The Role of Identity Development within Tensions in Ownership of Science Learning

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Abstract: Ownership of science learning is defined as learners being able to fully participate in the practicing culture of science, having greater control and possession over the ideas put forth, knowledge developed, and the science learning process. While ownership is beneficial to promoting science engagement, in this study, we show that conflicts in ownership of science learning manifest and can hinder learning. We document three focal learners who faced tensions and conflicts in their ownership of science learning. Specifically, we examine how learners' development and conceptions of ownership at home and school influenced how ownership of learning was expressed in an afterschool program called *Kitchen Chemistry* (KC). We argue that learners' expressions of ownership are a reflection of their identity development in science and that conflicts are a part of this manifestation.

Introduction

For many years, educational researchers have documented that many youth find aspects of traditional school science to be disengaging and irrelevant to their everyday lives (e.g., Atwater, 1996). Often in school science, teaching science is the equivalent of transferring knowledge from an authority (e.g., teacher, curriculum, software) to the students. Learners are often obligated to acquire knowledge from these credible and authoritative sources and later reproduce this abstract knowledge as correct answers (e.g., Fusco, 2001). Fusco (2001) argues that for science to be made relevant, learners need to engage in a *practicing culture of science learning* in which learners' own concerns, needs, issues, and experiences are brought to the forefront of learning. O'Neill and Barton (2005) contend that if learners were to have ownership of the science they were learning, they would be more motivated to engage. ***Ownership of science learning*** is defined as learners being able to fully participate in the practicing culture of science, having greater control and possession over the ideas put forth, knowledge developed, and the science learning process. Researchers argue that ownership can be a powerful way to support learners' engagement in science inquiry (e.g., O'Neill & Barton, 2005; O'Neill, 2010). The core assumptions of these studies are that having ownership in the learning process leads to greater motivation and participation in science learning.

However, within the literature there is an overly positive assumption that if science connected to learners' lives or encouraged active participation in a culture of science, this would help learners develop ownership of the knowledge and processes of science. Only a small number of studies have started to document the evolution of learners' ownership in science (e.g., O'Neill & Barton, 2005; O'Neill, 2010). Few studies have examined how social, personal, and cultural factors influence how a person interprets ownership and how an individual's own interpretation from one context (e.g., home) may change the dynamics of ownership in another context (e.g., school). In particular, as a learner transitions between different contexts, he or she may encounter conflicts in ownership of science learning, depending both social interactions and identity development (e.g., Pierce, Kostova, & Dirks, 2003). In this study, we document three focal learners who experience tensions and conflicts in ownership of science learning. Specifically, we examine how learners' development and conceptions of ownership at home and school influenced how ownership of learning was expressed in an afterschool program called *Kitchen Chemistry* (KC). We argue that learners' expressions of ownership are a reflection of their identity development in science and that conflicts are a part of this manifestation. Specifically, we ask two questions: 1) *what is the role of learners' identity development as they encounter tensions and conflicts in ownership of science learning?* and 2) *how do we best support learners' ownership in science learning, particularly in informal, project-based learning environments?*

Background

While there is consensus that learners' ownership can lead to higher engagement, researchers often examine ownership from different perspectives: individual and social. First, studies of ownership can take an *individual outcome* perspective; learners' ownership is a set of feelings and emotions that evokes a sense of control and possession within individuals and groups (e.g., Pierce et al., 2003). In their extensive review, Pierce and colleagues (2003) conceptually define *psychological ownership* as the "state where an individual feels as though the target of ownership or a piece of that target is theirs" (p. 5). Ownership is expressed in possessive emotions commonly associated with 'my', 'mine' and 'our.' Here, individuals might "feel" as though the target of

ownership is theirs. From an individual standpoint, learners' experiences, beliefs, goals, and cultural influences shape how ownership manifests. In this view, ownership is something that is achieved, and once achieved, ownership can provide a means for motivation and engagement in learning.

Ownership can also be examined from a *social process* standpoint. From this perspective, social contexts influence how ownership manifests; thus, ownership varies moment-to-moment for learners in various domains (e.g., Bandura, 2001). Ownership depends on the interacting relationships between learners, teachers, and the context. Although support of ownership needs to take place in the community, a lack of ownership can also be traced to power relations. Cornelius and Herrenkohl (2004) identify ownership of ideas as a manifestation of power in student-teacher relationships. Ownership of ideas implies a relation in power between individuals and concepts. In the realm of education, "whomever students perceive as having ownership of an idea - either themselves, their teachers, their textbooks, or their peers - will influence the relation that the student has to the idea itself" (Cornelius & Herrenkohl, 2004, p. 470). Therefore, students' expressions of ownership of knowledge are not standalone, but are tied up with the attitudes, participation and perspectives of adults and other learners. Using O'Neill and Barton's (2005) conception, our study acknowledges this duality: "Ownership is a dynamic and generative (social) process that exists in tension with ownership as an (individual) outcome" (p. 299). In this interpretation, there exists an acknowledgement that ownership is delicate and changing, but is still an innate part of people; thus, ownership exists as the dialectic between process and outcome and the dialectic between individual and social.

Ownership as Tensions and Conflicts in Science Learning

While most of the literature on ownership portrays the construct as an important and vital component to motivation and engagement (e.g., O'Neill, 2010; O'Neill & Barton, 2005), a limited number of studies in science education acknowledge the role of conflict in ownership of learning. Ownership of science learning often deals with power struggles between teachers and learners. O'Neill (2010) recognizes that classroom culture and structures impact learners' ability to take on ownership. Teachers and facilitators need to give up control and this is often a formidable challenge. Hay and Barab (2001) noted that learners' ownership of science learning conflicted with the actual practice of science. During their study, learners spent time working with actual scientists on an authentic investigation with real-life consequences. However, scientists needed to take control of the investigation away from learners to make sure the results were viable. Hay and Barab (2001) note the tension between ownership and authenticity that, "as authenticity increases ownership decreases" (p. 315). As the project became more authentic to a real-world community of scientists, the rules and cultural practices of science needed to be adhered to. Learners could not simply take control of the project and try out new practices.

Another aspect of control is placing structures, guidance, and scaffolds into science, which can diminish ownership. Reiser (2004) notes that in project-based science, great care is taken to contextualize the problem in learners' lives to support learners' ownership of the problem. However, project-based STEM learning is not full open inquiry. Similar to the authenticity issue, providing scaffolds and guides to those problems can take control away from the learners, thus weakening ownership. Finally, ownership of learning can cause learners to be overprotective of arguments and ideas. Haglund and Jeppsson's (2012) study directly examines the concept of ownership as pre-service science teachers learn to develop analogies for thermodynamics. As learners invested in their ideas and arguments, Haglund and Jeppsson found they became overly protective of the analogies.

Tensions in Ownership as a Reflection of Identity Development

As individuals become acculturated to the practices of science, they may encounter manifestations of power and social tensions that prevent them from taking full ownership. Within these documented conflicts of learner ownership in science learning, we do not yet fully understand the connection between social conflict and individual *identity development* and how to support learning in these moments. Identity development has a known strong connection to ownership. Organizational theorists Brown, Lawrence, and Robinson (2005) suggest that psychological ownership and self-identity are so correlated and tied to each other, that people mark and defend their territory as an extension of themselves. When individuals form strong feelings of ownership over physical or non-physical objects, they may attempt to mark these possessions exclusively as their own. If the possibility of infringement or threat to take ownership away from those objects occurs, individuals may engage in protective territorial behaviors that attempt to maintain levels of ownership. Pierce and colleagues (2003) call this threat, "the dark side of ownership" (p. 30). Both the processes involved in ownership and the innate characteristics of individuals leading to ownership are inextricably tied to how learners see themselves and are coming to see themselves. Ownership is thus tightly connected to learners' identity, but the connection has been rarely studied in the context of learning. In order to understand the role of ownership in learning, we need to not only recognize ways to promote ownership and identity development, but also remain aware of the limitations ownership can present to learning.

While studies have begun to tie ownership to identity development, few studies of ownership make direct connections to identity research. To better understand the role of identity development and conflicts in ownership of science learning, we utilize Wenger's (1998) conception of identity development through modes of belonging: imagination, engagement, and alignment. Modes of belonging are the ways participants see themselves as members of a community based on their engagement in practice, alignment in coordinated activities, and imagination of their world. *Engagement* is the process of how a member participates in the community. Through engagement, people work together to build relationships and communities of practice. *Alignment* is the process in which members take actions to align themselves to the goals and purpose of the community. Alignment is indicated through commitment, allegiance, and investment of energy. Alignment bridges space and time; participants can coordinate their energies, actions, and practice across other communities. Finally *imagination* is how members see themselves as connected (or not connected) to a broader community. Here, people imagine themselves as part of the community and gain a sense of connection with others. Imagination is broad, connecting to an extended identity. It involves seeing ourselves within a larger purpose and community. Using Wenger's identity framework, we shed light onto the conflicts arising in ownership and how we can best begin to address them to support learners' science ownership.

Methods

We employed the methods of a comparative case study (Yin, 2003) on a single implementation of Kitchen Chemistry (KC). KC is an afterschool program in which learners engage in scientific inquiry through cooking. We took on the role of participant observers; we both facilitated and observed the KC program. In the first four sessions of KC, learners engage in *semi-structured activities* to help prepare them to observe, reflect, and record food science activities. For this study, we specifically analyzed learners' participation on *Choice Days*. During these activities, learners are given opportunities to use what they have learned in KC to develop questions, hypotheses, and experimental procedures for their own food investigation. We observed learners making decisions on what recipes they want to modify, what variables they will control, what data to collect, and how to interpret their findings (Yip et al., 2012). Integrated into Choice Day was the use of several mobile apps. In this paper, we highlight *Scientific INQuiry* (SINQ), a social media app used by learners to develop and share questions, hypotheses, and investigation ideas (Gubbels, Yip, Kim, & Ahn, 2013). For this case study, we examined three focal learners and the conflicts that arose in KC based on their ownership of science learning. We analyzed learners' imagination, engagement, and alignment (Wenger, 1998) in science to investigate the role of identity development in ownership of science learning. We chose KC as a context for studying identity and ownership tensions because of the transformation in relationships of power (e.g., Cornelius & Herrenkohl, 2004); learners lead the investigation while facilitators played the supporting role.

Context and Data Collection

KC was implemented as a 12-week afterschool program that met once a week for roughly two hours in a local private school. Six learners between the ages of 8 to 11 participated in the program each week. The learners all attended the Montessori school that hosted KC. Each day we collected video recordings of all activities and discussions and software artifacts. We also conducted semi-structured interviews with four of the learners and their parents at two intervals of the program. In addition, we conducted interviews of the teachers of the focal learners and conducted classroom observations. Lead facilitators also recorded post-observational field notes of their experiences each day in KC. The facilitators in KC in the case studies are Beth, Emily, and Jason. We refer to the learners as Arman, Freddie, and Donna (pseudonyms).

Criteria for Case Selection and Data Analysis

We used the following three questions for the selection criteria: 1) What personal views did learners have of science?; 2) How did learners socially collaborate with each other and with facilitators?; and 3) What are the participation styles of the learners? Based on these questions, we selected three focal learners and vignettes that were representative of the present conflicts in ownership. We began the data analysis through an initial examination of the interview data, video recordings, software artifacts, and facilitator field notes. During this time, we wrote analytical memos and transcribed certain key portions of the data. Using methods outlined by Strauss and Corbin (2007), we used open coding to identify instances of social tensions, which included codes focused on learner distractions, social breakdowns, interruptions, arguments, difficulties in choice-making, frustration, and selfishness. We also coded for how learners engaged, aligned with, and imagined science. Using our analytical memos, photographs, and videos, we triangulated the data to determine if all pieces of evidence supported each other (Merriam, 2009). To establish validity in the coding scheme, we presented the codes to two external reviewers not closely involved with the study for an external code audit (Creswell, 1998). To make sure the cases were representative of ownership and conflict, we presented the case to the corresponding facilitator for validation. Finally, once the cases were thoroughly examined and developed, we conducted a cross-case analysis of the three cases to investigate similarities and differences in the data.

Key Findings

We begin each case with a description of the Choice Day activity that the learners and facilitators engaged in. In our analysis we then use Wenger's (1998) modes of belonging as a framework to analyze each case to understand the role of science identity development in ownership. Finally, we frame the conflict in each case through the individual and social processes perspective of ownership and its connection to identity development.

Case 1: Arman and the Spreadable Cookies

On Week 10 of KC, Arman, a 5th grade boy worked with Beth (facilitator) to create an investigation on spreadable cookies. Over the course of KC, we noticed that Arman tended to be quiet and did not always push for his own opinions. His teacher even expressed that Arman would often defer his choice and let others lead. In this Choice Day investigation, Arman was given the chance to follow through on an idea that he had initiated. Using SINQ, Arman entered his question: "What affects the spread of a chocolate cookie?" Arman wanted to pursue this cookie question and take control of the investigation. Beth also wanted to support his decision-making practices and cultivate his ownership over the spreadable cookies question.

Initially, Arman thought that butter affected the spread of the cookies. Beth suggested that they do a trial experiment to see which melts first, butter or vegetable shortening. Unfortunately, the pantry did not have any vegetable shortening to test out. Therefore, the duo needed to alter their plan. As they talked more about how to adjust the investigation, Arman showed Beth a website that might describe what the acid is in baking powder. She stated, "So without this, without the acid that is in this (baking powder), it should not rise." Arman pointed out, "So this should be flat (baking soda), flat cookies (points to baking soda) and not flat (baking powder)." Beth agreed and wrote down, "We should try one experiment with baking powder and one with baking soda and compare. We predict these will be flatter (baking soda) and we predict these will be fluffier (baking powder)." Beth called the final setup a "double or nothing" arrangement, in which their predicted more spreadable cookie consisted of liquid butter and baking soda, while their predicted less spreadable cookie was made with solid butter and baking powder. Although this was Arman's own investigation, he started to exhibit challenges with self-confidence. For instance, after this decision was made of the investigation setup, they needed to figure out the proportions for the recipe. Beth asked Arman, "Can you do the math and I'll type it in?" However, Arman looked hesitant and said, "You type it in, I'm not good at math." Being supportive, Beth said, "Oh well, we'll figure it out together." Even though the duo appeared to be making setup decisions together, Beth became concerned about her role as a facilitator. She stated she was worried the entire time about "taking over too much" or that he was not excited about the investigation. Beth claimed that, "*Arman might be opinionated, but you don't hear him voice his opinion*." Since it was difficult for Beth to interpret Arman's expressions of ownership, she acted cautious and did not want to overstep her bounds. Beth conveyed that she felt a tension in leading and supporting him.

Case 1: Analysis

In examining Arman's identity development, we must consider how his engagement and alignment tie together to his larger imagination of science and himself. With respect to engagement, Arman spent time working with Beth on the investigation. He was not distracted and his level of engagement with Beth did not decrease over time. He made investments into his cookie investigation. Arman aligned the cookie investigation to the practices of KC. The cookie investigation was not just about baking desserts. Arman spent time looking up ideas for his investigation in a cooking website and wanted to test out his question through an experimental design. However, even though Arman may have engaged and aligned with the practices of the investigation, he had difficulty taking complete charge of it. Specifically, we observed that Arman exhibited lower confidence; this might have affected how much control of the decisions he wanted, and how much ownership he exhibited. Wenger (1998) suggests that understanding imagination allows us to develop a more full picture of alignment and engagement. Towards the end of KC, we asked him if he could identify himself as a cook, designer, investigator, and/or scientist. He consistently reported what he called his "*slow progress*" with respect to these roles. Arman imagined people in these roles as being able to explain some knowledge or information to someone else, but expressed his limited imagination with respect to them in stating, "like I can't explain things really well." He reported he did not even think people at home and school would care to listen, "I just think like if I tell them and they don't really care, I don't know if they will really listen."

Arman's difficulty in imagining himself in these roles may have influenced his reluctance to take on stronger ownership of the investigations. As an individual aspect, Arman's outward behavior may have indicated a learner that took on aspects of ownership of the investigation, such having control over decisions in the food investigation and aligning his works through investments into the practices. However, in the social process of ownership, Arman also took on a deferential perspective to adults in his home and school life. This view of himself in comparison with adults might have made the choice-making process difficult for him. Although Beth attempted to support any decision he made to cultivate ownership, Arman may have wanted the "right" decision in KC or at the least decision he thought would make the adults happy.

Case 2: Freddie and the Greenies

On Week 06, Freddie, a 5th grade boy, was extremely excited to start his "Greenies" investigation. Since Week 03, Freddie had been clamoring to make green brownies (Greenies) as his Choice Day investigation. He worked with Emily as his facilitator. Upon the start of the session, Freddie immediately went to his station to begin. However, his enthusiasm soon deflated as he found out he had to fill out a goals chart, a scaffolded worksheet that learners fill out to determine what outcomes they wanted and what tasks they needed to accomplish their goals. Freddie, frustrated at even the notion of slowing down, raised his hands in the air to show his irritation, "Why don't I, I don't get this piece, cause it says what leavener should we use for taste and stuff? Like for texture? Seriously?" Emily, being patient, asked him, "What leavener should we use to make cakey brownies?", "Texture?", "Smell?" None of these were really pertinent questions to Freddie; all he wanted was to make brownies with a green color.

Instead, Emily wanted Freddie to consider how green food coloring would show up since all the other ingredients had different colors and tones. She suggested that they change something in the recipe to make sure the green food coloring shows up more. Freddie just wanted to add the green food coloring, "Let's just add it (green food coloring), just because it's (white chocolate) white, it will show up more." Emily again slowed him down, "Well hold on, that's the thing. Not everything in the recipe is white." Freddie argued back, "Brownies are brown because of the chocolate!" Needless to say, Freddie started to grow impatient with waiting and thinking. We observed that Freddie began to breathe heavily at this time; he wanted to go and just grab the ingredients. Emily asked him, "Are you getting frustrated?" to which Freddie nodded yes. She suggested they go get some fresh air. Emily also reminded Freddie they were a team and there was no rush to what they were doing. Once Freddie calmed himself a bit, Emily reminded him the Greenies might not be perfectly green and they need to consider how much white chocolate they would put in and how much green food coloring goes with it. Freddie stated that it does not matter how green it gets, "Anything green is good." Freddie was still excited, but was frustrated, "I just can't wait to start!"

Case 2: Analysis

While Freddie's frustration could be easily dismissed as impulsiveness, we argue that Freddie's identity development played a key role in his ownership and conflict. Freddie stated that he imagined that scientists and investigators 1) mix chemicals together in random ways; 2) serendipitously discover new substances; 3) make close observations; and 4) work in a lab that would be very similar to a kitchen. To Freddie, being a scientist meant doing a lot of hands-on mixing and making close observations of the final result. Wenger (1998) describes alignment as translating imagination into coordinated action. In KC, Freddie did not want to align with the slower and reflective practices emphasized in KC. Freddie expressed science activities at home (e.g., experimenting in the kitchen; determining if his cat lands on its feet) rarely had limitations, "At home you can choose, I can choose whatever I want" and "I like doing my own thing". In contrast, standing around and planning an investigation was not what he imagined scientists and investigators doing, and therefore, did not want to align to the KC practices. For engagement, Freddie wanted to take time to invest in the Greenies, but wanted to do this on his own terms. Freddie's goal was simple; he just wanted the brownies green. He wanted to start fast, get his hands into the cooking quickly, and not reflect on the investigation at hand. As part of his identity development, his reactions suggested he wanted to be known as the person that figured out how to make brownies green, not as the person that slowly planned the investigation.

In this case, science in KC and home came into conflict with Freddie's ownership, control, and imagination of roles. From the individual standpoint of ownership, Freddie wanted to keep his home science perspective of full autonomy and choice in the investigation. His perception of home science was of freedom of choice and supported his impulsive personality and bricoleur style of learning and engagement. Clegg and Kolodner (2007) describe Freddie's style of learning as a "bricoleur", one that investigates by manipulating objects and letting the product and learning emerge, often without planning. In contrast, from a social process standpoint, Emily took on a planner role; she preferred a more reflective and rule-based perspective. In this sense, when Emily wanted him to slow down and plan, she denied him full control and ownership over his investigation, even though she wanted to support his ownership. As Freddie's identity development took on the practices of how he conceptualized science learning, his ownership came into conflict with the more methodical and reflective inquiry practices of KC.

Case 3: Donna and the Puffy Cakes

Donna, a 5th grade female, wanted to make puffy cakes for her food investigation. She worked with Jason, a facilitator, for her Week 07 Choice Day. The investigation was focused on developing variations of cakes to determine what factors influenced cake density. As part of her ownership, Donna wanted to pursue the making of a cake. In SINQ, Donna entered the question "How do you make things (cakes) puffy?" and came up with the hypothesis that variations in eggs contribute to the puffy nature of a cake. Over the course of discussion, Jason suggested to Donna that they could do three egg preparations: eggs normal (yolk + egg white), egg white alone,

and the yolk alone. A fourth cake with just the batter alone (no eggs) would serve as the control since this was what the original recipe had indicated. Jason checked with Donna to see if this would work with her. She agreed with this setup. Meanwhile, Donna showed Jason that she could now crack an egg and separate the egg whites, a technique that she was very proud of.

Once the batter was mixed with the three different types of eggs in the cake ramekins, Jason set the mixtures into the oven. After the four cakes were baked, he brought them over to Donna. However, Donna started to become distracted by her friends. Jason tried to bring her back into the investigation by asking her to help him make measurements of the cakes. Donna noted that she was distracted by the noise and said she was tired of the measuring activity. In order to get her attention and reignite her ownership, Jason had her begin to taste some of the cakes. He had Donna try the control and she expressed enjoyment tasting it. However, as they continued with the measurements and observations, Donna appeared even more distracted. She looked tired and wanted to go play with an iPad™. Although others started to come and ask Donna questions about her cakes, Donna did not seem interested in answering them. Jason attempted to prompt her to wrap up her investigation, asking, "so which one is the most dense?" Again, she thought the egg white variation was the densest, but had difficulties articulating why. She thought the control and egg yolk versions were "too grainey" and that the egg white helped to enhance the flavor After all these observations were complete, Jason asked her, "So what do you think the egg is doing to all of these things right now that's different than the control?" Donna licked her fingers and shrugged her shoulders, indicating she did not have anything to say.

Case 3: Analysis

Similar to other KC learners, attention was a significant personal factor that influenced Donna's ownership of learning. Both Donna's mother and teacher brought up Donna's attention difficulties in interviews. As a result, Donna's ownership of the investigation waxed and waned as her attention shifted. However, attention alone does not provide the full story of what she chose to pursue in the investigation. We argue that understanding the roles of imagination, engagement, and alignment in identity development gives us stronger insight into her shifting ownership. First, Donna called herself a dreamer, someone that could come up with ideas and make them come true. For example, when we asked her about her career choices, cooking and designing careers always prevailed, but becoming a scientist always ended up last on her list of considerations. Like the bricoleur style of learning (Clegg & Kolodner, 2007) cooking and designing was meant to be free of restrictions. Donna's imagination of science was not due to lack of exposure to science; Donna's mother worked as a research scientist, studying allergies. During lab visits, her mother would often give Donna small experiment kits and let her play around with the equipment. She imagined that scientists constantly "make explosions" and "mix stuff" and they would inevitably "find cures and discover new things, stuff like that." Donna negotiated her engagement in science learning the way she imagined how she enacted the roles of scientist. She wanted hands-on mixing and exciting explosions, not the slower reflection and planning processes or the careful measurements and observations. Initially, when she was given the opportunity to come up with ideas, she took this task seriously. As such, Donna's alignment towards the hands-on aspects of sciences (e.g., mixing), the idea generation, and the end product development coordinated well between home and KC. However, when Jason and Donna began the slower reflection and measuring processes, she began to disengage.

Donna's conflicts of ownership over certain aspects of KC are a reflection of her identity through imagination, engagement, and alignment. From the perspective of the individual outcome, Donna chose targets of ownership that fit into her identity, such as science as hands-on activities that are constantly filled with "fizz", "explosions", and "fun". While Donna recognized that reflection and critical thinking were part of being a scientist, she did not think of herself as engaging in these characteristics. Instead, Donna wanted control and ownership over aspects she was familiar with from cooking at home and mixing in her mom's lab. Donna, who already had attention issues and imagined herself as a candy maker dreamer, had difficulties latching onto the slower paced tasks. From a social process standpoint, the conflicts in ownership are also a result of alignment between what Jason and Donna wanted. Wenger (1998) comments that since alignment concerns directing energy, it also concerns the power to exercise, inspire, and demand alignment. The coordination of actions constitutes shifts in identity and participation. However, in Donna's case, as her identity focused more on the fun scientist role, difficulties occurred as Jason tried support an alignment towards deeper reflection. As a result, Donna disengaged and disowned aspects of the investigation that did not fit with her identification.

Discussion: Connecting Identity Development to Ownership

In examining these three cases, we observed a variety of tensions in ownership of science learning. This study shows that while personal factors contribute to these conflicts, learners' existing identities and imaginations of science also play a significant role in how ownership is expressed. Each of these imaginations of science contributed to the tensions surrounding ownership. Arman imagined his identity development in science and design as slow going and not up to an imagined standard in which he could be confident to take control and ownership of his investigation, even with a supportive facilitator. In contrast, Freddie's case represents a learner

who wanted absolute control over his investigation. While impulsivity was a contributing factor to his ownership, for Freddie doing science meant having the ability to make any decision he wanted as long as it meant making his Greenies. Finally, in Donna's case, she faced challenges with attention, which illustrates her ownership as strong in the beginning, but waning in the end. However, she also imagined science as "fun" and full of explosions and color changes. When these dynamic occurrences did not happen, she chose to disown the investigation. Our work highlights the need to connect science learning to learners' existing imaginations about science. Learners like Freddie and Donna needed to see the fun parts of science – the explosions and the actions – to begin to align to the practices of the investigation. At points in the investigation, both Freddie and Donna needed to do science on their own terms for initial engagement.

However, supporting ownership of science learning is a complicated balancing act of authority and freedom. Even with their desires of engaging in the fun aspects of science, the learners needed some structure. Research has shown that reflection is powerful and necessary, both as learners are engaging (reflection in action) and later as they reflect on their engagement (reflection on action) (Schon, 1987). Typically schools designate the role of power to adults, while authority can be more shared in informal learning environments (O'Neill, 2010). This study reveals that issues of authority that appeared similar to formal learning were still an issue in our informal learning environment. Even though opportunities for learners to take more control were present, the facilitators still needed to think carefully about how to balance power and structure. We wanted learners to adhere to a culture of science, in which careful measurements and observations were paramount. However, some learners wanted to just cook and bake. Other learners wanted to do science the way they imagined it from their experiences at home, often in a very unplanned fashion. For these learners, placing guidance caused tensions in ownership. Some may advocate that more open inquiry environments in which learners have more control can promote ownership in learning. However, minimal guidance during instruction has been shown to be problematic due to cognitive load (e.g., Kirschner, Sweller, & Clark, 2006). Scaffolds and guidelines are still needed for learning, even in more open activities (e.g., Reiser, 2004). These cases reveal that simply giving learners a chance to control, possess, and own their activities is not enough for science learning. Without slower reflection and guidance, learners can miss important aspects of the science process.

Implications for Fostering and Supporting Science Ownership

Fostering learners' ownership can lead to deeper learning and engagement (e.g., O'Neill, 2010), but this study argues that cultivating ownership in science learning is complex due to the learners' identity formation in science. These cases show that one-size fits all approaches to supporting ownership did not exist since each learner's own identity development differed in trajectory. Some learners needed structured guidance to help make decisions and build confidence to take ownership, while others found guidance stifling. Our findings suggest that it is not enough to simply balance the amount of time and effort between fun activities and structured reflection to promote ownership. These two aspects need to be interconnected in ways that help learners see the necessity of both in science learning. For example, during interviews, Freddie spent time reflecting on the Greenies investigation and expressed the mistakes he made in the experimental setup. Freddie came up with new ideas about why his Greenies did not turn out well. He even worked with his mother on a more structured investigation at home to examine the differences between dark, milk, and white chocolates. Freddie needed an opportunity to cycle back and contemplate on the process and the importance of reflection.

Facilitators also need to be aware of the different needs of learners and be able to flow between structure and freedom dynamically. Quiet learners like Arman needed guidance from the facilitator to help develop ownership in his investigation. Arman expressed in the interviews he was overwhelmed with making choices in an inquiry environment. Without facilitator supports, it would have been even more difficult for him to take some aspect of ownership. For learners, like Freddie and Donna, who wanted to take stronger ownership over their investigations, we attempted to negotiate with them. We used strategies such as allowing them one set of ingredients they could "mess around" with, while another set would be used strictly for the investigation. Another strategy was to have learners switch roles from cook to technology recorder so that they could slow down and make closer observations. Supporting ownership was a give and take dynamic. Sometimes we needed to enforce structure so that learners could focus more. Other times, we allowed learners freedom to take risks and engage in experimental play in the ways they wanted. In all three cases, finding the right balance of control and ownership was delicate and did not always work the way the facilitators planned. Finally, this study shows that fostering ownership over the investigations was not always an immediate process and may not be long lasting. Arman needed time to gain confidence to take on more ownership of his investigation. Donna started strong in taking responsibility in the cooking aspects of the investigation, but her ownership dissolved quickly at the end, during the measuring and reflection process. For Freddie, it was only when he needed to figure out why his Greenies did not turn out well, he began to take on ownership of ideas and inquiry-based processes. We argue that fostering science ownership takes time and depends on how learners' identities and imaginations of science shift towards science dispositions.

Conclusion

This work shows that conflicts in ownership are not just an indication of authoritative power, but also a reflection of learners' identity development in science. We do not simply imply that facilitators surrender the responsibility of guiding the learning process to increase learners' ownership (e.g., Cornelius & Herrenkohl, 2004). Instead, we observed that each learner experienced science learning in diverse ways outside of KC. From these experiences, the learners developed different ways of imagination, engagement, and alignment in science, which ultimately influenced how they took ownership of their investigation and how they dealt with issues of power and social interactions. Our findings suggest that a delicate balance power between learners and facilitators is needed to foster engagement, imagination, and alignment, conducive to learners' ownership development. We make the argument that understanding the evolution of ownership of science learning also means further examining how learners' modes of engagement interact in multiple contexts.

References

Atwater, M. M. (1996). Social constructivism: Infusion into the multicultural science education research agenda. *Journal of Research in Science Teaching*, *33*(8), 821–837.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, *52*(1), 1–26.

Brown, G., Lawrence, T. B., & Robinson, S. L. (2005). Territoriality in organizations. *The Academy of Management Review*, *30*(3), 577–594.

Clegg, T. L., & Kolodner, J. L. (2007). Bricoleurs and planners engaging in scientific reasoning: A tale of two groups in one learning community. *Research and Practice in Technology Enhanced Learning*, *02*(03), 239–265.

Cornelius, L. L., & Herrenkohl, L. R. (2004). Power in the classroom: How the classroom environment shapes students' relationships with each other and with concepts. *Cognition and Instruction*, *22*(4), 467–498.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage Publications.

Fusco, D. (2001). Creating relevant science through urban planning and gardening. *Journal of Research in Science Teaching*, *38*(8), 860–877.

Gubbels, M., Yip, J., Kim, J., & Ahn, J. (2013). Scientific INQuiry (SINQ): Social media for everyday science learning. In *Proceedings of the iConference 2013* (pp. 1102 – 1105). Fort Worth, TX.

Haglund, J., & Jeppsson, F. (2012). Using self-generated analogies in teaching of thermodynamics. *Journal of Research in Science Teaching*, *49*(7), 898–921.

Hay, K. E., & Barab, S. A. (2001). Constructivism in practice: A comparison and contrast of apprenticeship and constructionist learning environments. *Journal of the Learning Sciences*, *10*(3), 281–322.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, *41*(2), 75–86.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: John Wiley and Sons.

O'Neill, T. (2010). Fostering spaces of student ownership in middle school science. *Equity & Excellence in Education*, *43*(1), 6–20.

O'Neill, T., & Barton, A. C. (2005). Uncovering student ownership in science learning: The making of a student created mini-documentary. *School Science and Mathematics*, *105*(6), 292–301.

Pierce, J. L., Kostova, T., & Dirks, K. T. (2003). The state of psychological ownership: Integrating and extending a century of research. *Review of General Psychology*, *7*(1), 84–107.

Reiser, B. J. (2004). Scaffolding complex learning: The mechanisms of structuring and problematizing student work. *Journal of the Learning Sciences*, *13*, 273–304.

Schon, D. A. (1987). *Educating the reflective practitioner*. San Francisco, CA: Jossey-Bass.

Strauss, A. L., & Corbin, J. (2007). *Basics of qualitative research: Techniques and procedures for developing grounded theory, 3rd ed*. SAGE Publications.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge Univ Pr.

Yin, R. K. (2003). *Case study research: Design and methods* (Vol. 5). Thousand Oaks, CA: SAGE.

Yip, J. C., Clegg, T. L., Bonsignore, E., Gelderblom, H., Lewittes, B., Guha, M. L., & Druin, A. (2012). Kitchen Chemistry: Supporting learners' decisions in science. In J. van Aalst, K. Thompson, & P. Reimann (Eds.), *Tenth International Conference of the Learning Sciences* (Vol. 1, pp. 103–110). Mahwah, NJ, USA: Erlbaum.

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