

Chapter 14

“Draw What You See” Transcending the Mathematics Classroom



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Abstract To gain insight into ways student’s experiences with mathematics can support them to reach their human potentials, we explored children’s engagement in a collaborative art project. We describe the teacher-developed project and facilitation approaches that supported the exploration. Using a narrative inquiry methodology and artefacts from the experience, we narrate children’s experiences using four dimensions: autonomy, authority, success, and relationships with others. We contend that the children were involved with ideas and peers in ways that resulted in building a positive relationship with mathematics, producing a counter-narrative to one of failure and helplessness typical of mathematics as a discipline. Recommendations for further study focussed on mainly mono-disciplinary contexts are shared.

Keywords Mathematics · Art · Student collaboration · Affective behaviours

14.1 Introduction

In today’s school climate, the teaching of mathematics has acquired a sense of urgency, which has deterred teachers from creating joyful opportunities for engaging in mathematics. Rarely are students encouraged to be curious, posing and investigating their own questions. Such activity is often seen as drawing away from the more

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urgent task driving instruction, which is to learn the mathematics that will result in gains on achievement tests. D'Ambrosio and D'Ambrosio (2013) assert that the primary goal of education is to support individuals to reach their human potential. The discipline of mathematics serves this goal, as it takes on many forms in human activity beyond the completing of exercises with a single answer often seen in mathematics classrooms and on achievement test. Interdisciplinary mathematics education (IdME) (Williams et al., 2016) provides a lens through which to view the complexity of mathematics in human activity.

In this chapter, we discuss the landscape of investigation, as described by Skovsmose (2001), and opportunities for exploring mathematical ideas and building human relationships provided in such contexts. We take these explorations outside the mathematics classroom and examine a landscape of investigation drawn from the art classroom. Using narrative inquiry (Clandinin & Connelly, 2000; Polkinghorne, 1995), we characterize fourth-graders' (ages 10–11) experiences in the “mainly mono-disciplinary” context (Williams et al., 2016, p. 19) of the art class using four dimensions: authority, autonomy, success, and relationship with others. The democratic environment created in the art classroom supported children to find and use their mathematical voices, as they identified and overcame social and mathematical challenges by negotiating and co-constructing ways of knowing mathematics to complete the project.

We contend that the children were involved with ideas and each other in ways that contributed to building a more positive relationship with mathematics, producing a counter-narrative to one of failure and helplessness typical of mathematics as a discipline. We conclude by discussing opportunities and challenges involved in increasing the level of complexity of this landscape of investigation “on the continuum of relations between disciplines” (Williams et al., 2016), while maintaining support for children to build mathematics identities and power in their efforts to reach their human potential.

14.2 Literature

Those who use the rhetoric of “mathematics for all” and defend the idea as a goal of mathematics education, assert that all students should have equal opportunities and resources to learn rigorous mathematics. For D'Ambrosio (1990) the teaching of mathematics occurs within the structures of schooling and education, and should contribute to achieving the lofty goals of education where:

Mathematics education ought to prepare citizens so that they will not be manipulated and cheated by indices, so that they will be allowed to change and to accept jobs which fulfil and appeal to their personal creativity; that is, so that individuals will be allowed the satisfaction of their own creativity and will be free to pursue personal and social fulfilment thus being able to achieve happiness. (p. 21)

Learning mathematics in this way, results in supporting individuals to achieve their human potential. Contrary to this goal, school mathematics:

fulfils social functions of differentiation and exclusion... Instead of opening opportunities for all, mathematics education generates selection, exclusion, and segregation. A demarcation is established between those who have access to the power and prestige given by mathematics and those who do not. (Skovsmose & Valero, 2001, p. 41)

As students experience school, they come to embrace their success as young mathematicians, or accept that mathematics is beyond their comprehension. This troubling reality oppresses learners into limiting their dreams and aspirations from a young age. It is beyond the scope of this paper to explore the reasons that students fail at school mathematics. Many scholars have dedicated their careers to understanding this situation and proposing alternative educational experiences. For the purpose of this paper, we have chosen to highlight the work of scholars who propose to enable all students as viable mathematicians. Central in this proposition is providing experiences that will empower the young to be citizens who engage in finding creative solutions to the social and economic injustices of society, by understanding the world in a critical and conscious way (Gutstein & Peterson, 2005). Real-life references for meaning making “seem necessary in order to establish a detailed reflection on the way mathematics may be operating as part of our society” (Skovsmose, 2001, p. 131).

A democratic mathematics education process that allows all students to fulfil their human potential would include opportunities for students to develop mathematical voices as they describe what they know and how they understand the world. Students’ experiences in the discipline of mathematics shape and define their identities as mathematical beings (Walshaw, 2005). In addition, their perceptions of how others view them, plays an important rôle in shaping their identity. It is in a climate of inordinate amounts of testing that young people’s identities are currently taking shape. As such, they perceive their “value” as learners by their scores on standardized tests. These quantitative views of their value leave them feeling dehumanized and lead to negative relationships with the subject matter.

According to Freire (1998), teaching begins with respect for what students know. When their existing knowledge is the foundation for learning, students will acquire autonomy and agency. Considering democracy as social interactions of individuals relating to each other as they collaborate to “produce their cultural and material living conditions” (Skovsmose & Valero, 2001, p. 46), allows us to interpret classroom settings as microcosms of society where such interactions occur. In such environments, students learn to speak up, question others, and defend their thoughts, while maintaining a relationship of kindness, care, solidarity, and respect. In the art class we describe, the students collaborated to create a cultural artefact and negotiated decisions with respect for each other’s ideas while attempting to create mutual understanding. We interpret this experience as supporting the development of a key component of children’s participation in a just and equitable society. This is the view Signe and Rachel held while in the classroom with the children, and that the research team later used to analyse field texts and construct a narrative.

We tell the story and analysis of our experience through narrative.

Narrative inquiry, the study of experience as story, then, is first and foremost a way of thinking about experience... Narrative inquiry as a methodology entails a view of the phenomenon. To

use narrative inquiry methodology is to adopt a particular view of experience as phenomenon under study. (as cited in Clandinin, 2006, p. 45)

Narrative inquiry is a methodology “for studying lived experiences” (Clandinin, 2006, p. 44), resulting in stories that illustrate how people experience and make meaning of the world. In our situation, Signe entered in the midst of a story, and lived the experience alongside Rachel, the art teacher, and the children. Signe and Rachel created field texts by making a digital photo record of the experience. They then added to the field texts by writing about the experience and by discussing their observations of the children’s work and interactions. During weekly meetings the research team discussed the continuing events in the art classroom to gain insight into the children’s actions and how Rachel and Signe were supporting these actions. Our collection of “descriptions of events and happenings” (Polkinghorne, 1995, p. 12) served as the data and our conversations provided early insights into the critical actions taken by Rachel and the children in the production of the cultural artefact. Analysis of the field texts and images was recursive as we developed “a plot that serves to configure data elements into a coherent story” (Polkinghorne, 1995, p. 16). We read and re-read field texts and images, building from initial views of important actions, taken by Rachel and the children, toward a narrative explanation of what happened that contributed to the collaborative construction of the cultural artefact. In addition, through weekly discussions, we negotiated, collectively, the way in which we would narrate the story of the children’s experience. This methodology also allowed us to analyse the field texts once away from the classroom. These conversations involved looking for “connections of cause and influence among the events” (Polkinghorne, 1995, p. 18) and the reasons actions were undertaken by the children. Through this process, we identified four dimensions that we use to narrate the children’s experiences from our perspectives as researchers. The viewing and reviewing of the events, the many questions we asked of Rachel and Signe, the many questions they asked of themselves, and the return to the classroom to ask the children questions as well, resulted in our deeper understanding of the experience. Our narrative contains digital photos and excerpts from field texts that help represent dimensions of the children’s experiences, as we understood it. The narrative we created reflects the shifting landscape of our understanding of the children’s experience, as we lived, interpreted, and continue to make it meaningful personally. Importantly, the narrative reflects our understandings of the children’s experience, not the childrens’ own understandings of their experience.

Typically, educators in the discipline of mathematics focus on the use of numbers in the fabric of life, overlooking other mathematical content that is part of that fabric. Yet in landscapes of investigation, contexts serve as invitations to students “to formulate questions and to look for explanations” (Skovsmose, 2001, p. 125). In the work that we describe from an art class, children seem unaware of the mathematical qualities of their actions. They seem liberated from their imposed (quantitatively informed) mathematical identities and anxious to engage in a creative act, so different from computational work typical of mathematics classes. Yet listening to discussions in the art class revealed language of space and lines, and the management of both,

as the children overcame obstacles involved in scaling. Such challenges and related reasoning have been explored in mathematics education (for example, Streefland, 1984; Cox, 2013) without explicit attention to development of notions of identity and power, possible, in such contexts. In the art class, we describe the mathematics involved as embedded in actions and conversation that also supported the development of identity and power. Teaching in this context supported children in ways that moved them toward their human potential, constructing opportunities for them to create with and enjoy using mathematical reasoning, to engage in conversations that involved genuine mathematical talk, and to appreciate the beauty of mathematical patterns and relationships.

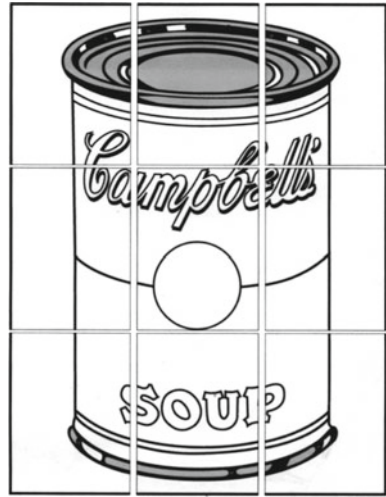
We anticipate that in listening to stories of the experiences of the children, we will begin to imagine different possibilities for stories in mathematics classrooms involving dimensions of the discipline of mathematics that include, but extend beyond, knowledge and knowing as the computation of a single answer. We believe that narratives of the experiences of the children will allow mathematics educators to build insights about children’s learning of the discipline of mathematics outside mathematics classrooms that attend to children’s learning of mathematics embedded in action (Skovsmose, 2001). These narratives may have the power to encourage children to re-story their experiences with mathematics as more positive, more engaging, and more relevant to their lives.

14.3 Context and Task

In art, viewed as a mono-discipline, inspiration and creative voice are expected and anticipated. These inner voices give rise to opportunities for the development of technical skills as well as emotionally provocative creations. In her planning and interactions with the children, Rachel searched for ways to bring different materials to life so the children could have opportunities to explore and discover with different mediums. She wanted the children to feel accomplished and proud of their artwork. She assumed that the critical thinking skills and decision-making the children do in art is carried with them into other academic areas in particular the discipline of mathematics. For Rachel and the research team the disciplines of art and mathematics involved problem solving, meaning seeing different possibilities and answers to dilemmas, yet methods of inquiry in these disciplines vary tremendously.

In 2013, Rachel sought to “create new ways of incorporating math[ematics] into art projects without the children feeling like they are actually doing math[ematics].” She wanted to “find a bigger project for the children than just using a 9 by 12 inch paper” and “have the children do their own critical thinking.” This effort was motivated by Rachel’s desire to contribute to the children’s mathematical development. Rachel found a lesson that involved scaling up a version of Warhol’s Campbell’s Soup Can (Stephens, 2013). The children worked in small groups of three or four, during one 45-minute period per week for 8 weeks. Each group was given one 8 ½ by 11 inch [approx. 21.5 cm by 28 cm] picture of a “sectioned” can (see Fig. 14.1). The children

Fig. 14.1 Sectioned soup can



were asked to fill in the can with complementary colours and then to cut the can into sections. Each section was then to be recreated on an 8 ½ by 11 [21.5 by 28] sheet of paper. After reassembling all nine scaled up pieces, the children were to colour the artwork and present the work to their classmates for discussion. The final goal was to use all the enlarged cans to create a mural for the school by placing the cans alongside one another. Each enlargement resulted in a version of a can that was roughly 2 feet wide by 3 feet [60 cm by 90 cm] tall and a mural that was 10 feet [300 cm] wide.

14.4 Narrative of Experience

In this section, we highlight the four dimensions that helped us describe and make sense of the children's experience. In particular, the concepts of authority, autonomy, success, and relationships with others take on new meaning in the context of the art classroom. For us, the collaborative experience in which children were co-constructing their art product and making sense of the underlying mathematics involved, was unique. Throughout the experience, the children set parameters regarding when they had succeeded in completing the task, when they had a product they could be proud of, and what explanations would reveal their collective thinking and decision-making. In the environment of the art classroom, the children authored "narratives of confidence and capability, seeing themselves as powerful and whole" (Paley, 2011, p. 745). These narratives are in stark contrast to the ones many live in the mathematics classroom. They are counter-narratives to ones of failure and frustration, inadequate achievement, and disenfranchisement.

14.4.1 *Redefining Authority*

In mathematics, the “world-view and the knowledge system of the educator” (Freire, D’Ambrosio, & Mendonça, 1997, p. 8) is often used to manage the space that develops for learners to explore, choose, decide, and explain, thereby constraining children’s opportunity to use their intuitive sense, to choose a path, and learn from errors. In the soup can project, while Rachel’s initial description of the project framed the inquiry space, the children used their reasoning and communication skills to engage in exploration and explanation of the landscape of investigation Rachel described. Their actions and discussions became a real-life reference for mathematics learning, what Skovsmove described as a learning *milieu* (2001). The landscape of investigation, initially described by Rachel, quickly became a landscape redefined by the children. The children, rather than Rachel, were authorities on their work as they chose paths for the investigation and managed social interactions.

Negotiations among group members started before they began scaling up the picture of the soup can, as groups worked out different sensitivities and preferences of group members. Choosing colours and creating a way to colour together on one piece of paper was a problem solved in a variety of ways. One group debated the different colours they might use and then, initially, took turns with crayons. This was not satisfying since all the group members wanted to colour. To give everyone a chance, one child found crayons of similar colours and passed them out. With hands on the same paper, each child began colouring a section of the picture. Heads and hands often touching, the children talked about life, the result of their colouring, and their sense of satisfaction with their work.

In the beginning the children split up the task with each child taking responsibility for enlarging a section of the picture. As a child finished one section, he or she moved on to another. When all sections were complete, problems emerged. With pieces laid side-by-side, different lines and spaces of the sections were not aligned (see Fig. 14.2). Disappointment, gave way to brain-storming how to move ahead. With the class ending and not reconvening for another week, the children put away their work and put aside the debate. The interruption gave the children time to build a strategy for solving the alignment problems that continued to emerge as one artist made adjustments to a section of the picture without consideration, yet, for the work of other artists. After a few weeks several artists began to co-ordinate activities. Signe sat watching one group of boys for the greater part of a class period, documenting steps and mis-steps that they identified. They answered her questions about their actions and decisions patiently. But when they felt she had stayed too long, one boy suggested: “You should go watch someone else now. You can talk to us again next class.” He was an authority on what the group needed to do in order to move the work forward. Signe left following Rachel’s practice of moving about and just watching or asking questions about decisions. As promised, during the next class the boys again invited Signe to explore their work and patiently answered all her questions about decisions they had made in her absence. The children had the authority to create

Fig. 14.2 Aligning sections

their own paths and make decisions when challenges arose, or when prying eyes and words became an impediment to their work.

In each phase of the project the children made choices and accepted the challenge of, and the responsibility for, decisions they had made. This approach to authority was based on Rachel's respect for the children's process. She understood the need to attend to children's learning and awareness of how they moved from common sense to creating ideas "uncommon" to adults (Paley, 1986, p. 127). The reality of the children and the remaking of a model of that reality through the soup can project involved a redefinition of authority that led to a growth of intellectual autonomy in the art class.

14.4.2 Redefining Autonomy

Students in schools often rely on the teacher to define how they should think and behave in the mathematics classroom, diminishing their autonomy. By redefining authority, so that children have a chance to manage social interactions of the group, choose a path, and learn from errors, teachers can promote and sustain intellectual

autonomy among their students. In classrooms where teachers attend to the landscape of investigation and provide authentic ways for students to engage in mathematics, intellectual autonomy develops. They “are aware of, and draw on, their own intellectual capabilities when making mathematical decisions and judgments as they participate in these practices” (Yackel & Cobb, 1996, p. 473). Intellectually autonomous children, engage in judgments and negotiation of what is right and wrong in the *mathematics*. The teacher facilitates students’ development of intellectual autonomy by creating environments where inquiry is valued and mathematical discussions amongst students are paramount. Intellectual autonomy differs from children’s authority in that the focus is mathematics and mathematical decision-making.

Many instances of intellectual autonomy emerged in the completion of the art project. Rachel, in developing and attending to the landscape of the investigation, nurtured intellectual autonomy by encouraging the children to design their work plan and decide when their scaled picture of the can was acceptable. The children did not ask Rachel or Signe about scaling or how to scale. They called an adult when tools were needed or to share a new insight or achievement. Even when Rachel encouraged one group of children, struggling to align enlargements of the three sections in the first row of the picture, to “draw what you see, not what you know,” the children interpreted this advice in ways that made sense for their intellectual work. Rachel and Signe saw the children’s problem as one of “seeing” the lines and spacing, yet the children reasoned that their initial approach to scaling, each child scaling a section or two, had created the problem. To solve the problem, they co-ordinated their efforts. They first enlarged adjacent sections (two sections at a time) and then reasoning that coordinating three sections containing a continuous line or lines (such as those on the top of the can) was necessary. While Rachel’s suggestion provided a welcome break from the challenge of aligning the enlargements, the children used their intellectual autonomy to revise their approach to scaling rather than Rachel’s suggestion.

Intellectual autonomy was evident throughout the project, individually and collectively. When children employed their own capabilities and judgment to draw their portion of the scaled up version of the can picture, they exercised individual intellectual autonomy. Their negotiations within the group as they brought “together the pieces” and resolved discrepancies within the scaled up image that arose from piecing together individual work, illustrated their collective intellectual autonomy.

14.4.3 Redefining Success

Student’s participation in school often results in feelings of dis-empowerment as they feel unable to live up to the standards established by the teacher, schools, or districts. Continually falling short, according to norms that assume that all students will learn a list of topics at the same pace, in the same order, and by a certain date in the school year, leave students feeling helpless. Students come to believe that the goal of the discipline of mathematics is to learn procedures, rather than to learn when to use mathematics to develop and solve problems. They rarely, if ever, experience

the exhilarating feeling of identifying and defining problem situations and solving problems by using creative approaches to challenging dilemmas.

In the art classroom, as the children worked, there were many opportunities to discuss their work, negotiate what was correct, and consider what needed to be fixed. Children seemed to use visual cues and their intuitive sense of aesthetics to judge their success and decide on directions for revision. The children relied on themselves and on each other to decide whether to continue along a path or to alter the direction taken in their work. There were many instances where Rachel and Signe turned to each other and said, “we will need to wrap this up,” since the children seemed frustrated and no longer interested in the inquiry or dilemmas they were trying to resolve. Yet each week, the children returned to the investigation with new energy and ideas, regarding how to solve a problem from the previous session.

Together the children created, although not explicitly, criteria for success. With each decision to alter or fix their product they approached something that they considered better and more pleasing. Their satisfaction with their work was evident in the whole class discussion at the conclusion of the project. Each group of artists had an opportunity to describe their work and the decisions they made along the way.

The children spoke with conviction when they were asked about decisions they had made or characteristics of the can that others had not included. For example, one group had a black spot on the lid of their can (see Fig. 14.3). When asked about the meaning of the spot, they quickly noted that it was an opening. The children reasoned that cans are meant to be opened and when they are, there is often a hole in the top. This hole illustrated the authenticity of the picture in their enlargement. In addition, the children shared what they understood and what still confused them. They were sure that you could align sections of the can by lining up not two but three pieces in a column and checking for alignment. Lining up two sections at a time had caused problems for all the groups and they were quick to point to this challenge, ways they had overcome the challenge, and to point out evidence of their success on their art work.

Children constructed the definition of success implicitly, and used it to describe their work. Use of their criteria to describe the work, was evident in their pride and justifications. Peers’ appreciation for each other’s work, effort, and specific details of the art, was authentic and full of respect and admiration. Children expressed their delight in the opportunity to hear from others about challenges they had experienced in enlarging the picture and how they had overcome them. For example, one child asked another group who had aligned the curved lines on the top of the can, “How did you get the lines on the lid of the can to match up so well?” The group explained that the lines were drawn and checked and erased “again and again until we were done.” Their response was delivered with a tone of satisfaction and humility in their acknowledged success, characteristic of this final discussion.

Fig. 14.3 A group’s enlarged can



14.4.4 Redefining Relationships with Others

Rachel posed the project to the children as a collaborative effort. After initially splitting the scaling task, the children began to discuss problems and collaborate. Throughout the interactions, there was evidence of caring relationships among the children, as they listened to each other in kind, respectful ways. The children worked productively together, building understanding and voicing their observations, evaluations of the progress they were making, and proposing ways to improve the product. While the children did not formally spend time establishing norms for working together, they behaved in ways that adhered to implicit norms of respect and care for each other’s ideas. They did not agree on all dimensions of their work or decisions made, but they discussed possibilities, tried things out, and came to an agreement of the direction that seemed most reasonable.

Some of the most difficult moments for groups occurred as they put the pieces together and realized there were problems with alignment of the sides of the can, or the top of the can, or—what proved most difficult to all—with the lettering. Collectively, the children made decisions of whether to erase and redo the enlargements, or come up with another strategy for fixing the problem. These were often tense dis-

cussions beginning with conflicting claims about whose enlargement was best. Yet, the children moved to resolve differences by removing themselves from the discussion for a time or negotiating which enlargement could be called “best,” ultimately looking for evidence of the relative positions of the lines on each section to decide and overcome their differences of opinion.

The lettering challenged all the groups. During final presentations, when Signe asked the children to identify the most difficult parts of the project, the children pointed to the lettering. They also accepted not quite knowing “how to do that [cursive writing] yet” and complimented those whose work showed some measure of success. For example, peers considered the lettering of “SOUP” on the can in Fig. 14.3, as “really good.” The presenters explained how they had accomplished this success by having a single artist work with the three sections that contained the letters, working exclusively on the lettering. They acknowledged the expertise of the group member by giving this one artist the responsibility—and the honour—of doing the lettering himself. Individual group members were recognized for artistic talent or extra patience for the task of reproducing and enlarging the lettering of the original artist.

Throughout the project, each child assumed rôles that aligned with their personal talents. Peers recognized ways in which specific group members could contribute to producing a more appealing and successful product. Group members shared power equally and leadership shifted with each new challenge or action. Both comradery and solidarity were evident in the group interactions.

14.5 Discussion and Conclusion

In the art classroom children worked collaboratively to enlarge Warhol’s painting of a Campbell’s Soup Can. In the process, they refined their perceptual understanding of scaling and proportional reasoning. While the primary goal was to create a mural for the school, intermediate goals developed and spurred side inquiry. Of particular interest to IdME are opportunities within this landscape of investigation that could be further explored within the discipline to increase the level of complexity of the enquiry. In the art investigation, the children’s challenges with the lettering on the can, is one such opportunity. The letters are examples of what has been described as internal marks called “secondary lengths” (Cox, 2013, p. 8). Such lengths, in proportional reasoning, must be situated in relation to “primary lengths” such as the height and widths of the can and “gap lengths,” implicit lines between primary and secondary lines. Cox describes intuition involving these lengths as standing at the intersection of geometry and number in the discipline of mathematics. In scaling tasks such as this one, according to Cox, students focus on primary lengths and work to relate these to secondary lengths, thereby developing insight into gap lengths. In the art class children were successful in developing strategies for managing alignment issues with exterior lines (primary lengths), but were still dissatisfied with their approaches to internal letters (secondary lengths).

Dissatisfaction with the lettering involved in the investigation opened potential opportunities for movement beyond the use of intuition toward more formal approaches to scaling the lettering such as measurement and computation. Although a child at one point during the investigation, began to use a ruler to measure primary lengths from sections of the enlarged picture, when he was queried about his activity by his group mates, he could not yet describe why measuring might help. This opportunity might have served as a jumping off point for explorations to answer the question regarding the utility of measurement. Skovsmose (2001) identified such opportunities for consolidation of more formal mathematics and mathematical ways of knowing in action during the project as creating “harmony” (p. 129) between modes of activity within the discipline. Further, Guitérrez (2013) suggests that considering the use of tools, such as measurement in formatting realities in projects like the soup can, would provide children with opportunities to think “critically about the benefits and drawbacks” of using mathematics, thereby developing insight into how and when they would want to deliberately use/create mathematics in their everyday lives (p. 47).

While adding a mathematics disciplinary exploration of measurement as it related to the challenge of alignment in lettering could have increased the disciplinary complexity (Williams et al., 2016), what is unclear are the ways in which such an addition might have had an impact on the dimensions of experience of the children. The central goals of the art inquiry involved movement toward the construction of the enlargement. Mathematical thinking was contextual and embedded in action, rather than consciously used to achieve perfection or precision in the enlargement. Only the teacher in collaboration with the children can determine whether more formal mathematics inquiry would enrich or interrupt the investigation and evaluate the potential of such a direction to support the development of identity and power. In addition, we wonder whether the imperfection of the enlargement contributed to the children’s view of their created object as art. If so, then movement to pursue disciplinary complexity by exploring and developing more precision in lettering could spoil the artistic character of the creation. Again, only Rachel and the children could evaluate the advantages and potential disadvantages of movement toward more precision in lettering using measurement to support new insights about “gap lengths” and their impact on the lettering. There is always a possibility that pursuing disciplinary complexity in such interactions will result in shifting priorities in a landscape of investigation in ways that could diminish the experiences of authority, autonomy, success, and relationships that derived from the project. Further research exploring characteristics of investigations, teachers, students, and systems of interaction may allow IdME researchers to hypothesize about and provide examples of when and how “mainly mono-disciplinary” (Williams et al., 2016, p. 19) investigations produce dilemmas, recognized by teachers as potentially mathematically productive, should be pursued.

Examples of IdME contexts have the potential to illustrate opportunities for learners, needs of teachers, and unearth researchable questions for the IdME research community. In the case of the landscape of investigation in the art class, we see opportunities to discuss dimensions of children’s experience such projects afford.

As Engle (2011) points out, children's curiosity is endless. In the example of the art class children's curiosity was piqued, intuition about space developed, and the children used their voices in powerful ways to communicate about their work. The children redefined dimensions of experience in art, in ways that contrast with typical definitions in the discipline of mathematics. This example illustrates possibilities for the study of IdME contexts, in particular suggesting that one strand of study should involve inquiry into shifts in power and identity in such contexts.

The study of this art class suggests the potential of "mainly mono-disciplinary" (Williams et al., 2016, p. 19) contexts and actions of teachers for creating experiences that extend ways of operating, being, and knowing typically developed in the discipline of mathematics. The artistic investigation, of the children, generated opportunities for their reconceptualization of their identities as learners of mathematics. The art classroom environment afforded children with the chance to liberate themselves from self-images shaped by experiences of success or failure in the mathematics classroom. Repeated failure tends to leave students feeling disempowered when trying to learn mathematics. By shifting the learning of mathematics to other subject areas, teachers have a chance to rebuild students' self-confidence, self-image, and views of their power and human identity. The respect and solidarity that children showed towards each other in the wake of appreciating each other's artistic creations was evident in the conversations held throughout the project. We conjecture that when the authority of determining what is problematic, how to explore such problems, and what is right and wrong, is in the hands of the students, they are flexible in accepting alternative ways of seeing things and as a result, more accepting of the ideas and products of others. Constructing IdME contexts involves creating opportunities for students to explore, and represent creatively, their worlds, thereby reframing their identities and sense of power in school in ways that support their efforts to reach their human potential.

Rachel's work with the children and their engagement in the landscape of investigation involved the discipline of mathematics as it is embedded in the actions of creating objects for society. Yet without explicit discussion of mathematics, what are children learning? Contexts where mathematics is embedded in action as part of the "continuum of disciplinarity" (Williams et al., 2016, p. 32) is not identified and separated from other disciplines, yet as Cox (2013) has shown in the case of proportional reasoning, the intuition that develops in such context may be critical to success in mathematics class. Researchers have discussed human actions used in such contexts, and the danger in devaluing them (Civil, 2016; Fasheh, 2015). Human actions embedded in the beauty of creating in domains outside mathematics (Fasheh, 2015) may support individuals to reach their human potential (D'Ambrosio & D'Ambrosio, 2013). What is less understood is the value of mathematical intuition that develops when children are involved with ideas and peers in ways that support learner empowerment. Is such mathematics, viewed through the lens of the discipline, necessarily weak? Further research in IdME is needed to explore whether and how such context balance disciplinary goals and the primary goal of education as described by D'Ambrosio and D'Ambrosio. Additional narratives can illustrate ways teachers and students use such context to inform mathematical identities of

young people and their sense of power to identify, communicate, and participate in constructing solutions to problems that contribute to self- and societal-satisfying activity.

We further wonder how multi-disciplinary teams of teachers, with a shared goal of helping students reach their human potential, might use “disciplinary ‘identity’ and division of labour” (Williams et al., 2016, p. 4) to contribute to this goal. Rachel sought to support her colleagues, other elementary school teachers, in their efforts to build children’s critical thinking in mathematics. She felt satisfaction at contributing to colleagues’ discipline specific goals and school culture through the children’s production of a mural. Research focussed on multi-disciplinary teacher teams could take up this idea and explore teacher’s emotional and affective responses to engagement in making curriculum to address discipline specific goals as well as to support engaging future citizens in understanding of the value of being human and contributing to the work and joy of other humans.

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