten (2011) offers several other common traits, suggesting that both artists and scientists “show curiosity and are observant of the world”,

“value honesty and creativity”, “use tools to help them in their work” and “use communication skills to express … ideas and record their observations” (p. 32). Moreover, both art and science “are charged with an ethical burden”, since both are socially and culturally relevant human constructs (Erez, 2001, p. 9). Both artists and scientists must therefore be critical of their work and carefully consider the implications to society at large.

All of these points suggest that an integration of art and science does not involve the rationalization of two opposed ideologies, but rather an embrace of the similarities between very relatable disciplines each contributing to the development of the whole person. The following section will outline an example of art and science integration that has embraced these similarities.

STEAM - A New Frontier

Given the many connections that exist between the disciplines of art and science, there have recently been calls to expand the idea of STEM to include art. This modern field, known as STEAM, has been compared to “a watercolor painting in which colors bleed together and blur the boundaries between disciplines, and where vibrant new colors reflect the importance of these emergent spaces” (Guyotte et al., 2014, p. 14). Through this level of integration, the objectives of STEM could still be realized, while opening up the opportunity to meet many more. For example, some claim that as a direct result of STEAM, “Art students become better technicians and conceptual thinkers … while science students become more imaginative and innovative” (Wynn & Harris, 2012, p. 47). While this potential outcome is significant, it is equally important to consider what STEAM can do for all learners, regardless of discipline. This rests on how STEAM as an integrated approach to curricula, “enables students to explore a single concept from different vantage points” and assists in “the formation of more neural pathways” in the
brain, which connect both scientific and artistic concepts with the learner’s personal experiences (Land, 2013, p. 549), and embraces a more expansive view of what it means to be scientifically literate. The art component in particular also provides opportunities for learners to use their own voice (Wynn & Harris, 2012) and to connect to their own personal experience. Connecting to learners’ personal lives and voices increases the relevance of material for them and therefore “provides pathways for personal-meaning making and self-motivation” (Land, 2013, p. 552). As a consequence, STEAM has great potential to engage and empower learners and in doing so, motivate them to continue to pursue studies in both art and science, and become responsible, informed creative consumers and decision-makers in their own life and beyond.

Although the potential for art and science integration through STEAM programming is evident, there are challenges to its regular implementation in a formal classroom environment. Some of these challenges are more practical concerns regarding “class management, working with crowded classes, insufficient material, working area and time” (Turkoguz & Yayla, 2010, p. 2040). Others however question whether students will be proficient at applying the creativity and imagination skills that are fostered in a STEAM environment to other contexts (Hadzigeorgiou, Fokialis & Kabouropoulou, 2012). Consider also, that integrating more areas of subject matter generally calls on teachers to recall, develop and apply skills in areas outside their comfort zone. Although studies have shown that teachers have expressed interest in professional development that would prepare them to implement STEAM more effectively (Craciun, 2012), this often involves a commitment of time, energy and perhaps even money which some teachers may not be willing or able to allocate. Teacher comfort and expertise in all of the STEAM subject areas therefore serves as a challenge to classroom integration.
It should be noted that these challenges have been described in the context of formal learning environments. What about the informal context? This study took place in an out-of-school, informal learning setting and provided insight into some of the challenges experienced as STEAM is practiced in these settings. The potential of informal opportunities for learning will be discussed in a later section of this literature review. The following section describes some of the fundamental theory on Whole Child Education, which, I would argue, has the potential to contribute to the growing understanding of STEAM and inform its implementation.

Whole Child Education

The following section will explore the relevant theory behind Whole Child Education (WCE), a field of education that “attempts to educate the whole child (body-mind-spirit) and also connect the child to the surrounding community and the world at large” (Miller, 2010, p. 8). It is evident through this definition that the idea of ‘wholeness’ or unity is central to WCE, and I would argue, to STEAM education. The following discussion will present the three main principles of holistic education, connection, inclusion and balance, as lenses through which the findings of this research study are interpreted. Each principle will be explored in relation to a particular opportunity to achieve ‘wholeness’ in educational settings. For the purpose of this study, these opportunities for ‘wholeness’ will be identified as the curriculum, teaching strategies and a holistic conception of the learner.

Whole Curriculum

One of the main principles of holistic education is connection. Miller (2007) notes that by exploring these connections in different contexts, including but not limited to the relationships between linear thinking and intuition, between mind and body, between self and community and
to the Earth and soul, a student “gains both an awareness of them and the skills necessary to transform the relationships where appropriate” (p. 13). This has particular relevance to the field of curriculum integration, a specific example of connection that emphasizes the relationships between disciplines of study. This integration is thought to better prepare learners to understand how the disciplines are connected to one another, and use that information to problem solve and innovate. In this section I will review the relevant literature on curriculum integration, paying particular attention to what it could mean or look like in a typical classroom environment. I will also discuss why curriculum integration is a significant pedagogical practice, while also highlighting challenges to its implementation in the classroom.

There has recently been great interest in the field of curriculum integration, which through the weaving together of different disciplines “enables students to look towards multiple dimensions that reflect the realities of their experiences outside and inside school” (Rennie et al., in press cited in Rennie, Venville & Wallace, 2012, p. 19). As a growing area of study, however, various theorists have conceptualized curriculum integration differently. The following discussion serves to explore three different interpretations of curriculum integration used to analyze the findings of this research study.

1. Drake’s model – A continuum of approaches.

This particular model suggests that there are three approaches to curriculum integration, which exist on a continuum from least to most integrated. The first and least integrated approach occurs when “two or more subject areas are organized around the same theme or topic” (Drake, 2000, p. 3). This is known as the multidisciplinary approach, which makes “an attempt at making explicit connections across subject areas” and to “view the content through an number of
disciplinary lenses” (Drake, 2000, p. 3). In the second approach, referred to as *interdisciplinary*,
the acquisition of “skills are the organizing center for two or more subjects” (Drake, 2000, p. 3).
For example, numeracy and literacy skills may be used to anchor learning in science, language
arts and geography (Drake, 2000). Drake’s (2000) final approach is the *transdisciplinary*
approach, where there is a “real-life context, and the student needs to act at the organizing center”
(Drake, 2000, p. 5). In this approach, which is the most integrated, disciplines emerge as a result
of certain paths of student inquiry.

Although a very efficient and clear way of understanding integrated curricula, the notion
of integrative approaches that exist along a continuum can be problematic. Implicitly, it may
suggest, “moving along a continuum represents progress to a more desirable state; that more
integration is better” (Rennie et al., 2012, p. 19), when, in fact, studies have suggested that “there
is no inherent quality of ‘bitterness’; rather, the effectiveness of each [approach] must be judged
according to its purpose” (Rennie et al., 2012, p. 19). Therefore, although Drake’s model serves
as a useful tool for understanding the forms of curriculum integration and is used as a way to
describe the model of integration observed in this case study, it is important that the purpose for
integration is also carefully considered.

2. *Case’s model – Modes of integration.*

Case’s (1991) model refers to four distinct modes of curriculum integration. The first
mode, ‘*fusion*’ involves joining disciplines that are traditionally taught independently, such as
science and language arts. The second mode, ‘*insertion*’, involves adding in a new element into a
larger discipline, which does not disrupt the larger discipline. For example, “writing science
stories in history class” (Venville, Wallace, Rennie & Malone, 2002, p. 49). The next mode,
'correlation' focuses on “drawing connections and noting parallels between elements that remain separately taught” (Case, 1991, p. 220), for example noting the similarities between engineering design and artistic design. In the final mode, ‘harmonization’, “different skills, concepts, attitudes, etc. [are brought together] across separately taught elements (e.g. critical thinking)” (Venville et al., 2002, p. 49).

Although consisting of four distinct modes of integration, this model does not imply that one mode is superior to another by placing them on a spectrum; they are simply four distinct strategies to achieve integration. Similar to Drake’s model, however, Case’s modes of integration must be selected purposefully, depending on the aim of integration. By keeping these ideas in mind, this model also presented a useful way of interpreting the findings of this case study.

3. The worldly perspective.

Although the models of curriculum integration discussed thus far will serve as useful tools to explore the findings of this research project, one model in particular, the ‘Worldly Perspective’ addresses this integration from a holistic perspective. As Rennie et al. (2012) note:

A Worldly Perspective – is focused around interesting and significant ideas that promote wholeness and unity rather than separation and fragmentation. Importantly, a Worldly Perspective recognizes the legitimacy of the different knowledge interests and the need to find an appropriate balance among those interests. It also recognizes connections between local and global issues (p. 51-53).

This perspective therefore “invites teachers and students to view the curriculum from whole to part, with big issues, concerns or interests becoming the organizing framework” (Rennie et al., 2012, p. 50) and maintains that curriculum must call on both disciplinary and integrated
knowledge objectives. Lloyd and Wallace (2003) have presented a useful framework for this Worldly Perspective as a practical means to accomplish all these tasks in a learning environment. Their framework was restated by Rennie et al. (2012) and includes five connected steps:

- Selecting the topic around a big curriculum idea;
- Eliciting students’ prior understandings;
- Learning about the way the world works;
- Making personal sense and solving practical problems; and
- Acting thoughtfully to find harmony between personal, community and local as well as global future generational needs. (p. 50)

In summary, this approach is able to consider how disciplines connect to one another through their relation to a main curricular idea, and how they collectively can be used to address real-life global, regional and local concerns.

Again, this outline of various curriculum integration strategies provides the framework for examining those observed in the field. It is important to note that this discussion does not seek to prioritize any one strategy or step over another. In their own way, they each represent a different and useful conception of curriculum integration. Regardless of the strategy, however, curriculum should not simply be integrated for integration sake. There must be a purpose and rationale for integration, which, at its core, aims to improve student learning.

Although the field of curriculum integration continues to grow in prominence in educational circles, more research much be done to explore its effect in classroom settings and to justify its widespread implementation. Some of the studies completed to date, however, do suggest that integration can improve student engagement and skill acquisition (Drake, 2000) and understanding of scientific concepts (Guthrie, Van Meter, Hancock, Alao, Anderson & McCann,
1998). Beyond these studies, which clearly show integration to benefit student learning, relevant literature points to several other arguments for curriculum integration, which will now be explored.

**Arguments and challenges for curriculum integration.**

The first argument for curriculum integration considers the function of the human brain. Beane (1996) mentions:

According to widely reported research, the brain processes information through patterns and connections with an emphasis on coherence rather than fragmentation. Those who advocate integration from this research claim that the more knowledge is unified, the more it is “brain-compatible” and therefore, more accessible for learning. (p. 8-9)

This is very consistent with what is referred to as the ‘focus’ argument for integration, which is “based on the belief that students are more likely to learn when their attention is focused on a few objectives rather than diffused among many” (Ross & Hogaboam-Gray, 1998, p. 5).

Another argument that favors integration is known as the transfer argument. According to Ross and Hogaboam-Gray (1998), “The transfer argument gives primacy to the ability of students to apply their knowledge when it is needed” (p. 5). Sometimes this application will involve scenarios that require the use of the knowledge from different sources. The transfer argument for curriculum integration will be of need to solve many of the problems that society is currently and will continue to face, including global climate change, food insecurity, and political refugee resettlement to name a few.

Evidence has shown that integrated classrooms have “held pupils’ interest and enhanced learning across the curriculum” (Venville, et al., 2002, p. 52). Integration can therefore foster a
more engaging learning environment, and improve learning in each of the integrated disciplines. By stimulating learner interest, integrated curricula also involve the motivational argument, which Ross and Hogaboam-Gray (1998) identify, “is based on the belief that students like some subjects more than others. Curriculum integration encourages students to access less favored subjects through more favored ones” (p. 6). Curriculum integration therefore can provide an avenue into subjects that students traditionally do not enjoy or where they experience difficulty. It has become clear through this discussion that there are distinct reasons why curriculum integration has a place in learning environments.

As with any pedagogical strategy, there are challenges that teachers, administrators and school boards will have to navigate as they attempt to implement integrated curricula. Most of these challenges “can be largely explained by an underlying tension between a curriculum approach [integration], which by its very nature is flexible, multidisciplinary and democratic, and a schooling context…which is rigid, disciplinary and hierarchical” (Rennie et al., 2012, p. 37), similar to how curriculum documents are currently structured. This therefore implies that if integration as a curricular approach is to be successful, then it must be able to negotiate itself within the context of the school or learning environment. Rennie et al. (2012) do recognize that flexibility and responsiveness to student and teacher needs are crucial if this strategy is to be successful. They also note that this flexibility may involve “small and stable learning environments, active leadership, productive team activities, planning time, flexible timetables and links to the community” (Rennie, et al., 2012, p. 51). Although some schools may be able and willing to accommodate these needs, others may show more resistance, particularly if they maintain the attitude that “An integrated curriculum does not accord with the ongoing expectation … that the school curriculum should be academically oriented, emphasizing written work and
individual study and focusing on examinable aspects of the syllabus” (Kaplan 1997, cited in Venville, et al. 2002, p. 54). This does however present an opportunity to explore the informal sector and to investigate curriculum integration in settings where there is more flexibility and less of an imposed systemic order. The informal sector and its potential role in curriculum integration and this study will be explored in a later section of this literature review.

**Whole Teaching**

Another principle of the holistic curriculum is *inclusion*, which embraces a comprehensive approach to teaching aimed at reaching the whole learner, that is the spirit, body and mind (or heart, hands, and head) (Miller, 2007). This vision of inclusive teaching involves three distinct but related approaches, which will serve as a means to interpret how teaching and learning strategies are implemented through this case study. The first approach involves *transmission teaching* through which “the student receives and accumulates knowledge and skills” from the teacher (Miller, 2010, p. 9). Usually this one-way transmission involves imitation or repetition, with “little or no opportunity to reflect on or analyze the information” (Miller, 2010, p. 10). This is also the approach many would consider to be more traditional or perhaps even typical in some learning settings. The next approach, *transactional teaching* places an emphasis on processes of inquiry and problem solving. In contrast to the first approach, it involves a bi-directional flow of information between teacher and student, but “this dialogue stresses cognitive interactions as analysis … more than synthesis and thinking … over feeling” (Miller, 2010, p. 11). The final approach, or *transformational teaching* is best able to nurture the whole child, as “curriculum and child are no longer seen as separate but connected” and opportunities for personally relevant and meaningful learning are realized (Miller, 2010, p. 11).
It is important to note that although the transformational approach directly seeks to address the whole learner, all three approaches can be used in WCE. The key is to establish how the three approaches can “be used together in a way that nurtures wholeness” and “creates a flow or rhythm in the classroom” (Miller, 2010, p. 41). A teacher who is able to use all three approaches purposefully may be better able to reach the head, hands and heart of a child more so than one that chooses one approach over another.

**Whole Learners**

The final principle of the holistic curriculum is balance. Miller (2007) mentions that this balance “seeks the ‘right relationship’ between the part and the whole where both are acknowledged and nourished” (p. 9). This definition is central to how WCE and this research project conceive of learners. According to this perspective, learners are seen as “an indivisible whole” with hearts, hands and heads (or spirits, bodies and minds) (Miller, 2010, p. 9). In terms of science education, these labels “refer, respectively, to students’ interest in their learning as evidenced by their engagement in the science experiences they encounter, their interaction with concrete materials through firsthand science…., and their willingness to try and make rational sense of how their physical and natural world works from a scientific perspective” (Skamp, 2007, p. 18). In another similar conception, Inan and Inan (2015) mention that heart related science education involves “children loving science-related subject matters and being interested in science issues”, hands related science occurs when “they [learners] used their hands and body to engage in science activities” and head oriented science occurs when learners “searched for information about what they inquired, asked questions and created theories, and then tested their theories” (p. 1983). By balancing and engaging all three elements of the learner, particularly in
arts centered environments, teachers may be able to “nurture a self-esteem that encompasses aesthetic and moral sensibilities as well an intellectual competence” (Easton, 1997, p. 94) and in doing so, students might become more motivated to learn.

**Informal Learning and the Third Space**

The following section will explore the definition of informal learning, and describe the model of free-choice learning used in this study. Afterschool programs are discussed as an example, including mention of the advantages and challenges of this particular type of programming.

The process of schooling is expected to help us learn. In truth, however, our learning is not limited to a classroom, building or schoolyard. As Falk and Dierking (2002) note, “learning is something that happens not just during the school day, or even at work, but throughout the day and across our life span. More and more of our time, at work and play, is invested in learning” (p. 5). They have even gone as far as to state that only 5% of a person’s life is dedicated to formal schooling (Falk & Dierking, 2010), leaving an enormous portion of time to learn through other sources. Of these alternative avenues for learning, leisure learning, or learning for fun, has become very popular and significant (Falk & Dierking, 2002). Consider the vast amount of information available at your fingertips through the internet. Learning doesn’t have to occur any further than a click away! Traditionally, learning for leisure would have been classified as informal learning, “refer[ring] to activities that occur outside the school setting, are not developed primarily for school use, are not developed to be part of an ongoing school curriculum, and are characterised as voluntary as opposed to mandatory participation as part of a credited school experience” (Crane, Nicholson, Chen & Bitgood (1994), p. 3, cited in Stocklmayer, Rennie & Gilbert, 2010, p. 8).
These experiences can include learning that takes place in settings such as museums, science centers, aquariums, community or afterschool programs, etc.

It should be noted however, that learning outside of school is not the only type of informal learning. For example, some scholars have offered a more “‘hybrid’ definition”, which suggests, “that informal learning experiences can occur in formal learning environments (e.g., schools) as well as informal learning environments (e.g., museums, zoos)” (Hofstein & Rosefeld, 1996, p. 90). By extension, I would argue that formal learning is also facilitated in informal, out of school environments through field trips, community outreach programs and other opportunities that directly contribute to or reinforce the learning done in the classroom. If we adopt these latter ideas, then the traditional tendency to assume that informal and formal learning inhabit different spaces, each with their own distinct opportunities for learning can be quite problematic. As Hofstein and Rosenfeld (1996) note:

We suggest that this linkage [in-school as formal and out of school as informal] is at best artificial and at worst harmful to the pedagogy of science teaching and learning. It is artificial because a person's knowledge of science cannot be limited to what is learned in schools, and it can be harmful by limiting the types of learning opportunities available to students (p. 106).

Falk (2001) extends this notion by providing an example: “there is no basis to assume that open-ended, optional, inquiry-based experiences within a school setting are somehow fundamentally different from open-ended, optional, inquiry-based experiences within a museum setting” (p. 7). For these reasons and for the purposes of this research project, the idea of where learning happens will be framed according to a more inclusive perspective. As scholars have suggested, “when disciplinary, classroom, and everyday Discourses inform one another and build new knowledge
and Discourse” a ‘third space’ is created (Gutiérrez, Baquedano-López, Tejeda & Rivera, 1999, cited in Moje, Collazo, Carrillo, & Marx, 2001, p. 490). In these settings “the very different and competing discourses of the school system and the everyday world are reconciled” (Stocklmayer et al., 2010, p. 26) presenting valuable strategies and opportunities for facilitating relevant, engaging and authentic learning in science. Although this study took place in an afterschool program, an informal (out of school) environment in the traditional sense, it is important to note that scientific understandings and skill development that emerge from this setting contribute to the discourse of the ‘third space’ and may also be applicable to ongoing student learning in formal settings and in their daily lives.

**Free-choice Learning**

In order to promote discourse in the third space, I believe that a more inclusive and open perspective of not only where, but also how learning happens is necessary. One strategy to consider is free-choice learning, which “recognizes the socially constructed nature of learning – the interchange that goes on between the individual and his or her sociocultural and physical environments” (Falk, 2001, p. 7). Free-choice learning is regarded as subject to the context in which it occurs and places learner autonomy at the forefront, presenting the learner with “reasonable and desirable learning choices…that he or she possesses the freedom to select or not to select” (Falk, 2001, p. 8). Regardless of context, however, free-choice learning opportunities are “typically voluntary, open-ended, non-sequential, self-directed, hands-on, and evaluation-free” (Pedretti, 2006, p. 1). As a result of these traits, free-choice learning generally occurs in environments that are neither judgmental nor rooted in competition (Rennie 2007, cited in Stocklmayer et al., 2010). This is not to suggest that these environments do not challenge
learners, but instead do so in ways “that stretch the student’s understanding and develop scientific skills” (Stocklmayer et al., 2010, p. 27) rather than perpetuate the idea that only individual learners with specific knowledge, skills and abilities will be able to engage. Consequently, these opportunities for learning nurture a level of collaboration, cooperation and social interaction which is usually “heterogeneous with regard to age”, meaning that learning is able to emerge through interaction between peers of varied ages or between teacher and student (Rennie, 2007 cited in Stocklmayer et al., 2010, p. 10).

Perhaps most importantly, these free-choice informal settings for learning can “contribute to our construction and understanding of scientific knowledge—our attitudes towards, and participation in, science” (Pedretti, 2006, p. 1), meaning that these settings are significant not only to learning science content, but also to motivating and inspiring learners to continue learning. To do so, these settings rely on “framing the science in an engaging context” (Stocklmayer et al., 2010, p. 28), to entertain, yet inform learners through relevant and authentic experiences for learning. Stocklmayer et al., (2010) have suggested that this relevance arises due to the free-choice format, which takes into consideration learner interests and curiosities, while it also “reflects the processes and current conclusions of science” (p. 28). These settings, therefore, adapt to new developments in science much faster than in formal settings (Stocklmayer et al., 2010) and have the opportunity to share very real, up to date and sometimes groundbreaking understandings of scientific phenomena with learners.

Through interest in authentic and relevant science, informal learning settings, and by extension, programs developed around the notion of ‘free-choice’, are uniquely positioned to contribute to affective learning (Pedretti, 2006), or learning associated with learner emotion or feelings. This affective response is often influenced by learner “attention, curiosity and
exploration, and interest” among other traits (Meredith, Fortner & Mullins, 1997, p. 808). Although often considered less significant than cognitive learning, scholars suggest that the “Emotional and affective dimensions of learning are central to visitors’ [students] learning and understanding of science” (Pedretti, 2002, p. 20). In addition, “it is hypothesized that the short-term affect experienced in non-formal science learning may serve to influence cognitive learning and may initiate or reinforce long-term affective dispositions such as sentiments, attitudes, interests, values, and commitment” which may consequently “serve as the motivation for extended patterns of behavior, such as voluntarily engaging in further science learning experiences” (Meredith et al., 1997, p. 813-814). Acknowledging the role of affect in the learning process might be a powerful way to encourage learners to continue studying science.

**Afterschool or Community Programs**

Although it has been noted that informal learning can occur in a myriad of different environments, it would be helpful to focus on the environment in which this investigation took place, the afterschool program, and what this particular environment offered learners.

Studies involving afterschool programs that are oriented around science have demonstrated that this type of programming can have a positive effect on student performance, attitudes toward science careers, self-confidence and interest (Stocklmayer et al., 2010). These results could be a consequence of how afterschool programs, in their unique and flexible structure are able to engage learners. In some cases, these programs present “a testing ground for the doing of meaningful and relevant science” as they not only “help youth better understand the pertinence of science to their daily lives” but do so in a way that fosters or reinforces learner interest (Rahm & Moore, 2005, p. 288). This ability may arise from the fact that these programs are often not linked to government-mandated curricula, giving instructors the flexibility to explore unique and
interesting science content and teaching strategies in-depth, creatively (Newell, Zientek, Tharp, Vogt & Moreno, 2015), “in terms [learners] were familiar with and in ways outside the mainstream dominant culture permeating the traditional [formal] settings” (Rahm & Moore, 2005, p. 289). It has been noted that this particular characteristic of afterschool programs may be a valuable way of presenting opportunities for underrepresented groups to engage and develop interest in science (Newell et al., 2015).

Although there is great potential in using afterschool programs to develop student interest and improve student performance in science, these programs also offer a distinct set of challenges that could prevent positive effects from taking place. First, “Student attendance…usually is voluntary and dependent on factors such as transportation and other competing activities (such as sports)” (Newell et al., 2015, p. 218). Therefore, as with any informal learning setting, learners must elect to participate in these programs and maintain a level of commitment over time. To do so, involves a level of interest and attraction (Friedman, 1995), a feeling of satisfaction as a consequence of participating in the program and a dedication of resources. The most significant resource that serves as a limiting factor to influence student attendance is the financial expense generally associated with these programs. It is important to note that the afterschool program that I am studying for this research project also requires the payment of a fee. Realistically, all learners and their families may not be able to make that type of commitment and consequently may be unable to access the positive learning effects associated with these settings.

A second challenge that afterschool programs and informal learning experiences in science in general often experience involves the hiring of individuals qualified in science to develop and facilitate programming. As Friedman (1995) notes, “If informal science education institutions continue to be the major source of learning outside of school, the staff of these
institutions must set and maintain standards of quality and scientific integrity in their public programs” (p. 218). These programs should therefore place emphasis on recruiting trained STEM professionals to ensure that through their programming, they are able to maintain the positive learning outcomes previously discussed.

**Putting it All Together**

This literature review began with an introduction to STEM education and explored a distinct and pressing dilemma associated with it. To briefly summarize, STEM education, if conceptualized according to a traditional positivist scientific paradigm and by selecting for specific knowledge producers to the exclusion of others, creates barriers that prevent many students from accessing learning in science. These learners may therefore not have their due opportunity to develop the functional understanding, skills and attitudes generally nurtured through studies in the STEM disciplines. The intention of this study is to examine a real-life example of STEAM programming in practice to see if it could ensure learners access to these critical understandings, skills and attitudes. In other words, this study seeks to explore if STEAM, as a strategy for teaching and learning, opens doors and presents opportunities for learners in science. To explore these important ideas, I researched the goals, implementation (including challenges), and student experience of a particular example of STEAM programme.

There is, of course, no metric to determine the extent of ‘science accessibility’ for the learner provided by this program. However, by looking at the data of this study through carefully selected lenses, I was able to explore why it might be a valuable tool for teaching and learning in science, art and beyond. Consider the aforementioned theory on Whole Child Education (WCE). WCE, by its very nature, sees the unique value within each learner and wants to help the learner realize that potential through the thoughtful engagement of body, mind and spirit. Therefore, for
the purpose of this study, the holistic tenants of connection, inclusion and balance are the lenses through which the data was organized and interpreted. Additionally, it is critical to recognize that as an afterschool program, this example of STEAM occurs outside of the typical school setting. Therefore, this data was explored with reference to theory regarding informal out-of-school experiences, but more specifically, to free-choice experiences. By using these selected lenses, it is hoped that this case study of STEAM provides insight into a new and more inclusive and accessible vision of science education.
CHAPTER 3: METHODOLOGY

In the following section I outline the methodology of this research project, beginning with an introduction to qualitative inquiry. The introduction will frame the interpretivist or constructivist research paradigm, which guided this research. Case study methodology and a brief introduction to the case of study will be provided and used to rationalize the research design, which consisted of a particular set of data collection and analysis methods. Each method will be discussed individually. Ethical implications of the research will be carefully considered, in addition to the ways in which the researcher was able to give back to participants and show gratitude for their time, effort and invaluable contribution to the research process.

Qualitative Inquiry and Research Paradigm

The qualitative research tradition seeks to understand and make meaning of social phenomena. To do so involves the understanding that these phenomena, in their social nature, are contextual and nuanced, dependent on the distinct reality as experienced by individuals. Therefore, the qualitative researcher, in order to better understand this particular reality, “must be grounded in the experience of those who have had the experience or process or phenomenon” (Strega, 2012, p. 206). By locating themselves within the reality of a particular experience, as it is experienced, qualitative researchers are able to generate “Rich, “thick” description [which] brings a deeper, more complex understanding” (Strega, 2012, p. 206) to the phenomenon of interest. This description of reality, however, does not reveal itself to the researcher in a fully formed, cohesive and complete manner. The researcher must act as a quilter, who “stitches, edits, and puts slices of reality together. This process creates and brings psychological and emotional unity to an interpretive experience” (Denzin & Lincoln, 2000, p. 5). The way in which a
qualitative researcher chooses to ‘sew’ together their vision of reality depends on a particular research paradigm they have selected to develop and guide their study.

Each research paradigm stipulates a specific ontology (worldview), epistemology or “philosophy as what counts as knowledge and ‘truth’”, and methodology (Strega, 2012, p. 201). The research paradigm that guided this research project is the constructivist paradigm as described by Denzin and Lincoln (2000). This particular paradigm specifies a relativist ontology (Denzin & Lincoln, 2000, p. 21), which has particular implications for the researcher as ‘quilt-maker’. Although the researcher ‘sews’ or assembles a unified version of reality, it is neither the only possible conception of an experience, nor a complete or ‘finished’ interpretation. As Wallace and Louden (1997) note, “Understanding is in principle incomplete and continues to grow in each interpreter’s encounter with new texts and experience” (p. 321). No researcher, including myself, can therefore claim that their qualitative construction of meaning or understanding of a given phenomenon completely resembles a universal reality as multiple realities are considered to exist (Denzin & Lincoln, 2000).

In consideration of this particular ontological perspective, the constructivist paradigm specifies a subjectivist epistemology, which suggests that the “knower [researcher] and respondent [research participant] co-create understandings” (Denzin & Lincoln, 2000, p. 21). This perspective maintains that because knowledge arises from social interaction and dialogue, it is idiosyncratic, contextual and unable to objectively describe reality. Therefore, the researcher is not alone in their ‘sewing’ together of reality, and any knowledge or understanding of that co-constructed reality depends on the particular context of the experience of study. Because context is so relevant to understanding an experience, according to this epistemology, the methodology that corresponds to this paradigm is naturalistic, meaning it seeks to understand reality as it is
experienced “in the natural world” (Denzin & Lincoln, 2000, p. 21). This gives the researcher the opportunity to truly observe the specific factors that influence a particular experience and to ‘sew a quilt’ that “does not seek to uncover universal truths about social reality…but to better understand how reality is constructed” (Sears & Cairns, 2010, p. 45).

**Case Study Methodology**

Case study is one example of a research strategy consistent with the constructivist paradigm previously described (Heck, 2006). These studies tend to look at a phenomenon in its real-life context, particularly where “boundaries between phenomenon and context are not clearly evident” (Yin, 2003, p. 13). Therefore a case study, not only approaches research from a naturalist, real-world perspective, but also does so in a way that explores contextual factors as relevant to the case itself (Yin, 2003). Case studies are also defined according to three specific features. First, case studies are *particularistic* meaning that they “focus on a particular situation, event, program, or phenomenon” (Merriam, 1998, p. 29). Second, case studies are *descriptive*, suggesting, “that the end product of a case study is a rich, ‘thick’ description of the phenomenon under study” (Merriam, 1998, p. 29). Finally, case studies are *heuristic*, “illuminat[ing] the reader’s understanding of the phenomenon under study” (Merriam, 1998, p. 30.) All of these features make a case study a unique and potentially insightful piece of qualitative research.

Case studies are particularly “useful for descriptive purposes and are applicable to studies where process (how and/or why) is a key concern because they focus on collecting data over time (i.e., as processes unfold and evolve)” (Heck, 2006, p. 378). Choosing to conduct a case study, therefore, depends not only on the research paradigm that scaffolds the study but also on the research questions themselves. Since this research project is focused on exploring the goals
(why), implementation (how) and student experience (so what) of a particular program, case study will be a relevant and effective way to conceptualize the research design and interpret the research findings.

As with any case study, however, it is important to create a boundary, which limits the scope of the research design. This helps to “see the case as a thing, a single entity, a unit around which there are boundaries” (Merriam, 1998, p. 27), to keep the study manageable, while ensuring potential insights are relevant within the specific bounds of the case. The creation of this boundary may involve the selection of a particular set of methods for data collection, assembling the case around a concern, issue, hypothesis, or interest, or basing the case in a particular setting or program (Merriam, 1998). It may also involve setting a timeframe for the collection of data (Heck, 2006). The following section will explore how the case in this study has been bounded.

**Case Study Introduction and Boundaries**

This case study focuses on a community-based afterschool program. This setting places a particular emphasis on generating programming that integrates art and science. The site shares this programming through organized workshops, birthday parties, and community outreach that includes school field trips, summer camps and afterschool programs. Programming is oriented to a variety of age groups, spanning from grades K-12 and including opportunities for adult engagement as well.

Upon selecting this particular site, I carefully chose the boundaries for this case study. I explored the afterschool program, which ran for a 10-week period between April and June. This program took place for an hour and a half, once a week. The afterschool program is designed and
facilitated by the site founder and director, Laura and Amy, the site’s science educator. Research participants included Laura and Amy and the nine students from whose parents I received a signed consent document. Further description of the research setting and participants as well as an outline of a typical day in the program and the themes and activities explored are present later in this chapter.

**Research Design**

To conduct this research, I developed a research design according to the process described by Merriam (1998). I first began this research design by selecting an area of personal interest, STEAM oriented curricula. I generated a theoretical framework, or “the structure, the scaffolding, the frame of [the] study” (Merriam, 1998, p. 45). As noted by Merriam (1998), “The framework of your study will draw upon the concepts, terms, definitions, models and theories of a particular literature base and disciplinary orientation” (p. 46). As I conducted my literature review, I began to learn more about the history of the STEAM field, its goals, teaching strategies, and challenges, and to establish not only the context for what I aimed to investigate but also to frame my inquiry within specific disciplinary discourses. As my developing theoretical framework and literature review began to evolve together, they informed my identification of the research problem and the specific research questions (Merriam, 1998). To review, the research problems identified in this study include a need: to generate more competent and passionate STEM professionals that are also creative thinkers; to fuel economic growth, innovation and solve post-modern multi-dimensional local and global problems; and to enhance scientific literacy and citizenship science. It has been proposed that STEAM programming may be able to

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2 All participant names are pseudonyms.
achieve these goals. To that end, I developed a series of related research questions, which sought to explore an example of STEAM programming (in an informal setting) in action. These questions have been restated below:

- What are the goals/objectives of an after-school program which specializes in the integration of art and science?
- How is an afterschool program, specializing in the cross-curricular integration of art and science implemented? What factors or challenges experienced by educators influenced the way the program was implemented?
- What are the experiences of students in an afterschool program which specializes in the integration of art and science?

In order to address these questions I completed the final step of Merriam’s (1998) outline for research design, which involved purposefully selecting a particular sample to study. A purposeful sample is usually selected because it is assumed that from that sample, “the most can be learned” (Merriam, 1998, p. 61). A series of informal conversations with the site director, Laura, suggested that this afterschool program would serve as a unique sample, “based on unique, atypical, perhaps rare attributes or occurrences of the phenomenon of interest” (Merriam, 1998, p. 62). I then was able to carefully consider the data collection and analysis techniques that would best suit this study. These techniques are discussed in detail in the following sections.

**Data Collection**

Qualitative inquiry presents a myriad of options for data collection, however, those that are implemented for a particular research project must be purposefully selected with reference to the theoretical framework and specific research methodology. With reference to case studies in
particular, Merriam (1998) has suggested that the three collection techniques that should be used are observation, interview and analyzing documents. For this reason, I selected these three strategies as my means of data collection for this research project. Through the collective use of these three methods (participant observation, interview and analysis of artifacts), a process also known as “triangulation”, I was “attempt[ing] to secure an in-depth understanding of the phenomenon in question” (Denzin & Lincoln, 2000, p. 5), that is STEAM oriented programming in an afterschool setting. In the discussion that follows, I will outline how I approached each method through the course of this study.

Field Notes as a Participant Observer

Field notes was a central method of data collection for this study. An afterschool integrated art and science program was observed weekly for a period of ten weeks. Each workshop was an hour and a half in duration. Detailed field notes were recorded during each session.

The selection of field notes as a data collection method for this study was intended to not only immerse the researcher in the STEAM programming offered by the site, but also to assist in generating the “rich” or “thick” description the study called for. As Heck (2006) notes, participant observation “involves actually gaining access into a setting and getting up close to the members of a group or an organization such that one can observe and interview them to determine how they participate in and make meaning of their social and cultural situations” (p. 381). To facilitate this process Wolcott (1981) has suggested four strategies to guide participant observation (as discussed in Glesne, 1999). The first involves a broad sweep, where the researcher records as much sensory information, including what they see and hear as possible.
The second involves looking for nothing in particular, which involves paying close attention to the unique or unusual. The third and fourth strategies involve searching for paradoxes, inconsistencies or problems. These four strategies guided my process of participant observer and served as a foundation for my ongoing thoughts and field notes.

By using these four described strategies, I wanted to “learn firsthand how the actions of research participants correspond to their words; see patterns of behaviour; experience the unexpected, as well as the expected; and develop a quality of trust with [the research subjects] that motivates them to tell [me] what otherwise they might not” (Glesne, 1999, p. 43). I therefore adopted the role of ‘observer as participant’, where “The researcher remains primarily an observer but has some interaction with the study participants” (Glesne, 1999, p. 44) and seeks a level of membership in the case setting. Through the course of the afterschool program, I did not adopt the traditional role of passive and distant observer, but instead engaged with the subjects in the setting to develop a more complete understanding of the experience. As I often lent a helping hand during some activities, I was able to engage learners in informal conversations while also observing their decision-making processes, their creativity and their attitudes or responses to activities. These conversations or interactions, in contrast to the formal interviews described later, “are marked by equal participation among participants and by flexibility” and present opportunities for the researcher to truly listen and get to learn about the experience (Clandinin & Connelly, 1998, p. 168).

It must be noted however, that adopting this particular identity in the research setting did have particular emotional consequences (Angrosino & Mays de Perez, 2000) for myself as the researcher. As the observer explores their role as a participant and gets to experience (think, feel and do) the setting, it can influence their observations of what other subjects experience and
consequently, that can have implications on data collection and analysis. I, therefore, made sure to constantly remind myself through the process that although my personal experience and involvement helped to enrich my understanding about the case, the purpose of my participation was to increase the breadth and depth of the observation of the participants.

Through the weekly observation of the art-science afterschool program, I generated a body of field notes. These notes were both descriptive and analytic in nature (Glesne, 1999). To guide my note taking, I attempted to follow Fontana and Frey’s (2000) suggestions that notes must be taken regularly, promptly and inconspicuously, keeping in mind that they should be analyzed frequently. I contributed to my field notes each session, taking them at times when it would not distract or disrupt the lesson or activity. I would also try to look over the notes in the following days to add details I recalled or to analyze them for potential emergent themes that might be useful for later data analysis. Although these notes provided a wealth of insight, it is important to note that they are “necessarily incomplete and insufficient”, only representing “a tiny fraction of the fieldworker’s own memory of the research period” (Van Maanen, 1988, p. 118), and are also “selectively chosen from field experience and thereby embody an interpretive process” (Clandinin & Connelly, 1998, p. 162). I did however use these notes in combination with the other two data collection strategies (interview and document/artifact analysis). Through this process, the insights that arose from the research process are better legitimated.

**Interview**

The interview was also an integral data collection strategy for this research study. Interviews were conducted with both instructors of the afterschool program, and with eight students that participated in the program. These interviews occurred twice, once toward the
beginning and once towards the end of the program. Interviews were all individual, with the exception of one student whose parent requested to be present. Interviews took place at the program site, a setting where participants were familiar and comfortable, immediately before or after the weekly afterschool sessions. Interviews were audio recorded to facilitate the collection of “a nearly complete record of what has been said and permits [the researcher to devote] easy attention to the course of the interview” rather than its documentation (Glesne, 1999, p. 78).

The use of interview as a data collection method in this research study was meant to compliment the participant observation previously discussed. As Glesne (1999) notes, interview presents “The opportunity to learn about what you cannot see and to explore alternative explanations of what you do see” (p. 69). Observations can then be further explored through interview. The set of questions used were developed according to two criteria: they “fit the topic”, meaning “the answers they elicit must illuminate the phenomenon of inquiry” and they were “anchored in the cultural reality of your respondents: the questions must be drawn from the respondents’ lives” or experiences at the site (Glesne, 1999, p. 70). A complete list of the interview questions can be found in Appendix B.

Although interview was a useful strategy to assist in the creation of a “rich and thick” description of the case, its limitations should also be noted. First, an interview is a social experience between two or more people. Therefore, the interaction and behaviour of these individuals can influence the data collected and its subsequent analysis. As Clandinin and Connelly (1998) note, “The way an interviewer acts, questions, and responds to an interview shapes the relationship [between researcher and participant] and, therefore, the ways participants respond and give accounts of their experience” (p. 165). Therefore the researcher must remain especially cognizant of their actions during the interview process, and I would argue before and
after as well, given that interactions during participant observation can also influence participant responses. It is also important to consider, that the data collected through interview is incomplete, meaning it is “selective and produced from the present perspective of the respondent. The significance and meaning of the event in the present may differ from its effect at the time of the original experience” (Polkinghorne, 1995, p. 20). The researcher must keep in mind that data gathered from interviews is not an objective representation of reality, and has been influenced by known and perhaps unknown factors since the time of the experience.

**Documents and/or Artifacts**

Merriam (1998) mentions that there are several types of documents that can be analyzed through case study. This study will focus on one type of document, which is what Merriam (1998) refers to as “physical material” or the “physical objects found within the study setting” (p. 117). These objects will be referred to as artifacts and will include samples of in-progress or completed student work. Photographs of these artifacts will be gathered throughout the research process. The use of these artifacts is to “corroborate … observations and interviews and thus make … findings more trustworthy” (Glesne, 1999, p. 58). They also provide insight into student thought process and serve as exemplars that demonstrate the ‘take-home results’ of the program.

The following section will describe how the data, collected through the aforementioned strategies, was analyzed.

**Data Analysis**

Data analysis, in practice, works cooperatively with data collection. As Merriam (1998) notes:
Data collection and analysis is a *simultaneous* activity in qualitative research. Analysis begins with the first interview, the first observation, the first document read. Emerging insights, hunches, and tentative hypotheses direct the next phase of data collection, which in turn leads to the refinement or reformulation of questions, and so on. It is an interactive process throughout that allows the investigator to produce believable and trustworthy findings (p. 151).

Data analysis was therefore an ongoing process throughout this study, informing data collection and the representation of findings.

The findings of this study were explored through both inductive and deductive methods. Consistent with Patton (2002) who mentions, “qualitative analysis is typically inductive in the early stages” (p. 453), data will first be explored for sets of “emergent categories” that can be drawn from the data (Heck, 2006, p. 382). This inductive process “involves discovering patterns, themes, and categories in one’s data. Findings emerge out of the data, through the analyst’s interactions with the data” (Patton, 2002, p. 453). These categories were established according to a constant comparative method of data analysis, wherein “The researcher begins with a particular incident from an interview, field notes, or document and compares it with another incident in the same set of data or in another set. These comparisons lead to tentative categories that are then compared to each other and to other instances” (Merriam, 1998, p. 159).

The “emergent categories” identified through this process of inductive analysis were then be analyzed according to the ideas and frameworks for curriculum integration, whole child education and informal learning experiences presented in the literature review. According to Patton (2002), this process is referred to as deductive analysis and represents the “confirmatory stage” of data analysis, which involves “testing and affirming the authenticity and
appropriateness of the inductive content analysis, including carefully examining deviate cases or
data that don’t fit the categories developed” (p. 454). This affirmation process was not intended
to generate a definitive and largely generalizable conclusion, but rather to suggest that the
theories or conclusions drawn are valid, relevant and accurate to the case at hand.

Finally, as a case study piece of research, the results are not necessarily generalizable, nor
are they intended to be. However, through rich, thick description, readers will be able to better
understand their own particular contexts. I do however, generate a series of recommendations or
implications from this case study, that within the proper context, may be useful.

Ethics

Any study involving interaction with human subjects requires careful consideration of the
ethical implications of the study. As Clandinin and Connelly (1998) note, “As personal
experience researchers, we owe our care, our responsibility, to the research participants and how
our research texts shape their lives” (p. 169). This involves engaging in a critical reflection of the
ethical implications of the study while designing, conducting, analyzing, writing and publishing
the study, and making decisions and putting strategies in place to minimize any foreseeable harm.

To minimize this potential for harm, only participants that had provided their informed
consent (or in the case of minor age students, parental assent) participated in the study. This
process was facilitated through the creation of an informed consent and information letter which
participants (or their parents) were required to sign. This letter notified participants that their
participation was voluntary and could be stopped at any time without explanation or penalty of
any kind. I have also taken the utmost care to protect privacy and the identity of research
participants by using fictitious names in transcripts, field notes and in the final written report.
Giving Back

Engaging in field research necessarily involves interacting with other individuals. These individuals are often an invaluable resource in the research process as they provide unique and situated insight into experience. As researcher, I owe the research participants a debt of gratitude. Glesne (1999) notes that “The degree of indebtedness varies considerably from study to study and from participant to participant, depending on the topic and the amount and type of time researchers spend with their [participants]” (p. 126). Although there are many ways to express this gratitude, I focused on “acknowledging how important their time, cooperation, and words are; by expressing [my] dependence on what they have to offer; and by elaborating [my] pleasure; with their company” (Glesne, 1999, p 127). Additionally, I paid keen attention, throughout the research process, to ways I could reciprocate their generosity. For example, I shared resources with the site director when she expressed interest in learning more about holistic education. I lent a helping hand to as many activities as I could, which I believe was much appreciated by Laura and Amy on numerous occasions (I will be sure to share this complete study with them, again to thank them for their insight and generosity). I brought popsicles on the last session of class to thank all participants for their invaluable contribution to this project. These small actions hopefully assured participants that I valued their contribution.

In the next section I explore the context of the research site, including a detailed description of the setting and participants, while also outlining a typical day and the themes explored through the course of the program.

Context of the Research Site: Program Outline and Setting

The afterschool program explored in this study is part of a community based learning institution in a major Canadian city, which focuses on programming that connects art and
science. The site shares this programming through organized workshops, birthday parties, and community outreach that includes school field trips, summer camps and afterschool programs. Programming is oriented to a variety of age groups, spanning from grades K-12 and including opportunities for adult engagement as well.

The afterschool program in particular is developed for learners from JK to Grade 3 and is usually held twice a year, once in the fall and once in the spring. This study explored the spring session, running from April to June. The program spanned a ten-week period and each class or lesson within the session was an hour and a half in length. All lessons took place at the program site, except for the final activity (tie-dye shirts), which took place in the park across the street.

The program site is a former apothecary building with many windows that create a bright space. A wall along one side of the site is adorned with plenty of shelves that display books, scientific models, bones, shells, rocks, student work and other artifacts. Another wall has been converted into a blackboard, on which lesson content and important information such as the student code of conduct is posted. There is a large sitting area on the floor in front of the blackboard where students gather for instruction or to play during moments of free time. Several long tables provide plenty of workspace. Posters on other walls explore anatomy, ecology and physiology. A corkboard labeled the ‘Question Corner’ (pseudonym) encourages learners to write questions on sticky notes for instructors to address. The environment is very colourful, organized and welcoming.

Participants

This session of the afterschool program was developed and facilitated by two instructors: Laura, the site founder and director and Amy, the art and science educator. Laura has
postsecondary experience studying both science and fine art. Her studies were interdisciplinary, focusing on different media and bringing art and science together. Laura also worked as a teaching assistant and under/post graduate course instructor. She has a great enthusiasm for providing learners, young and old with opportunities to explore the synthesis of art and science. She has been directing programming at the site for three years. Amy is an engineering graduate with a passion for teaching. She hopes to pursue a teaching degree. She and Laura work collaboratively to develop and deliver the programming for the site. Laura and Amy were both interviewed twice through the course of this project.

A total of thirteen students signed up for the spring session of the afterschool program. Nine consented to participate in the study; only eight were interviewed. Six of the students were male and three were female. Student ages ranged from JK to Grade 3. Of the eight interviewed students, at least six had attended some type of programming at the site prior to this afterschool program.

**A Typical Day in the Afterschool Program**

Learners began to arrive at the afterschool program site by 4 pm. Upon entry, learners and their caregivers were greeted by Laura and Amy. Students dressed in their lab coat and had about fifteen minutes to adjust to the space. During this time, they were free to build with blocks, stack magnetized shapes, draw in their personal sketchbooks or colour in the colouring books provided. Once all students had arrived, Laura would sound a Tibetan singing bowl, which would signal the beginning of class. With this signal, learners tidied up their workspaces and joined Laura and Amy on the floor in front of the blackboard. At this time, the instructors welcomed learners back to the space and answered questions posed in the ‘Question Corner’ from the previous week. The
‘Question Corner’ is a weekly activity, usually occurring at the beginning of class, where learners are encouraged individually to ask new and interesting questions about anything that interests them. Students write these questions on a sticky-note and pin them up on a corkboard on the wall. Each week, Amy and Laura select one or two questions to answer with the whole group, crediting the learner who asked the question. Upon answering these questions, the instructors prompt each of the learners to think of a new question to post up.

Once learners have had an opportunity to think about, write down and post their new questions, everyone once again gathers on the floor in front of the blackboard. At this time, the theme for the lesson and main hands on project are introduced. On some days this involved a mini lesson through which new vocabulary was introduced or a discussion that explored a new topic or theme. Learners were then prompted to take their seats at the long activity tables and were given detailed instruction on the hands-on task they were to accomplish. They were then given ample time to complete the task for the day, which varied in length. Students that completed their project early had the opportunity to interact with the blocks, sketchbooks and colouring books they had worked with at the beginning of the class. Once everyone had finished their projects, all learners helped to tidy up the workspace and had a chance to wash their hands. If there was time, everyone was asked to come together again. Laura and Amy wrapped up the lesson and if the hands-on project spanned over two weeks, they introduced the task for the following class. To conclude these discussions, learners often got a chance to express how they felt about certain activities. By the time these discussions concluded, parents and caregivers had usually arrived. Learners often took their parents to see what they had crafted that day before leaving for home.
Thematic Outline of Lessons

The following table summarizes the lessons that occurred throughout the afterschool session by theme. It will also include the main topics of each lesson and a list of the art-science activities learners participated in that day. Many of these activities will be described in further detail in the subsequent chapters. The list of activities included in this table will not include those that occurred every week as part of the routine of the program, such as the ‘Question Corner’ or the opening activities previously described.

Table 1 – Major Themes and Hands-On Activities Explored in the Afterschool Program

<table>
<thead>
<tr>
<th>Week</th>
<th>Theme</th>
<th>Main Topics</th>
<th>Hands-On Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ecosystems</td>
<td>Ecosystems Decomposers</td>
<td>Building a worm composter</td>
</tr>
<tr>
<td>2</td>
<td>Ecosystems</td>
<td>Ecosystems Decomposers Producers</td>
<td>Planting producer seeds in pods</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Making home-made paint from producer specimens and decomposer byproducts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Creating artwork with the homemade paint</td>
</tr>
<tr>
<td>3</td>
<td>Ecosystems</td>
<td>Consumers</td>
<td>Making plaster masks</td>
</tr>
<tr>
<td>4</td>
<td>Ecosystems</td>
<td>Consumers</td>
<td>Decorating plaster masks</td>
</tr>
<tr>
<td>5</td>
<td>Ecosystems</td>
<td>Predator-prey relationships</td>
<td>Owl pellet dissection and bone mounting</td>
</tr>
<tr>
<td>6</td>
<td>Engineering</td>
<td>Windmills</td>
<td>Building and testing a working windmill</td>
</tr>
<tr>
<td>7</td>
<td>Engineering</td>
<td>Bridges</td>
<td>Working together to build and test a bridge</td>
</tr>
<tr>
<td>8</td>
<td>Paper</td>
<td>Recycling paper</td>
<td>Making homemade recycled paper</td>
</tr>
<tr>
<td>9</td>
<td>Paper</td>
<td>Working with paper</td>
<td>Decorating homemade recycled paper</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Collage</td>
</tr>
<tr>
<td>10</td>
<td>End of program celebration</td>
<td>Review of the program</td>
<td>Tie-dye t-shirts</td>
</tr>
</tbody>
</table>
CHAPTER 4 – FINDINGS AND ANALYSIS
STEAM POWER: THE GOALS OF AN ART-SCIENCE AFTERSCHOOL PROGRAM

Introduction

STEAM programs are not all created equal, particularly those that take place in settings outside of a typical school. In these settings, where there is generally no imposed curriculum, programs can be developed according to different visions of what STEAM is or beliefs of what it can achieve. Given this diversity, it is important to consider the specific goals of the program in question to understand the vision of STEAM around which the program has been created. This chapter presents the findings and interpretation of data related to research question one, concerning the goals or objectives of the afterschool art-science program.

The afterschool program explored in this study does not claim to be a STEAM program, but rather, to focus on art and science and their connections. Interestingly however, the goals of the program, as revealed through careful analysis of the data, bear many similarities to those of STEAM as explored in the literature, including (1) the development of scientific literacy and (2) a nurturing of creativity. The data also suggest that an additional goal of the program is (3) to help facilitate learner emotional development. These three main themes will be explored independently in each of the following sections.

It is important to keep in mind that all the lessons and projects that will be described throughout this discussion include hands-on experiences. Although this commonality suggests hands-on learning could be a goal of the program, I consider it instead to be a strategy, which deeply influences the learner experience. Hands-on learning is discussed in detail in Chapter 6.

1. Developing Scientific and Artistic Literacy

There is general agreement across the discourses of science education that fostering
scientific literacy in learners is significant. What scientific literacy is however, is more challenging to agree on. As previously mentioned, the working definition of scientific literacy for this study involves an integration of perspectives. Scientific literacy concerns a learner’s ability to (a) develop the knowledge, skills and attitudes of science professionals, and (b) engage in the application of this knowledge and skill through active and responsible citizenship (Hodson, 2004).

Although these ideas are specific to science education, it can be argued that nurturing these same principles through art education is also significant, if the intention of education is to create well-informed, and well-trained citizens. As Shulsky and Kirkwood (2015) note, “As students create works of art and engage in conversation about their work, they can begin to find connections between their artistic endeavors and the world. Such activities allow for young learners to make sense of the world around them in meaningful and creative ways” (p. 365). Therefore, the program’s vision to nurture both scientific and artistic literacy will be explored with reference to particular examples from the data.

**a) Content knowledge and skill development.**

A clear aim of this afterschool art-science program was to help learners develop content knowledge and skills in both science and visual art through hands-on projects. This was most evident through the instruction of art and science content and the practicing of art and science techniques throughout the term. For example, in one lesson learners explored the role of an owl in an ecosystem through discussing predator/prey relationships. In addition to this scientific content knowledge, they also got to practice two scientific skills: dissection, through the dissection of an owl pellet, and classification through the sorting of bones according to their type and species. In another set of lessons, learners were introduced to the process of paper recycling
in a facility, while also exploring the varied uses of paper in art. To accompany these new understandings, students learned the skills of making their own collage and recycled paper.

It became clear that facilitating new understanding and skill development was an intention of the program, not only through these observed lesson designs, but also though discussion with program developers and instructors. For example, Amy shared that there was distinct science content knowledge that she intended the students to learn through the lesson focused on the role of decomposers in ecosystems:

We want to teach them about decomposers, so learn the word decomposers and learn how worms are decomposers and how they are going to transform all these materials into worm poop, which helps feed plants, which is another part of the ecosystem, and sort of see that connection. (Interview 1, April 2016)

Laura and Amy shared this specific content knowledge with learners through a mini-lesson. They began by presenting learners with the question “What does the word ecosystems make you think of?” in the center of a piece of chart paper. Learners were free to volunteer answers by raising their hands, and their answers were included on the chart paper to form a mind map. Student answers were varied, including words such as recycling, pandas, water, electricity, Costco, skeletons and pirates. The instructors then provided learners with a definition of ecosystems as “living systems”, and some examples. They also introduced the parts of an ecosystem with a particular emphasis on decomposers and their role. This was followed by the hands-on activity in small groups of building a composter with a live specimen of a decomposer, the worm. They added shredded paper, sand, soil and worms to their bins, and the following week they even added oatmeal as an example of compostable food waste which worms can break down to fertilize the soil. Through building and observing the composters, students were able to observe
the process of decomposition as facilitated by a decomposer over time. Although it is difficult to determine the extent to which learners retained the knowledge they gained through this lesson, my field notes state that the following week, learners were able to recall vocabulary on decomposers well when prompted by the teachers in a large group.

The extent to which each lesson focused on subject content or skill development varied throughout the program. Some lessons were more oriented toward scientific concepts like the described decomposer activity, and others were focused on learning to work with a certain artistic medium or material like plaster. Amy described this variety as she discussed how lessons were developed:

So it’s usually distilled to 4 or 5 short points or keywords and that seems to work the best in the one-hour format. But some weeks are different, for example, this week we were doing plaster masks, so it was more focused on the task [skill] and next week we will talk a bit more about consumers, [content knowledge] which is what these masks are for.

(Interview 1, April 2016)

These comments suggest a definite flexibility in what knowledge and skill were explored and when throughout the program, but maintains that both content knowledge and skill development were significant to the program. With that said, if this goal truly was accomplished, which I believe it was through the examples provided, the program can play an important role in nurturing scientific literacy in young learners.

b) Responsibility and active citizenship

Although it is significant that learners gain knowledge and skill through their engagement with art and science programming, it is equally, if not more important that they learn how to
apply this knowledge and skill responsibly and thoughtfully out in the world. As Hodson (2003) notes, a critical element of science education for citizenship involves “ensuring a level critical scientific and technological literacy for everyone as a means to bring about social reconstruction” (p. 654). To prepare students for the real-world application of their learning, exposure to meaningful, problem-solving tasks with social implications can be valuable. This situates learning in a particular context and perhaps more importantly reminds learners that “Because art and science influence society, they are charged with an ethical burden” (Erez, 2001, p. 9), which, in my view, is to use knowledge and skill responsibly and in pursuit of the common good.

This type of learning was also a goal of the afterschool art-science program. Amy expressed this idea during our first interview at the start of term: “I don’t think strictly science and art knowledge is the goal, it’s more [pause], sometimes it can be how can you teach them [students] these other social and emotional things through a science and art project” (Interview 1, April 2016). She extended this thought by explaining that because these learners have the privilege of access to art-science programming, it is a valuable opportunity to extend learner thinking towards doing good and making positive change:

Because I think a lot of these kids that come to these art programs have access to engineering and science and art and math … because they can pay for the programs, it is important for me to teach them how to be great citizens of the world and so, you are in this position where you have access to this, you can do great things with it. (Interview 1, April 2016)

As Amy suggests, it is an unfortunate truth that not all learners are able to access these types of learning opportunities. For those that can, it is imperative that they are encouraged to use these resources to make positive change. As Curry-Stevens (2007) notes with regard to social justice,
when working with privileged groups, learning must involve reflecting on “how one understands the world and one’s place within it as well as understanding the responsibility one holds for creating change” (p. 44). It is equally imperative, however, to provide all learners with equitable opportunities for learning. That will involve finding ways to remove barriers to ensure all learners receive the learning benefits to which they are entitled. Perhaps that involves finding a way to integrate this model of programming into the regular school system, which all children have access to. This idea is developed further in Chapter 7.

The most striking example of programming catered toward responsibility and active citizenship that I observed during this program involved teamwork. Unlike other lessons of this session, this activity was posed as a challenge. After being introduced to the structure and function of a beam bridge, learners were to use a set of building materials provided to them to construct a small section of the bridge between two cups. Laura was careful to review the building materials with the group, which included 2 large red cups, a few drinking straws and pipe cleaners, construction paper and a certain length of tape. She encouraged learners to think about the materials and how they might be used, as each learner had a finite number of each material. Once learners had completed their bridge segment, they would then work together to join them into one long passage connecting two cities. A toy car would then be used to test the stability of the bridge from end to end.

Two features of this activity helped it to effectively encourage teamwork. First, it began as an independent activity, where learners were limited in the materials they could use. As the building went on, some learners began to run out of materials they needed and wondered how they could get more. As Jackson, one of the participants, joked, “Can I buy supplies with my bank card?” (Field Notes, May 2016). The instructors had predicted this would become an issue,
so as part of the activity, each learner received a ‘material shipment’ of one building material, at random. Sometimes this was a material the learner needed, in other cases it was not. It was at this time that Laura and Amy encouraged learners to trade their materials for ones they might need. For example in his ‘material shipment’, Walter, another child in this program, received two long stretches of tape, which he offered to other builders who may have needed the precious commodity. The ‘material shipment’ element of the activity was an opportunity for learners to help one another by sharing their resources. At this point the activity was no longer an individual effort, but rather a co-operative experience through which “students learn to trust each other and work together” (Miller, 2007, p. 148). In doing so, I believe it showed learners that there is value in working together, an important and necessary insight for the upcoming assembly of the bridge.

The group assembly of the bridge was the second feature of this activity that effectively nurtured teamwork. Once learners had completed their small bridge segments individually, Laura asked them to help with connecting the segments to form the major bridge structure. Steph and Frankie worked together to reinforce weak areas of the bridge, particularly at segment junctions. Jackson shared ideas: “Use the extra tape to reinforce here!” (Field Notes, May 2016). Emily and Frankie spontaneously made decorative flags. Once the bridge was assembled, each student stood by their segment, as Jackson tested out whether the toy car would make it from one side to the other. After having observed that Timothy’s part of the bridge could not bear the weight of the car, Frankie went over to help reinforce the bridge segment with more pipe cleaners and straws. Before they left for the day, Laura gathered the class together and praised learners for working together so well. All these instances demonstrate that learners worked together to accomplish the bridge building challenge. Beyond that, it served as evidence that learners had recognized their positive interdependence, or that their success at the task was dependent on the success of their
peers (Johnson & Johnson, 1994 cited in Miller, 2007), helping to build a sense of personal responsibility to the project.

The above example clearly illustrates that the bridge building activity nurtured a sense of responsibility in learners, linked to the citizenship component of scientific literacy. It is important to note however, that this activity also facilitated further learning with respect to collaboration. As Amy pointed out towards the end of the program, the bridge building activity was specifically chosen to give the learners an opportunity to work as a team:

Midway through the term with the bridge building I was thinking, these kids are enjoying the activities, but I saw that there was an opportunity to teach them a little bit more about something beyond science and art, which was the teamwork aspect … and I think the best case is the next week they are more comfortable with each other ... So there was the physics part of the bridge, but by having that teamwork piece, we enabled maybe some activities to happen later on in the term. (Interview 2, June 2016)

Beyond the direct advantage of having learners work together in the present, this type of activity nurtured a feeling of comfort and community, which positively benefited subsequent lessons and activities through the session.

2. Creativity

The National Advisory Committee on Creative and Cultural Education (NACCCE) (1999) identified four challenges facing modern education. These challenges ranged from preparing learners to cope with the dynamic and every changing worlds of work and technology to encouraging learners to make positive social change and live “purposeful and fulfilling” lives (NACCCE, 1999, p. 24). These challenges have been identified in consideration of the fact that
the world is a complex, ever-changing place in which novel and complex economic, social, environmental issues can and do arise regularly. To address these highly contextual and constantly evolving issues effectively, equitably and with a lasting effect, creative solutions will be required. It therefore becomes important that learners get to explore what it means to think creatively in different settings and in response to different ideas or contexts.

Through the course of this study and as a result of careful analysis of the data, it was clear that nurturing creativity was a goal of the art-science afterschool program. This was accomplished through (a) the program’s focus on nurturing an appreciation for the connection of art and science in learners and (b) opportunities the program provided which empowered learners to think divergently. The following subsections will describe these methods of nurturing creativity separately with specific examples and data from the afterschool session provided for each.

a) Nurturing an appreciation for the connection of art and science

It was very evident from the get-go that this afterschool program’s intention was to engage learners in ways that brought art and science together. On the very first day of the program, both Laura and Amy introduced themselves to the students by describing how their past learning or work experiences had explored the merger of art and science. This suggested to learners up front that they would also be exploring similar connections. The setting of the classroom also revealed that art and science would be integrated through the program as books, materials (ie: construction paper, markers, paint, etc.), posters (ie: butterflies, sharks, fungi), models (ie: taxidermy rabbit, insect specimens, skeleton), and samples of student work (ie: cell plushies) spanned both disciplines. In fact, Laura and Amy tried to make it as clear as possible
through their programming and behaviour and actions, that this space is one where art and science are coupled. As Laura noted at the end of program:

I feel like because we always talk about this is a science and art [site], and we are doing science and art, we use that in our vocabulary, that I’ve heard Jackson before say, well I forget the words exactly, but he will use science and art together … you know he’s proud to say that. (Laura, Interview 2, June 2016)

As a result of being explicit about this goal, some learners were able to appreciate that this was an environment in which art and science were coupled. Laura expressed this intention of the program as follows:

My hope is there is no divide [between art and science] because later in life there is going to be a divide, and my hope is that at this point it still feels like it is fused together, and very open and creative, both science and art. (Interview 2, June 2016)

It would be interesting to explore whether learners had carried this understanding into their school or daily lives, but this is beyond the scope of my study.

Throughout the term, the unity or fusion that Laura described was facilitated through different lessons, activities and hands-on projects, which brought art and science together. One of the most striking and innovative activities, involved learning about the role of decomposers and producers in an ecosystem, and using them to create homemade paints. This session began by reviewing the ecosystem vocabulary and expanding on the mind map students had created the previous class. This week, learners were provided with an expanded definition of ecosystems, “living things that are connected to survive” and asked to think of more examples to add to the mind map. Learners provided answers such as food, water, bees, seeds, plants and volcanoes. I had written in my field notes, “with this definition, learners were able to provide very
accurate/insightful elements of an ecosystem” and reflected that they were much more accurate than the previous week (Field Notes, April 2016).

Following this discussion, learners observed the worm compost bins they had made the previous week as an opportunity to explore the role of decomposers. This activity led to an introduction of producers, or plant members of an ecosystem that create their own food through photosynthesis, which are nourished by the waste of the decomposers in the soil. When prompted, learners provided examples of producers such as carrots, lavender, tulips and peonies. Amy introduced a few different types of plants indigenous to the area and showed an image of each. She also used another sheet of chart paper to create a diagram representing an ecosystem, with decomposers labeled at the bottom in the soil and producers labeled and drawn growing out of the soil. This was followed by a brief activity where learners were able to plant their own seeds into soil pods, but the major art-science project for this session involved taking three specimens of producers, and one byproduct of decomposers and making them into homemade paint.

Each specimen, which included raspberries, blueberries, turmeric and soil/decomposed matter from the worm bins, was placed in a blender, mixed with some water and pulverized. A binding/adhesive agent was added to each blended specimen. Students received samples of all four paints and a sheet of paper, and were prompted to create a piece of art. Interestingly, some of the images learners painted related to terms discussed during the lesson or while creating the mind map, such as flowers, volcanoes and sunshine.

Upon reflecting on this activity, Laura found it had been a really effective way of bridging both art and science:

We were going along this path, which Amy and I carved out at the beginning of the semester of following the ecological systems. That was going to guide our lesson plans.
… I think that was great because we were working from a more scientific place in terms of ecology, the terminology and then to make an artistic material out of it and having kind of a ‘gross’ factor, I think that was a really good bridging of science and art. (Interview 2, June 2016)

The merger of art and science is valuable because it can nurture creativity and divergent thinking in learners. Consider the definition of creativity as posited by the NACCCE (1999) report: An “Imaginative activity fashioned so as to produce outcomes that are both original and of value” (p. 30). In a unique way, the homemade paint activity met all the criteria of this definition. First, by repurposing producers and decomposers as sources of pigment for paint, learners were presented with “an alternative to the expected, the conventional, or the routine” (NACCCE, 1999, p. 31). Rather than taking a bottle of paint out of the craft cupboard, learners were making their own paint from sources they might not have known could ever be used for this purpose. Second, the activity had an objective or intended ‘outcome’. Learners were expected to leave this activity with new art and science understandings, presented in a do-it-yourself format they could try again at home. Third, the artwork learners created was original, in relation to one another, and likely in relation to activities learners had done before. Finally, the activity was valuable because it provided a foundation for further learning in school, which Amy pointed out in our discussion:

Later on when they actually get to Grade 4, where the producers, consumers, and decomposers come in they are like “Oh wait, we did that! But then we also got to make paint out of producers” and using the art, as a way to aid in the understanding of the science, or [making learning] more memorable because we didn’t just learn about plants, we made art with the plants. (Interview 2, June 2016)
Amy’s comments are important because they suggest that the creativity nurtured through this activity, and through the program in general, can be enduring and applicable to even further learning in school. Perhaps then, learning facilitated through this afterschool program occurs in what Moje et al. (2001) have referred to as the ‘third space’, or the place between formal schooling and everyday life where art and science can be better understood and viewed as relevant, engaging and authentic by learners.

Although this example demonstrates an intentional weaving of art and science content and skill in one lesson, the program as a whole showed considerable variety in terms of how art and science were brought together. As I noted in my field notes, “Integration of art-science isn’t always uniform, it is iterative and plays off content, time and other constraints” (Field notes, April 2016). Sometimes lessons were focused mostly on science concepts, like the worm bin example, and others were more art focused such as when we spent an entire class crafting plaster masks. It was clear however, that in terms of when, where and how learners were exposed to either science or art, there was always a flow or flexibility. This flexibility ensured that there was no imposed hierarchy between the knowledge, skills or attitudes of either science or art, but that both were useful, interesting and worth exploring.

b) Empowering learners to think divergently.

Teaching for creativity has been said to emphasize divergent thinking, that is “exploring many possible solutions to a problem” (Madden et al., 2013, p. 542). The art-science afterschool program being explored encouraged learners to think “outside-the-box”, to explore and to be curious about both scientific and artistic phenomena. It accomplished these tasks by ensuring (i)
learner needs were respected and met and (ii) learner ideas were honoured. This empowered
learners to think divergently and nurtured the value of creative thinking.

\textit{i. Respect learner needs}

Before students can be encouraged to think divergently or engage fully in any learning
process, their basic learning needs must be met. This can occur by ensuring learning is structured
according to their abilities, attitudes and interests. In consideration of these needs, learners must
be imparted with the strategies or tools they need to succeed in the learning environment, and
then encouraged to use these resources to widen the scope of their thinking. It was evident on
many occasions that this program was developed with learner needs in mind.

All activities implemented throughout the course of the afterschool program were, in my
view, within the abilities of the learners. There was no instance where a learner could not
participate due to their age, prior knowledge, or level of physical or motor development. I believe
this arose from two important approaches instructors took toward developing the program. First,
in cases where instructors were unsure about how to best accommodate a learners needs, they
approached their parents/caregivers. In one case, Laura reached out to a parent/caregiver to
discuss the most effective strategies for connecting with a particular learner, so that “we [parent
and teacher] can be on the same page” (Interview 2, June 2016). As Laura noted, it “made me
feel really good to know how best to work with that student to then enhance that student’s
experience” (Interview 2, June 2016). This type of instructor-parent partnership can provide
valuable insight into the distinct needs of a learner, which instructors can then use to develop
programming accordingly.
The second approach instructors took involved considering the diversity of learner ability in a mixed age classroom. Laura touched on the importance of this understanding: “But we have a good understanding now of what an SK student is capable [of] versus a Grade 3, so that is the first thing; understanding the age group that you are working with” (Interview 1, April, 2016). Her comment suggests that over time the instructors were able to refine their understandings of what different age groups of learners could accomplish, and used that understanding to design instruction in this session of the afterschool program. This is a particularly important insight because the afterschool program ranges from JK to Grade 3, which spans five years in which learners generally demonstrate considerable cognitive, physical and emotional development. Therefore, through working with parents, and developing programming according to learner ability, all learners were able to engage in the activities throughout the program.

Developing programming with regard to learner needs requires not only consideration of learner ability in a particular lesson, but also throughout the course of the whole program. As Amy pointed out, sometimes learner abilities change through the course of the term and programming must be modified accordingly:

It’s an after school program and it’s the end of the school year, student’s ability to focus and hold attention on complex concepts, we understand it’s just diminishing as the days go by. So if we can do something that is still fun and incorporates our pillars of science and art but maybe had less steps and is a lot more free form, that maybe might fit their needs a lot better. (Interview 2, June 2016)

Amy is referring to the fact that as the program wound down, in the last few weeks activities became less structured, slightly more art focused, and with less explicit content knowledge to be imparted. By the eighth week, the program had transitioned into paper making, which was then
painted and decorated in week nine. In week ten, during the final class, learners got to tie-dye their own t-shirts to commemorate their time in the program. This was all intentionally selected in consideration of where the instructors perceived learners to be at in terms of energy level and attention span by the end of the program. It also permitted a celebration of what had been learned throughout the program through the creation of tie-dye shirts.

Beyond catering to learner ability, the program also sought to accommodate learner attitudes or feelings. An afterschool program needs to keep in mind, that learners, even those as young as 5 or 6, have already spent over six hours in school. They are likely tired physically and perhaps even emotionally depending on what had happened earlier in the day. The instructors accommodated this need by ensuring that learners had “buffer time at the beginning [of each lesson] for the kids to just get adjusted to the space” (Laura, Interview 1, April 2016). This meant that for the first fifteen minutes of each class learners had time to adjust to the space and to their classmates. They usually began by finding their lab coats on the rack and putting them on. A variety of educational toys were available including stackable blocks or magnetized shapes that could be linked together. Students could draw freely in their own sketchbooks or colour in a colouring book. As the term progressed, learners knew they had this period to do what they chose to, and automatically went to the stations of their choice until they were called together to begin the day’s lesson. Intentionally beginning each day with this “buffer time” helped learners to get ready to participate in the following activities and helped to keep them enthusiastic and motivated for what was to come.

These resources (the blocks, sketchbooks, etc.) were always on-hand and therefore they served another important learner need. When students had finished their hands-on project for the day, they were welcome to take out and use these materials. Meanwhile, other learners who
wanted to continue working on their art-science project could do so, and all learners were kept engaged and satisfied. As Laura noted in our second interview:

You want to make sure that the people that take the time to be very diligent or detail oriented, they get to have that time and not feel rushed, where I’m sure in classes [at school], there is not that time to work at their own speed and at the same time, satisfy the kids that are done and not have them be bored or running around. (Interview 2, June 2016)

These ‘buffer time’ materials accomplished this task so that in cases like Steph’s, where she wanted to add a butterfly to the nose of the jaguar mask she had cast and decorated with a pink and grey spotted print, she was able to do so without feeling rushed.

Thus far I have discussed the ways in which the afterschool art-science program catered to student ability and attitude or feelings, but it also ensured that learner interests were accommodated. This involved providing learners with a level of autonomy or choice. For example, although each lesson had a general series of activities associated with it, if a learner decided they wanted to contribute in a different way, or wanted to proceed in a different order, they were generally able to. While the class was making recycled paper, Toby decided he wanted to continue to help making pulp by blending old paper scraps with one of the instructors, rather than work on his own paper sample. When Timothy decided he did not want to decorate his windmill and instead focused on assembling and experimenting with it, he had the freedom to do so. The afternoon we worked on the bridge activity, I observed that Emily was not building her bridge segment immediately, as many of the other learners had done. Instead she played with the building materials given to her, organized them and decorated some of them. When she was ready, she assembled her bridge segment. These examples illustrate that learners maintained a level of control in the decision making process through the course of the program. As
Stocklmayer (2010) notes, these free-choice types of experiences, common in learning settings outside the school classroom, can be valuable to ensuring learning is truly authentic.

This discussion has demonstrated that the afterschool program in question indeed catered to diverse learner needs. I would hope that by meeting these needs, learners could be encouraged and empowered to open up their minds to allow for more divergent and creative thinking. In fact, I observed a case of just that during the session. After decorating her animal mask to look like a jaguar, Neve told me she wanted to use some of the printed felt she was working with to make a tail she could wear. We worked together to use pipe cleaners and the printed fabric to fashion a type of belt from which her tail could hang. In this example, Neve was given the space and resources to extend the activity beyond the mask building and into further imaginative and creative pursuits.

**ii. Honour learner ideas**

If learners are to be encouraged to think in novel and interesting ways, then logically, to motivate them to do so, they need to be shown that their ideas have value. There can be no desire to think creatively, if when they do, their ideas are not recognized. There are several ways in which this afterschool art-science program sought to honour the ideas of learners, not only allowing these ideas to be present, but using them to facilitate further learning.

Central to the daily activities of the afterschool art-science program was the ‘Question-Corner’ [pseudonym]. After the daily opening activities described above, Laura and Amy would ask learners to tidy their work areas and join them on the floor in front of the black board. Here learners would be prompted to contribute a question to the ‘Question-Corner’, a cork-board posted on the wall nearby. Each learner was given a sticky note and a pencil and asked to write a
question on anything they were curious about. Sometimes their questions were related to topics explored in class, for example one learner asked “How do you make bones?” (Field notes, May 2016). This was likely in response to the activity where learners extracted bones from an owl pellet, sorted them and created a piece of art with them. At other times, questions were seemingly unrelated to specific course content, for example, another learner asked “what is the molecular biology of the cell?” (Field notes, May 2016). This activity occurred almost every week, giving learners a chance to probe deeper into content we had explored together or to open up a dialogue regarding new ideas.

In addition to simply getting learners to ask creative questions, Laura and Amy made sure that learners knew their questions were interesting and valuable by answering one or two each class, pulled directly from the ‘Question-Corner’ board. In response to Neve’s question, the instructors asked the class what they thought bones were made from. Jackson responded that “bones are mostly calcium and they make you stronger” (Field notes, May 2016). To supplement this comment, Laura gave her own brief answer. When answering the question about the molecular biology of the cell, Laura brought over a large university biology textbook, introducing the field of molecular biology and explaining that if the students continued to study biology they might need to use that textbook. Often answers to ‘Question-Corner’ inquiries were put up on the blackboard with the name of the learner who had posed the question. Laura reflected on the effectiveness of this activity during our interview:

I think question asking, as a skill, is something I’ve seen kids nervous to do at the beginning and [they] have gotten more interested in that [skill], knowing that we also follow through with it. If you ask a question, eventually we get to it ... and honouring that it’s a great question and no questions are stupid. I think that through the ‘Question-
Corner’ [pseudonym] activity, and watching the kids get more and more comfortable with it is something that I can clearly outright see. (Interview 2, June 2016)

Although it is not possible to determine whether questions became more or less creative, it can be said that this activity gave learners the opportunity to think independently and divergently and perhaps because of that it was able to sustain learner interest throughout the program.

Another method through which the afterschool program honoured learner ideas was to encourage learners in paths of inquiry that they had self-identified. As Laura noted:

… when kids come in and they are really interested to show me things … like Jackson brought some leaf over to show me or when Steph just recently brought her caterpillar in. I think the parents feel comfortable knowing that their kids can come in with this stuff and we would accept it and I want to show them that I appreciate it by dedicating some time. So with Steph I took them all outside and got some plant life to feed it and I let her do the ‘show and tell’ for the group too. To let her have center stage with this thing that she brought in and honour that. When Jackson had this cool leaf he wanted to explore, I gave him a mortar and pestle and I added some water and said “go for it”, and then he was showing the other students. (Interview 2, June 2016)

These two examples with Jackson and Steph illustrate clearly that learner ideas were not only acknowledged, but also encouraged to grow. By sharing these explorations, it demonstrated to learners that it was okay to be curious and think in new and interesting ways about the world around them.

Furthermore, learner ideas were valued not only in specific activities throughout the term like those described, but through the ongoing development of programming. By engaging learners in reflective discussions throughout the term, where they are prompted to provide
feedback on activities, they begin to feel they are a part of the learning process and that what they think matters. For example, after the activity in which learners crafted their own plaster masks, Laura held a discussion with learners to get their opinions of the task. Steph mentioned that taking the plaster off her face was uncomfortable because it stuck to her hair and face. Frankie commented that the petroleum they had placed on their faces prior to the plaster felt “weird” (Field Notes, April 2016). Not only did this discussion give learners an opportunity to voice their opinion, but in this case it also became a valuable learning opportunity for the instructors to see how they can improve activities and make them more accessible and interesting for learners.

All of the above activities have been described to illustrate that the afterschool program in question valued learner ideas and in doing so encouraged and motivated learners to think creatively. Beyond that it also gave students opportunities to explore and discover their unique “creative strengths” (NACCCE, 1999, p. 104) and practice creativity related skills. These three characteristics, which the NACCCE (1999) refer to as “encouraging, identifying and fostering” (p. 103), are referred to as the principles of teaching meant to nurture creativity. It is clear that the art-science afterschool program, in displaying these characteristics, does indeed present learners with an opportunity to be creative.

3. Emotional Development

Scholars have noted the role that informal or out of school learning opportunities can play on the affective or emotional dispositions of learners (Meredith et al., 1997; Pedretti, 2002; Pedretti, 2006). In addition to nurturing scientific literacy and creativity, it was evident through the course of the program that emotional development was also a significant goal. Providing learners with opportunities to work outside of their comfort zone and encouraging them to
demonstrate perseverance facilitated this emotional development. The following examples illustrate how this was accomplished.

At times, some of the activities learners participated in were a little uncomfortable. For example, during the making of the plaster masks, learners had to work with partners, trusting the partner to place Vaseline and wet plaster on their face and out of their eyes and nose. Although Walter commented that the Vaseline felt “smooth” on his face, many other learners mentioned it felt “weird” (Field Notes, April 2016). Neve touched on this discomfort during our first interview:

Neve: I don’t like when they putted that thing on my face.

Researcher: Oh, last week when we made the masks?

Neve: Yeah

Researcher: Why didn’t you like that?

Neve: It was weird kinda feeling. (Interview 1, April 2016)

Neve was very vocal about her thoughts on activities that she considered to be outside of her comfort zone. When she was dissecting her owl pellet and removing the tiny bones she shouted, “This is disgusting! I never want to feel a bone again” (Field Notes, May 2016). Interestingly however, despite her discomfort, she continued to work diligently at the activities, completing both the mask and owl pellet projects. I wrote in my field notes “Some students experienced some discomfort. They mentioned it was sore to take off, uncomfortable and felt weird, but most upon completing the mask were excited to see their product” (Field notes, April 2016). Although the activity was uncomfortable, most learners persevered, and were rewarded with a beautiful plaster mask. Laura commented on the value of these experiences:
Overcoming discomfort as a skill, I think, is something that has been really special here.

… With the mask making, I was so impressed. There are a lot of uncomfortable factors in that activity, and trusting a stranger, but they went through it, and really enjoyed it and that can be a bonding experience as well. (Interview 2, June 2016)

Working outside of one’s comfort zone requires a demonstration of perseverance and a willingness and dedication to finding a way to surpass the challenge. At times, the challenges learners experienced weren’t of physical discomfort such as those described above, but rather social discomfort. On the day we were casting the plaster masks learners worked in pairs. One student applied the plaster to the other’s face and then they switched roles. Jackson was upset he had been paired with Emily, his younger sister. He insisted that he “works better alone” (Field notes, April, 2016). Laura mentioned that the activity wasn’t possible to complete individually, and I remained with the pair for the course of the plaster casting to lend some extra support. Despite his misgivings, he slowly completed his sister’s mask and then sat patiently while she applied the plaster to his face. When he expressed discomfort, I reassured him that he was doing very well and the process was almost over. At the conclusion of the class, both Jackson and Emily had wonderful masks, which they would leave to dry and decorate the following week. Hopefully, this experience would have demonstrated to Jackson that he had the determination to persevere through discomfort and that in doing so he was able to accomplish great things, in this case, creating his own unique mask crafted in the image of a Komodo dragon.

These examples illustrate that the program provided opportunities, some perhaps unintentionally, for learners to grapple with physical and social discomfort in a controlled and caring environment. In doing so, it gave learners a chance to demonstrate perseverance and
resilience, perhaps supporting their overall emotional development. It also helped to build trust among classmates.

In summary, through the analyses of data collected and the many detailed examples of program activities, I identified three goals of the art-science afterschool program under study. The first two goals, to develop the scientific literacy of learners and to nurture learner creativity, are very similar to the intentions of STEAM curricula. The third goal, to support learners in their emotional development is a characteristic often linked to informal, or out of school learning settings. In consideration of these three goals, the following chapter will explore the implementation of the program in detail and outline ways in which the program was presented to learners. In addition, it will discuss challenges instructors experienced while implementing the program to gain insight into how these challenges influence the unfolding of the program.
Introduction

The kaleidoscope is a useful metaphor for STEAM programming in a few ways. First, it represents a beautiful merger of art and science. This kaleidoscope functions through the use of mirrors and their patterns of reflection. As the colourful beads or glass pieces within the kaleidoscope, are reflected by the mirrors they create the lovely images we observe. Second, the images produced in a kaleidoscope are ever changing. With each turn a new image is produced with its own unique characteristics and patterns. STEAM programming can be thought of very similarly. Each example of STEAM is developed with a distinct set of goals, as discussed in the previous chapter, and implemented through a unique and diverse set of strategies. Just as the rotation of the kaleidoscope changes the presented image, so to can the distinct strategies used to implement a STEAM program influence what is presented to learners.

This chapter presents the findings and interpretation of data related to research question two, mainly, delivery and presentation of the afterschool art-science program, and challenges identified by the instructors. The first two sections will provide insights and details into how sessions of the afterschool program were implemented, focusing on (1) how the program sought to make connections between disciplines and topics throughout the term and (2) the particular teaching and learning practices observed. The next two sections focus on elements that influenced the implementation of the program, looking particularly at (3) the ongoing development of the program throughout the term and (4) the challenges that instructors encountered along the way. It is my hope that this chapter serves to clearly outline the
implementation of this afterschool program, providing insight into one vibrant and unique kaleidoscopic image of STEAM.

1. Making Connections

   It was evident through the course of the afterschool program that helping learners to make connections was a key element of its implementation. Sometimes these connections were between subject areas, between activities or particular lessons and sometimes they linked what students were learning to their personal sense of self. These connections are reminiscent of the whole curriculum, a central element of Whole Child Education. As Miller (2010) notes, “The whole curriculum is the connected curriculum. The whole curriculum focuses on relationships so that students can make connections” (p. 60). By making these connections, learners may become better able to understand the intricacies of the connections around them as they go through their daily life. The following sections will explore (a) discipline integration and (b) the linking of lessons, themes and ideas, which characterized the program.

   a) Integration of disciplines.

   The previous chapter outlined in detail the objectives of the afterschool art-science program, one of which was to nurture in learners an appreciation for the connections between art and science. Naturally, to meet this objective the program must be implemented in a way that presents art and science as linked, or even integrated. This section will explore the way in which art-science integration was used in the program with respect to models of integration presented in the literature.
The afterschool art-science program can best be described as a multidisciplinary or fusion program. It can be considered multidisciplinary because both disciplines, art and science, were brought together with respect to a common theme (Drake, 2000). For instance, the first five classes were thematically based on ecosystems. All lessons, activities and hands on projects sought to bring art and science together to enhance learner understanding of ecosystems. The same can be said of the next two classes in which art and science were brought together to build an understanding of engineering projects. Case’s (1991) mode of integration, ‘fusion’, can also be applied to these cases, as subjects that are normally taught separately like art and science were brought together. It is important to note because of this intentional ‘fusion’, there was rarely a time that Laura or Amy said “We are doing science now” or “We are doing art”. There was a mutual understanding between learners and instructors that through the course of the program they would be engaging in both, sometimes even at the same time.

There is one other model of curriculum integration that partially applies to this afterschool program and that is the Worldly Perspective. As noted by Rennie et al. (2012), “The Worldly Perspective advocates balance between disciplinary and integrated knowledge and connection between local and global knowledge” (p. 119). In consideration of this description, it is significant to note that not all lessons or activities implemented through the course of the afterschool program demonstrated such a close integration of art and science as the homemade paint activity described in Chapter 4. Sometimes, activities were more art focused, such as the papermaking set of sessions, while others were more science oriented, like building the compost bins. This is in keeping with the Worldly Perspective, which recognizes that both discipline specific and integrated knowledge are of value and should be balanced with one another.
Although the afterschool program did meet the first expectation of the Worldly Perspective to balance disciplinary and integrated perspectives, it did not readily emphasize the formation of deep links between global and local contexts. There were instances, however, where making these connections were possible, such as when Laura discussed recycling as we made our own paper or as Toby brought up that “people hunt snow leopards for their skin” (Field notes, April 2016) during a discussion. In both cases, these topics were discussed superficially, with a focus on the tasks at hand rather than to consider their implications to broader contexts. This may however have simply been a consequence of how the instructors planned this particular session, or the timing of specific activities.

It should be noted however, that these deep connections are possible to facilitate in this afterschool program context. In fact, Amy provided an example of past programming in the afterschool program that would have more readily met the local and global requirements of the Worldly Perspective. During our first interview, Amy mentioned that in the past term of the afterschool program she had delivered a two-week lesson on the endangered caribou as a way to focus on “our responsibility to help the environment” (Interview 1, April 2016). Although I did not observe these lessons, the topics of endangered species and environmental sustainability can lend themselves nicely to a discussion that considers both local and global perspectives, suggesting that the potential to incorporate a Worldly Perspective for curriculum integration does exist within this afterschool program, despite the fact that it was not emphasized in this iteration of the program.
b) Linking lessons, themes and ideas

Beyond the integration of different discipline areas, the afterschool art-science program presented interesting opportunities to make connections within the program itself between lessons, themes and ideas. The most prominent example of this is lesson-to-lesson connection facilitated by linking individual lessons to an overall theme. Consider, for example, the ecosystem arc, which linked five lessons in this program together in the sequence of a food chain. The program began by exploring decomposers, then moved on to producers, consumers and finally, to predator-prey relationships. By linking these ecology lessons, it became commonplace to review and recall past information.

The ecosystem series of lessons was the most ‘connected’, where ideas were often reviewed and expanded upon. The rest of the term saw less of a direct connection from lesson to lesson, but still focused on grouping lessons according to specific themes. Following five highly integrated lessons on ecosystems, two lessons were focused on engineering where structures were built, tested and refined and another two were focused on working with paper. Although all ten lessons were not linked into a cohesive whole, exploring these three different themes was important to provide a balance between different scientific disciplines and art mediums throughout the program. As Amy noted,

We try to have a balance. We try to have some physics and some chemistry and some biology and try to work with different art mediums. So we look at it [the program] as a whole … we try to incorporate as diverse an experience throughout the whole semester as we can. (Interview 1, April 2016)

In doing so, the program is able to maintain learner interest while providing varied opportunities to explore the breath and depth of both art and science disciplines.
As a final note, the ‘Question Corner’ activity described in Chapter 4 provided another interesting method of linking ideas throughout the term. Sometimes these questions were imaginative and beyond the scope of what was taught in the afterschool program, but often they linked to lessons or activities from previous weeks or were used to introduce the present week’s lesson. For example, one question asked “How long does it take plaster to dry?” (Field notes, April 2016), likely in response to the previous week’s activity, where learners crafted plaster masks. Another asked, “How do snails come out of their shells?” (Field notes, April 2016) which was addressed by Laura and Amy and used as a way to transition into a new conversation about consumers. In either case, this activity provided an additional avenue for ideas to be linked throughout the program.

2. Teaching and Learning Practices

Over the course of the ten weeks that I observed the afterschool art-science program, a host of different teaching and learning strategies were used. Interestingly, this variety is consistent with the idea of whole teaching. Miller (2010) notes, “Since we should reach the head, hands, and heart of the student, we need a broad range of teaching approaches that reach these different aspects of the child” (p. 9). He goes on to detail three different teaching approaches, transmission, transaction and transformation, which, when used in collaboration with one another, can lead to whole teaching, or teaching capable of nurturing the whole child. Nurturing this wholeness in children can be important to helping learners recognize their purpose and how they are connected to the world around them (Miller, 2010). This can help to keep learning relevant and meaningful, maintain learner interest and encourage further learning. The following subsections will explore transmission, transaction and transformation teaching approaches
respectively, outlining examples that illustrate how the afterschool art-science program accomplished each.

a) Transmission

The transmission approach to teaching and learning is perhaps the most traditional, focused on imparting “facts, skills and values to students” (Miller, 2010, p. 15). These facts, skills and values are usually passed in one direction, from teacher to student and the intention is for students to accept this information without question or further analysis (Miller, 2010). Although relying on this more passive vision of learning alone can be problematic because it limits learner opportunities for analysis and critical thinking, using this approach in combination with the transaction and transformative teaching strategies discussed later can be essential to educating the whole child. The following three subsections will explore the facts, skills and values imparted in a transmission style by the afterschool program.

i. Facts – Teacher Centered Lessons

At most meetings of the afterschool program, there was usually a period of time that was dedicated to a short lesson. This lesson was teacher directed and intended to impart learners with a certain knowledge or skill which would be necessary for the completion of their hands-on task or project. These lessons also made regular use of visual aids like photographs, videos, mind maps and the blackboard to help reinforce the knowledge or skill instructors were trying to transmit. One such example, described in detail in Chapter 4, focused on the role of decomposers in ecosystems. At this point, I will illustrate another example of a lesson facilitated through the program, related to the theme of engineering.
The sixth class of the afterschool program was based on windmills. After the weekly opening exercises, Laura and Amy introduced the topic and began a mini lesson. On the blackboard in front of the class a windmill and a sailboat were drawn. Amy prompted the class to consider the following question: “What is a windmill?” (Field notes, May 2016). Frankie responded by saying, “when it’s really windy, turbines or windmills create energy using the wind” (Field notes, May 2016). Also on the blackboard was a fill in the blank phrase reading “A windmill is a ______ that uses energy from the ______ to do work” (Field notes, May 2016). Jackson filled in the blanks with the words “turbine” and “wind” respectively. The instructors mentioned the word “machine” could also fill in the first blank. To extend this thinking, Laura and Amy asked, “What kind of machines/animals use the wind to work?” (Field notes, May 2016). Walter responded “one of those on your house that goes around and around…a weather vane” (Field notes, May 2016). Then Amy asked, “What is the difference between a sail boat using wind and a windmill?” Neve responded that it was “because of the weather” and Toby mentioned the main difference was a “motor” (Field notes, May 2016). The instructors offered an alternative answer, stating the main difference was that a boat travels in a line, while a windmill travels in a circle. The purpose of these questions was to get learners to understand the three takeaway points of the lesson (the purpose of windmills, other uses of wind and how different machines use wind in different ways) prior to moving onto the hands-on activity of building a windmill.

According to a transmission perspective of teaching, “Information or ideas can be broken down into small, manageable units that make it easier for students to learn” (Miller, 2010, p. 16). Structuring the term to explore three different themes independently (ecosystems, engineering and paper), facilitated this division. It is important to note that although a division of theme
existed, the program itself was not completely fragmented and many connections were facilitated between lessons, from lesson to theme and to ideas expressed throughout the program. These connections were discussed in the previous section.

**ii. Skills – Demonstration/Model.**

Transmitting skills was also another important element of the afterschool program. These skills were often necessary to accomplish the hands-on project of the lesson or were scientific or artistic skills that learners would be able to use in their daily lives or at school. Generally the instructors imparted skills to learners through modeling, where they would demonstrate a certain skill and then ask learners to imitate or repeat after them. As Miller (2010) has noted, “When a child is learning to perform a skill, transmission teaching tends to be imitative and repetitive. The young child learns to talk by imitating the speech of his or her parents” (p.10). This very phenomenon occurred on a few occasions throughout the term. For example, before learners crafted their plaster masks, Laura and Amy demonstrated how to work with plaster on someone’s face. Each assumed a role, one was the model who would be sitting very still as plaster was added to their face and the other was the plaster applicator. They modeled the whole process beginning with covering the area to be plastered with Vaseline. They showed learners how to wet the plaster, wring out the excess water and apply the plaster to the face, careful to smooth it out and keep it away from the nose, eyes and mouth. After this demonstration, learners had observed all the skills of working with plaster that they would need to safely create their masks. They then got to try it out themselves.

On another occasion, while Amy and Laura were delivering a lesson on making homemade paint from samples of producers and decomposer waste, they demonstrated the skill
of wafting. One of the paint samples contained turmeric, a pungent yellow spice. To give learners an opportunity to smell the spice, Laura flattened her hand and moving it slowly back and forth over a bag containing the sample, she drifted the scent towards her nose. Each learner then had a chance to waft the turmeric scent and followed the directions carefully (Field notes, April 2016). She explained to the class that this is an important science safety skill, which allows experimenters to smell samples and minimize danger of inhaling chemicals. This example is particularly important because safety skills, by their very nature, must be transmitted. There can be no room for interpretation of a safety procedure meant to keep learners safe; they simply must accept the procedures as necessary to ensure their safe participation. Collectively, these examples illustrate that through demonstration and modeling, specific skills were transmitted to learners.


The afterschool program also transmitted a set of values to its learners through the rules, expectations and routines that were established by the instructors from the first meeting. During the first class learners were introduced to the Code of Conduct. This code, to which each learner was expected to abide, contained four points: raising your hand to participate, using one’s indoor voice, keeping one’s hands to themselves, and finally, not touching the belongings of others. These ‘rules’ were shared with students orally and printed on a sheet of paper that all learners were expected to sign. The signed document was posted on the blackboard for the remainder of the semester. I noted that the document was not large and distracting, but an ever present reminder of the expectations of the program (Field notes, April 2016). Laura discussed the success of this strategy in an interview when she mentioned,
I think what we did this semester, having a Code of Conduct from the beginning and having them sign it and having it read the first, second and third week was really important. (Interview 2, June 2016)

She also commented that being firm on these expectations at the beginning set the tone for the rest of the program:

Maybe at the beginning we were more strict on certain aspects, but once you get to learn the group then you can give a little more leeway and I think we weren’t reminding everyone of the rules, ‘the Golden Rules’ or the Code of Conduct. They were really good about understanding the kind of system of the class and so that was nice and we could lay off and we didn’t have to be as structured as we are when we are teaching other classes.

(Interview 2, June 2016)

Presenting a Code of Conduct and expecting learners to become accountable for it (through signing their name) helped to establish a set of behavioural values in the classroom. At first learners were reminded weekly, but then as they adopted these practices naturally, reminders became less and less frequent or necessary.

In addition to the Code of Conduct, Laura also made frequent use of a Tibetan singing bowl which she would sound when she needed the class’ attention. From the first class she mentioned to students that upon hearing the sound of the bowl, the expectation would be that they folded their hands and “Stopped, looked and listened” to the instructor (Field notes, April 2016). Similar to the Code of Conduct, the use of this bowl became routine and all learners would almost instantly stop what they were doing and refocus on Amy and Laura. I even found myself, hands folded, and waiting on instruction when I heard the soothing sound! Again, this
established an expectation, which learners were expected to understand, value and appreciate, about how to be and act within this context.

**b) Transaction**

The transaction approach to teaching and learning is characterized by interaction and dialogue between teacher and student (Miller, 2007). In response to my observations of the afterschool program, I mentioned in my notes that “Teachers are also artists/scientists meant to help and guide [learners] – seen less as a controlling figure and more as a partner in learning” (Field notes, April 2016). This comment suggests that interaction between teacher and student was a significant element teaching and learning in the afterschool program. Through these types of transaction interactions, learners are able to work on their development of problem solving, critical thinking and inquiry skills (Miller, 2010), generally through an exploration of elements of the scientific method (Miller, 2007). The following discussion will provide a few brief examples of how this was accomplished.

On several occasions throughout the course of the afterschool program instructors and learners worked together to follow a procedure, hypothesize, observe/describe, and/or prototype. For example, consider the lesson in which Amy and Laura worked with students to make homemade paper. Before crafting their own samples, Laura showed the learners an example of homemade paper she had made previously and asked them to feel its texture and compare it to paper from the store. Learners made their own observations in response to these prompts, commenting on its fragility, appearance and texture. The instructors and students then went through each step of the procedure together. In this instance, this partnership was necessary to ensure the blender was used safely, but it also prompted learners to hypothesize and make
observations about the process, which began by getting learners to rip all sorts of scrap recycled paper into tiny bits. As the instructors placed handfuls of this shredded paper and some water into the blender, students hypothesized what colour the resultant ‘slop’ would be. Toby mentioned that the colour would become “golden because it’s the goldest/lightest colour” (Field notes, May 2016). With each successive addition of paper to the blender, learners continued to guess if the colour would change. They then observed as the blender churned the paper scraps into a colourful paper ‘pulp’. Toby commented on the appearance of the blended pulp saying, “It looks like a party!” (Field notes, May 2016). The instructors then guided the learners through the rest of the steps of the activity. This example demonstrates that by working in partnership to make homemade paper, learners were prompted by instructors to hypothesize and observe, important elements of the scientific method.

The compost bin activities also provide an example of students and instructors working together through stages of the scientific method. The instructors and students went through each step of the compost bin procedure together. With each step that the instructors described, the learners followed with the corresponding action. Some steps also prompted learners to hypothesize about what might happen next. For example, as learners shredded pieces of paper into strips, Laura prompted learners to hypothesize “where might this step lead to?” (Field notes, April 2016). Learners responded with words like “explosion”, “stale” or “mouldy” (Field notes, April 2016). In the week after they had built the compost bins, instructors and students had an opportunity to observe and describe their creations. The JK/SK students who were all seated at the same table noticed the worms moving and eating and described the smell of the compost. They commented that the worms might not like sound and would need nametags to help tell them...
apart. This serves as another example of instructors working with learners to follow a procedure, hypothesize and describe what they were observing.

In yet another example, before learners decorated their plaster masks to resemble a consumer in a food chain, Amy provided learners with an opportunity to prototype. She showed learners the variety of materials available to them to decorate, including paint, decorative tape, streamers, feathers and many other supplies. Learners then had time to brainstorm how they would design their final product by sketching on a prototype mask on a separate sheet of paper. Although this prototyping element is more reminiscent of the process of engineering design than the scientific method, it is still a useful element of inquiry and an example of transaction between teacher and student.

All of these examples illustrate that in the afterschool art-science program, instructors and students work together through certain paths of inquiry. The instructors may have guided learners through a procedure or provided learners with a prompt to encourage them to hypothesize, observe, describe or brainstorm, but this seemed more of a helpful reminder than an attempt to control the inquiry scenario or guide learner thinking in a certain direction. In this way, these examples demonstrate a transaction between teacher and student.

c) Transformation

At the center of a transformative approach to teaching and learning is the notion that the learner and the curriculum (or what is learned) are connected (Miller, 2010). As Miller (2010) notes, “In transformational learning, the barrier between the learner and subject disappears as the learner becomes what he or she is studying or observing” (p. 31). Nurturing this sense of unity is critical in helping students to foster wisdom, compassion and a sense of purpose, while
recognizing learning as “personally and socially meaningful” (Miller, 2010, p. 11). The following subsections will describe two methods through which the afterschool program nurtured this ‘curriculum-to-self’ connection: immersive experiences and linking learning to life experiences.

i. Immersive experiences

To truly connect the learner with the subject they are studying, immersive experiences can be very valuable. I use the term immersive to represent experiences wherein the learner is fully enveloped into the world they are studying and adopts a specific role to generate more full and authentic understandings. The two types of immersive experiences I observed through the course of the afterschool program included role-plays and visualizations.

Opportunities for learners to role-play came up at several instances during this afterschool program. The most notable of which was the opportunity for learners to assume the identity of a scientist/engineer by dressing and behaving like them. For example, each day at the beginning of class, learners would walk over to a coat rack and pick out their lab coat with their handmade name-tag on it. They would slip it on and generally wear it for almost all the activities of the day, returning it before they went home. This was an interesting strategy for learners to ‘dress the part’ of a scientist. As Guha (2013) notes, this strategy can help learners “cultivate imagination by portraying the person they represent” (p. 48). In doing so, it suggested to these young learners that they were scientists, experimenters and thinkers; just like the grown-ups they likely imagined working in faraway laboratories.

Beyond looking like a scientist/engineer, specific activities gave learners a chance to act like them too, perhaps “put[ting] themselves in situations they have never experienced before”
(Guha, 2013, p. 48). As Laura revealed to learners that they would be dissecting an owl pellet, she mentioned that dissection is how scientists see inside of something, linking this activity to the very real actions of scientists out in the world. On the afternoon that learners were challenged to build a bridge, Laura and Amy encouraged learners to adopt the role of engineers. On the blackboard they had written, “The year is 1940. We are all engineers and builders … We have been hired to design and build a bridge that will connect two countries: Canada and the USA” (Field notes, May 2016). Introducing this activity in this way ensured that learners knew that the task they were about to accomplish and the behaviours they were about to display were also common to engineers working in the field. These role-playing tasks encouraged learners to believe that they were not simply students learning science, but scientists or engineers actually doing science in the real world.

As an art-science afterschool program, learners were also provided with opportunities to role-play as an artist. For example, before learners worked in pairs to cast their plaster masks, they got to dress the part of a real artist. They put on green smocks and tied their hair back. They put on shower caps to make sure plaster did not get stuck in their hair. I noted in my field notes “dressing up is exciting”, suggesting the learners enjoyed the opportunity (Field notes, April 2016). Once they looked like artists, they then got the opportunity to act like them by crafting their masks.

There was even an instance in the program where learners got to role-play beyond the role of a scientist or artist. On the afternoon learners were dissecting the owl pellets, Laura prompted learners to all pretend to be owls. She then walked them through the steps an owl goes through to create an owl pellet. Owl pellets are formed from the skeletal and fur remains of the rodents and birds an owl has eaten, which have compressed into a compact ball in the owl’s stomach and
been vomited out. Laura asked learners to turn their head to the side and pretend to cough or vomit up a pellet. The class followed her direction happily, making interesting sound effects as they assumed the role of an owl. In a way, this experience helped learners not only to understand what an owl pellet was, but to also appreciate the creature that donated the pellets they would soon be exploring.

Visualization was another strategy used to immerse students in what they were learning. While discussing predator/prey relationships, Laura asked learners to close their eyes and imagine they were a rabbit hopping around in a forest. Suddenly, they notice a fox is staring at the rabbit. She asked learners to consider, in this relationship who is the predator and who is the prey? She then asked learners to identify more examples of predator/prey relationships. Following this discussion, she asked learners to close their eyes again, and visualize a rabbit and an ant. The rabbit as it is hopping around accidentally jumps on the ant. She used this visualization as an example of a relationship that is not predatory. These guided visualizations were valuable immersive strategies, which can help “to facilitate relaxation, to help motivate student interest in the subject matter and, to facilitate creative writing” (Miller, 2007, p. 98). Although it was not used in this case to promote creative writing, I do believe it encouraged learners to think creatively and call on prior knowledge in ways that a transmission approach to learning may not have facilitated.

**ii. Links to life experience/personal meaning**

In addition to planned immersive experiences such as those described above, the program also spontaneously made connections between the learner and what they were learning. This was evident on several occasions throughout the term when learners enthusiastically shared how the
lessons or activities they were participating in connected to their own lives. On some occasions learners were excited to share how lessons touched them personally, like when Timothy shared with the class that he had seen a wind farm on a trip to Maine, linking to the lesson on windmills, or when Jackson mentioned he had found an owl nest near his cottage in response to the lesson on owl pellets (Field notes, May 2016). Both examples illustrate that the topics of study found ways of connecting to learner life experience, and in both cases, likely made learning more personally meaningful and interesting.

The most significant example to illustrate that the afterschool program nurtured connections between subject matter and the experiences of the learner was revealed through an interview with Jackson. Jackson commented that his favorite project through the course of the program was the owl pellet dissection and mounting. His explanation as to why it was his favorite was very telling:

Researcher: Why was it your favorite [project]?

Jackson: Because I really really really like [pause], because it reminds me of my past and of fishing and when we caught fish and home made [cooked] them. They were really really really good. And I got to see the bones of them.

Researcher: Is that how it reminded you of your past?

Jackson: Yeah, because I helped my dad fillet them.

Researcher: Oh that’s how you saw the bones, interesting! How did doing that project make you feel? Happy? Sad?

Jackson: It helped me feel really really content and nice. (Interview 2, May 2016)

Jackson enjoyed working with the bones in the owl pellet activity because he had a prior positive experience working with them. The activity helped him to recall happy memories and likely
motivated him to complete the project and talk to me about it. In fact, in the final week of the program in June, when Laura prompted learners to recall their favorite activities, Jackson still maintained that working with the owl pellet was his favorite. This example most clearly illustrates that learners were able to connect their lives and personal experiences to their learning in the afterschool program.

As previously mentioned, whole teaching requires the use of diverse teaching and learning strategies. Through the balanced use of the transmission, transaction and transformation approaches, the afterschool art-science program in question was able to nurture the whole child. Later, (in Chapter 6) I consider how these strategies reached the head, hands and heart of the learners.

3. Ongoing Program Development

Programming at the afterschool art-science program was not stagnant and repetitive, rather it was an ever-evolving process informed by the ongoing learning of the instructors. This learning was facilitated in two ways, (a) through practical experience, which sometimes called for the adaptation of certain activities or strategies, and (b) through collaboration between the two instructors. In response to this learning, the particular strategies Laura and Amy selected to implement the program were modified to run more smoothly and effectively.

a) Adaptation in response to practical experiences.

According to Paolo Friere, there can be “no teaching without learning” (Friere, 1998, p. 31). In fact, he extended this idea, stating, “Whoever teaches learns in the act of teaching, and whoever learns teaches in the act of learning” (Friere, 1998, p. 31). This reciprocal process can be
fundamental to the selection and implementation of teaching practices in any classroom, and in this particular case, to the development of the afterschool program. For example, learning from students, through observing them throughout the course of the program and by asking them questions can provide valuable insight into how to best structure the program. Amy provided an example:

This term we have really been able to connect it [the program] to this big arc of ecosystems, but previously, it was just random. We would find cool ideas and say “Let’s try it in a class, I’ve always wanted to try this,” or “Some stuff [worked] really well with one group, let’s try it with another”. So over the last two semesters we have tried to make it more of an arc because we found that our students retain a lot more when we spend several weeks repeating the same core concepts. (Interview 1, April 2016)

Amy’s comment suggests that studying the strategies used to implement the program in the past provided a valuable learning opportunity. Rather than selecting content areas randomly, Amy decided to develop the first half of this program according to the theme of ecosystems, claiming that by repeating certain ideas, learners gain a better understanding of the topic. She made this decision based on reflections she had made on past attempts to deliver the program. In this case, the reactions and behaviours of the students were what facilitated Amy’s learning. In a way, the students became the teachers.

In addition to adapting the program as a result of interactions with students, the implementation of the program was also influenced through trial and error. In these cases, a strategy was attempted, and after carefully studying the results, a modified or completely new strategy was developed. Consider for example, the ecosystem thematic arc. Learners began to explore ecosystems through activities with decomposers and then producers. After being
introduced to several of Ontario’s indigenous plant species, learners had the opportunity to plant seeds, water them, and observe their growth over time. Although the plants were present for the first few weeks in the classroom, and learners did often check to see if they were growing, the plants were never used in another lesson. The reason for this became clear in the final week of the program, when Laura gifted each learner a celery plant revealing the original plants had all eventually died. Amy expressed in an interview that the intention for the original plants had been to get learners to engage in a true scientific investigation:

   Usually, we try to incorporate an actual true experiment where we get kids to record. Next week, when we come back something has changed and we have to look at the pictures [to note the change] ... The goal was to do that [with] plants, but because of the pace of the semester and everything else going on and the logistics of our other classes … it just wasn’t working out. And they weren’t growing fast enough. (Interview 2, June 2016)

In response to the fact that the plants were not growing well, Laura and Amy decided to continue along their planned ecosystem arc. They completed a homemade paint project, which reinforced the concept of producers and then moved on to consumers and predator-prey relationships. This example serves as evidence that the program implementation at times was influenced by the trial and error of certain strategies, which, when they did not work out, required the instructors to be creative and adaptive, modifying programming in a way that remained educational and fun.

b) Ongoing collaboration between instructors

It was immediately evident, from my first day of observation at the program site, that collaboration between Laura and Amy would be critical for the successful implementation of the program. I arrived early on my first day of observation as Laura requested, and got to sit in for their pre-class meeting. Laura and Amy ran through the plans for the day and talked over details
that might help the activities to run smoothly. I noted in my field notes, “Teachers talk over lessons, constantly refine ideas to help run smoothly, but also to make [activities] more fair and effective” (Field Notes, April 2016). I wrote this comment in response to their discussion of how they were going to facilitate the building of the compost bins. Once the bins were made, learners were going to decorate them (unfortunately, during the actual lesson we ran out of time for this step). Only one bin was set up for each group of several students, so to ensure that all learners were able to contribute equally to decorating, each student was given the same number of stickers to design and place on the bin. These types of details were often negotiated between Laura and Amy in the pre and post class discussions, and influenced how they chose to deliver the program.

Both instructors were consistently engaged in a dialogue throughout the term, which not only influenced the present activities, but also those they might consider in the future. For example, one of the most memorable activities this term was when students crafted plaster masks. Working in pairs, they took turns placing wet plaster on one another’s faces, a slimy, slippery and overall uncomfortable experience. As Amy noted, “Today’s class was hard because I think a lot of kids were really uncomfortable and so, of course, Laura and I talked to each other and said how can we make this less uncomfortable” (Interview 1, April 2016). Although the lesson went well and all learners ended up with beautifully crafted plaster masks, Laura and Amy had a detailed discussion on how to make it a more pleasant experience in the future. In my field notes I wrote that during their debriefing of the activity, they worked to “refine [the activity] to make it work better for next time – what works best, in what space, with what kids” (Field notes, April 2016). In consideration of these variables they decided that if they were to use this activity again, it might be best to focus on casting the hands rather than the face. This might help learners to feel less discomfort and might also manage the mess and clean up.
Both of these examples serve to illustrate how important the ongoing collaboration of instructors was to the implementation of the program. However, in response to this ongoing program development, future sessions of the program are likely to appear very different from the one I observed. Although the program goals may remain the same, the specific content areas or teaching strategies selected are surely going to vary. As Laura noted:

I’m excited to change up all of the content and to keep on pushing ourselves to do something different. That will keep the kids who want to come back excited and feel like they are learning all new things. (Interview 2, June 2016)

Over time the implementation of the program will change and evolve. In doing so, it provides a precious opportunity to integrate new and exciting ideas, and perhaps even information at the frontier of scientific discovery or artistic expression. As Stocklmeyer et al. (2010) noted, “Knowledge that comes from the informal sector can more readily be authentic, in that it reflects the processes and current conclusions of science” (p. 28), and by extension art. By consistently evolving and taking new forms the program can stay fresh and relevant, continuing to engage returning students, while also exciting newcomers.

4. Challenges

In the literature review of this study, I outlined several challenges facing the implementation of STEAM curricula in a formal school environment. To review, Turkoguz and Yayla (2010) mention that “class management, working with crowded classes, insufficient material, working area and time” (p. 2040) are all pressing concerns that can influence if, when and how teachers attempt STEAM in their classrooms. Another challenge is finding teachers qualified and interested to facilitate this unique style of integration. Interestingly, several of these
challenges did not seem as significant in the afterschool environment studied. For example, consider the effectiveness of program’s strategies for classroom management. In the previous discussion I described how Laura was pleased that the Code of Conduct helped learners to understand the behavioural expectations or values of the classroom. I also mentioned that I regularly observed how effective the Tibetan singing bowl was at getting learner attention and helping them to focus on a new task. It is also important to note, however, that a reason these strategies may have been so successful in this case was because the class size of thirteen was small and because many of the learners were repeat visitors to the program, already familiar with the routine and expectations of the learning space.

In terms of the amount of material Laura and Amy had to work from to develop the program, it seemed relatively wide. They constantly worked in collaboration with one another to develop new and exciting programming and to improve what they had already done. Therefore, finding material seemed less of a challenge in this setting than in a traditional classroom. This can likely be attributed to the fact that the afterschool program did not have a mandated curriculum in which a specific set of learning expectations or content areas had to be effectively addressed. In this setting, Laura and Amy were free to use whatever material they felt would most interest and benefit the learners. Finally, the afterschool program did not appear to have an issue with finding qualified and interested instructors. Both Laura and Amy had experience studying science and/or art and teaching in different settings, and both were passionate about using the program to share their enthusiasm for how art and science come together.

These examples suggest that the model of STEAM implemented through the afterschool program seems to mitigate many of the challenges of the formal school environment. However, whether in school or outside of it, challenges do emerge. The next section addresses challenges in
delivering and creating this afterschool program. Three themes emerged from my data analyses: timing, space and age group/ability respectively. Each is described below.

i. **Timing**

As is the case with planning any type of lesson or activity, considering timing is crucial. Without this deliberate consideration, lessons might go unfinished or become rushed and incomplete, limiting their impact. The following examples serve to illustrate that although an ever-present challenge, in the case of the afterschool program, the timing of exercises was carefully monitored. This influenced how long each activity within a lesson would take. For example, in the first week of the afterschool program, learners were introduced to the concept of decomposers and worked together to build compost bins. Once the bins were put together, the students were supposed to have time to decorate their new worm habitats. Unfortunately, they ran out of time and they did not get a chance to, that day or any other. This was the only obvious instance of a situation where timing influenced what learners were able to complete. It happened only during the first class of the program. Through all the remaining classes, all activities were completed within the allotted time. I believe this was likely the result of the ongoing collaboration between instructors, through which Laura and Amy were able to continuously tweak lessons to ensure the timing of activities would suit their objectives for the day and their students.

Timing was also significant to determining how many lessons were used to cover a certain topic. For example, creating and decorating the plaster masks spanned over two weeks. The first week involved introducing learners to the concept of consumers, casting the mask and setting it to dry and the second week involved decorating it to look like a consumer of their
choice. It simply would not have been possible to accomplish all this in one session, and the instructors had to make the conscious decision to dedicate two weeks to this activity. This ensured that the project could not only be completed, but also completed thoroughly.

Another important timing consideration involved determining how to accommodate learners that complete their projects at different speeds. It is difficult to have half a class ready to move on and half a class still working away on an activity. Laura noted that throughout the term, as they got to know the learners, the instructors became better able to negotiate this challenge: “Especially now that we know the kids, which happens only after a few weeks in, we get to devise a secondary activity to make sure there is always something to do afterwards” (Interview 2, June 2016). Rather than having learners sit idly by waiting for the next activity, the instructors made sure that there were always options to continue learning and exploring, whether that meant another small activity, working in their sketchbooks or building with blocks.

Again, although timing was a constant challenge through the course of the afterschool program, these examples illustrate concrete ways in which the instructors overcame this challenge.

ii. Space

Another common challenge in any classroom, whether in school or out, is negotiating the learning space and the resources therein. Learning is often structured according to the resources available in a certain place. In the case of the afterschool program, this involved the program site. Laura mentioned that the resources at the setting of the program limited what the instructors were able to accomplish: “Can we do tissue engineering in a place that doesn’t have a flame hood or whatever? No, so you have to work within what your budget and surroundings are and then also
try to get into the mind of what students would be interested in” (Interview 1, April 2016). I should highlight that as Laura mentioned, budget also can influence the space and the resources within it.

In the cases where classes were taken to another setting, namely the park across the street, which only happened once through the course of the program, this presented other challenges. For example, the program setting was equipped with a washroom and cleanup area and contained additional resources for the instructors to use, as they were needed. In the park, these resources were not readily available and required the instructors to come up with alternative options. Ensuring that the class had a chance to go to the washroom before proceeding to the park, and packing playdough to ensure there was something for students who finished early to work with, we set off for the park where we created tie-dye shirts in a grassy area. The park provided a distinct advantage over the program setting, because there was less of a concern of dye spilling on the floor or staining work surfaces. Negotiating the challenges of this alternative setting therefore presented a valuable opportunity do a messy but rewarding final activity for the term.

iii. Age Group/Ability

The afterschool program also presented a unique challenge to the implementation of programming. Because learners varied in age, spanning from JK to Grade 3, there was a diversity of ability and range of development in the classroom. This is a unique challenge, as most formal classrooms do not show more than a year in age difference. To mitigate this challenge, the program instructors were careful to develop programming that was multi-age appropriate, while also encouraging learners to work with one other. As Amy noted,
We really look at the age of the kids, what is appropriate for them, and also [aim] to give a balance. Because for some kids, group work is really challenging but we still want to teach them how to work together. (Interview 1, April 2016)

A strategy through which Amy and Laura accomplished this goal was to work with different seating arrangements and partnerships. Laura mentioned how significant changing the seating dynamics became through the session:

We thought to try things out for the first few weeks to see what pairs worked well together and who could sit at the little table. Over time we tried to adjust and I think that by the last week when we were doing the two different tables, we seemed to have a good kind of grouping. (Interview 2, June 2016)

This type of trial and error process helped to establish partners who worked well together, which made group or pair activities easier to facilitate and relieved the concern that the age or ability difference between learners would impact adversely on program implementation.

This chapter has outlined the implementation of the afterschool art-science program at the heart of this investigation. It has aimed to describe not only how the program was implemented through content integration or teaching and learning strategies, but also to reveal and explore factors that influenced its planning and implementation, including ongoing program development and challenges. In doing so, it provided one rich and colourful image from within the STEAM kaleidoscope. The next chapter presents the students’ responses to, and experiences in, the program, paying close attention to how, through these implementation strategies, the program was able to nurture the head, hands and heart of learners.
CHAPTER 6 – FINDINGS AND ANALYSIS
WHOLE ENGAGEMENT: THE LEARNER EXPERIENCE IN AN ART-SCIENCE AFTERSCHOOL PROGRAM

Introduction

This chapter addresses the final research question exploring the experiences of students in an afterschool program. It seeks to provide a rich, thick description of the learners’ participation in the art-science afterschool program, in an effort to understand their experiences and gain insight into how after school programs might nurture the ‘whole’ child. For the purposes of this study, student experience will be defined according to the three parts of the learner nurtured through holistic teaching practice, that is the head, hands and heart. Exploring the program with this framework provides insight into how each of these critical parts of a person are addressed, thereby nurturing the whole learner.

Reaching a student’s head, hands and heart through learning is not a simple task. Although conceptualized as three fundamental elements of a student’s being, the way they come together in educational settings varies and sometimes can be quite complicated. As Skamp (2007) notes, “there are connections between hands, hearts and heads-on science; none should be overlooked, although the connections are not necessarily straight-forward. There can be effective heads-on science without hands-on science, but usually only if hearts are turned on; there can also be hands-on and hearts-on science without effective heads-on science” (p. 20). Given the variety of ways of connecting heads, hands and/or hearts in a classroom, describing ways they come together can be challenging. This might explain why Inan and Inan (2015) have noted that although heads, hands and heart are seen as integral elements of the learner experience in science, they are often “kept separate and not much discussed in terms of how to get all three to work together” (p. 1975). They do however, go on to describe how activity stations and projects are
strategies they have observed in early childhood which take all three elements into consideration (Inan & Inan, 2015). The following discussion aims to outline how the afterschool art-science program sought to engage learner’s (1) heads, (2) hands and (3) hearts, providing a rich description of the student experience.

1. **Engagement of the Head**

An important element of the learner experience in the afterschool art-science program involved opportunities for engagement of the head or mind. Thinking or inquiry is critical to head engagement, prompting learners into “asking questions and inquiring about issues related to science”, while also getting them to research, theorize and test their ideas (Inan & Inan, 2015, p. 1983). Although this conception is related to science, the same can be said for head oriented learning in art. In fact, getting learners thinking about the connections between art and science, disciplines that have traditionally been conceived of as separate, is an inquiry exercise in itself. With this in mind, there are two main ways through which the art-science afterschool program engaged learner minds: (a) through granting learners control over the testing, refining and making of their art-science projects, and (b) through exploring the connections between art and science.

**a) Control over testing/refining/making of art-science projects**

Constructivist perspectives of teaching and learning generally emphasize the building up of knowledge, skills and attitudes by learners over time. Although many models of constructivism exist, the democratic constructivist model expressed by Bencze (2000) is particularly useful to the art-science program in question. In this model, which is an amalgam of many cited in educational literature, “students are encouraged to express their current conceptions
prior to acquiring understanding of those of others, and before determining their commitments through tests engineered and controlled by them” (Bencze, 2000, p. 860). In other words, learners get a chance to (a) express their prior knowledge, (b) gain new knowledge through interaction with others (teachers or peers) and (c) get a chance to apply and test this knowledge through self-directed inquiry (Bencze, 2000). As Bencze (2000) has noted, ideally through this model of constructivism “learners would be empowered to achieve egalitarian literacy and self-actualization” (p. 860), developing a more intricate and meaningful understanding of what it means to be a whole, autonomous being.

In the case of this afterschool program, learners were presented with opportunities to engage with each of the three phases of the democratic constructivist model. They had a chance to demonstrate their present knowledge through activities such as the ‘Question-Corner’ or through prompting questions posed by instructors during lessons or activities. This was described in detail in Chapter 4. They also learned new information through these lessons and activities, and through their inquiry partnerships with instructors, which were discussed in Chapter 5. Beyond these experiences, however, the program provided opportunities for learners to also gain ownership and autonomy over their learning. As Bencze (2000) has noted, these opportunities provide learners with the freedom “to construct their own knowledge, relatively unimpeded by those who might jeopardize their autonomy” (p.861), which can deepen their understanding and assist learners in the development of a unique set of beliefs and by extension, their sense of self. Opportunities to exercise this autonomy were facilitated through activities or projects in which learners had complete control over making, testing and refining their project.

One such example occurred on the afternoon learners built their own windmills. Following a lesson on windmills and the use of wind by machines, described in Chapter 5,
learners had the opportunity to build and decorate their own working models. The instructors led learners through the step-by-step instructions to build their windmills. This particular model of the windmill was also able to demonstrate the ability of wind power to do work. Hanging by a string from the rotating shaft of the windmill was a small paper cup, filled with beads. As the wind caused the paper blades of the mill to rotate, the shaft also rotated, causing the string to wind around the shaft and lifting the cup. Once the windmills were built, control of the activity passed into the hands of the learners, which mainly involved testing and refining their models.

I observed Timothy blowing hard to generate enough wind to get his windmill to work, and noted that he was proud when he got the cup to lift (Field notes, May 2016). Emily was also using her hands and her breath to get her windmill working. When she needed more wind power, she cupped her hands around her mouth and blew even stronger breaths (Field notes, May 2016). In some cases, like with Jackson and Toby, the windmills would not lift the paper cup when rotating. This caused Jackson and Toby to express some frustration, which prompted them to work together to trouble-shoot and resolve the issue. Of course instructors, and myself were available to help to assist with these types of issues, but as in this case, learners had the freedom to test and tweak their models according to their own ideas, rather than feeling obligated to reach out to an adult.

Perhaps the most exciting part of this exercise involved taking the learners outside to get to experiment with real wind. All the learners lined up along the sidewalk and got a chance to see their windmills in action. When the windmills spun round, the students were very excited and wanted to point out whose windmills were working (Field notes, May 2016). In cases where the windmills were not spinning, learners moved around the sidewalk to find a stronger wind current. I spotted Timothy licking his finger and holding it up to the air to find the best place to test his
windmill, while Jackson shared a tip with the class on how to improve spinning, which he had learned through trial and error with his own windmill (Field notes, May 2016). Again, this exploration of the wind was completely student directed. They were responsible for determining the best approach to get their windmill to work and had the freedom to try different strategies.

Beyond the autonomy to test and refine projects, the program also provided learners with opportunities to exert control over the making of certain artifacts. Consider the mask-making pair of lessons, wherein learners casted plaster masks and decorated them according to their favorite consumer in a food chain. Learners had the freedom not only to choose what animal they would model their mask after and what materials they would use, but also how they chose to use the materials. I noted that it was “neat to see how learners repurpose items” when decorating their masks (Field notes, April 2016). For example, Frankie, who wanted his mask to represent a fox, black bear and wolf, used orange party streamers to decorate his mask. Damien on the other hand used recycled paper to decorate his shark, with pipe cleaners to represent the fins (Field notes, April 2016). These examples demonstrate that learners had the opportunity to think outside the box when decorating their masks, and that would only have been possible in a situation where they were empowered to make their own creative decisions. Both the windmill and mask scenarios demonstrate that through specific activities or projects, the program was able to encourage learner autonomy, a strategy aimed at engaging learner minds in problem solving and deep thinking tasks.

b) Exploring the connections between art and science

Another important way through which the afterschool program was able to engage the ‘head’ of the learner involved providing a space to explore the connections between art and
science. Examples of how this connection was achieved are described in Chapter 4. These types of activities not only linked the knowledge and skill of art and science through the completion of specific tasks, but also helped learners to see connections between the nature of both disciplines. Making these types of connections is an inquiry in itself, and involves complex, higher-order thinking therefore effectively engaging the mind of the learner.

The interviews with students served as evidence that this was an accomplishment of the afterschool program. In both the first and second interview, learners were presented with the question “Do you think science and art work well together or are connected, and if so, how?” A summary of learner responses to this question are seen in Table 2.

<table>
<thead>
<tr>
<th>Student</th>
<th>Do you think science and art work well together, and if so, how?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jackson</td>
<td>“Well science you can do a bunch of cool stuff, but it doesn’t really involve much drawing. Except for equations. And art requires more drawing, but there’s almost no equations.”</td>
</tr>
<tr>
<td></td>
<td>Researcher: Do you think art and science are connected? Jackson: Yeah Researcher: Why do you think that? Jackson: Because, because of this program in general. Researcher: And how has the program showed you that? Jackson: Umm, in every single experiment combined you will find quite a bit of art and science. Because the owl pellet dissection, when you did that, you got to learn what owls ate and you also got to make an artistic design with the bones.</td>
</tr>
<tr>
<td>Frankie</td>
<td>“They are both messy” “They are both very messy”</td>
</tr>
<tr>
<td>Neve</td>
<td>Neve: Because some art is science. Researcher: Can you give me an example? Neve: Like the masks we made, it was like an experiment but we are going to decorate it like art. Researcher: Do you think art and science work well together? Neve: Yeah Researcher: Why do you think that? Neve: Because they are both art Researcher: How are they both art?</td>
</tr>
<tr>
<td>Learner</td>
<td>Quote</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>Neve</td>
<td>Like they are the same thing almost, just made with different things doing it.</td>
</tr>
<tr>
<td>Toby</td>
<td>“Art and science camp”</td>
</tr>
<tr>
<td>Damien</td>
<td>“Because I have an art class at my school and it’s kinda exactly like a part in science and in art class.”</td>
</tr>
<tr>
<td>Walter</td>
<td>N/A</td>
</tr>
<tr>
<td>Emily</td>
<td>Researcher: Do you think that art and science are connected to each other? Emily: Yeah Researcher: How? Emily: You also do art. Researcher: You also do art in what? Emily: Here, because last time I was here I did art.</td>
</tr>
</tbody>
</table>

Of the eight learners interviewed, four (Jackson, Neve, Toby and Emily) mentioned in either their first or second interview that art and science were connected and elaborated on that connection by either mentioning the afterschool program or describing a specific example from the term. The learners made these connections to the program without prompting from the
interviewer. This suggests that in these learners’ minds, the program directly contributed to their understanding of the connections between art and science by providing opportunities for learners to engage in both.

Of the remaining interviewees, three learners (Frankie, Damien and Steph) described the connection between art and science through hands-on experiences. Their comments emphasized ‘making things’ and ‘getting messy’, likely experiences they had personally engaged in or observed at some point in their young lives. This learning could have happened in any number of learning scenarios including, but not limited to school, home, while watching television or through the afterschool program itself. While I cannot directly attribute this learning to the afterschool program, I cannot discount it either. Since all three of these students had prior experiences with some type of programming at the learning institution before this session, they had significant exposure to hands-on activities that connected art and science. Therefore, there exists the possibility that their hands-on understanding of art and science was facilitated through their participation in the program or their engagement at the program site. It is also important to note that Walter did recognize that there was a connection between the processes of art and science, but had difficulty articulating exactly how they were connected. Walter had never attended any type of programming at this site before, and was also one of the younger students (in SK).

In summary, careful consideration and analyses of the interview data, suggests that the afterschool program did play a significant role in getting at least half of the learners to think about the connections between art and science, another strategy to engage learner minds.
2. Engagement of the Hands

Another significant element of the learner experience of the afterschool art-science program was hands-on engagement. As Inan and Inan (2015) have noted, hands-on science can involve “children and teachers working ‘actively’ on science, instead of children learning science as passive learners. That means that they used their hands and body to engage in science activities. They touched things, manipulated objects and so on” (p. 1983). In every meeting throughout the afterschool session there was at least one major project or activity that required the learners to use their hands, faces, and bodies to accomplish a task. As Amy noted in our interview, “The hands-on project is always at the core of how we teach. The hands-on project is the student’s way of embodying what they have learned … or they learned by physically doing the project” (Interview 1, April 2016). These activities have been described in detail throughout this discussion.

It is clear that hands-on experiences were fundamental to the afterschool program, but they also played another specific role. In order to make these experiences tactile, while also unique and memorable for learners, some of the hands-on activities completely immersed learners and their bodies in the messy, sloppy and sometimes even dirty worlds of art and science. Of the nine students sampled in this study, six mentioned either through interview or through in-class discussions that their favorite activities were the plaster masks or the owl pellet dissection and mounting. Another student mentioned that making the compost bins was her favorite. Of all the activities presented throughout the program, these were three of the messiest or conceivably most disgusting. Interestingly, ‘gross’ hands-on experiences, in the case of these learners, seemed to be the most memorable or interesting!
To explore this in more detail, consider one of the two most liked activities, the plaster masks. As previously mentioned through the course of this paper, the crafting of the plaster masks was a challenging experience for many learners. The sensation of the wet, sloppy plaster on their face could have turned learners off. In several instances in the interviews, however, learners demonstrated that they saw this challenge as fun and charming, rather than uncomfortable. Emily shared that the masks were her favorite activity saying she enjoyed them “Because they were fun and it tickled” (Interview 2, May 2016). Steph commented that making the masks “was kinda funny” as the texture “on my face, it’s kinda slimy” (Interview 2, May 2016). In both cases, learners embraced the ‘icky’ nature of the task, which may have contributed to their appreciation of the activity and the lasting positive affect of the experience.

The owl pellets were another well-liked activity, with a distinctly gross element. Learners had to pull apart an owl pellet, made from the compacted fur and bones of small rodents and birds that an owl had previously ingested. They used their hands and a toothpick to pull apart patches of fur and sort out the tiny bones, which they saved in a paper cup. Learners had the chance to sort their bones according to species and type by comparing their bones to a chart the instructors had provided. Each learner was also given a piece of foam board and a handful of play dough to create a take-home mounting of their bones. The play dough was pressed firmly and flatly onto the foam board in the desired shape and then learners took each of their miniscule bones and pressed them into the play dough in whatever pattern they chose.

Some learners were very enthusiastic about this activity. As Jackson exclaimed on the day of the activity “This is bone heaven!” (Field Notes, May 2016). Damien also enjoyed this activity, discussing in interview that it was also his favorite. When asked why it was his top choice, he responded, “I like touching bones and digging into stuff” (Interview 2, June 2016).
When asked if he would approach the project differently if he had another chance to complete it he responded, “I wouldn’t use a toothpick, I would use my hands”. When prompted to explain, he supported his answer by claiming “Because I like touching weird stuff” (Interview 2, June 2016). Damien’s comments demonstrate that the ability to engage with his hands in this ‘weird’ activity caught his attention, and likely made the activity more fun and memorable to him. It also catered to his natural curiosity about the world around him.

It is clear throughout this study that hands-on activities were an integral part of the student experience in the afterschool art-science program. However messy or gross, hands-on experiences were most memorable or significant to most learners. Amy commented on this phenomenon when I asked how learners had responded to the program in past sessions:

> Generally, across the board, every time we do something, there’s no worksheets, everything is hands-on and we get messy and I think kids just automatically gravitate towards programs like that. So we never have a problem with them falling in love with what they are doing so, it’s good. (Interview 1, April 2016).

Her comment points to another significant insight, which is that these hands-on experiences can influence a learner’s interest in science, art or both. Keeping learners interested and excited might have the potential to spark a passion or love of art and science in learners. In doing so, these experiences also play an important role in engaging the heart of learners, an element of the learner experience discussed in the following section.

### 3. Engagement of the Heart

The afterschool art-science program also played an important role in engaging the hearts of learners. Inan and Inan (2015) write that heart experiences can involve “children loving
science-related subject matters and being interested in science issues” (p. 1983). Heart experiences must therefore nurture a love of science, and in the case of this program, art as well. As a free-choice informal learning setting, the afterschool program is uniquely positioned to accomplish this task through opportunities to engage learners’ affective or emotional dispositions. As Pedretti (2006) notes, “Interest in the affective domain in informal learning environments is growing, as non-formal science education facilities become recognized as being uniquely suited to facilitate affective learning” (p. 2). This focus on emotion is significant, as emotion carries with it the potential to motivate students, “opening up possibilities for learning” (Pedretti, 2004, p. 42). If, through programs such as this, learners grow to like or even develop a passion for art and science, they may be more motivated to continuing pursuing these disciplines in school and perhaps beyond.

The previous two sections provided a detailed discussion of the methods through which the afterschool art-science program engaged learner heads and hands. These elements of the learner are more straight-forward to describe because they are directly observable through student participation in the program. Engagement of the heart, however, is more challenging to describe as it happens within the learner and can be a rather personal experience. With that said, through the careful consideration of my observations and re-readings of interviews I have identified two main strategies through which the afterschool art-science program may have engaged the hearts of learners: (a) through building a learning community between students, teachers and parents and (b) through providing learners with an opportunity to have fun while exploring both art and science. Both of these approaches will be explored below.
a) Belonging to a community

Feelings of belonging are potent. Some individuals spend their whole lives trying to determine exactly where they ‘fit in’ in the world. For young people, finding a place to belong can be empowering and significant to their developing sense of self. For that reason, nurturing a sense of community in learning environments, where learners spend a large amount of their time, is significant. Ideally, the building of learning communities would help to cultivate these feelings of belonging, hopefully turning young people on to learning.

The learning community at this afterschool program was nurtured through interaction between peers. At times, these interactions were facilitated through working in pairs or groups on a certain project. At other times, learners interacted through dialogue or personal conversations as they played with blocks or worked on their own individual artifact. Through all of these interactions, however, there was the potential to build positive relationships and create a welcoming, inclusive learning environment, thereby encouraging all learners to participate. When I asked Laura if the teaching strategies or the structure of the lessons had changed through the course of the program, part of her response alluded to this building of a positive learning community over time:

I had the intention that maybe Jackson and Frankie … could connect because they are around the same age, and by the last few days they really did. And because we did the bridge activity, people were just more comfortable sharing in the paper making activity as well. (Interview 2, June 2016)

Laura’s comment suggests that the program was able to bring learners together. In some cases it fostered relationships between two individuals like Frankie and Jackson, who by the end of term were so comfortable with one another, they chatted regularly, comparing their school science
experiences and discussing past activities they had experienced at the afterschool site (Field notes, June 2016). In other cases, it brought the class together as a whole. For example, the bridge building activity discussed in Chapter 5 was intended to get the class to work together to accomplish a task. As Laura suggested, this activity could have made future interactions between classmates easier as a sense of comfort in the learning community had already been established.

It is important to note that the relationship between learners and instructors was also significant in developing a learning community. As Skamp (2007) has noted, “Trust and support are essential in turning hearts-on in all phases of a science teaching sequence, not just when eliciting ideas at the start of a sequence” (p. 20). This comment emphasizes that without a trusting and supportive relationship between teacher and student, getting learners to love science, and by extension art, can be challenging. Two scenarios demonstrate that Amy and Laura were able to accomplish this feat.

On the first day of the afterschool program, after learners got a chance to adjust to the new space, Laura and Amy called all the learners together to the front of the room, where they gathered on the floor. Laura introduced herself and gave the class some insight into her personal background, studying and teaching art and science. She prompted the class to raise their hands if they had attended the program before. At this time, Jackson proudly raised his hand in the air and commented that he had a great time in the first term session and went on to describe his favorite activity (Field notes, April 2016). Jackson’s spontaneous comment was telling. He clearly enjoyed his past experience in the program and wanted to share that with his new classmates in this new and developing community. This incident, occurring at the beginning of the program, also suggests that a relationship had been established between Jackson and the instructors in the
past session, where he felt comfortable to share a personal insight, trusting that Amy and Laura would value and respect his comment.

In another case, when Amy was absent for two lessons close to the conclusion of the program, learners asked where she was and wanted to know when she would be coming back (Field notes, June 2016). Their curiosity and desire to see her again demonstrate a definite positive connection and may even allude to the fact that students recognized and valued her as a part of the learning community.

The relationships learners fostered with their peers and with their instructors through the course of the afterschool program helped to create a learning community. Belonging to this community was an element of the learner experience that had the potential to turn learner hearts on to the program and on to art and science.

b) Having fun!

It seems straightforward that one of the most effective ways to reach a learner’s heart is through fun! Fun experiences provide people, young and old, with joy and motivate them to continue seeking out these experiences. Rarely would you hear someone say “That was so much fun, I never want to do it again!” Throughout Chapters 4, 5, and 6 I have analyzed and interpreted data, and described in detail many of the activities of the program from the perspectives of students and instructors. Together, the emergent themes, descriptions and comments should illustrate a rich and fun afterschool program with the potential to reach learners hearts. The heightened interest that learners demonstrated about the projects planned for them, confirms that their hearts have, in fact, been touched positively.
The afterschool program was uniquely positioned to ensure that learners had fun. There was no mandated curriculum, allowing instructors to pick content areas, activities and projects that were entertaining. The class size was small (13 students) and each session was able to dedicate a full hour and a half towards an art/science topic. All of these factors created flexibility in the program that accommodated fun, exciting and hands-on activities, which may not have been as possible or as regular in a formal school setting. That is not to say that school science or art is not fun or exciting, but limitations such as class size and limited resources do influence what teaching strategies or activities are frequent and feasible in a conventional classroom. Furthermore, the issue of assessment is not central to afterschool programs. In formal schooling, assessment often drives the curriculum, and can cause some students stress and anxiety. My findings suggest that this afterschool program, through its focus on fun, was able to more effectively reach learners than formal school science. Damien, a participant in the program, explored this idea in our second interview:

Researcher: How do you feel about learning science here at the program, compared to learning it at school?

Damien: I like it more at the program.

Researcher: Why?

Damien: Because you get to play with toys right away.

Researcher: Ok, anything else?

Damien: Because it’s way more fun.

Researcher: Why is it fun, do you have any examples?

Damien: Because you do fun stuff after you play with the toys. (Interview 2, June 2016)
Damien’s comments reveal that the toys presented to learners at the beginning of the session to help get learners used to the space were well received. He liked that he was able to enter the space and start playing, without having to do more formal activities first. Not only that, but the activities that followed the playtime, which was normally the main hands-on project, were entertaining. Damien reveals that allowing opportunities to play and have fun can, in some cases, make learning more enjoyable than at school. This would suggest that fun out-of school experiences like this afterschool program can be better suited to engaging learners’ hearts than in-school alternatives, making them valuable opportunities to get students interested in learning.

This discussion suggests that, through building community and presenting opportunities to have fun, this afterschool program ‘successfully’ engages learner’s hearts. Although it is hard to definitively state whether either of these factors contributed, there is evidence to suggest that learner hearts were ‘turned-on’ to the program. Consider that six out of eight of the interviewed students had experienced at least some type of programming at the learning institution in the past. The volume of returning students suggests that the institution fosters at least some level of heart engagement and perhaps even loyalty in learners. Jackson discussed these feelings in our second interview saying, “This is my third time here, so I will probably do it again. I never want to miss an experiment” (Interview 2, May 2016). This deep interest might have been facilitated by the sense of community or the fun nature of the program. Jackson’s comment confirms the value of this afterschool program in nurturing his interest in art and science and eagerness to experiment and remain curious about the world around him. In order to stimulate this interest, head, hands and heart must all be effectively looked after through careful program design. In turn, this heightened level of curiosity provides deeper and richer understanding and appreciation of both art and science.
CHAPTER 7
CONCLUSION: SIGNIFICANCE AND RECOMMENDATIONS

This case study of an art-science afterschool program sought to provide insights into a specific example of STEAM programming in practice. My research questions sought to explore in detail the goals of the program and how they resonated with those expressed for STEAM programming in academic literature (see Chapter 2 and 4). Furthermore, this case study aimed to provide a detailed description of the afterschool program, presenting the specific methods or strategies through which STEAM was implemented, and factors that influenced program implementation (see Chapter 5). Finally, this study examined the potential of STEAM programming by exploring the student experience within this specific program (see Chapter 6).

Findings with respect to these three research questions, shed light on how STEAM can be realized in educational settings, particularly those outside of formal school. This is not to say that the findings of this study are universal to all STEAM programs. This is a description of one of many variations of STEAM programming, meant to give teachers, program instructors and academics a concrete description and set of findings particular to this case, which they can reflect on and adapt based on the context of their own educational settings.

To conclude this study, I think it is important to try and synthesize my findings from the course of the fieldwork with the personal reflections and insights developed as I planned, carried out, analyzed and wrote up this project. The following discussion aims to facilitate this synthesis by: providing a summary of findings and their significance, and to present recommendations for developing and implementing STEAM programs, while understanding the student experience. I conclude with a discussion of potential extensions to this study, which would continue to deepen our understanding of STEAM programming as it is carried out and experienced in varied learning settings.
Overview and Implications

Through the course of this research, I had the valuable opportunity to explore an example of afterschool STEAM programming in action, which largely interested and excited learners. I explored specifically the goals of the program, the integration and implementation of art and science programming, while also seeking to understand the student experience of that programming.

To develop this engaging, educational and entertaining program, instructors developed their own unique vision of STEAM based on academic, practical and theoretical ideas located in research literature and their experience. My research findings suggest that afterschool art-science programs have the potential to provide the following goals:

• To nurture scientific literacy, by both helping learners to develop content knowledge and skills in both art and science through hands-on experiences, while also engaging learners in meaningful problem-solving to nurture responsibility and active citizenship.
• To nurture creativity through an appreciation of the connections between art and science and to empower learners to think divergently by respecting their needs and ideas.
• To further emotional development by providing learners with opportunities to work outside their comfort zone and demonstrate perseverance.

In creating this vision of STEAM, Laura and Amy were able to develop a program that was their own. The research findings provide significant insight into the unique implementation of the art-science program, which can be characterized by four elements:

• Making connections between content areas through the integration of different disciplines, particularly art and science, and through the linking of lessons, themes and ideas.
• Holistic teaching and learning practices, including the transmission of facts, skills and values from teacher to student, transaction between teacher and student as partners in problem-solving and inquiry, and through transformational learning experiences which were immersive and connected to life experience.

• Ongoing program development, through the adaptation of programming in response to student feedback, practical experience and collaboration between instructors.

• Taking into account challenges to program delivery, which bound what is possible to accomplish in the program.

By delivering programming according to these four elements, the instructors were uniquely positioned to facilitate a student experience, which engaged the heads, hands and hearts of their learners. My findings suggest that, it is important for instructors of programs (both in and out of school) to:

• Engage the head of learners by presenting them with opportunities to exert control or autonomy over making, testing and refining their work, and by encouraging the exploration of the connection between art and science.

• Engage the hands of learners by encouraging them to embrace the potentially messy or gross nature of art and science.

• Engage the hearts of learners by nurturing a sense of belonging in community while also ensuring that learners are having fun.

By engaging learners in this whole, balanced way, the program was able to accomplish something very significant; it was able to get learners excited about art and science. This was evidenced through their reactions to activities, their enthusiasm to participate and their willingness to return to the program again. These significant findings prompt me to consider
potential extensions to this study, which may further contribute to our understanding of STEAM as an effective and significant way of learning art and science.

Extensions

Central to STEAM’s objectives is the significance of creating more professional scientists, while also nurturing a broader vision of scientific literacy among all students. I returned to this notion when I asked study participants what they wanted to be when they grew up. I was surprised to see that almost all learners had a positive affinity for art and science careers. Most mentioned pursuing a career in science (geologist, scientist), art (sculptor), or a career that integrated both (chef, video game designer, owner of restaurant). Although I cannot say that the after-school program alone was responsible for inspiring these career ambitions, by giving learners the knowledge and skills to succeed in art and science, it may indeed have played a role in motivating and empowering learners to follow these dreams.

By extension, I often considered if STEAM could in fact, contribute to the creation of more scientists, while also nurturing scientific literacy in all students (that is, nurturing the development of informed and responsible citizens capable of applying their learning to different and complex situations in the real world). This latter point, of course, is significant to all learners and not only those who are considering a career in the sciences. Although the after-school program in question did accomplish this through its programming (as discussed in Chapter 4), I suggest that in order for STEAM programs to fully realize this objective, they could use an STSE (science, technology, society and environment) perspective to anchor all learning. STSE (which is an important strand in science curriculum across most of the country) “places science squarely within social, technological, cultural, ethical, and political contexts” (Pedretti & Nazir, 2010, p.
In this way, STSE can bring or embed the STEAM disciplines into the real-world, increasing the relevance and interest of learning science for students (Pedretti & Nazir, 2010) in school and non-school settings. Beyond that, STSE asks or encourages learners to think about real-life issues from a holistic perspective, including a “systems style of thinking able to deal with complex webs of relationships, multiple interdependencies, feedback systems and unpredictability” (Hodson, 2003, p. 660). This is precisely the type of thinking required to solve the complex and dynamic issues facing society today, such as global climate change.

Hodson (2003) has proposed four components of a curriculum that would address STSE, issues-based learning. Interestingly, the afterschool art-science program addresses two of these components already: learning and doing science and technology. Through the course of the program learners not only gained knowledge and skills in art and science, but they also got to experiment, problem solve and inquire (Chapter 5). The afterschool program is therefore already on the way to addressing STSE related issues, however to do so in a way that best prepares learners to engage in informed and active citizenship could require the addition of Hodson’s (2003) other two components: learning about science and engaging in sociopolitical action. It would be interesting to explore an example of STEAM programming structured according to an STSE model to see the unique ways program goals, implementation and the student experience are similar or different from that observed through the course of this study.

In addition to the integration of STSE perspectives, I think that an important next step in continuing to explore and develop STEAM involves determining how all learners can access these types of learning opportunities. Again, this afterschool program was a private paid experience, presenting an obstacle to learners whose families might not have the funds to send their child. Because of this, the potential benefits of this type of program, such as scientific
literacy, creativity, emotional development and the holistic engagement of the heads, hands and heart of learners may remain solely in the possession of those who can access these programs. A solution, therefore, is to ensure that learners have access to similar opportunities in their formal, public school experiences. This would involve a careful study of the Ontario Curriculum, across all grades, that forms links between art and science curriculum expectations. These connections can and should be shared with teachers, providing ideas, examples and perhaps even resources teachers can use to learn about STEAM and practice it in their classrooms. Doing this might help to ensure that all learners have at least some access to STEAM programming and the positive and valuable learning that comes from it.

**Researcher’s Final Thoughts**

As a science educator who is admittedly invested in nurturing student enthusiasm toward science, this research project is particularly close to my heart. I became a science educator and, now, a science education researcher, because I thought it would be the most effective and efficient way of helping learners come to know that they all have a place in science. Although the findings of this study are not meant to be universally generalizable, it is my hope that they provide teachers with useful insights regarding how to nurture connections between art and science in all learners. Additionally, it is my hope that this study not only enriches our understanding of STEAM curricula and programming, but also reveals some useful strategies for STEAM implementation in both formal and informal learning settings. By extension, I hope this research offers some practical ideas about how teachers, in any scientific learning setting, including those that take place outside of the formal classroom environment, can effectively integrate art and science to engage students. I also hope that STEAM can help to ensure that
science education is not exclusively oriented toward learners who seek to become STEM professionals, but also toward nurturing scientific literacy and encouraging active citizenship in all learners.
References


Stocklmayer, S. M., Rennie, L. J., & Gilbert, J. K. (2010). The roles of the formal and informal sectors in the provision of effective science education. *Studies in Science Education, 46*(1), 1-44. DOI:10.1080/03057260903562284


APPENDIX A
Letters of Informed Consent

Information Letter and Consent Form – Site Director/Program Facilitator

Research Project: Exploring Science & Art Integration in an Afterschool Program
Researchers: A. Bolotta and Dr. E. Pedretti (Supervising Professor)

April 2016

Dear Site Director/Program Facilitator,

The following letter is intended to confirm your consent to participate in a research study conducted in the afterschool program at the site where you regularly direct and facilitate art and science programming. This study is being conducted towards the completion of a Masters of Arts degree at the Ontario Institute for Education (OISE) at the University of Toronto. The purpose of this study is to explore an example of science-art integration in practice, and to look specifically at the goals of the program, its implementation and the experiences of students as they participate in this type of programming. This research study is particularly relevant at a time when opportunities for informal, or out-of-school learning grow in number and prominence, and as more attention is placed on integrated visions of science education, to help prepare learners for participation in a dynamic and ever changing world.

The data for this research project will be collected through interview with teachers and students, participant observation during the afterschool program, the collection of in-progress or complete student work and through a journal you will be invited to keep through the course of the program.

Your participation in this study will specifically involve participating in two individual interviews, one at the beginning and end of the afterschool session. Each interview will be an hour in length, and take place in a private area of the program site. With your approval, both interviews will be audio recorded. Your participation will also involve permitting the researcher to observe each of the ten to twelve workshops that are delivered during the session. Field notes will be recorded through each observation period. With your permission, workshops and interactions between teacher, student and/or researcher will also be audio recorded. Some of the conversation or quotes from these interactions may be used in the final report.

There is a very low degree of risk associated with participating in this study. Both observation and interview are intended to be non-invasive, occurring within the program site, during, before or shortly after scheduled afterschool program meetings. It is my intention to gather your insight into science and art integration in practice. Information gathered will therefore not be of a sensitive nature. Also note, that this study is not evaluative in nature, but rather exploratory as I try to understand and describe the program and students’ experiences. Potential benefits to your participation in this study
may involve the development of a more intricate understanding of the programming at the site, which may influence its future development and implementation.

All personally identifiable data collected through the course of the study will be strictly confidential and only accessible to myself and my thesis committee. Any proper names, including the name of the afterschool program, teachers and students will be removed from interview transcripts or any written materials and replaced with pseudonyms. All audio recordings will be destroyed once they have been transcribed into text. All data will be stored securely and will be destroyed five years after the completion of this study.

As a research participant you can withdraw from the study at any time, without reason, and without any negative consequences.

If you are content to participate in this study, please fill out and sign the attached form, at your convenience. Alternatively, completed forms can be scanned and sent to me at alanna.bolotta@mail.toronto.ca.

If you have any questions, please do not hesitate to contact me at the aforementioned email address or my thesis supervisor, Dr. Erminia Pedretti at erminia.pedretti@utoronto.ca

Sincerely,

Alanna Bolotta, HBSc, BEd, OCT
MA Candidate in Curriculum Studies and Teacher Development
Curriculum, Teaching and Learning Program
Ontario Institute for Studies in Education, University of Toronto
Email: alanna.bolotta@mail.utoronto.ca
Consent Form – Site Director/Program Facilitator
Research Project: Exploring Science & Art Integration in an Afterschool Program

I (name of site director/program facilitator), ______________________ give my consent to participate in the study entitled Exploring Science & Art Integration in an Afterschool Program, as described in the above information letter.

The purpose and structure of this research study has been explained to me by Alanna Bolotta and I have been given the opportunity to ask questions.

Signature of Participant: ______________________ Date: ______________________

Please check one box for each set of statements:

☐ I consent to having the interviews audio-recorded.

☐ I do not consent to having the interviews audio-recorded.

☐ I consent to having the workshops audio-recorded.

☐ I do not consent to having the workshops audio-recorded.
Dear Parent,

The following letter is an invitation to have your child participate in a research study conducted at the site where your child is scheduled to begin an art-science afterschool program. This study is being conducted towards the completion of a Masters of Arts degree at the Ontario Institute for Studies in Education (OISE) at the University of Toronto. The purpose of this study is to explore an example of science-art integration in practice and to look specifically at the goals of the program, its implementation and the experiences of students as they participate in this type of programming.

Your child’s participation in this study will involve participating in two individual interviews, one at the beginning and one towards the end of the afterschool session. Each interview will be ten to fifteen minutes in length, and take place in a private and comfortable area of the program site. You can elect to be present for each interview if you choose. With your approval, both interviews will be audio recorded. I will also be observing each of the workshops that are delivered during the session. With your permission, workshops will be audio recorded. Samples of your child’s in-progress, or completed work may also be collected, or photographed. I will request your written permission prior to including quotes from your child or any of their work in the final written report. Photos of your child will not be collected through this study.

There is a very low degree of risk associated with participating in this study. Both observation and interview are intended to be non-invasive, occurring within the program site space, during, before or shortly after scheduled afterschool program meetings, and there is no evaluative component to this study. I am interested in exploring how students respond to the program, interact with activities, their enjoyment levels and their views on both art and science. Information gathered will therefore not be of a sensitive nature. Potential benefits to your child’s participation in this study may involve the development of a more intricate understanding of their particular vision of science, art or both.

All personally identifiable data collected through the course of the study will be strictly confidential and only accessible to myself and my thesis committee. Any proper names, including the name of the afterschool program, teachers and students will be removed from any written materials and replaced with pseudonyms. All audio recordings will be destroyed once they have been transcribed into text. All data will be stored securely and will be destroyed five years after the completion of this study.

You can withdraw your child from the study at any time, without reason, and without any negative consequences.
If you are content for your child to participate in this study, please fill out and sign the attached form and return it to me at your convenience. Alternatively, completed forms can be scanned and sent to me at alanna.bolotta@mail.toronto.ca.

If you have any questions, please do not hesitate to contact me at the aforementioned email address or my thesis supervisor, Dr. Erminia Pedretti at erminia.pedretti@utoronto.ca.

Thank you for considering this request. I am very excited about spending time in this program with the teacher and children.

Sincerely,

Alanna Bolotta, HBSc, BEd, OCT
MA Candidate in Curriculum Studies and Teacher Development
Curriculum, Teaching and Learning Program
Ontario Institute for Studies in Education, University of Toronto
Email: alanna.bolotta@mail.utoronto.ca
Consent Form - Parent
Research Project: Exploring Science & Art Integration in an Afterschool Program

I, __________________________ (name of parent) give my consent for my child, __________________________ (name of child) to participate in the study entitled Exploring Science & Art Integration in an Afterschool Program, as described in the above information letter.

The purpose and structure of this research study has been explained to me by Alanna Bolotta and I have been given the opportunity to ask questions.

Signature of Parent:_________________________ Date:________________________

Please check one box for each set of statements:

☐ I consent to having interviews with my child audio-recorded.

☐ I do not consent to having interviews with my child audio-recorded.

☐ I consent to having the workshops audio-recorded.

☐ I do not consent to having the workshops audio-recorded.
APPENDIX B
Interview Guide

Introductory Interview for Students
1. What grade are you in?
2. Have you participated in this afterschool program before? If so, when?
3. What does the word science mean to you?
4. What do you like about doing science? Why?
5. What do you not like about doing science? Why?
6. What does the word art mean to you?
7. What do you like about doing art? Why?
8. What do you not like about doing art? Why?
9. Do you think art and science work well together? Why or why not?
10. What do you want to be when you grow up? Why?
11. What is your favorite part of each day’s activities here at the program site? Can you describe this activity in detail? How does this activity make you feel?
12. How do you feel about learning science in the afterschool program compared to learning science at school?

Introductory Interview for Site Director/Program Facilitator
1. Tell me about this program...
2. Why did you choose to focus the afterschool program in science-art integration?
3. How do you see science and art as being connected (if at all)?
4. How has your professional and academic background prepared you to direct/teach at this site?
5. What do you see as the goal or objective of integrative science and art programming through your delivery model?
6. How and why are specific science and art content areas selected for each lesson? Please provide an example.
7. How do you determine what knowledge and skill learners are expected to take away from each lesson?
8. How are lessons specifically structured to facilitate the development of this knowledge and skill?
9. How and why are specific teaching strategies selected for each lesson?
10. Can you provide specific examples of how students have responded to the afterschool program in the past?

End Interview for Students
1. What is your favorite artifact/project you’ve made in the afterschool program so far?
2. How was this artifact made? Can you describe the artistic process used to create this artifact?
3. Why is this your favorite artifact you’ve made in the afterschool program so far?
4. How did making this artifact make you feel? Why?
5. What did you learn by making this artifact?
6. If you had to create this artifact again, what might you do differently?
7. Do you think art and science work well together? Why or why not?
8. Did art make science more fun and/or understandable?
9. Do you like science more after taking this program?
10. Would you be interested in doing this program again or taking another like it? Why or why not?
11. What do you want to be when you grow up? Why?

*End Interview for Site Director/Program Facilitator*

1. How do you think students feel about science upon completion of the afterschool program? What evidence do you have to support your conclusions?
2. What evidence have you observed of learner knowledge and skill development through the course of this afterschool program?
3. Have teaching strategies or workshop structure changed at all through the course of the program? If so, how and why?
4. Have the goals of the afterschool program changed at all through the course of the program? If so, how and why?
5. Have you received any feedback on the afterschool program from parents? If so, what is their general response?
6. Do you think students have developed an understanding of how science and art are connected to one another as a result of their participation in this afterschool program? What evidence do you have to support your conclusion?
7. As we approach the end of the program, what have been some of the challenges of designing and implementing this program? How were these challenges mitigated or overcome? What would you do differently the next time you plan and implement this afterschool program?
8. What evidence have you seen to suggest that students have developed a greater appreciation for science through this experience?
**Table 3 – Data Analysis Summary Table for Chapter 4**

<table>
<thead>
<tr>
<th>GOALS</th>
<th>Detailed Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Scientific Literacy</strong></td>
<td></td>
</tr>
<tr>
<td>a) To help learners develop content knowledge and skills in both science and visual art through hands-on projects.</td>
<td>▪ Compost Bins</td>
</tr>
<tr>
<td>b) To engage learners in meaningful, problem-solving tasks which nurture a sense of responsibility and active citizenship.</td>
<td>▪ Bridge Building</td>
</tr>
<tr>
<td><strong>2. Creativity</strong></td>
<td></td>
</tr>
<tr>
<td>a) To nurture an appreciation for the connection of art and science in learners.</td>
<td>▪ Homemade Paint</td>
</tr>
</tbody>
</table>
| b) To empower learners to think divergently by respecting learner needs and honouring learner ideas. | i. Respect learner needs:  
  ▪ Ability – Working with parents; consideration of age-level, ability to focus on tasks  
  ▪ Attitude – ‘buffer-time’ for learners to get used to the space; not feeling rushed to complete activities  
  ▪ Interest - learner choice and control of decision making  
  ii. Honour learner ideas:  
  ▪ ‘Question-Corner’  
  ▪ Self identified explorations  
  ▪ Learner feedback on plaster masks |
| **3. Emotional Development** |                                                                                  |
| To provide learners with opportunities to work outside their comfort zone and demonstrate perseverance. | ▪ Working through physical and social discomfort – Mask Making; Working in partners |
Table 4 – Data Analysis Summary Table for Chapter 5

<table>
<thead>
<tr>
<th>IMPLEMENTATION STRATEGIES</th>
<th>Detailed Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Making Connections</td>
<td></td>
</tr>
</tbody>
</table>
| a) Through the integration of different disciplines, particularly art and science. | ▪ Multi-disciplinary, Fusion  
▪ Potential to integrate the ‘Worldly Perspective’ |
| b) Through the linking of lessons, themes and ideas. | ▪ Lesson to lesson – Decomposers, Producers, Consumers  
▪ Lesson to theme – Ecosystems, Engineering, Paper  
▪ Question Corner |
| 2. Teaching and Learning Practices             |                                                        |
| a) Through the transmission of facts, skills and values from teacher to student. | ▪ i. Facts - Lessons:  
  ▪ ii. Skills - Demonstration/Model:  
  ▪ iii. Values - Rules/Expectations/Routine:  
  ▪ Windmills  
  ▪ Modeling how to work with plaster  
  ▪ Modeling how to waft a scent  
  ▪ Code of Conduct  
  ▪ Tibetan Bowl |
| b) Through a transaction approach to teaching and learning where teacher and student are partners in problem solving and inquiry. | ▪ Homemade Paper  
▪ Compost Bins  
▪ Mask Making |
| c) Through a transformation approach to teaching and learning via immersive experiences and linking learning to life experiences. | ▪ i. Immersive Experiences:  
  ▪ ii. Link to Life Experience  
  ▪ Role play – scientist/engineer; artist; owl  
  ▪ Visualize - predator/prey scenario  
▪ Personal Memories - Fishing |
| 3. Ongoing Program Development                 |                                                        |
| a) Through the adaptation of programming in response to student feedback and practical experiences. | ▪ Learning from students – repeating core concepts  
▪ Trial and error - plant investigation modified |
| b) Through ongoing collaboration between instructors. | ▪ Consistent Dialogue – decorating worm bins fairly; making plaster masks less uncomfortable |
| 4. Challenges to Program Delivery              |                                                        |
| Timing, space and learner age group or ability bound what is possible to accomplish in the program. | ▪ i. Timing:  
  ▪ ii. Space:  
  ▪ iii. Learner Age Group/Ability:  
  ▪ Length of activities  
  ▪ Resources  
  ▪ Indoor/Outdoor  
▪ Seating dynamics/partners |
Table 5 – Data Analysis Summary Table for Chapter 6

<table>
<thead>
<tr>
<th>STUDENT EXPERIENCE</th>
<th>Detailed Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Engagement of the Head</strong></td>
<td></td>
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</tbody>
</table>
| **a) Control over testing/refining/making of art-science projects.** | ▪ Testing Windmills  
▪ Decorating Masks |
| **b) Exploring the connection between art and science.** | ▪ Learner Interview Responses |
| **2. Engagement of the Hands** | | |
| Embracing the potentially messy or gross nature of art and science. | ▪ Mask Making  
▪ Owl Pellets and Mounting |
| **3. Engagement of the Heart** | | |
| **a) Belonging to a community.** | ▪ Building relationships between peers and between peer and instructors. |
| **b) Having fun!** | ▪ Ongoing throughout the program |