Cultivating Confidence and Connecting Curriculum: Exploring an Integrated Approach to Science and Art

by

Kim Ward

Bachelor of Education, Simon Fraser University, 2016

Bachelor of Arts, Simon Fraser University, 2014

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Declaration of Committee

Name:	**Kim Ward**
Degree:	**Master of Education**
Title:	**Cultivating Confidence and Connecting Curriculum: Exploring an Integrated Approach to Science and Art**
Committee:	**Chair: Beth Marshall** Associate Professor, Education
	Gillian Judson Supervisor Assistant Professor, Education
	Daniel Laitsch Committee Member Associate Professor, Education
	Michelle Pidgeon Examiner Associate Professor, Education

Ethics Statement

Abstract

While science and art are often taught as entirely separate subjects, there are numerous historical and contemporary connections between these two fields of study. What will happen when the intersections between science and art are encouraged through teaching an integrated unit in an elementary school context? This research, conducted within a Grade 6/7 classroom context, explores how a decompartmentalized approach to science and art positively impacted confidence and enhanced student engagement. This mixed-methods study utilized a variety of tools to reflect student learning and insights including surveys, directed drawing activities, and class discussions with a focus on limiting barriers (e.g. written output) that could have prevented students from authentically sharing their ideas and experiences.

Keywords: art curriculum; cross-curricular; integrated curriculum; science curriculum; STEAM education; student confidence

Dedication

This paper is dedicated to my students— past, present, and future. I am so grateful for everything that you have taught me.

Acknowledgements

I would like to acknowledge that my research took place on the ancestral lands of the Coast Salish nations of Musqueam, Tsleil-Waututh, and Squamish, within whose traditional territories I have the privilege of teaching, learning, and living.

I also want to extend my gratitude to everyone who has helped to support me on my learning journey so far. Thank you to my advisor, Dr. Gillian Judson, for your expertise, guidance, and insight. Thank you to the faculty at Simon Fraser University for your support with formatting and editing my paper. Thank you to my teaching partner, Danielle Ramen, for always supporting my (sometimes ridiculous) ideas. Thank you to my parents, Don and Kathy, for your compassion and patience. Finally, thank you to my husband, Ian, for helping me to be brave.

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List of Acronyms

BIPOC	Black, Indigenous, and People of Colour
EA	Educational Assistant
ELL	English Language Learning
IEP	Individualized Educational Plan
SFU	Simon Fraser University
STEAM	Science, Technology, Engineering, Art, and Math and Mechanics

Introduction

As an educator, some of my most meaningful lessons and learning moments have come from facilitating science experiments and encouraging artist expression: observing the enthusiasm that students demonstrate when mixing chemicals or blending paint colours, the engagement as they use learned concepts in real-world applications, and the confidence with which they communicate their understandings and connections have all been inspirational and foundational to my pedagogy. These experiences, alongside my own memories of learning science and art as a student, are what inspired me to further explore the interwoven nature of these two subjects within the classroom, in history, and in contemporary contexts. While the idea that science and art are connected is “a strange one to us today” (Roche, Farina, & Commins, 2018, p.13), this has not always been the case. There are numerous examples of artistic and scientific collaborations throughout history and in the modern day: Renaissance thinkers like Da Vinci, scientific illustrators like Ernst Haekel, and contemporary artists like Jen Stark are all extraordinary exemplars of science and art working harmoniously together. Rather than being diametrically opposed or wholeheartedly different, science and art are instead connected in ways that create a deeper understanding of both subjects that can encourage artists, scientists, and educators (Wenham, 1998). Despite these connections and intersections, however, art and science often operate within separate spheres inside the classroom, “taught as... discipline[s] apart” (Plonczak & Goetz Zwirn, 2015, p. 62). This arbitrary division can impact student success and confidence in both areas as it “deprives students of [the] holistic, personally meaningful learning experiences” (Plonczak & Goetz Zwirn, 2015, p. 62) that are fostered during interconnected lessons. Treating science and art as divergent fields of understanding, limits the opportunities for more meaningful, extensive, cross-curricular explorations and learning opportunities for students and teachers alike (Roche, Farina, & Commins, 2018). Numerous scientific concepts are intrinsically linked to, or directly benefit from, artistic representation (and vice versa)— an interconnected and decompartmentalized curriculum encourages those connections.

Before beginning my exploration of science and art through my research, I wanted to critically examine my own experiences with these subject areas. I began to reflect upon my relationship with science and art as a student, a teacher, and a researcher in order to unpack any possible biases I may have. As a child, I frequently observed clear boundaries between science and art throughout my education. Art was often taught through a lens that fostered creativity and encouraging self-expression, where science often involved a more cold and regimented teaching approach. I noticed dramatic differences in both the way science and art were taught. I perceived many rifts between the scientific and the artistic. For example, to prepare for science, we would be asked to put away our pencil crayons, to turn our eyes to the chalkboard, and to prepare for note-taking, theory analysis, memorization, and equations. While these skillsets are important and useful, I remember feeling that there was no room for questioning, curiosity, exploration, or creativity. I also recall struggling to clearly demonstrate my scientific learning during these lessons in a way that earned positive feedback or good grades. Often, the method by which I would be expected to express my scientific understanding would be tests and worksheets that encouraged route memorization. I felt pressured to adhere to the supposed ‘objective’ nature of science.

Getting ready for an art lesson, by contrast, was usually a much more joyful experience for me, often involving clearing our desks, putting on smocks, gathering paint and supplies, and beginning to chat while the teacher put on music. During most art lessons we were encouraged to explore and emote, to be unafraid of making messes, and were provided with a very different learning environment in which I felt more comfortable and confident. In my own experiences in school, I recall becoming much more self-conscious about my abilities in science-based activities as I entered the upper intermediate grades. I instead focused my attention more on art. While my teachers never explicitly said I should gravitate towards the arts in lieu of a science-based hobby or career, there were many examples of coded language that communicated this idea to me. Many of my teachers made mention of my natural inclination towards what they termed ‘right-brained’ thinking and they often gave positive feedback on my creativity; my art was used as exemplars for other students and my report cards were filled with words of praise in this subject area. Art also came much more easily to me than the increasingly challenging scientific concepts and their corresponding mathematical understandings. Looking back, I realize that I unknowingly sought to follow the path of least resistance and gravitated towards the subject that required less resilience. In my experience, art was comfortable and enjoyable, whereas science was challenging and frustrating.

During my first few years of teaching and through my initial research and reflection, I have begun to realize that this divide between subjects is wholly imagined and unfairly implemented. The kind of science that I likely would have gravitated towards and found success in as a student would have involved all my favourite things about art: creatively communicating ideas, encouraging self-expression, exploring curiosity, asking questions, and being encouraged to get messy. I am reminded of the adage I was told so often in my journey to becoming a teacher, the importance of ‘being who you needed when you were younger’, and I wonder what adjustments to the science lessons and learning environment would have encouraged and empowered me. Through this research, I sought to explore whether creating cross-curricular science lessons that a younger me would have enjoyed would have a positive effect on my students’ skills and confidence. However, it was important to also consider what types of lessons would benefit students with learning styles and preferences that were different from my own. I wonder if other students may have felt discomfort and experienced challenges during art lessons and flourished during science? Would a different approach to how art is taught help these students feel more comfortable and confident as artists? How could I ensure that my integrated curriculum enhanced the experiences of students who were dissimilar to me in their preferred learning methods and areas of focus? How could an interconnected curriculum encourage students to be more confident in their own capacity and capabilities? I considered all these questions as I began investigating what scholars had learned through research in this subject area.

Literature Review

Enhancing the interconnectivity between art and science has been found to be mutually beneficial, both in the real world and in the classroom (Aikenhead, 2019). Specifically, many traditionally artistic attributes (such as curiosity, imagination, and exploration) can have a positive influence on scientific concepts and curriculum (Lima, 2019). Through investigating examples of educators, scientists, and artists who have identified the intersections of science and art, several recurrent themes emerge: the importance of observation, the identification of possible biases and barriers, and the methods by which students can document and demonstrate their learning. In many cases, an integrated approach fosters student engagement, increases student confidence, and improves the specific skills necessary for successful performance in science curriculum (Densmore, Kolecki, & Miller, 2005; Petto & Petto, 2019; Plonczak & Zwirn, 2015). Students were more likely to feel confident in their scientific abilities when educators prioritized an innovative and intersectional curriculum, worked to remove barriers, and diversified their assessment practices (Costello, 2006).

Observation and Transformation

Both artists and scientists must possess a keen sense of observation (Roche, Farina, & Commins, 2018). Whether witnessing the results of an experiment or seeking to recreate a landscape through painting, the ability to carefully examine (and clearly reflect) visual information is key. Encouraging observation in students can be as simple as presenting a piece of art (e.g. Van Gogh's Starry Night) or natural wonder (an image of a celestial body) and encouraging students to generate ideas about what they see (Plonczak & Zwirn, 2015). Interpreting visual cues is a skill that proves just as useful in the realms of artistic analysis as it does in scientific exploration as it helps students skillfully and accurately communicate information about what they see and notice (Buczynski, Ireland, Reed, & Lacanienta, 2012). Facilitating student learning about artistic concepts also had a positive correlation with students creating more detailed, intricate, and expressive scientific reflections and diagrams according to the results of selected studies that fully communicate student understanding (Plonczak & Zwirn, 2015; Stellflue, Allen, & Gerber, 2005). Explicitly encouraging observation in students also lends itself exceedingly well to encouraging curiosity, facilitating questioning, and prompting students to make connections between learned curriculum and science in the real world (Wynn & Harris, 2012). Additionally, art and science are both involved in the communication of understanding and the sharing of ideas, and furthermore, taking observations and translating them into something meaningful (Zhu & Goyal, 2019).

The power of the transformation of ideas cannot be underestimated, as it provides students with the opportunity to show what they have learned through a variety of methods. In many of the aforementioned studies, students demonstrated increased confidence in their own abilities because they were able to communicate their understanding in diverse and meaningful ways. By expanding assessment from merely tests, worksheets, and written reflections to include artistic representations of scientific concepts (such as painting, comics, dance, poetry, etc.), students were able to explore their learning and explain their ideas in "visual, tactile, kinesthetic, spatial, and metaphorical [ways]" (Petto & Petto, 2019, p. 53). This is especially beneficial for students who may struggle with written output, students with diverse needs and abilities, and students for whom so-called 'left-brained' thinking does not come naturally. Numerous researchers and educators reflected that fostering an integrated curriculum allowed students to utilize their own strengths, skills, and types of intelligences in order to learn curricular material (Petto & Petto, 2019; Zhu & Goyal, 2019). In this way, educators set up students to be successful, which led to increased engagement, confidence, and enthusiasm (Lima, 2019).

Representation in Science Curriculum and Media

After reviewing the literature, another theme that serves as an undercurrent is the idea of accessibility (or lack thereof) in the sciences. Educators should consider who, historically and contemporarily, has been privy to scientific knowledge and who is held up as an exemplar of scientific understanding. One possible barrier mentioned in several reports is the role that gender and cultural identity can play in students' understanding of who can be a scientist (Fisher, 2017; Forget, 2021; Zhu & Goyal, 2019). Several researchers drew upon the idea that the image of the scientist has remained one of a man wearing a lab coat and spectacles (Miller, Nolla, Eagly, & Uttal, 2018). Often, scientists who do not fit this schema (including BIPOC and/or female scientists) are noticeably absent from media, libraries, and curriculum. However, it seems that students are expanding their understanding of who can be a scientist more than ever before (Forget, 2021; Miller, Nolla, Eagly, & Uttal, 2018); this trend is reflected through a marked increase in depictions of female scientists and BIPOC inventors (Miller, Nolla, Eagly, & Uttal, 2018). Clearly, there is a need (and a demand) for more diverse representation of different identities within science!

Kyne, a Canadian drag performer and scientist, is one notable example of more diverse voices in the scientific community. Kyne is a content creator who blends their passion for performing arts with their interest in STEM-focused content. In a 2022 interview, Kyne reflected that part of the reason their content has been so well-received by students (and educators) is that by "being an Asian, queer drag queen, [they] show people that you can be feminine and still have a career in STEM" (Davis & Viterbo, 2022). They reflected that students should feel that they "don't have to hide [their] queerness [or other parts of their identity because] what really matters is what's in [their] brain[s]" (Davis & Viterbo, 2022). Kyne also uses more open source and publicly accessible methods of sharing information, choosing to post to YouTube and TikTok rather than publishing their work in journals or submitting it to a textbook. This communication of information allows a diverse audience to easily access their lessons (Buczynski, Ireland, Reed, & Lacanienta, 2012). With over 1 million followers on their social media platforms and numerous positive comments from children and adults alike, Kyne is an example of the importance of opening the scope of who can be a scientist. By amplifying the voices of traditionally marginalized or silenced communities, educators can engage and encourage those students who may stray away from science because they do not see themselves in the curriculum (Forget, 2021).

Rather than continuing the cycle of scientific knowledge as a being part of a closed circuit, integrated curriculum prioritizes making understanding more accessible to students of all genders, cultures, and backgrounds (Zhu & Goyal, 2019). This encourages the idea that science is not reserved only for a specific subset of the population, but is a useful, interesting, and necessary part of everyone's everyday life. Furthermore, this approach could serve as a meaningful first step towards "bring[ing] scientific discoveries into homes... [and creating a] belief in science that extends far beyond the scientific community" (Zhu & Goyal, 2019, p. 5) into the lives of each and every person. Curriculum that is developed with this in mind emphasizes the idea that science can be viewed as ever-changing, awe-inspiring, and readily-available to all learners. An integrated approach to science and art also serves to support students with negative self-perception and self-talk that may underestimate their scientific capacity and abilities (Forget, 2021). By helping all students feel that they can be scientists, and by removing roadblocks to success, these students will feel more empowered to explore science both within the classroom and in the world beyond.

Demonstrating and Documenting Learning

For an integrated science and art curriculum to be as meaningful as possible, many educators utilized backwards-design, focusing more on the intended skills rather than the curricular content. This ensured that their units authentically infused artistic curricular goals in a way that communicated them as being of equal importance as the scientific concepts (Petto & Petto, 2019; Stellflue, Allen, & Gerber, 2005). This way, the art was not merely a one-and-done activity that served to illustrate a scientific idea, but a tool to communicate learning (Stellflue, Allen, & Gerber, 2005). Students were encouraged to use art to transform, rather than just make visible, their thinking (Petto & Petto, 2019). Many educators chose to create summative projects that allowed students to express their learning in a variety of ways. These projects included having students keep a journal of their successes and struggles during hands-on projects (Petto & Petto, 2019), utilizing assessment probes that encouraged students to access prior knowledge and apply it to a newly-taught concept (Plonczak & Zwirn, 2015), using a rubric to assess a song or skit based on scientific concepts (Merten, 2011), or employing numerous assessment tools that extended beyond tests and essays. Additionally, educators could use this integrated curriculum as an opportunity to collaborate in meaningful and mutually-beneficial ways (Wynn & Harris, 2012).

Not only does a cross-curricular approach encourage educators to work together and play to their strengths and passions but infusing art into science could help emphasize how useful the arts can be in the real-world, as many art programs face decreased funding while demand for STEAM subjects rise (Wynn & Harris, 2012). Rather than further the divide between the artistic and the scientific, explicitly teaching the connections between science and art could help document how these lessons support student success in the classroom and in their future pursuits (Buczynski, Ireland, Reed, & Lacanienta, 2012; Wynn & Harris, 2012). As more career paths prioritize innovative thinking and more jobs encourage STEM skillsets, an integrated curricular approach seeks to prepare students for the world beyond the classroom (Buczynski, Ireland, Reed, & Lacanienta, 2012; Wynn & Harris, 2012). As I investigated literature surrounding integrated art and science curriculum, I noticed that the majority of research depicted how beneficial this approach was to educators and students. However, few studies documented student experiences from their perspective or amplified students' voices and opinions. This led me to consider—how would students report feeling about themselves (and about the curriculum) before, during, and after an integrated art and science unit? How could I use their thoughts, opinions, and reflections to further examine my teaching practices? And could what I learned from this research inform how other educators and policy-makers approach teaching science and art?

The Research Questions

In the process of designing my inquiry question for this research, I looked to my students to guide me. How did they feel about science and about art before I began my research? What experiences and exposure to these subjects did they have? What strengths, successes, and struggles did I notice in these two subject areas? In my observations of my students from September until May, I noticed that many of them expressed some enthusiasm and excitement when faced with science lessons; often, students would respond “yes!” or “finally!” when it came time to engage in science lessons on a weekly basis, and I noticed that work-avoidant and disruptive behaviours would often be somewhat reduced during this time. I believe it is likely that this was due, in part, to them observing my own passion for science activities; students were likely picking up on positive feelings towards these lessons and, because I found science interesting, I put more time and effort into creating engaging lessons that I myself found interesting. I had introduced science curriculum to the classes through a chemistry experiment in the first few weeks of school involving mixing Mentos with soda to cause a fizzy, messy reaction. Students would consistently ask when we could do “our next science experiment” and if we could “set something on fire” or “mix chemicals together” or “build something for STEM”. While the majority of my class communicated positive feelings towards science lessons, it was clear their scope of what science could be was limited (e.g. chemistry experiments, ADST projects).

In contrast, however, many students did not express the same enthusiasm for art activities. In previous years, when I taught younger students, art was usually a favourite amongst students. However, with my Grade 6/7 class, it seemed that many students had little confidence in their artistic abilities and did not find art activities enjoyable or engaging. Some students would even audibly protest when they noticed art lessons on our daily schedule, and more still would express that they were “bad” at drawing. I had three students who self-identified as being artists, but the majority of my students would measure their own artistic skills against them (e.g. “Look at their art! Mine looks nothing like that! Can they just draw it for me?”). I wondered, is there was a way that I could encourage students to build upon and expand their understanding of science to include the arts? If so, could that help our students feel more positive and confident in their own artistic abilities? Hence, the idea of examining a cross-curricular unit that brought science and art together started to take shape.

Guiding Question

How will an integrated approach to science and art impact student confidence in these subject areas?

When designing my research question, I knew that I must be mindful of the possible challenges and limitations that could come from collecting data within my own classroom. Additionally, with my research taking place during the months of May and June, there were many additional responsibilities and activities that impacted my proposed data collection schedule (e.g. field trips, Grade 7 graduation events, end-of-year routines). Furthermore, student energy (and anxiety) would be at an all-time high. Our Grade 7 students expressing complex feeling about transitioning into high school, and many students had complex feeling about beginning their summer vacation. With the time constraints and other influences and factors in mind, I began to consider what sub-questions I could explore, with a focus on how this integrated unit might influence and impact the students. I relied not only on how students reported feeling (e.g. responses to surveys and reflections and discussion questions), but also how they communicated non-verbally through my own observations (e.g. student energy levels during activities, voicing enthusiasm or disdain towards lessons). This research was not only intended to examine how to support student learning, but also how I could adapt my own practice and pedagogy to teach these subjects more effectively.

Sub Questions

How will students communicate feeling about their capacity to learn, understand, and transform science and art concepts?

What, if any, changes can be observed in student enthusiasm and engagement during these lessons?

Methodology

I took a qualitative approach to my research, with a goal of deepening my understanding of student learning and self-perception in regards to an integrated science and art curriculum. Within this qualitative study, I applied mixed-methods designs when collecting data. This section provides further context about my research site and participants, specific considerations when designing my unit, and further details on my data collection methods.

Unit Design

When designing the cross-curricular unit I would be using as the basis for my research (see **Appendix E**) I implemented backwards-design in order to be mindful of the needs of my students (both as individuals and as a class). Before beginning this research, I observed that many of the learners in my class demonstrated different forms of anxiety and stress in many subject areas, which often manifested as negative self-talk, work-avoidance, or disruptive behaviours (see **Research Site & Participants**). My goal was that, through the course of the lessons and experiments, students would further develop confidence in themselves, increase their enthusiasm, and present opportunities for students to communicate their learning in meaningful ways. In order to do this, I created a unit designed to take place over a minimum of 2-3 weeks, with the potential to be expanded upon in the future. It was also important to me to create a unit where I would have the ability to adapt depending on student interest; for example, many of my students were very interested in the history of paint, so we dedicated more time to this study and did not get to the lessons on animal colouration. The activities were designed to explore the concept of colours in ways that were scientific, historical, sociological, cultural, and artistic. All the responses, reflections, and projects were created with accessibility in mind; I wanted to downplay the reliance on written responses and provide different options for students to demonstrate their understanding (e.g. illustrating ideas, verbal responses, creating a painting using key skillsets). Again, it was important to me to design this unit with the unique needs of these specific students in mind. I chose activities as well as data collection methods that would accommodate our students' needs for one-to-one support, for the diverse and differentiated group of learners, and for the fluctuation of energy that many students experienced after sitting for too long.

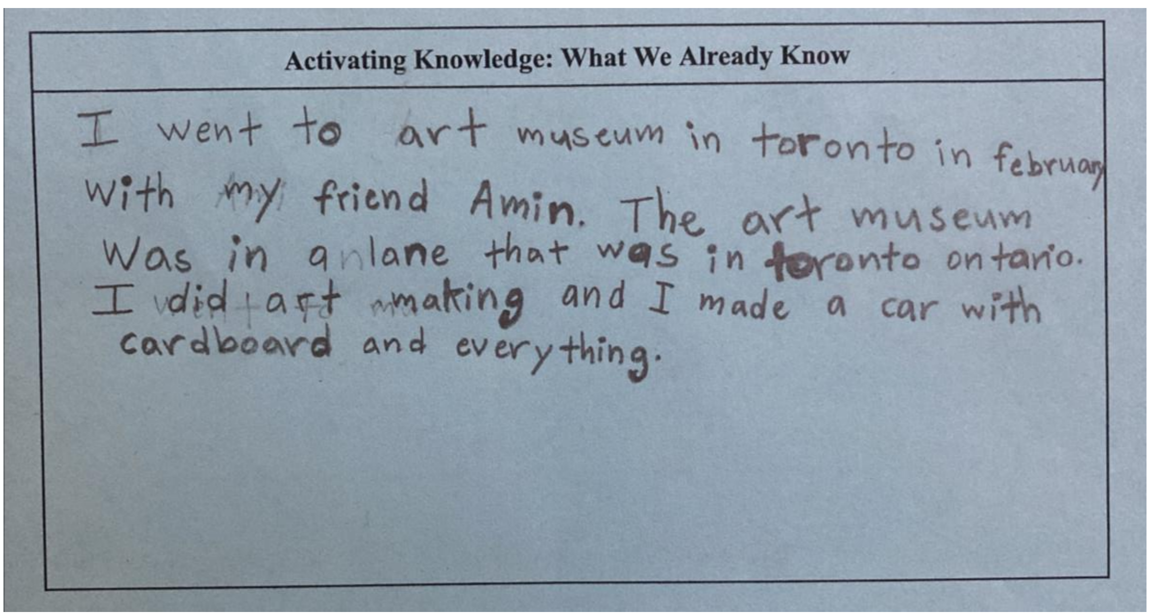
All the activities, lessons, and reflections/observations took place during normal classroom instructional times, though I did adapt our daily schedule to allow for more time for "science/art" instead of separating the two subjects as I usually did. Throughout the unit, I wanted to provide students with opportunities to discuss, explore, and question what we had learned. Not only did this de-center me and provide students with more independence and agency, but it allowed me to make detailed observations of what students were saying and doing during these activities so that I might record them for my data. Finally, I knew this unit needed to be created with the needs of my most vulnerable learners in mind, so I collaborated closely with our classroom Educational Assistant (EA) and our learning support team to try and remove as many barriers to success as possible (e.g. planning self-regulation activities after an exciting and potentially overstimulating experiment, creating a differentiated response sheet for several students, adding many visuals to my presentations).

Evaluation Design

When exploring how I would collect a variety of data, I designed the activities to provide opportunities for demonstrating understanding in numerous ways and using a multitude of methods. This included short surveys, visual reflection sheets, formative art projects, observations (both verbal and written) during experiments, and class discussions. This triangulated approach allowed me to more accurately represent and reflect student learning, insights, and opinions throughout the course of my study and provided me with more sources of data to draw upon. This method of triangulation allowed me to feel confident that I was "collecting information from a diverse range of individuals and settings, using a variety of methods" (Maxwell, 2012, p. 245). I knew that with these students in particular, it was not reasonable to expect extensive written responses after each and every activity. For many students in these classes, lengthy and formal writing activities were a source of stress and frustration, and I would often notice an uptick in disruptive or distracted behaviours during this time. Instead, I sought to provide numerous, diverse, and brief moments for students to express their ideas and share their opinions. I chose to de-emphasize the role of written responses in this AR, seeking instead to have students reflect their learning in a myriad of different ways. One method I used frequently in order to reflect students' learning, ideas, and responses was keeping a field journal. This allowed me to honour and reflect the voices of my students in yet another way, as I was able to take notes, write quotes, and record key observations during class discussions, activities, and experiments.

Another aspect I considered as I developed my evaluation methods was that three students in my class had diverse needs and Individual Education Plan (IEP) goals regarding written output, reading comprehension, and sensory processing. I wanted to ensure that these students' ideas and input were accounted for in my data and analysis, so I worked to remove as many barriers to participation as possible. To adapt my approach with these students in mind, I designed surveys/reflections that did not rely solely on written output such as: a survey that used pictorial scales to self-assess (see **Appendix F**), reflections that encouraged and allowed for drawing ideas versus writing them, and providing targeted support during reflective time (EA and/or teacher scribing, reading the prompts aloud, etc.).

In addition to documenting learned concepts, I wanted to honour the lived experiences and background knowledge of my students. One method I employed was the utilization of assessment probes that encouraged students to access prior knowledge and apply it to a newly-taught concept (Plonczak & Zwirn, 2015). In these probes (see **Appendix J**), students were asked to brainstorm what they already knew about a topic (e.g. What do you already know about paint and pigment? Draw or describe what you think of.), and then applied this background knowledge to new material discussed in class (e.g. Today we learned about the history of cave paintings. How did your thinking change? What did you learn?



Activating Knowledge: What We Already Know

I went to art museum in toronto in february with my friend Amin. The art museum Was in a lane that was in toronto ontario. I did art making and I made a car with cardboard and everything.

Figure 1. Student RH2's pre-lesson reflection (May 2023)

I also wanted to have a clear understanding of where students were coming from regarding their enjoyment and understanding of science and art. At the beginning of my AR, students reflected and shared what they already knew (and how they already felt) about these two subjects using short responses with prompting questions such as "what images/words come to mind when you think of science?" and "would you consider yourself an artist?" I also prompted students to complete a survey and reflection before, during, and after my unit. I used their responses in addition to the class discussions and observational/anecdotal evidence as the basis for my evaluation and analysis. My main area of focus was determining whether students demonstrated an increased enthusiasm towards science and art curriculum, whether they reported feeling more confident in their ability to demonstrate their learning in these subjects, and if they felt their skills and capacity for learning science and art had increased through the course of the unit. These all served as pieces of evidence for my analysis and reflection.

Research Site and Participants

My research took place at “Lion” Community School, where I had been employed as a classroom teacher for 6 years. Our student population of over 350 learners is spread across grades Kindergarten to Grade 7. Our students and families represented numerous and diverse cultural, socio-economic, and experiential backgrounds. As a Community School, our outreach coordinators connect with our families through many initiatives that seek to create a welcoming environment, including parenting classes and seminars on children’s mental health, conversation circles for parents/guardians who are learning English, senior appreciation luncheons, and after- school activities (e.g. pottery classes, extracurricular science, robotics, and coding clubs, sports teams). During this time, our school had begun opening our doors to families again as restrictions related to COVID-19 were reduced. During this transitional time period, I observed that our parent/guardian community became increasingly active, involved, and engaged in school events and their children’s’ learning. It is important to note that several classroom teachers had recently completed their research projects through SFU at the time of my study, so many of the students and their families had been familiarized with the intentions and ethics of teachers collecting data within the classroom.

Each classroom has its own unique context, and it is important for me to describe where and when this research took place as it influenced how I designed, collected, and analyzed my data. My research project was conducted within my own Grade 6/7 classroom and the Grade 6/7 classroom of my teaching partner during the months of May and June. Our student community was, in many ways, very reflective of our school, with a diverse group of students from many different backgrounds. Within our two classrooms, we had 56 students in total, with 10 students with various ministry designations (including students who were on the autism spectrum, had moderate to severe behavioural needs, had chronic health concerns, and were diagnosed with learning disabilities) and over 20 students who received weekly English language acquisition support (ELL). Of those students, 40 met the inclusion criteria for this study. These students provided their assent and parents/guardians provided their consent to participate in my research (see **Appendix A** and **Appendix B**). I outlined all of these procedures and practices in order to obtain approval from Ethics on both a university and school-district level.

When designing this AR, I always kept my students (as individuals and as a group) at the front of my mind. How might this study impact their understanding of science and art? Could this research influence how confident they feel in these subject areas? Would collecting their data increase their feelings of uncertainty or anxiety? How could I use what I learned from this research to better support them, and my future students? One aspect of my students that I was very aware of throughout the course of this research was overall levels of anxiety that could manifest in a variety of ways. Many students demonstrated behaviours as a result of feelings of anxious, including word avoidance, burnout or reduced resilience, negative self-talk, etc. During reflective and self-assessment activities, many of my students would often struggle with identifying their own successes and had challenges sharing aspects of themselves that they felt confident in. Additionally, the majority of my students expressed concerns around external stressors that 'followed them' into our classrooms, such as complex home lives, food insecurity, worries around COVID-19, and uncertainty about transitioning into high school. However, despite all of this, my students still arrived at school each day with enthusiasm, energy, and curiosity. They still wanted to spend time discussing their ideas and opinions, connecting with each other and with their teachers. They still wanted to learn! I wanted to use my research to present these students with new opportunities to explore topics of interest, build their confidence, examine the world around them, reflect on their successes, and have fun!

Maintaining the trust and the relationships that I had built with my students, and with their families, was of the utmost priority to me. My research required me to simultaneously balance my role as a classroom teacher with my job as a researcher, which meant that I had to be very mindful and self-reflective as I proceeded with this task. It was very important to have open and honest communication with my students and their families in order to lessen any possible mistrust that some students and families may have felt regarding data collection, privacy, etc. I was very mindful to take necessary steps to protect student privacy, including using pseudonyms thorough the course of this research paper.

My goal was to keep our learning community informed every step of the way. Some methods I chose included using detailed consent and assent forms (for parents/guardians and for students respectively), providing parents/guardians with optional in-person conversations, creating an age-appropriate PowerPoint for students explaining what participation in my research would entail, and outlining clear explanations for both students and parents/guardians on how their identities would be protected and how their data would be used. However, I was very aware that many folks would still have feelings of uncertainty and mistrust around research practices, so I strove to be as reflective, respectful, and responsive as possible. Additionally, because the activities upon which I based my research took place during classroom instructional time, it was paramount that I communicated to students and families that participation in my data collection/documentation was optional. Any students who did not provide assent for participation in my research still learned alongside their peers and completed the same assignments and activities and would not be removed from the classroom or miss out on any science experiments or art projects. However, those students who were not participating in my research did not have their responses collected and/or their data used in my findings. For example, all students participated in each lesson and reflected upon their learning, but only those students who were part of the research had their reflections de-identified and collected for my research. I communicated to the parents, guardians, and families of my students that their choice to participate/not participate in the research would not impact my view of each child's academic success. Report card comments, scales, and assessment were entirely separate from research-related surveys, reflections, and/or discussions. This way, students and their families could rest assured that participation (or non-participation) would not impact their Term three report cards in either a positive or negative way.

Findings and Discussion

Prior Experience and Learning Preferences

Prior to beginning the integrated unit, I asked students to reflect upon what their ideal science project would be. If they were given the power to design a project for science, what would they include? I explained that they could either draw or describe an activity they would like to do, a method of learning (e.g. group projects, researching), or a lesson they have already done but really enjoyed. As I examined their written responses and reflected upon our discussions, there were several common themes that emerged. Most notably, many students demonstrated a keen interest and preference for chemistry-based activities. Five students wrote about experiments that we had completed as a class earlier in the year, including creating elephant toothpaste, mixing root beer floats, and combining Mentos and soda. Another 14 students explained that, in their opinion, the best way to learn about science was through hands-on experiments. Making a volcano using baking soda and vinegar was particularly common in these responses, with nine students writing that they would like to do this activity in class some day. Another three students were adamant that the best way for them to learn science as through “explosions” of some kind.

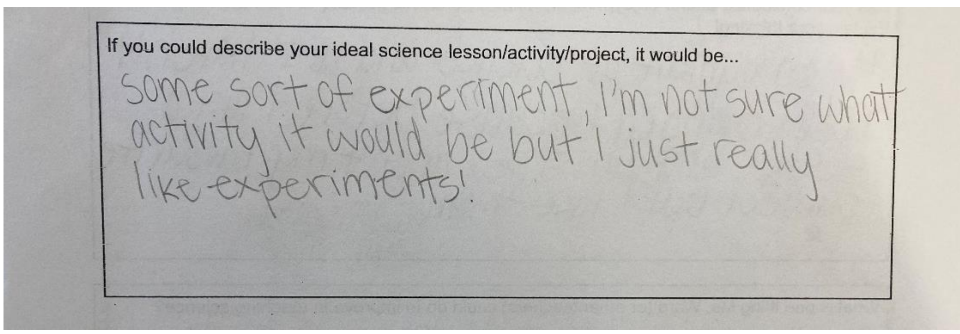


Figure 2. **Student V2’s learning preferences reflection (May 2023)**

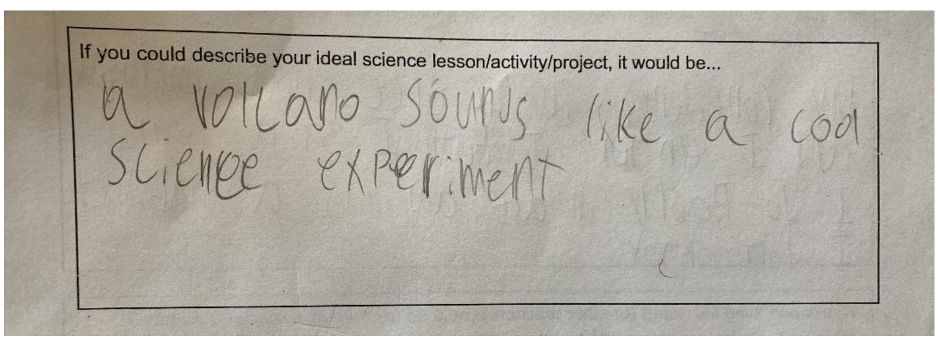


Figure 3. **Student J2’s learning preferences reflection (May 2023)**

Food-based science lessons were another common theme amongst the responses, with numerous students explaining (verbally or through writing) that they enjoyed experiments where the end result involved eating or drinking. Student C2 exasperatedly reflected that, “usually, Ms. Ward has rules about us not eating any chemicals or science stuff. But then she did the root beer float experiment, and we were supposed to drink it! So that was the best experiment. Can we do something about the science of candy next?” Unsurprisingly, sugar seemed to be an effective motivator in learning Science concepts!

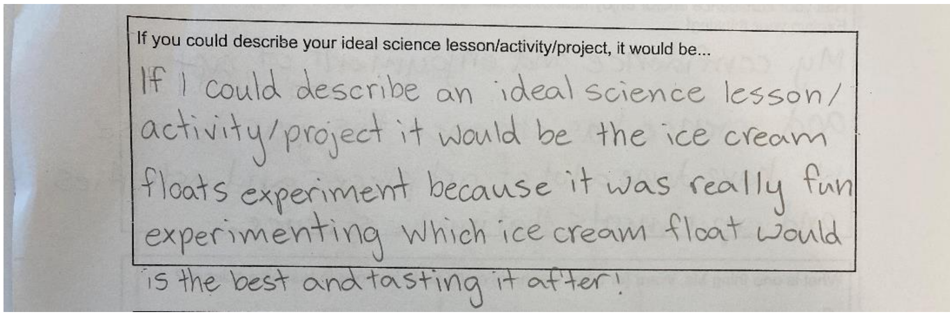

If you could describe your ideal science lesson/activity/project, it would be...
If I could describe an ideal science lesson/activity/project it would be the ice cream floats experiment because it was really fun experimenting which ice cream float would is the best and tasting it after!

Figure 4. Student K1's learning preferences reflection (May 2023)

I wondered if my approach to science lessons prior to my research had some influence on my students' responses. While we had completed a variety of science activities, including research projects on chosen topics, ADST building challenges that demonstrated physics concepts, and lessons exploring biology such as plant dissections, the activities involving chemical reactions seemed to be most prominent in my students' memories. This fascination with chemistry was clearly also reflected in our prompted drawing activity, where students had represented their scientists mixing potions or standing over smoking beakers (see **Perceptions of Scientists and Artists: Pre-Unit**). I was interested to see how students would express their ideal art activity, and to see if there would be connections between how they wanted to learn about art and how they pictured an artist in their directed drawing (see **Perceptions of Scientists and Artists: Pre-Unit**).

After providing students with their prompt, "if you could describe your idea art lesson/activity/project, it would be…", I examined their responses. This time, the class had unknowingly almost come to a consensus on how they wanted to learn about art—of the thirty responses, an astonishing twenty-seven described using paints. While a few other forms of art were mentioned (Student T2 voicing that they had a desire to write songs, student J2 reflecting that they would love to sculpt something), clearly my students were united in their desire to explore and express themselves through paint. Where many students had drawn upon previous in-class lessons and activities for their science reflection, their collective interest in painting was not based on recent experiences. We had not explored painting as an art form at this point in the year, beyond students simply using paint when completing a math fair project. Their artist reflective activity, however, also clearly represented this enthusiasm for painting, with the majority of students drawing their artist in the act of painting, holding paints, or being splattered with paint (see **Figure 10, Figure 11, Figure 12**). I was beyond thrilled with this discovery, as I had pre-planned my integrated science and art unit around the study of pigments, paints, and colours; with my students' expressed interests in mind, I decided to alter my unit slightly to delve deeper into the history, sociology, chemistry, and artistic importance of paint.

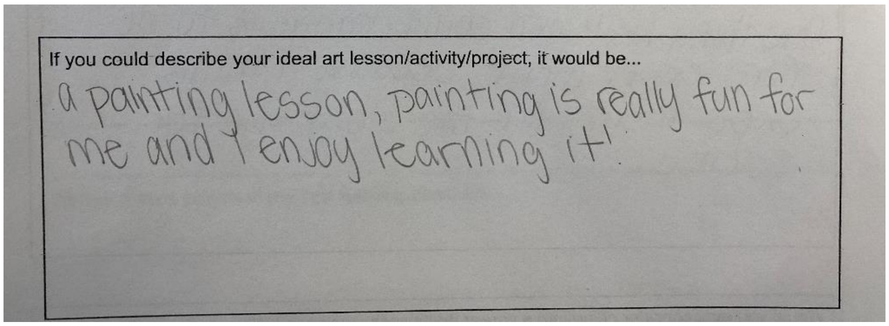

If you could describe your ideal art lesson/activity/project, it would be...
a painting lesson, painting is really fun for me and I enjoy learning it!

Figure 5. Student K1's learning preferences reflection (May 2023)

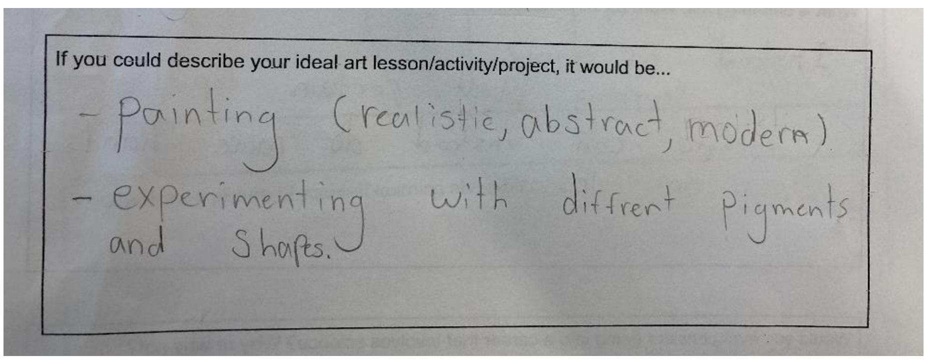

If you could describe your ideal art lesson/activity/project, it would be...
- Painting (realistic, abstract, modern)
- experimenting with diffrent Pigments and Shapes.

Figure 6. Student J2's learning preferences reflection (May 2023)

A few days after completing our learning preference sheets, I informed students that we would be embarking on our next unit of study, which would involve us learning all about colours and pigments. I explained that we would not be having separate science and art lessons, but instead lessons that combined the two subjects. At first, some students were skeptical, with student T1 blurting, "but I'm so bad at drawing! My science mark is going to tank!". I asked students to chat at their table groups about their initial feelings about learning science and art together. The energy was high, with most students expressing either cautious optimism, enthusiasm, or (in the case of a few students) frustration. I asked students to write their initial thoughts and feelings onto a sticky note, providing them with the prompting question "should science and art be taught together? Explain your thoughts". Overwhelmingly, most of my students responded that they were unsure, with fifteen of the twenty-three responses stating either "I don't know" or "maybe".

Student T1 continued to demonstrate exasperation at this idea, writing “no, because science is ugly”. I wondered if, through the course of this unit, my students would change their minds about science and art, and if they would be engaged and enthusiastic as we learned and explored concepts together. Most of all, I wondered if their reflections would reflect any shifts in their confidence in these subject areas and their self-perception.

The integrated science and art unit took place over the course of three weeks, with lessons and activities occurring three or four times weekly; this intensive schedule was in part due to time constraints and in part to keep students frequently and actively engaging with concepts so that their ideas would be fresh in their minds. Throughout the course of the unit there were many interesting learning moments, but one lesson stood out as being particularly meaningful in the context of my research. After exploring the history of several hues (including examining historical and contemporary uses of blue and purple), Student C2 wondered aloud, “has anyone invented new colours recently?”. In order to explore this question, I turned to several products created by artist Stuart Semple and his company Culture Hustle: two paints titled “the world’s pinkest pink” and “black 2.0”. Expanding on our previous discussion of how colours were invented, I showed an interview with Stuart Semple where he discussed how he created the “world’s pinkest pink paint”. The class had many questions and reacted audibly when the paint was shown on screen (gasping, saying “whoa!”). Student C2 provided another insightful question, asking, “we’re only seeing the colour through the projector and laptop. What does it look like in real life?”. At this point, I presented the students with the necessary supplies and instructions on how to explore several different varieties of paint: finger paint, watercolour paint, acrylic paint, and Culture Hustle branded paint. We discussed the price points and the ingredients in each of the paints, and then students were prompted to explore by creating swatches and notes in their science journals (see **Appendix K**). I asked students to consider the experience of painting with each type of paint: which paint seemed the opaquest? What different in tones did they notice between colours? What was the texture of the paints? As I circulated the room, I made note of the visible signs that indicated student engagement was high; every member of our classroom was actively participating, the noise level had increased as students excitedly called out, and each student was in the process of producing a page for their science journal.

Field Journal #1:

Prompting activity: student reactions and responses while exploring "extreme" paints

"How did they make this paint? What chemicals is it made of? Ms. Ward, can you Google it?" -Student C1

"I never really thought about how different the same colour can be before." -Student V1

"What would happen if we painted a 3-D object? Could I paint this pencil and see what happens?" -Student S2

"I wonder how they make this paint and why it's so expensive. Are you paying for the brand?" -Student P2

"This doesn't look exactly like the picture. Ms. Ward, did you get ripped off?" -Student T1

"Could I invent my own colour? Could I name it after myself?" -Student P1

Perceptions of Scientists and Artists: Pre-Unit

As we began exploring an integrated approach to science and art curriculum, I wanted to examine what my students already believed about scientists and artists based on their prior experiences, peer and teacher influences, and media representation. I wondered if these beliefs would change after the completion of this unit, or if their perceptions of scientists and artists would remain the same. My method for this was based on the research compiled by Miller, Nolla, Eagly, & Uttal, (2018) wherein students were asked to draw what a scientist looks like based on the image in their minds. I was able to use these drawings to examine what my students' schemas and pre-conceived notions about scientists were, both as individuals and as a group. To begin, students were given a reflection sheet (see **Appendix F**) and were prompted to include as many details as possible. I explained that their drawing should reflect whatever first popped into their heads, and to not overthink or question what they initially imagined. Within seconds, almost half of the students began drawing on their papers. For those students who had not yet begun, I invited them to close their eyes and practice visualizing. After a few moments, Student D1 asked if they could draw "a real scientist" or if their drawing had to be "made up". Student P1 questioned if they could “draw a character that’s a scientist” from a television show or movie. I explained to the class that whatever (or whoever) they pictured as a scientist was acceptable, and there were no wrong or right answers for this activity. This seemed to reduce some of the discomfort and confusion, and every student was now sketching their scientists on the provided sheet (with a small group of students receiving some additional prompting, scribing, and support from our classroom EAs).

This activity allowed me to identify possible gaps in how students perceive what scientists look like, what examples of scientists they have been exposed to, and who can become a scientist. We followed our drawing time with a class-wide discussion, where we explored what observations we could make about our drawings. For example, I asked students consider: What gender and race are most of our scientists? How are they dressed? What age are they? What adjectives did we use to describe them? When we examined our brainstorming sheets as a class, several interesting trends emerged.

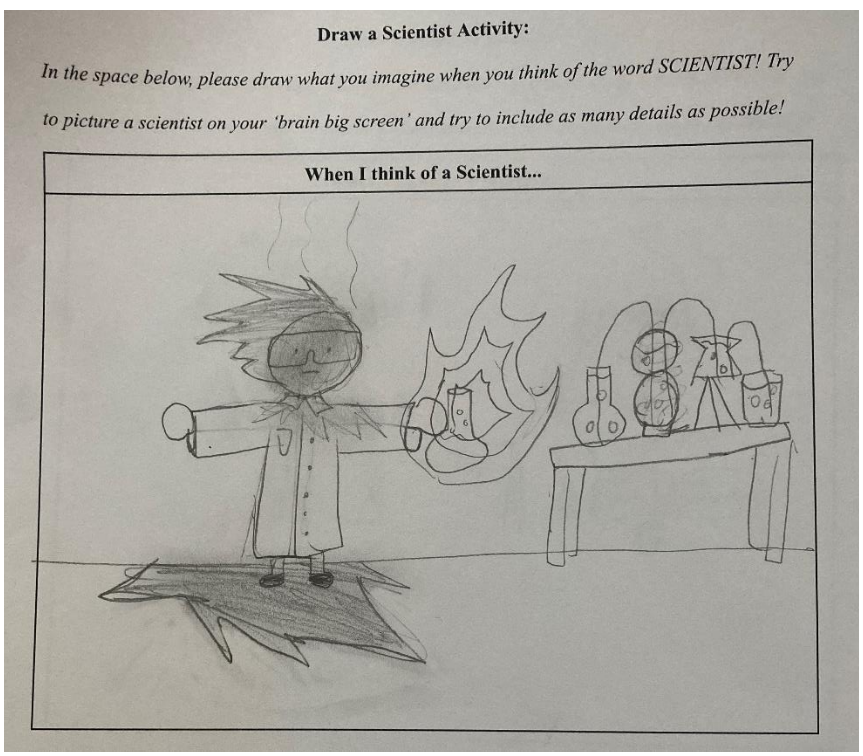


Figure 7. Student C’s scientist brainstorm (May 2023)

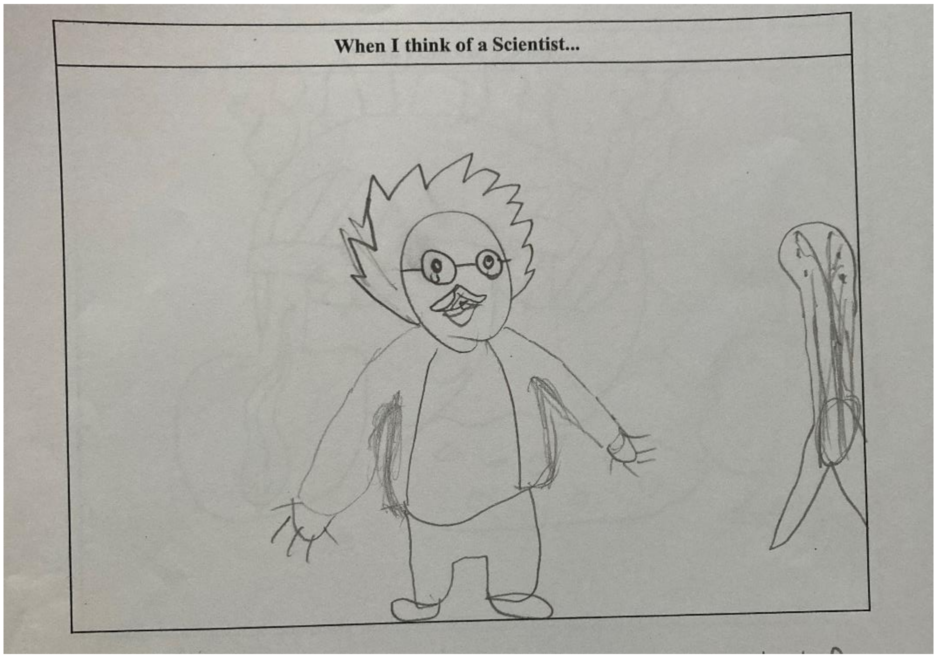


Figure 8. **Student G1's scientist brainstorm (May 2023)**

Upon inspection, the first aspect of their brainstorms that I noticed was the striking physical similarities between the scientists; of the forty brainstorming sheets I received, an astounding thirty of them portrayed scientists as men, most frequently older men with glasses and disheveled hair. As Student D2 shared in their reflection, it seemed that many students imagined scientists as having "crazy hair, white-looking doctor outfits [lab coats], glasses with think lenses, a nerdy look". Student A1 verbally added on to this idea by saying they always imagined scientists as being "old and kind of wrinkly" because it "takes so long to finish school for scientists". Only three students drew scientists that were identified as female (see **Figure 9** for an example), while the remainder of the responses did not specify the gender of their scientists. Many students also seemed to draw upon scientists that they had seen in television, movies, or had learned about in school. For example, over fifteen students referred to Albert Einstein as their visualization of a scientist, and ten mentioned Bill Nye in their reflections; even those students who did not explicitly refer to Einstein and Nye enthusiastically agreed when other students mentioned them. When prompted about what race the scientists in our reflections were, many students paused and seemed to consider before answering.

As mentioned in the Research Site and Participants section, my classroom community is very diverse in terms of the cultures and racial backgrounds of my students, and I was interested to see if our representations of scientists and artists reflected that diversity. Finally, one student spoke up. Student C1 (who is of Korean heritage) said tentatively, “well, I guess that my scientist is probably White, because unless someone goes out of their way to make a character Asian or Black, they’re usually White”. Numerous students nodded in agreement, with several echoing Student C1’s sentiments—many of the scientists they had drawn were white by default or were based on a White scientist they had learned about in school or in media. It was also interesting to note that several students mentioned that their initial schema for scientists, their first visualizations, were not always in line with reality. One student stated that “in movies, [scientists] have crazy hair. They’re always so smart but so crazy”. Another student reflected that they always thought of “Rick, from that show *Rick and Morty*, even though I don’t watch it. He is insane, giddy, dishevelled, and crazy. But in real-life, I think they are serious, curious, smart, and persistent”.

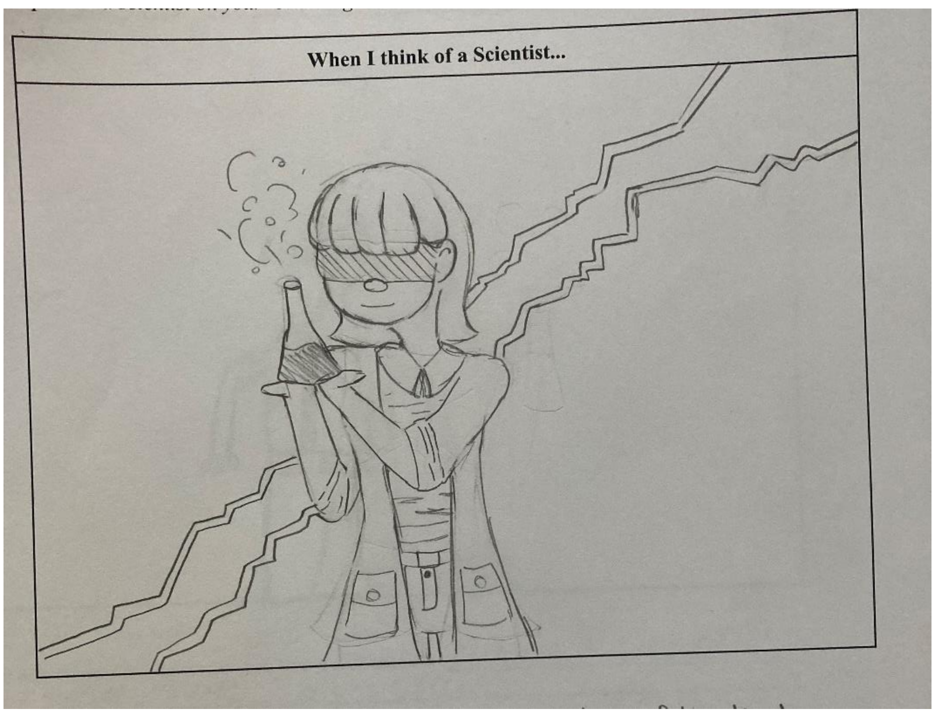


Figure 9. Student V1’s scientist brainstorm (May 2023)

Field Journal #2:

Prompting question: "What are some adjectives you would use to describe a scientist?"

"Very smart, very good at math." -Student R2

"Smart, hard-working, efficient, helpful, rich." -Student A1

"I'm not sure… some person who is really smart." -Student D1

"Smart, an expert, and a hero. I think they get to make potions all day!" -Student J1

"They have to pass university, they're smart (most of the time), and they are important to humanity." -Student P1

"Really smart! Logic over belief. Never gives up." -Student C2

"They mix chemicals. They make explosions." -Student R2

"Old and wrinkly. Smart. Never gives up." -Student V1

"Really cool!" -Student S2

"Nerdy. Maybe like a professor? They have to be smart and hard-working!" -Student E2

"World changing and important. They are powerful." -Student T1

"Dangerous, like a mad scientist!" -Student G2

"Smart. An inventor. Helpful. Discoverers of stuff." -Student K2

"Outgoing. Helpful. Genius. They are like detective discoverers." -Student J2

"Interested in how things work, so curious, and they like learning." -Student A1

Finally, almost every reflection completed by my students at this time included some aspect of mixing chemicals in a lab, with over twenty students drawing or describing "chemicals", "beakers", "science labs", or "explosions". While other types of science were mentioned sparingly, with two students writing about inventions and one describing coding, it was clear that to most of my students, "scientist" was synonymous with "chemist"!

A few days after our initial discussion, I expanded on this idea by having students draw and describe an artist. We then continued our discussion as a class, exploring what trends we noticed between the drawings and potential reasons behind our preconceived ideas. Here, too, there were many similarities between student responses; in the thirty-five responses I received, over twenty-five students drew their artists engaging in the act of painting, and ten emphasizing that artists, as student C2 explained, “need to wear a beret”. Just like the previous activity on “a scientist”, a famous real-world exemplar emerged for an artist; twenty students mentioned Bob Ross (either verbally or in their written reflection). Gender, however, was much more varied than with our scientist reflection, with fifteen students drawing artists that they identified as female, two students drawing non-binary/gender non-conforming artists, and the remainder portraying their artists as men. The perceived race of our artists was similar to that of our scientists, with the majority of students expressing that the people in their pictures were, as Student T1 said, “probably mostly White, unless you drew… [Jean-Michel] Basquiat”. Where three students reflected that their idea of a scientist is “rich” or “wealthy”, four students stated that they believed artists did not receive compensation for their work. Student A1 mentioned during our reflective discussion that they believed “scientists usually get paid, but art is often a hobby. My parents say you can’t make money as an artist”. Student V2 reflected that most artists are “tired, overworked, underpaid, unappreciated, and underestimated”. Student C1, who proudly identified as an artist even before beginning the research project, stated that “artists are tired…always tired”.

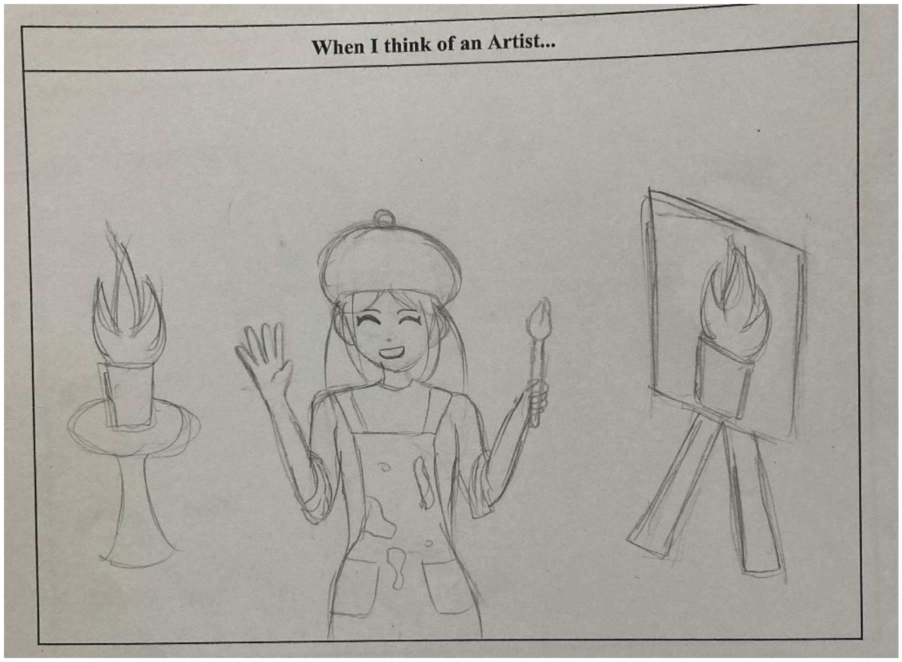


Figure 10. Student V2's artist brainstorm (May 2023)

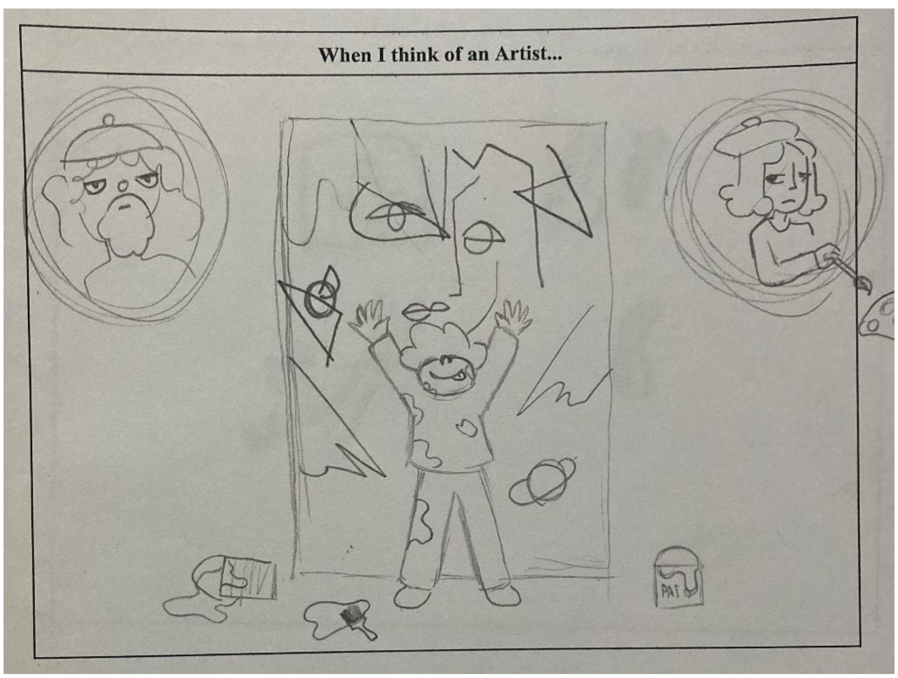


Figure 11. Student P1's artist reflection (May 2023)

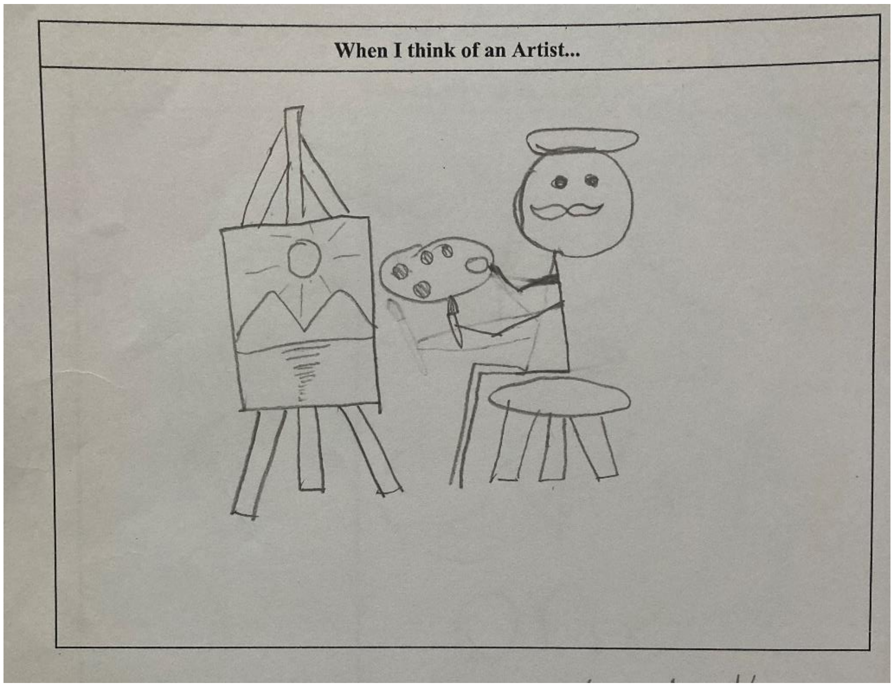


Figure 12. **Student P2's artist brainstorm (May 2023)**

Many students were also much more focused on the emotional well-being (or lack thereof) with artists, with five students responding that artists were usually "sad" or "depressed". Student K1 echoed this sentiment during our class discussion, explaining that "artists have to use their feelings to create their art, or else it doesn't mean anything". The idea of emotional state, beyond descriptions of being "crazy", was not reflected in our discussions and drawings of scientists.

Field Journal #3:

Prompting question: "What are some adjectives you would use to describe an artist?"

"Quiet, lonely, sad." -Student A2

"Creative, artistic, imaginative, colourful." -Student M2

"Artistic, creative, patient, and focused." -Student M1

"A limitless imagination." -Student P2

"An artist has to be creative and they have to make art. That's it!" -Student J3

"Cool and creative." -Student M2

"For some reason, I always think they are French. Because of the beret maybe?" -Student S3

"Messy! They must be talented. I think they have natural talent, but they work hard." -Student S2

"They are great at drawing. They are very patient, because when things don't go their way, they just fix it and continue on." -Student V3

It was clear to me that my students already had many ideas (and, potentially, biases) about artists and scientists! We repeated this reflective activity at the end of our integrated unit, where I prompted the students to draw an artist and a scientist again and had them informally compare their illustrations from the beginning of the unit and reflect upon if their thinking had changed.

Perceptions of Scientists and Artists: Post-Unit

When I initially examined my students' post-unit reflections, there did not seem to be a perceivable change in how students depicted scientists and artists in their drawings; in fact, had I not labelled the sheets with "before" and "after", I might not have been able to tell the difference between the two. The reflective sheets were filled with many of the same characteristics I had examined in the pre-unit responses. For example, the scientists were still predominantly engaged in chemistry, with twenty students continuing to base their scientists off either the "mad scientist" trope or referring to Albert Einstein. Many of the artists in their post-reflections were still shown expressing themselves through painting, with more than half of students referring to/drawing Bob Ross. My first thought was that the integrated unit had done nothing to shift students' perceptions of who could be a scientist or an artist. It seemed that altering students' established viewpoints--their schemas that had already been developed--was more challenging than I initially thought. However, as I examined my students' responses more closely and critically, particularly when looking at the language students used to describe their scientists and artists, several notable differences between pre and post-unit did emerge.

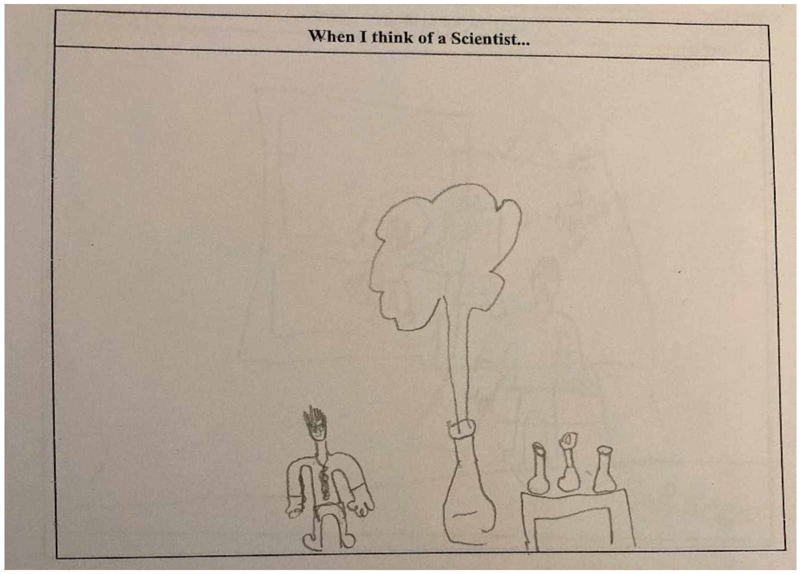


Figure 13. Student R2's scientist reflection post-unit (June 2023)

During this post-unit reflection, more students depicted their scientists as being female (six in total). Several students also elected to draw me as a scientist this time, with student P1 explaining that "Ms. Ward is our school scientist, so I drew her doing a crazy science experiment" (see **Figure 15**). An unforeseen side-effect from this unit was that many students had begun to label me as a scientist, with Student N2 writing that "I don't think I'm a scientist yet, but I think that Ms. Ward is… I have never learned science from a real scientist before". Student T4 reflected that, "since Ms. Ward is a scientist, and she teaches us, so that makes us her mini-scientists!" As someone with a degree in Arts and Education, with no formal training in the Sciences, I was surprised (and flattered) that many students considered me to be a "real" scientist! Ten students chose to draw scientists engaging in experiments we had completed in class (both before and during the AR), and two students drew themselves as scientists participating in these experiments.

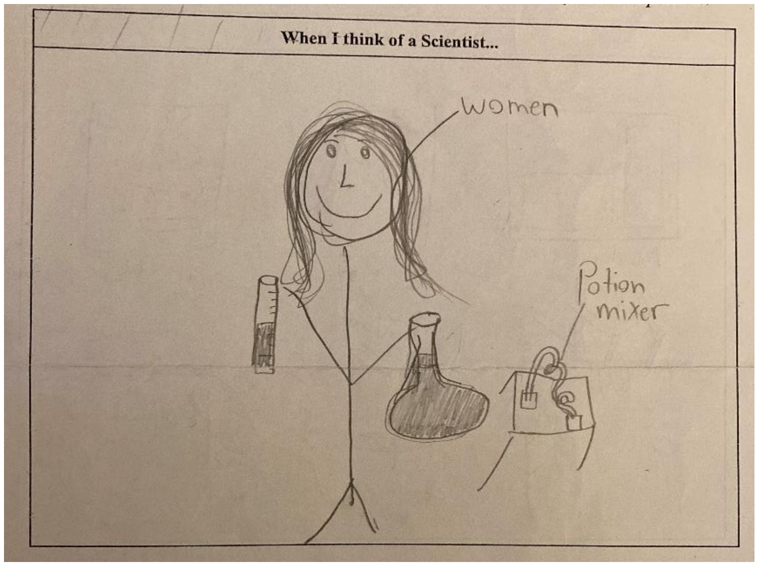


Figure 14. **Student P2's scientist brainstorm post-unit (June 2023)**

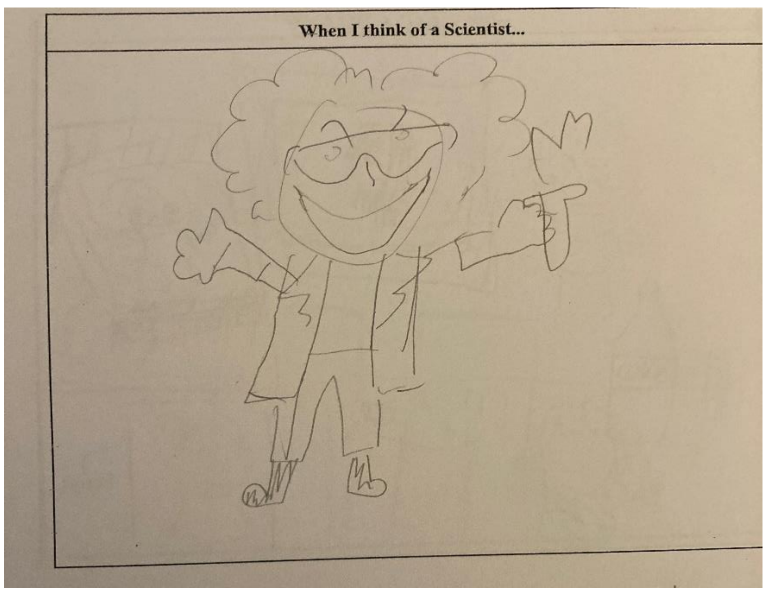


Figure 15. **Student P1's scientist brainstorm post-unit (June 2023)**

Field Journal #4:

Prompting question: "What are some adjectives you would use to describe a scientist?"

"Full of wisdom." -Student N2

“Scientists help us to understand everything in our world by doing observations and testing theories.” -Student V1

“They should get more credit for what they do!” -Student P1

“A scientist is anyone who works with chemicals, experiments, human behaviours… there are many different types of scientists.” -Student P2

“People who are able to save the world… or destroy it.” -Student J2

“Thinking outside the box.” -Student M2

“Anyone who does science is a scientist.” -Student R1

“I think scientists need to be careful because they are so powerful.” -Student G2

“Creative and cool. They need to use their brains in different ways.” -Student S2

While the images may have remained fairly similar, the ways that students were describing their scientists (through discussion and through writing) had changed drastically. I noticed that many more students were focusing on what scientists *do* versus what scientists *are*—despite being provided with the same prompt, many students had shifted their language to talk about what tasks or roles scientists could take on, rather than using only adjectives to describe character traits of their scientists. I observed a similar shift in the language students chose to use when describing their artists in their post-unit reflections as well.

Field Journal #5:

Prompting question: “What are some adjectives you would use to describe an artist?”

“Are very creative but must be strict with themselves. You need to stay organized because you are your own boss.” -Student D1

“Anyone who does art. You don’t have to get paid.” -Student J2

“To me, I usually think of painters, but I know there are many different types of artists.” -Student V1

“People who work with colours, shapes, objects, pencils, pigments, or any other art utensils.” -Student P2

“Artists are admirable for their creations, but as people I end up REALLY loving them or REALLY hating them, just their personalities I don’t know why.” -Student I1

“They help us see the world in a different way, I guess.” -Student U1

“They have extreme patience. I am not patient.” -Student A1

Once again, many students were much more descriptive and verbose in their reflections post-unit, despite their drawings remaining relatively unchanged. I noticed that where previously, most students had provided a list of adjectives, there was much more variety in the responses I received.

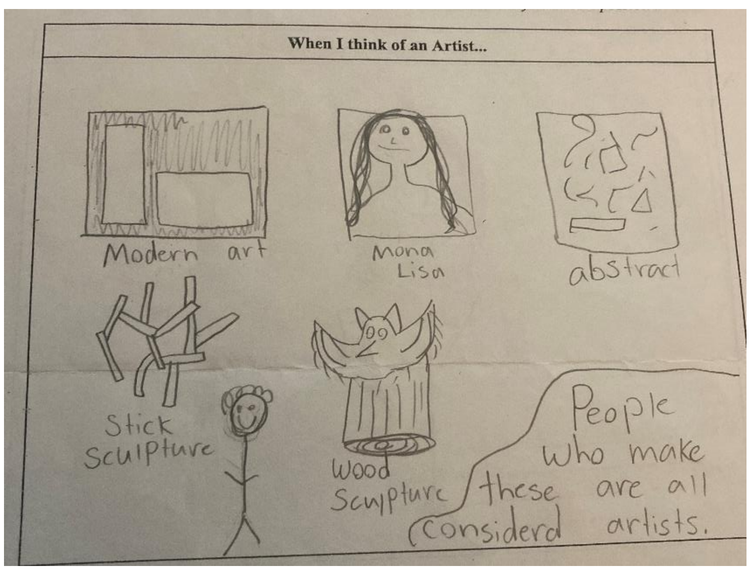


Figure 16. Student P2’s artist brainstorm post-unit (June 2023)

Surprisingly, ten students did not draw a scientist or artist at all, instead choosing to draw their supplies (e.g. beakers and test tubes, canvases and paint palettes). Additionally, two students replaced their human representations of scientists with cats wearing lab goggles and painting smocks. Perhaps this was an unintended side-effect of the class critically examining their previous drawings of scientists and artists; did these students no longer imagine the person completing science and art activities, but the activities in and of themselves?

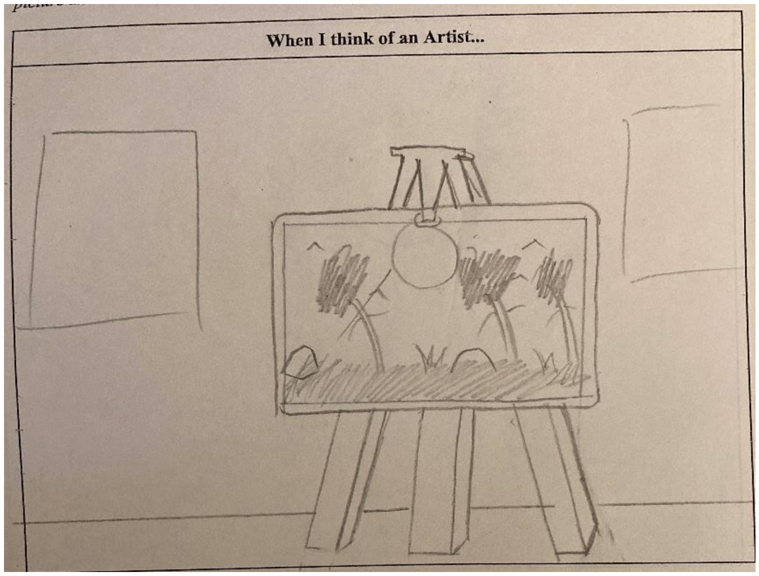


Figure 17. Student J1's artist brainstorm post-unit (June 2023)

Descriptive Language: Pre and Post-Unit

After examining my students' directed drawings, I began broadening my analysis to include de-identified science journal entries, student responses and reflections, and notes from my field journal during class discussions and experiments. While I was interested to see if there were any common themes amongst the data, I was mindful to take an inductive approach throughout this process. With so much data, from such a wide array of sources, my mindset was to examine trends that emerged and to document my most meaningful observations without having a pre-determined outcome in mind. After collecting student work samples and de-identifying them, I created a spreadsheet that documented each time a student used an adjective when describing a scientist (both pre-unit and post-unit). From there, I was able to represent the most commonly used words, which can be found in the tables below:

Table 1. **Ten most common adjectives used to describe scientists pre-unit *(left)* and post-unit *(right)***

Adjective	Occurrences	Percentage
Smart	32	24.06
Crazy	10	7.52
Nerdy	6	4.51
Creative	5	3.76
Discoverer	4	3.01
Curious	4	3.01
Helpful	4	3.01
Careful	3	2.26
Persistent	3	2.26
Hardworking	3	2.26

Adjective	Occurrences	Percentage
Smart	32	24.43
Creative	10	7.63
Hardworking	7	5.34
Crazy	5	3.82
Intelligent	5	3.82
Cool	4	3.05
Weird	3	2.29
Experimental	3	2.29
Rich	3	2.29
Serious	3	2.29

I received forty student responses for the pre and post-reflections in total, with students being encouraged to use as many adjectives as they wanted. Both before and after teaching the integrated unit, my students described scientists using terms that reflected intellect (“smart” and “intelligent”) as well as terms that fell into the mad-scientist trope (“weird” and “crazy”). When examining their reflective drawings of scientists after completing the unit, many aspects appeared to remain unchanged; the majority of students continued to represent scientists as performing chemistry experiments while wearing lab coats and glasses. Seven students reflected that they still pictured Albert Einstein when they thought of a scientist. It was interesting to see, however, that in the post-unit responses, the use of the term “creative” increased; initially only five mentioned creative before beginning the unit, whereas twice as many students (ten) described scientists as demonstrating this quality after. Another term, “hardworking”, rose from being the tenth most common term in the pre-unit responses to the third most popular term in the post-unit responses, with seven students reflecting that scientists needed to have a strong work ethic.

Using the same methods, I compiled student responses and created a table for adjectives used to describe artists, both before and after completion of the integrated unit:

Table 2. **Ten most common adjectives used to describe artists pre-unit *(left)* and post-unit *(right)***

Adjective	Occurrences	Percentage
creative	23	22.12
artistic	15	14.42
patient	6	5.77
cool	4	3.85
talented	4	3.85
crazy	3	2.88
smart	3	2.88
messy	3	2.88
imaginative	3	2.88
tired	2	1.92

Adjective	Occurrences	Percentage
creative	27	21.43
artistic	14	11.11
talented	7	5.56
smart	6	4.76
patient	5	3.97
quiet	4	3.17
hardworking	4	3.17
weird	3	2.38
cool	3	2.38
unique	3	2.38

"Creative" and "artistic" continued to hold the top spot in both the before and after reflections. However, the most interesting shift between students' before and after reflections here was the inclusion of the word "smart"; previously, adjectives involving intellect ("smart" or "intelligent" or "nerdy") were more commonly used in students' descriptions of scientists. After our integrated unit, however, "smart" became a much more commonly used word, with seven students describing their artists this way. Like their science reflections, the iconography that students used when drawing their artists (e.g. painting, wearing a smock and beret, Bob Ross) was mostly unchanged, with only three students including depictions of musicians or sculptors. With our intense focus on paint and pigment, I was not entirely surprised to see students' perceptions of artists to remain relatively unchanged. The largest shift that I observed when analyzing my data, however, came with examining how confident my students reported feeling in science and art throughout the course of my AR.

Student Confidence and Self-Perception

In order to reflect and record any shifts in their reported confidence in science and art, I asked students to complete a survey before and after the integrated unit (see **Appendix G**) using a pictorial scale, students were asked to communicate how confident they felt in their ability to learn, understand, and communicate science concepts. Students were also prompted, “do you consider yourself a scientist?” and asked to check either “yes” or “no”, though several students drew in a third box that they titled “maybe” or “sometimes”, which I represented as half-of a yes in my data. The results of these student reflections are located below:

Table 3: Student confidence in science reflections pre-unit (May 2023)

Average self-reported confidence with learning science (scale of 1-5)	What percent of students reported that they consider themselves a scientist
3.69	46.05%

Table 4: Student confidence in science reflections post-unit (June 2023)

Average self-reported confidence with learning science (scale of 1-5)	What percent of students reported that they consider themselves a scientist
3.88	55.61%

While there was only a slight increase in how confident students reflected feeling (shifting from approximately 3.7 to approximately 3.9 on a five-point scale), the most prominent difference seemed to be in how many students consider themselves to be a scientist. Only 46% of students shared that they believed themselves to be scientists at the beginning of the unit. I had prompted students to explain and explore the reasoning behind their answers using words or pictures or to verbally express their ideas to me. Student J2 explained that they were not a scientist because they “haven’t finished university yet”. Ten students expressed that they did not feel science was a subject they were particularly skilled in. Student T2 reflected that they “never got great marks in science”, so they could not be a scientist. Some students, however, did report that they believed themselves to be scientists, with the vast majority explaining that since we did science experiments in class, they would consider themselves to be scientists.

After completing the integrated unit, however, more students (almost 56%) expressed that they would now consider themselves scientists. Many students seemed to make the connection that to be a scientist, you had to be actively engaging in science; thus, our focus on science over the month had made them into, as Student A1 said, “amateur scientists”. During our discussion, Student P1 and student J3 expressed that they now believed that “anyone can be a scientist” and that “everyone is a scientist as long as they work hard and are curious”. One student even drew an image of themselves completing a science experiment in their post-unit reflective drawing activity, which meant that they now imagined themselves when they pictured a scientist (see **Figure 18**).

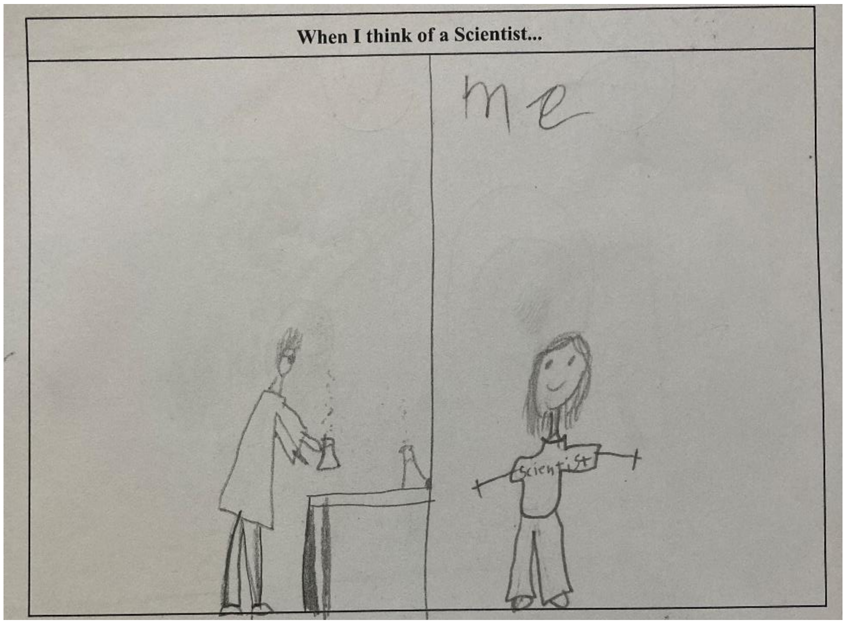


Figure 18. Student B1’s scientist brainstorm post-unit (June 2023)

Students were also asked to reflect upon how confident they felt learning art concepts and expressing themselves through art, both before and after the unit, and if they considered themselves to be artists. A similar shift appeared after analyzing the data:

Table 5: Student confidence in art reflections pre-unit (May 2023)

Average self-reported confidence with learning art (scale of 1-5)	What percent of students reported that they consider themselves an artist
3.64	44.19%

Table 6: Student confidence in art reflections post-unit (June 2023)

Average self-reported confidence with learning art (scale of 1-5)	What percent of students reported that they consider themselves an artist
3.74	54.55%

Students communicated that they did not feel a profound increase in their confidence levels in the arts, with the average shifting from around 3.6 to 3.7 out of five. However, there was a measurable increase in how many students reported that they considered themselves artists, with an increase of almost 10%. Even Student T1, who had previously expressed that they believed themselves to be "bad" at art, now included themselves in their post-unit reflective drawing of an artist, explaining that when they think of an artist, they picture "me", "yo[u]", and "everyone".

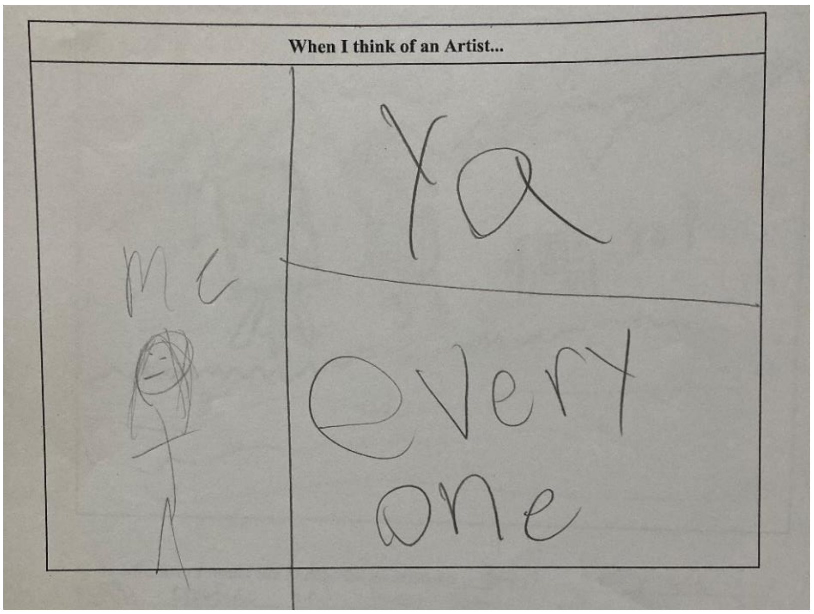


Figure 19. Student T1's artist reflection post-unit (June 2023)

Clearly, my data was showing that there had been some shifts in students' understandings of scientists and artists. In order to answer my research question, I knew that I needed to examine two aspects of my data more thoughtfully: how students responded and reflected upon their own confidence levels in art and science, and whether they identified themselves with the term "scientist" and "artist". According to the results of my data, it was clear that students had increased their confidence in both subject areas very slightly, but I knew that I wanted to collect further information from students to examine the "story" behind the numbers. To do this, I asked students to describe (using words or pictures) if their confidence in science and art had changed this year. Of the thirty-five responses, twenty-four students responded that they felt more confident in at least one of these subject areas than they had in previous years. Fifteen students also reflected that they "enjoyed" or "liked" these subjects more than before, with student C2 stating that this unit “felt like real lessons, not like you’d dumbed it down for us because we’re kids”. Five students expressed that the methods I had used to teach them science and art made them feel “happier” and had “increased” how much they liked these subjects, with Student I1 reflecting that science and art were “more enjoyable than [they] originally thought”.

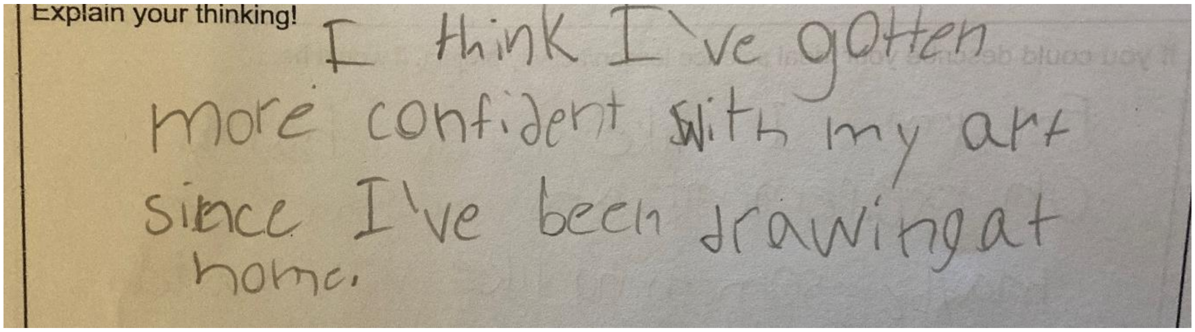


Figure 20. **Student M1’s response to the prompting question (June 2023)**

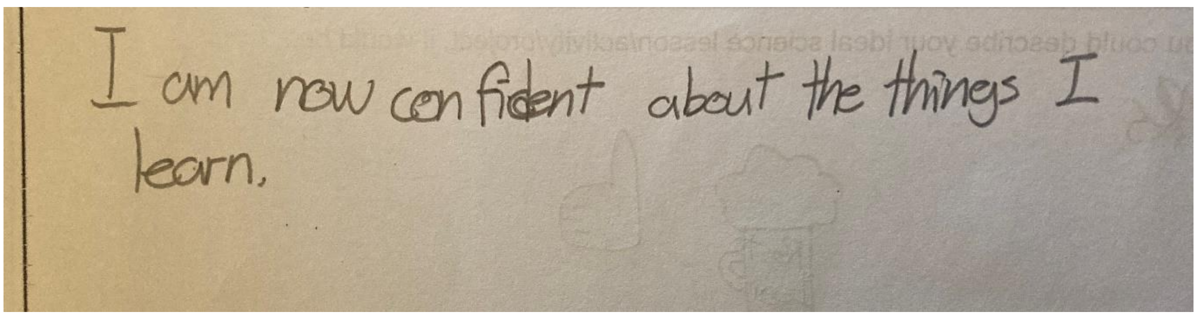


Figure 21. **Student D2’s response to the prompting question (June 2023)**

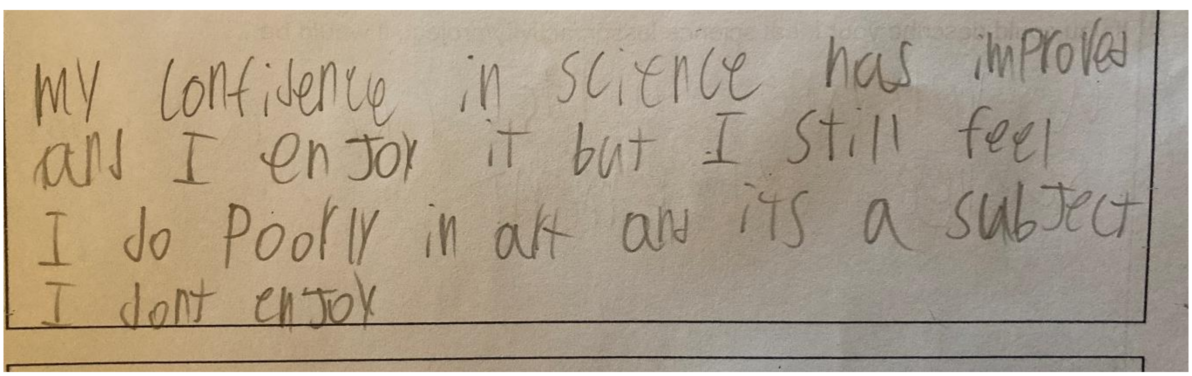


Figure 22. **Student R2’s response to the prompting question (June 2023)**

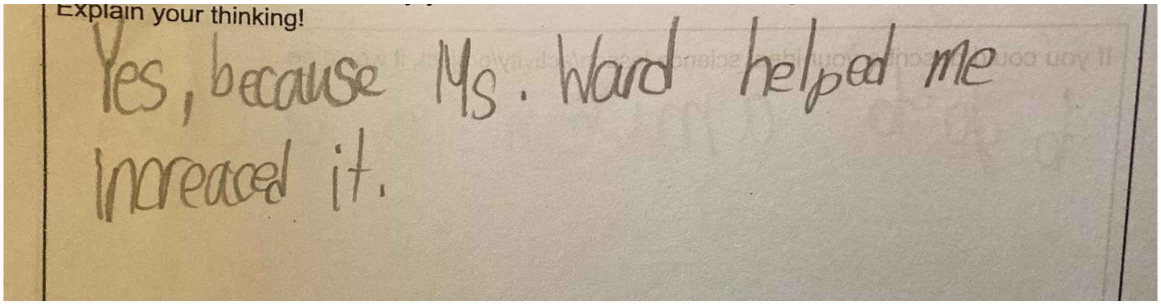


Figure 23. Student K1's response to the prompting question (June 2023)

While many students still did not feel confident in labelling themselves as either a scientist or an artist by the unit's end, I observed that there were now many more instances of students expressing that they could be a scientist or an artist in the future:

Field Journal #6:

Prompting question (post-unit): Would you consider yourself a scientist? Why or why not?

"I think that I should at least pass high school science first, then I can be a scientist with confidence!" -Student J3

"I consider myself to be an amateur scientist right now." -Student A1

"Yes, because I am learning science now all the time. I guess that I am a student scientist." -Student V1

"Not yet, but maybe someday if I have the right motivation." -Student P1

"Legally, no. I don't have a degree yet. But I'm an in-school scientist!" -Student K2

"In Ms. Ward's terms of being a scientist, I would consider myself to be a scientist. During science, I have lots of ideas to share and I am really engaged. The experiments are enjoyable for me and all of the ideas make sense. Is this what scientists do all day in the real world?" -Student T4

Prompting question (post-unit): Would you consider yourself an artist? Why or why not?

"I would not consider myself an artist. While it is an interesting subject, I don't think I would do it in the future. Personally, I think art is for people who don't like studying and I am very good at studying (sorry if I hurt your feelings, Ms. Ward)" -Student A2

"I consider myself an artist because I do art projects at school and crafts at home. Maybe I will do more art in the future as a hobby or a job?" -Student T4

"I think I'm an artist because I enjoy art and I never give up while making it. I learned that to be an artist, you don't have to be perfect." -Student D2

"Not yet, because I'm just a kid. I don't have any job yet. But I do like to play music and paint, so maybe someday." -Student T3

"While I'm not good at making art, I learned I am really good at analyzing other people's art. Maybe I can do that in the future." -Student P2

"No, I'm still bad at art and no one would ever buy my paintings. But maybe I can buy art or collect it someday." -Student G2

"No, not yet. I am very young, and I have never sold a piece of art yet." -Student J4

Conclusion

This research project has challenged me, inspired me, and motivated me to continue investigating all the ways that an integrated science and art curriculum can benefit my teaching practices and pedagogy (and, hopefully, influence how other educators might approach these subjects in the future). My goal throughout this research was to create opportunities for learning that I would have enjoyed as a student, while still being mindful of each student's own unique learning preferences, needs, and skills. While teaching this unit, I witnessed students from a variety of backgrounds participate fully in class discussions, engage in hands-on experiments, and thoughtfully complete self-reflections. Students would frequently ask me when our next lesson on science and art would be and would enthusiastically tell me they had "done research" at home about topics we had learned in class or would provide suggestions on future experiments and art activities we could do together. One student even mentioned that they had “already put a chemistry set and painting supplies” on their wish list for the holidays.

The energy in my classroom was consistently high during these research-related activities, and learners from all backgrounds were engaged in the lessons and were motivated to complete the experiments. Student T1, who frequently struggled with written output and frequently demonstrated work-avoidant behaviours, served as an indicator that this approach to learning had impacted their confidence and self-perception. Where Student T1 was initially very vocal about being bad at art and was very negative about their capacity to learn new things, by the end of the unit they had expressed that they felt their abilities had improved because “we can make messes and that’s how I like to learn”. From the perspectives of both a teacher and a researcher, this was one of many examples that I was able to observe, document, and reflect upon in terms of student confidence.

I wonder, were this research to be expanded upon, if there would be a measurable change before and after the unit in how likely students report they are to pursue science, art, or STEAM-based careers in the future? Could this be expanded upon into a career-education unit on different jobs that involve skillsets associated with science and art, thus further expanding upon our relatively limited schemas of “chemist” and “painter”? Would it be beneficial to have students investigate how many careers outside of the STEAM field actually involve aspects of science and art (e.g. the importance of chemistry and artistry for pastry chefs, the necessity of understanding physics and human biology for athletes)? If this research was expanded upon over a longer period of time, I would be fascinated to see if there would be a real, meaningful impact on students feeling empowered to become a scientist or artist in the future. I also think that it would be interesting to explore how this research could be conducted within a different classroom context. I wonder how this research could look different in a Kindergarten classroom, if educators introduced students to an interconnected approach to curriculum within their first year of school? How could an integrated curriculum be explored within a high school environment, where many subjects are separated and taught by different teachers?

In addition to an increase in confidence, I was able to witness numerous moments of meaningful student (and teacher) learning throughout the course of this AR. It was always amazing to see (or experience) a “lightbulb” moment where an idea clicked, or to find the answer to a deep-thinking question that had incited our curiosity. My students knew that my goal with this research was to better understand their perceptions of (and confidence as) scientists and artists. I was committed to reflecting upon my own teaching, analyzing what I could be doing better, and sharing what I had learned with other educators. It was important for me to document, and later amplify, their voices and insights to a larger audience. I have chosen to share a few examples of their suggestions below, the results of an optional reflection where students were asked what advice they would give to educators hoping to teach science in new and innovative ways. 23 students suggested that teachers should consider facilitating “hands-on” activities, doing “experiments”, and/or making connections between the curriculum and the “real-world”:

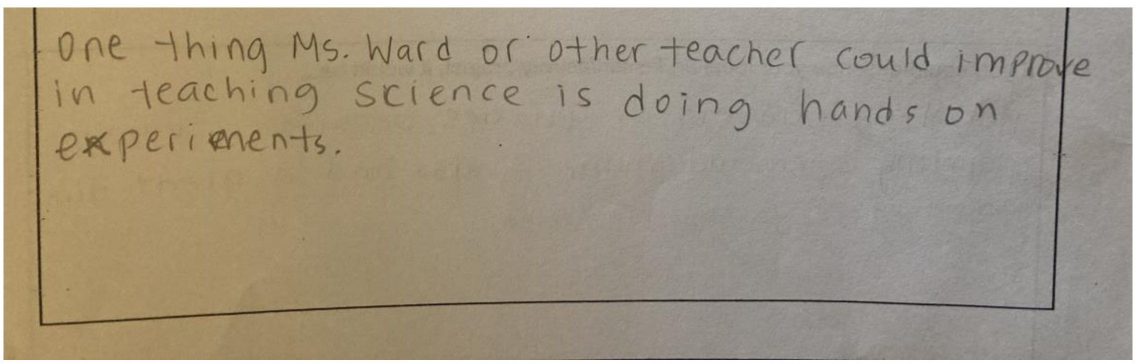


Figure 24. **Student V2’s suggestions for educators (June 2023)**

Additionally, ten students suggested that teachers should prioritize making learning more fun and interesting for their students. As Student C2 voiced during a class discussion, “you can’t learn when you’re falling asleep”.

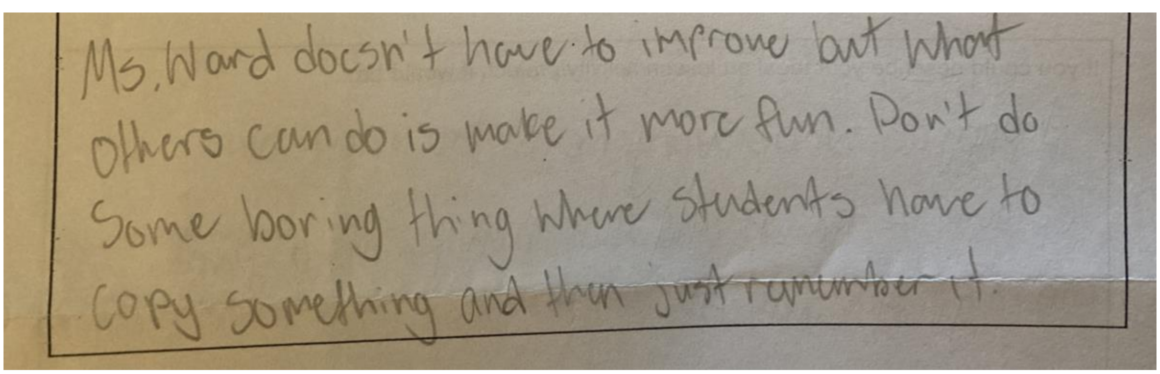


Figure 25. **Student K2’s suggestions for educators (June 2023)**

I understand that science and art are often taught separately due to assessment requirements (such as report card grading systems) and time constraints or scheduling needs. It also takes significant effort to re-examine how we teach these two subjects, and an investment of time to create new lessons, discover (or create) integrated resources, and set up the necessary supplies to run experiments and hands-on activities. This is a lot to expect from educators who are already working diligently and investing so much time and energy into their classrooms, but I truly believe that the benefits of cross-curricular learning are worth exploring further (both on a school level and on a district-wide scale). Changes never happen overnight, and shifting the approach to curriculum from teaching separate subjects to utilizing a more interdisciplinary approach, would likely require significant changes in structure, resource allocation, and policies. However, as Student E2, stated in their reflection, the most important thing that educators can do to help their students be more successful is to "talk less" about what we could be doing and spend more time investigating how we can inspire students to "do more". I believe that this could start on a school-based level through gathering educators together on a Professional Development Day to examine what possible connections can be made between science and art curriculum. I believe brainstorming as a team could allow for teachers to feel they are united in their commitment to an integrated curriculum. Not only would this help to facilitate opportunities for collaboration between educators, but it would benefit a school through determining which staff members have passions for and expertise in science and art. I know that there are many members of staff that could serve as amazing resources and could generate fantastic ideas. As Student T4 stated, "scientists and artists can be everyday people… teachers, students, parents…anyone who wants to learn more".

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Appendix A. Student Assent Form

May 8th, 2023

To our students,

As we have discussed, I am currently studying at Simon Fraser University (SFU) to earn my Masters in Educational Leadership. As both a student and a teacher, I want to find out more about what makes learning engaging and exciting and how I can help every learner feel confident! As part of my studies, I am creating a research project about how I teach science and art. I will be collecting data (information) from our classes that will help me in my own learning journey.

What will we be doing?

During April and May, our classes will be investigating colours and pigments. We will be doing experiments, projects, and lessons that help us to understand the history, chemistry, sociology, etc. of different colours. We will be looking at colours in food, in nature, and in art throughout time. We will be asking lots of questions and doing lots of hands-on experiments. Everyone, regardless of if they want to be part of my research, will be participating in this unit as part of our science and art curriculum.

Will the study help me?

Part of being a researcher means that I don't know what results I will get at the end of my study! I hope that this study will help me learn how to make science and art lessons more interactive and interesting. I may be able to use what we learn together to help support other teachers too!

What does participation in this study mean for me?

If you choose to participate in this research, it means I will include you in my data that I collect. I will be sharing the results of your surveys, examples from your worksheets, and quoting your ideas with the other members of my cohort (class) and my professors through a presentation at SFU and a report that is published through SFU's library. I will not include any identifying information (your name, your age, what class you are in) and will use a pseudonym (e.g. "Student A") if I am quoting you directly. You will not be asked to spend any extra time to participate in this study outside of the work we already do in class & normal homework you have.

Are we being marked on this?

This study will not impact your grades or influence how I write your report card. I will not base how I mark your work based on your choice to participate or not participate in the study. Everyone will still receive their regular report cards with proficiency scales and comments for Term 3.

Do I have to join the study?

You do not have to join this study. Asking for your assent means that I will respect whatever decision you make. You can say yes now and change your mind later and say you want to stop. I will not be disappointed in you if you don't want to be in the study or if you join the study and change your mind later and stop. I have asked your parents/guardians for their permission for you to participate in this research too, but it is important to me that I ask you too.

Who will know whether I participate in the study or not?

I have asked your parent/guardian for their consent (permission) to allow you to take part in my study. However, it is important you also feel empowered to make choices that work best for you. This means that you can decide not to be part of the study, even if your parent/guardian has already said yes. No one except me will know who if you have chosen to take part in the research; no other students or teachers will be told who is or is not participating. I will also use a pseudonym (a fake name) when doing my research to further protect your identity.

What if I have questions?

Before you say yes or no to being in this study, I will answer any questions you have. If you join the study, you can ask questions at any time. We will also discuss as a class what it means to collect data and how researcher can help make our society stronger (if used correctly). You can also talk to me during class or, if you are comfortable, you can e-mail me or write me a note.

If I sign up for the study, can I change my mind?

During my research, if you decide for *any* reason that you do not want to be part of the study anymore, you can revoke (take away) your assent. This means you can 'quit' being part of the study.

There will be no consequences for you. I will not be mad or disappointed! If you do not want to participate any more, just tell me (in person, over e-mail, in a note) before the end of May so I can remove you from the study.

Sincerely,

Ms. Ward

Assent Form (Students)

Please circle or highlight YES or NO:

Has somebody explained this study to you?	Yes / No
Do you understand what the study is about?	Yes / No
Have you asked all the questions you want?	Yes / No
Have you had your questions answered in a way you understand?	Yes / No
Do you understand it's OK to stop at any time?	Yes / No
Do you want to be in the study?	Yes / No

If you want to take part in the study, fill in the information below. If you do not, leave it blank.

I, ____________________________ (your name) have been explained this study and agree (assent) to participate.

By agreeing to be part of this research study:

- ✓ I understand my data will be used in Ms. Ward's research at SFU but she will not use my real name or any private/personal information.
- ✓ I understand that Ms. Ward's teacher (professor) will also be reading and analyzing the results of her study
- ✓ I know my participation in this study will not impact my grades or influence how Ms. Ward sees me as a person
- ✓ I can end my participation in the study at any time by talking to my parents/guardians and/or Ms. Ward

Signature Date (Day/Month/Year)

Ms. Ward will sign this part of the form:

Signature Date (Day/Month/Year)

Appendix B. Parent/Guardian Consent Form

SFU SIMON FRASER UNIVERSITY

May 8th, 2023

Dear parents, guardians, and families of our students,

I am currently working on my Masters in Educational Leadership through Simon Fraser University. This program enables me as an educator to reflect upon my teaching practice, as well as student learning, with the intention of developing my own pedagogy and practice. As part of my studies, I have developed an inquiry project to examine student confidence when engaging with an integrated science and art curriculum. I anticipate that my inquiry will provide me with insights on how to increase students' interest and enthusiasm in science and art, as well as developing the Core-Competencies of critical and creative thinking. It will also help me to reflect on my practice as a professional and improve my teaching.

My inquiry will be based on observations and reflections on my work as a teacher. Over the next two months, I will also collect student work samples, surveys, and self-assessments/reflections. All elements of my inquiry will take place within the context of normal instruction and practice during science and art lessons. Students will not be asked to commit any additional time or complete any extra assignments if they choose to participate in this study. While all students will complete the assignments and activities during science and art, only those students who provide assent (permission) will have their responses included in my report and research. I will be writing the results of this research in the form of a report that will be shared via a public presentation at SFU during the summer of 2023.

In addition to producing my final report and presentation required as part of my M.Ed. program, I may potentially share the findings through Professional Development presentations (Pro-D Days) in both our school district and other districts. Once I complete my M.Ed. degree requires, the data will be kept for no more than five years following the completion of my project.

This letter of notice is part of my ethical responsibilities as a teacher-inquirer. I am giving notice that I will be using student work samples, surveys, and self-assessments/reflections to present to members of my graduate cohort and my instructors to demonstrate my learning. As part of my responsibility as an educator, professionalism around issues of privacy and confidentiality will be ensured. Consistent with the ethical protocols of teacher inquiry, if your child is mentioned in the presentation of my work, an alias (pseudonym) will always be used to respect and protect their privacy.

This inquiry process is *not* intended to assess or evaluate your child in any way but will serve to strengthen my teaching practice. Students' participation in this research will not impact their academic assessment and will not be reflected on their report cards.

Students will be asked to provide their assent to participate in this study. This means that they will be asked to make an informed choice of whether they would like their responses, reflections, and work samples to be included in my research. While I am also asking for parent/guardian consent, I will respect the wishes of the students above all else. Students may withdraw their assent or 'quit' the study at any time without consequences. I would like to reassure you that regardless of my inquiry, my ethical best practices as a teacher will remain the same and the integrity of the relationship I have with your child will not be affected.

Consent Form (below)

Signing this consent form indicates that:

- You are providing consent to your child's participation in this research
- You understand that your child may stop participating in the research at any time without consequence
- By consenting, you do not waive any rights to legal recourse in the event of research-related harm.

Signature of Parent/Guardian   Date (Day/Month/Year)

Name of Student Participating

Please do not hesitate to connect with me via e-mail if you have any questions or concerns. If you would like to talk to my faculty supervisor, you can reach [redacted]. If you have any concerns about your child's rights as a research participant and/or your experiences while participating in this study, please contact the Director of SFU's Office of Research Ethics at [redacted].

Thank you for your consideration.
Sincerely,

Kim Ward

Appendix C. TCPS Certificate of Completion

PANEL ON RESEARCH ETHICS

Navigating the ethics of human research

TCPS 2: CORE 2022

Certificate of Completion

This document certifies that

Kimberly Ward

successfully completed the Course on Research Ethics based on the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2: CORE 2022)

Certificate # 0000834104

26 July, 2022

Appendix D. Ethics Approval Letter

SFU RESEARCH ETHICS

Minimal Risk Approval – Delegated

Study Number: 30001622
Study Title: Cultivating Confidence and Connecting Curriculum: Exploring an Integrated Approach to Science and Art

Approval Date: March 23, 2023
Expiration Date: March 23, 2024
Principal Investigator: Gillian Judson
SFU Position: Faculty
Faculty/Department: Education

Student Lead: Kimberly Ward
SFU Collaborator(s): N/A
Research Personnel: N/A
External Collaborator(s): N/A

Funder: N/A
Funding Title: N/A
Funding Number: N/A

Document(s) Approved in this Application:
Letter for Families (Parent/Guardian Consent Form), version 2 dated March 15, 2023
Assent Form, version 2 dated March 15, 2023
Survey Questions, version 2 dated March 15, 2023
Draw a Scientist and Learning Probes, version 2 dated March 15, 2023

Documents Acknowledged in this Application:
Unit Overview, version 2 dated March 15, 2023
Letter of Support from Lochdale Community School, dated March 13, 2023

Research Team Members TCPS 2 CORE Tutorial Certificates:
Kimberly Ward, dated July 26, 2022

The application for ethical review and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human participants.

The approval for this Study expires on the **Expiration Date. An Annual Renewal must be completed every year prior to the Expiration Date. Failure to submit an Annual Renewal will lead to your study being suspended and potentially terminated.** The Board reviews and may amend decisions or subsequent amendments made independently by the authorized delegated reviewer at its regular monthly meeting.

This letter is your official ethics approval documentation for this project. Please keep this document for reference purposes.

This study has been approved by an authorized delegated reviewer.

SIMON FRASER UNIVERSITY ENGAGING THE WORLD **Page 1 of 1**

Appendix E. Integrated Science and Art Unit Overview

Colourful Science: Exploring Science and Art		
GRADE 6/7	CROSS-CURRICULAR	2-3 Weeks
FIRST PEOPLES' PRINCIPLES: Learning is holistic, reflexive, reflective, experiential, and relational (focused on connectedness, on reciprocal relationships, and a sense of place). Learning recognizes the role of Indigenous knowledge. Learning is embedded in memory, history, and story.		
LIL'WAT PRINCIPLES: Emhaka7 - encouraging each of us to do the best we can at each task given to us		
AREA(S) OF FOCUS: Building confidence as scientists. Observing student engagement + enjoyment of Science. Observational techniques and visual cues. Communication of ideas and learning in a variety of ways. Examining how students perceive the concepts of science and art.		
POSSIBLE QUESTIONS: • How are art and science connected? What are some 'real-world' examples of scientists who use art, and artists who use science? • How can being better artists encourage our scientific skills, and vice versa? How can we become more confident in our skills? • Who 'invented' colours? Have colours always looked the same throughout history? How did artists in the past use colours, compared to artists in the present? • Do we all see colours the same way? What does it mean to be colourblind? What is synesthesia and how does our brain process colour and stimuli? • Why are parts of our bodies (skin, eyes, hair, etc.) different colours? What is the science behind skin colour? • How do animals use colours to survive and thrive? Why do some animals change colours and how does this help them survive?		

- How do people use colours in cultures around the world? Why do some colours have different meanings in different cultures (e.g. a white wedding dress versus a red wedding sari)?
- How can we use colours to communicate our feelings? How did artists like Picasso and Van Gogh use colors in their art to represent an emotion?
- Can we extract colours from different plants? Can we create pigments and paints? How have Indigenous communities used extraction techniques when dying/colouring woven art?
- What will happen if we mix different colours together? Will we get the same results each time we mix different colours?
- How can colour change reflect a chemical reaction (e.g. pH scales)? Will certain pigments change when exposed to different variables (e.g. pigment from beets drying overnight)
- What is the Science behind rainbows?
- What 'colour' are celestial bodies like stars and planets? Why are some planets different colours? How can we accurately 'view' the colours of space?
- Why do leaves change colour with the seasons? Why do flowers have so many different colours within species (e.g. roses)?
- Are certain colourful foods 'healthier' for us than others (e.g. beta-carotene)? What is the difference between a natural food colour and artificial food colour?

MATERIALS:

- *A copy (physical or virtual) of each GUIDING STORY*
- *Small test tubes or clear plastic cups*
- *Juice made from red cabbage (for pH experiment)*
- *A variety of acidic, neutral, and basic chemicals and substances (e.g. vinegar, baking soda, lemon juice, dish soap, milk)*
- *Yarn and fabric (for weaving)*
- *Paper plates to serve as 'looms' (one per student) or one large hula-hoop (for collaborative weaving)*
- *Paint chips in a variety of colors*
- *Crayons*
- *Crayola 'Colors of the World' Crayons (skin tones) and paints*
- *Acrylic paints (yellow, red, white, brown, black, green, blue, etc.)*
- *Specialty paints (e.g. "The Pinkest Pink" and "Black 2.0")*
- *Paintbrushes, paper, etc.*
- *Teas sourced from both local BIPOC-owned companies and larger-scale productions in a variety of flavours/types*
- *Fruits, spices, and vegetables that contain pigments (e.g. turmeric, beets)*
- *Clipboards and reflection sheets*

VIDEO VISUALS:

- AFTER SKOOL: "Why Don't Country Flags Use the Color Purple?"
  https://www.youtube.com/watch?v=CYB-pmNs4VQ
- ASAP SCIENCE: "Why the Ancient Greeks Couldn't See Blue"
  https://www.youtube.com/watch?v=D1-WuBbVe2E
- TOM SCOTT: "I can't show you how pink this pink is"
  https://www.youtube.com/watch?v=_NzVmtbPOrM
- TED-ED: "History's deadliest colors -J.V. Maranto"
  https://www.youtube.com/watch?v=gKfjHTk8KrY
- THE ATLANTIC: "How Leonardo Da Vinci 'Augmented Reality' -- 500 Years Ago"
  https://www.youtube.com/watch?v=GyT1wPQSER8
- INSIDER: "How Crayons are Made"
  https://www.youtube.com/watch?v=5QKl_MdeAZQ
- SUPERRAEDIZZLE: "Can I draw Mona Lisa with Only CRAYONS? *wish me luck*"
  https://www.youtube.com/watch?v=Dgj40520PZY
- TED-ED: "The Science of Skin Color -Angela Koine Flynn"
  https://www.youtube.com/watch?v=_r4c2NT4naQ
- GREAT BIG STORY: "The Artist Who Paints What She Hears"
  https://www.youtube.com/watch?v=zbh7tAnwLCY
- TEDMED: "Seeing Song Through the Ears of a Synthese"
  https://www.youtube.com/watch?v=1LUbxfnpez4&t=2s
- VSAUCE: "Is Your Red the Same as My Red?"
  https://www.youtube.com/watch?v=evQsOFQju08&t=239s
- CUT: "Kids Describe Color to a Blind Person"
  https://www.youtube.com/watch?v=MK94B9VcDyU
- BUSINESS INSIDER: "What Fruits and Vegetables Looked Like Before We Domesticated Them"

https://www.youtube.com/watch?v=EkJnOWGCejQ

- VOX: “Why these all-white paintings are in museums and mine aren’t” https://www.youtube.com/watch?v=9aGRHOpMRUg

- TED-ED: “How does the Rorschach inkblot test work? -Damion Searls” https://www.youtube.com/watch?v=LYi19-Vx6go

- TED-ED: “The Science of symmetry -Colm Kelleher” https://www.youtube.com/watch?v=3drtbPZF9yc

INITIAL INVESTIGATIONS

Guiding Story: *Georgie’s Terrific, Colorific Experiment* by Zoe Persico

- Do a prompted drawing where students sketch what a ‘Scientist’ looks like (see **Appendix F**); look for trends, similarities, differences; examine what gender, race, age, etc. the Scientists are
- Do another prompted drawing to create a sketch of what an Artist looks like (see **Appendix F**); compare and contrast the similarities and differences between these two representations
- Discuss whether students think art and science are connected in any way. Why or why not?
- Ask students to consider if science can be beautiful
- Read the guiding story. Facilitate discussion around how the protagonist, Georgie, blended their passion for science and art together. Ask students to make connections. We will revisit this later.

Define and Discuss: What Is Art? What is Science?

- Students brainstorm, discuss, and sketch/word-web what their definition of “art” and “science” are
- We examine our responses for similarities and differences
- Students work collaboratively to create a definition for each term; this definition can grow and change as the unit progresses

Area of Focus: Art Forgeries and the Mona Lisa

- Use PowerPoint to ask students if they can tell the difference between an authentic piece of art and a forgery (ending with the Mona Lisa as an example)
- Discuss how, and why, someone might make a copy or forgery of a painting
- Examine the Mona Lisa together. Ask who has heard of or seen this painting before. Learn about Da Vinci's life and his passion for science and art
- Explore how the Mona Lisa uses techniques to create an almost augmented-reality effect as her eyes follow the observer. How does this work? Use augmented reality apps or iPads for students to see this effect for themselves!

Guiding Story: ***Perkin's Perfect Purple*** **by Debbie Loren Dunn**

- Ask students to share what their favourite colour is. Discuss why we like certain colours more than others.
- Afterwards, discuss: where did these colours come from? Did someone invent these colours? Follow the discussion where it leads!
- Read the Guiding Story to the class. Project images of the snail from which purple used to be made.
- Connect to previous discussions about blending art and science. Can we use chemistry when 'creating' and observing colours?
- Explore chemical colour changes via the pH cabbage experiment: provide each student with a small cup of the 'indicator liquid' (cabbage juice), as well as cups of the acidic and basic chemicals/substances. Put a few drops of indicator into each substance and record the results! Ask the students to notice similarities or trends (e.g. what kinds of substances turn pink? Which substances turned blue? Which stayed purple? Why do we think that is?)
- Go through the idea of a pH scale. Explore what it means to have an acid versus a base. Using the results of our experiment, determine which substances are acidic, which are basic, and how the indicator liquid shows us which is which
- Finally, bring the students outside and have them mix the baking soda/cabbage solution with the vinegar/cabbage solution. You will observe the chemical reaction (fizzing, bubbling) as well as pH colour changes (ending in purple as the solution is neutralized)

Guiding Story: ***Blue: a History of the Color as Deep as the Sea and as Wide as the Sky*** **by Nana Ekua Brew-Hammond**

- Examine the similarities and differences between how purple was 'invented' and used throughout history with the 'story' of the colour blue
- Investigate colour use in art throughout history and in contemporary contexts (e.g. cave paintings, Renaissance Art, Van Gogh, Bill Reid); take students to an art museum and go on a colour scavenger hunt

• Examine Yves Klein and how he invented a new shade of blue • Afterwards, students can select a colour they want to find the history and 'story' behind; students can research and share-out what they learn
Extreme Colours: Dangerous and Divisive Pigments • Discuss how certain pigments and colours in history have had negative health effects on artists and consumers • Examples: lead white, arsenic green, Baker-Miller pink • Explore two examples of 'extreme' pigments: the "pinkest pink" and "blackest black" paints on the market • Students will compare these two paints to different brands/formats of paint (e.g. watercolour, school tempera, finger paint) and examine vibrancy, opacity, tone, etc.
Guiding Story: *The Crayon Man: the True Story of the Invention of Crayola Crayons* by Natascha Biebow • Brainstorm: what school supplies and art supplies do we use on a daily basis? What would our lives be like without these inventions? • Examine what crayons have looked like throughout history. Explore how colour names have changed, different hues have become more/less popular, etc. using http://crayoncollecting.com/ and http://www.jennyscrayoncollection.com/p/crayons.html • Read about the invention of Crayola crayons. Explore how providing emerging Artists with more colourful supplies impacted their work. • Debate whether we need expensive materials to create art that we consider "good". Can we create a masterpiece with just crayons? • Now, investigate the history of the 'flesh' coloured crayon. Why was this hue re-named 'peach'? Discuss.
Guiding Story: *Sulwe by Lupita Nyong'o* • Students can explore the colours and pigments of their skin tones through examining the 'science' (e.g. understanding how melanin and genetics play a role in skin colouration) and the 'story' (e.g. creating a poem about your skin tone, comparing/contrasting to family members) • Examine Crayola's 'colours of the world' crayons and try to find an accurate match for your own skin tone. • Explore how colorism affects BIPOC communities, using *Sulwe* by Lupita Nyong'o as a conversation starter; explore skin-tone representation in media

- Health connection: discuss sunscreen use and how to protect our skin from harm; explore how skin heals itself and how to treat cuts and scrapes; examine the dermal and epidermal layers (e.g. how 'deep' does our skin tone go?)

BRAIN SCIENCE: HOW DO WE PERCEIVE COLOURS?

Synesthesia and Colours:

- Discuss how our brains take in information... What senses do we rely on to learn about the world around us? Do everyone's senses function in the same way?
- Explain that for people with synesthesia, many of these senses can be 'blended'; show the two video examples of people with synesthesia who create art (music and paintings) based on their perceptions of the world
- Challenge the students to try to 'hear' colours by playing songs from different genres of Music
- Have students create their own piece of abstract Art based on a song; explore how each of the Art pieces looks different, what colours are prominent, what shapes and lines we can observe, etc.

Rorschach Tests: Blending Science and Art

- Have students examine a variety of examples from Rorschach tests (inkblots). Ask students what they perceive within the inkblots. Are our answers similar? Different? Why?
- Examine the history of tests such as these being used within psychology/psychiatry
- Explore symmetry in nature and why certain organisms are symmetrical, while others are not
- Students will create their own 'inkblot' art piece by folding paper in half, using paint on one side, and then pressing the halves of paper together
- Have students brainstorm what they 'see' in each others art pieces!

COLOURFUL SCIENCE: PIGMENTS IN NATURE

Colourful Teas & Cultural Ceremonies:

- Bring in a variety of different coloured/pigmented teas for students to explore, both in their dry form and when brewed (suggested: hibiscus, earl gray, butterfly pea tea, matcha)
- Investigate how tea looks and tastes around the world through *Great Big Story's* series on tea: https://www.youtube.com/watch?v=OS2tMqDIYfw&t=628s

• Amplify Indigenous-run tea crafters such as Ranger Teacraft https://rangertea.com/ and discuss how Indigenous cultures have used tea for ceremony, medicine, and flavour for thousands of years • Explore how the Sioux Chef gathers and prepares tea: https://www.youtube.com/watch?v=j19TyQcb9OM • Using the brewed teas, extract pigments and create 'paintings'
Pigments in Flowers, Fruits, and Vegetables: • Engage students in a 'mystery fruit/vegetable investigation' by presenting whole produce (e.g. durian, passion fruit, pink pineapple, watermelon radish) and having them create a detailed illustration; students then predict what the inside will look like • Explore how humans have used genetics and selective breeding re: produce (e.g. the history of carrots and why orange carrots are most common today); how did fruits/vegetables look 100 years ago compared to today? • Have students extract pigments from fruits, vegetables, and flowers (e.g. beets, turmeric root) and try to create paints by adding different substances (e.g. oil, water, egg yolk, corn starch) • Explore how fruits, spices, and flowers were used in addition to minerals to create the earliest paints

Appendix F. Draw a Scientist and Artist Activity *(completed before and after unit)*

Draw an Artist:

In the space below, please draw what you imagine when you think of the word ARTIST! Try to picture an artist on your 'brain big screen' and try to include as many details as possible!

When I think of an artist...

Some words I would use to describe an artist are: ________________________________
____
____

In my opinion, artists ____
____
____

Draw a Scientist:

In the space below, please draw what you imagine when you think of the word SCIENTIST! Try to picture a scientist on your 'brain big screen' and try to include as many details as possible!

When I think of a scientist...

Some words I would use to describe a scientist are ________________________________
____
____
____

In my opinion, scientists ____
____
____
____

Appendix G. Student Self-Reflection (*completed before and after unit*)

Using the stars, please share how confident you feel RIGHT NOW in your ability to learn, communicate, and understand science concepts (1 being not confident at all, 5 being extremely confident):

2. Would you consider yourself a scientist?

- ☐ YES
- ☐ NO

Please explain WHY or WHY NOT:

3. Using the stars, please share how confident you feel RIGHT NOW in your ability to learn, communicate, and understand art concepts (1 being not confident at all, 5 being extremely confident):

2. Would you consider yourself an artist?

- ☐ YES
- ☐ NO

Please explain WHY or WHY NOT:

Appendix H. Student Preferences (completed before unit)

Using words or pictures, please describe your ideal science lesson/activity/project:

Using words or pictures, please describe your idea art lesson/activity/project:

Appendix I. Post-Unit Reflection

Has your confidence and/or enjoyment of science and/or art changed this year? Explain your thinking!

What is one thing Ms. Ward (or other teachers) could do to improve when teaching science?

Appendix J. Learning Probe Example

Learning Probe #1: Painting

BEFORE: *In the box below, please brainstorm what you already know about painting.*

Word web, draw, list, or free-write what you have already learned/experienced!

Activating Knowledge: What We Already Know

DURING: *What are you thinking, feeling, and noticing about the lesson? What questions do you have right now?*

____

____

____

____

<u>AFTER:</u> *What is an observation that stuck out to you? What connections can you make between what you knew before and what we've learned? What learning can you 'share out' to a friend or family member?*

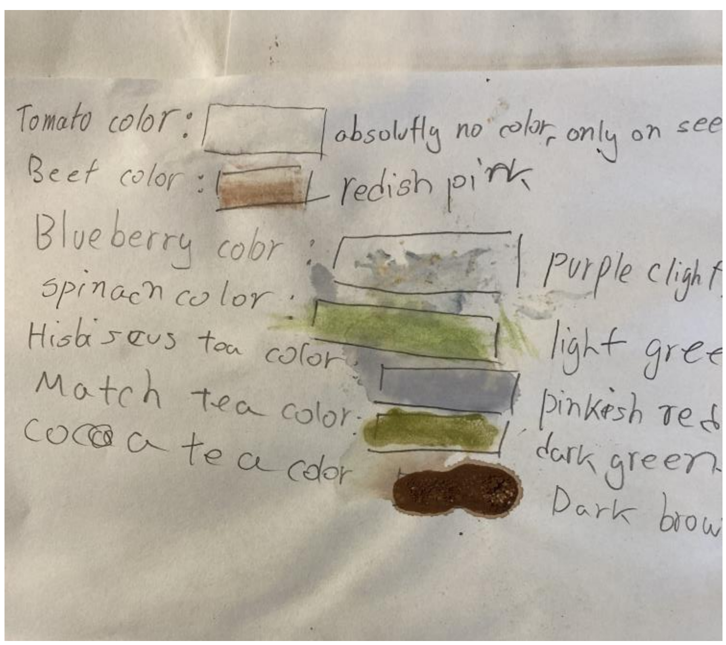
Amplifying Our Learning: What Are You 'Taking Away'?

What questions do you still have about this topic? What do you want to learn more about? Draw or describe your ideas below!

Appendix K. Photo Artifacts

Image description (above): a student combining pigment [beet juice] with a stabilizer [egg yolks and corn starch] to create paint.

Image description (below): an excerpt from a student reflection sheet with swatches of paint made from fruits, spices, and vegetables.



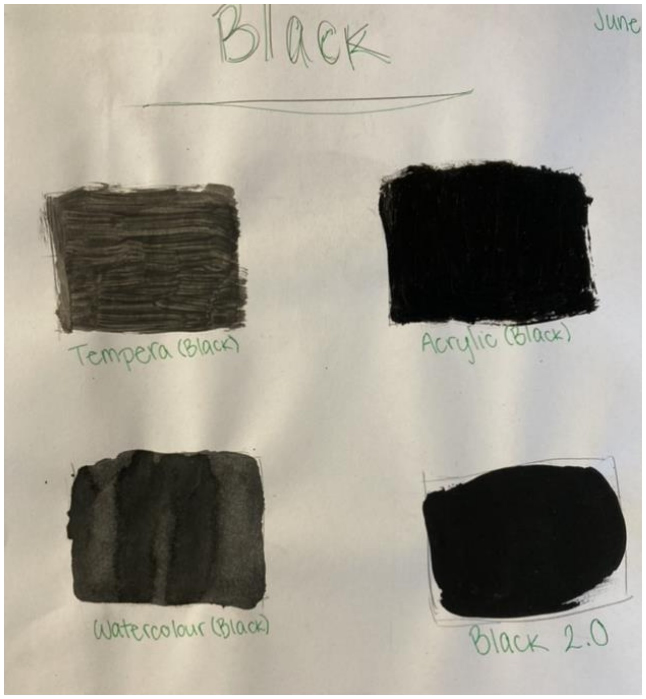


Image description (above): an example of a student's science journal with swatches of the various paints

Image description (below): an example of a student's science journal with swatches of the various paints