The Qualitative Report

Volume 23 | Number 12 Article 6

12-8-2018

Making the Invisible Visible: Affordances and Hindrances of Using Tangible Objects in Identity Research

Amber Simpson
Binghamton University--SUNY, asimpson@binghamton.edu

Making the Invisible Visible: Affordances and Hindrances of Using Tangible Objects in Identity Research

Abstract
The purpose of this manuscript is to highlight the role of tangible objects (i.e., rings) in understanding individual's STEM identity, which in this study is defined as an interdisciplinary belief that an individual has about her or himself regarding science, technology, engineering, and mathematics. The rings allowed participants to position themselves within STEM disciplines and to further illustrate and narrate this position through the various ring sizes, and for some, the spatial arrangement of the rings. However, the use of the rings seemed to limit participants to describing who they are within STEM in the moment, as well as not providing an opportunity to illustrate how micro- and macro-level external forces shaped their identity.

Keywords
Identity, Narrative Inquiry, STEM, Tangible Objects

Acknowledgements
I would like to thank my dissertation committee at Clemson University, Dr. Megan Che, Dr. Cassie Quigley, Dr. Nicole Bannister, Dr. Diane Perpich, and Dr. William Bridges. I would also like to thank Dr. Adam Maltese at Indiana University for his guidance and support in my research on STEM identity.

The Qualitative Report 2018 Volume 23, Number 12, Article 5, 2973-2988

Making the Invisible Visible: Affordances and Hindrances of Using Tangible Objects in Identity Research

Amber Simpson
Binghamton University, SUNY, New York, USA

The purpose of this manuscript is to highlight the role of tangible objects (i.e., rings) in understanding individual's STEM identity, which in this study is defined as an interdisciplinary belief that an individual has about her or himself regarding science, technology, engineering, and mathematics. The rings allowed participants to position themselves within STEM disciplines and to further illustrate and narrate this position through the various ring sizes, and for some, the spatial arrangement of the rings. However, the use of the rings seemed to limit participants to describing who they are within STEM in the moment, as well as not providing an opportunity to illustrate how micro- and macro-level external forces shaped their identity. Keywords: Identity, Narrative Inquiry, STEM, Tangible Objects

Introduction

For many individuals, their career is intimately associated with their professional identities—who they are and who they are becoming while on the job (Hoekstra, 2011; Inkson, 2007; Pratt, Rockmann, & Kaufmann, 2006). As stated by Chope (2000), one's career identity is the "kernel of all that you hope to be or become, the nucleus of your workplace confidence. It represents the accrual and integration of your experience, skills, interests, values, and personality characteristics" (p. 58). Further, individuals possess more than one professional identity as work-related tasks and activities are varied, specialized, and skill-based (Chope & Johnson, 2008; Ibarra, 1999). For example, an individual may identify as a software engineer, a computer scientist, and/or someone who addresses problems like a scientist.

This paper draws upon the notion of positioning as individuals recognize themselves as a member of a particular category or categories (e.g., mathematician, scientist) and not of others (e.g., engineer; Davies & Harré, 1990; Harré & van Langenhove, 1991); as a particular *kind* of person (Gee, 2011) in relation to other professionals in the field of science, technology, engineering and/or mathematics or STEM (e.g., "I am not a scientist because I don't conduct research."). Similarly, others may refer to this notion as identification (Ashforth, Harrison, & Corley, 2008) or the "perception of oneness or belongingness to some human aggregate" (Ashforth & Mael, 1989, p. 21) or "perceived organizational identity" (Dutton, Dukerich, & Harquail, 1994, p. 239).

I recognize that since the introduction of the acronym STEM in 2001 by Judith A. Ramaley to refer to science, technology, engineering, and mathematics curriculum (Teaching Institute for Excellence in STEM, 2010), there has not been consensus on how to appropriately define STEM (Breiner, Johnson, Harkness, & Koehler, 2012). I tend to agree with the argument by Moon and Singer (2012) that the acronym has been framed as fixed and isolated fields as opposed to a dynamic entity of shared practices and processes that transcend science, technology, engineering, and mathematics as isolated bodies of knowledge.

As such, participants' STEM identity is defined as positioning oneself or identifying oneself as part of a perceived interdisciplinary identity, or single-disciplined identity, which is dependent on their perceptions of self and work-related tasks and activities in relation to their

perceptions and understanding of work-related tasks and activities of other individuals. Considering one's identity in STEM as interdisciplinary will add to our current understanding because much of the research on individuals' identity as a particular kind of person in STEM is in relation to one discipline. In this manuscript, I considered how the use of tangible objects afforded and hindered participants' narrated identification within science, technology, engineering, *and* mathematics (STEM) as a certain kind of person. More specifically, I briefly discuss the methodological issues of this approach and explain different ways in which these tangible objects can be used to elicit more data from within an interview.

Kaleidoscopic View of Identity

As a way to make sense of the complexity of one's STEM identity, I liken the construct to that of a kaleidoscope. At one end of the kaleidoscope is an opening hole that is used for viewing; in this context, the viewing of one's STEM identity. The individual looking through this opening hole, and subsequently what they view at the other end of the kaleidoscope, is influenced by their beliefs, culture, history, role, and knowledge of the field. For example, how I view one's identity within STEM as a researcher, teacher educator, and outsider will more than likely be different from how an individual in one's respective field or someone in humanities may view another's STEM identity. In addition, what is viewed at the end of the kaleidoscope is bounded or constrained by the viewing tube—the narrow tube that houses three strips of mirrors, which reflects the influences shaping and informing one's identity. I liken this to tunnel vision as one cannot (and should not) extend what they see beyond the walls of the viewing tube. As argued by Krauss (2005), researchers are to understand the phenomenon of interest from the point-of-view of participants and to avoid imposing personal views and a priori understandings.

Another feature of a kaleidoscope is the turning mechanism, which alters and manipulates what one views with each slight shift. This mechanism in reality is controlled by a viewer's hand. In terms of one's identity, the mechanism is controlled by the verbal and non-verbal communicative acts of others (Bakhtin, 1981). In other words, this feature represents the different external influences, words, and social languages that individuals transform into one's own voice(s) through "her or his [sic] own intention, her or his own accent" (Bakhtin, 1981, p. 293), which shapes one's STEM identity with each turn. For example, particular STEM fields have historically and presently been dominated by men (NSF, 2017); in return, women and under-represented minorities are at times positioned as undervalued, isolated, and marginalized (Johnson, 2011; Malone & Barabino, 2009; McGee & Martin, 2011; Solomon, 2007).

At the opposite end of the opening hole is the object box that is typically composed of various colored beads, glass, or other reflective and translucent material. The object box for me represents one's STEM identity. Similar to how the image in a kaleidoscope is a myriad of colors and shapes moving in and out of one another, so is one's identity a myriad of positionings moving in and out of one another in a fluid motion as individuals negotiate the kind of person they are and are becoming as a STEM professional or not becoming as a STEM professional.

This kaleidoscopic interpretation of one's identity as represented within the context of analyzing interviews is a time-consuming process (Simpson, 2015; Simpson & Quigley, 2016) and has led to considering how the manipulation of physical objects might promote or hinder one's ability to express and physically represent their identification within STEM. This latter approach was addressed by considering the following research question: *Considering the view of identity as a kaleidoscope, how might rings or circles of varying sizes afford and/or hinder how STEM professionals narrate and illustrate one's identity within STEM?* These tangible objects were laser cut rings of five varying sizes, as well as the letters S, T, E, M, which served

as labels. As such, interactions and engagement with tangible objects, which may be referred to by some as manipulatives (e.g., Kelly, 2006), have been noted to be more inviting and more supportive of active collaboration than other interactions such as interfacing with graphical representations (Horn, Solovey, Crouser, & Jacob, 2009; Hornecker & Buur, 2006). The tangible objects also allowed participants a way to express their own understanding(s) of self within STEM both as a physical representation and through an opportunity to talk with and through the objects (Hornecker & Buur, 2006; Marshall, Price, & Rogers, 2003), a concrete representation of an abstract construct.

Self-of-the-Researcher

My interest in identity stemmed from my dissertation research in which I considered how eight middle school students' multiple voices (i.e., object box of a kaleidoscope) was an embodiment of how they narrated their beliefs and views of themselves as mathematics students. From my analysis, I developed voice mappings (Simpson, 2015). The voice mappings represented a student's multiple voices (e.g., recognition, confidence, sense of belongingness) in interplay with one another, continuously shaping and forming one's mathematics identity (see Figure 1). The size of the circles was symbolic of each voice's level of audibility within a participant's narrated mathematics identity. The largest and centermost circle represented one's lead voice, the voice in which participants most pervasively identified (Evans, 2008). One's lead voice was based on the amount of time devoted to the living nature of this voice in the interviews and validation interviews, including moments of silence. Sizes of subsequent voices were proportionally sized to one's lead voice. Additionally, the arrows are to show the relationship between the voices as explicitly stated by participants within either the initial interview or validation interview. Voice mappings influenced my use of rings of varying sizes for this study. I assumed most would construct a Venn Diagram similar to Figure 1, but I was surprised by the variety of representations (e.g., 3D models).

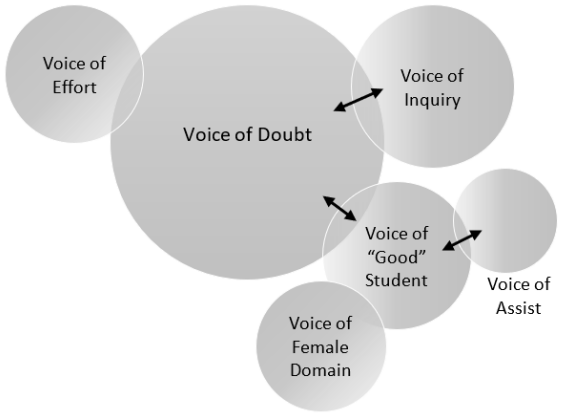

Figure 1. Voice mapping example.

My interest in STEM identity as an interdisciplinary or subject-specific discipline began as a curiosity as a researcher. Does an interdisciplinary STEM identity exist? If so, what is shaping individual's perception of self as a STEM person? How can we use this information in our work with underrepresented minorities in STEM fields? This curiosity started with a sample of STEM professionals, as I assumed I would gain a better understanding of this complex construct as opposed to collecting data from a sample that may or may not identify themselves as STEM persons or from a sample that has no understanding of what engineers

do, for example. I continue to explore the subtle nuances of individual's STEM identity as an interdisciplinary construct.

Research Study

In this study, I utilized narrative inquiry: the "study of the ways humans experience the world" (Connelly & Clandinin, 1990, p. 2). More specifically, this study was informed by descriptive narratives (Polkinghorne, 1988). The purpose of descriptive narratives is to "render the narrative accounts already in place", to render the narrative accounts or multiple voices as they are expressed by participants (Polkinghorne, 1988, p. 161).

The data that informed this paper was collected from 114 women engineers during an annual conference of the Society of Women Engineers (SWE). The participants specific engineering field spanned the discipline, from aerospace engineering to chemical engineering to biomedical engineering to manufacturing engineering, to name a few of the fields. Likewise, participants ages ranged from undergraduate students to retirees.

Prior to collecting data for this study, I sought approval from the Institutional Review Board at a large research university. Upon arriving at the table to engage with the different sized rings, I verbally explained to potential participants the purpose of the study, the risks and benefits, and confidentiality before seeking assent. Once a participant had verbally agreed to be a part of the study, I solicited the following: "Using these different sized rings, represent how you identify yourself as a woman engineer within science, technology, engineering, and/or science, or STEM. Consider the size of the rings and the relationship they may have with one another." Using an iPad, I video-recorded each participant's construction and explanation, with the camera focused on participant's manipulation of the rings. I transcribed each recording verbatim in a two-column format, considering both the verbal and non-verbal acts of communication—including the size and placement of the rings that accompanied their explanations. I referred to the size of the rings as Circle 1 for the smallest to Circle 5 for the largest. Using a two-column format afforded me the opportunity to record simultaneous acts of communication (Ochs, 1979). In Table 1, I illustrate my transcription from an interview with Mary, an electrical engineer. See Figure 2 for Mary's STEM identity representation.

Table 1.
Two-column Transcription Example

Line	Verbal	Non-verbal/Gestures
1		Begins with Circle 5
2		Adds Circle 3 to the top left of and overlapping Circle 5
3		Moves Circle 3 within Circle 5
4		Removes Circle 3
5		Places letter tile S outside of Circle 5
6		Places another Circle 5 (Circle 5b) to the right of and overlapping the first Circle 5
7		Places letter tile M outside Circle 5b
8	Okay, this is science…	Points to Circle 5

9	…and this is math…	Points to letter tile M
10	…and they intersect.	Moves finger back and forth from one circle to the other
11	Engineering also intersects.	Places Circle 3 on top of the intersection
12	And technology…	Places Circle 2 inside Circle 3
13	…also sub-factors from engineering.	
14	And…	Places Circle 1 inside Circle 2
15	…this is me.	

Figure 2. STEM identity representation for Mary.

Insights

The following describes ways in which the utilization of tangible objects afforded and/or hindered how engineering professionals narrated their STEM identity. Examples from the data are included to illustrate these affordances and hindrances, and various words and phrases are italicized for emphasis. It should also be acknowledged the insights presented are based on the kaleidoscopic view of identity of the researcher, as well as the initial analysis of the data that informed this paper. I began analysis of the data by reading through the transcripts and writing analytical memos to reflect upon and document initial codes, insights, and subjectivities. As researchers suggest, memos provide a mechanism to formulate and convey our thinking, communicate our assumptions and subjectivities, and challenge our interpretations when analyzing data (Birks, Chapman, & Francis, 2008; Saldaña, 2013). In this process, key words, particularly specific verbs (e.g., use, think) and adjectives specific to their constructions (e.g., small, overlap), began to inform my understanding regarding the manner in which participants used the rings to narrate and illustrate their STEM identity. A second analysis of the transcript data involved sentence-by-sentence *in vivo* coding or literal coding, which is a code directly extracted from participants' transcript (Saldaña, 2013)—in this case, verbs in relation to each STEM discipline, as well as words used to describe their representation. Yet as I began analyzing this data in terms of one's STEM identity, I identified areas of strengths and areas of weaknesses of the rings in terms of my kaleidoscopic view of identity which informed this paper.

Affordances

The use of tangible objects allowed participants to illustrate their identification in STEM through narrating work-related actions and activities through the size of the rings and through the spatial arrangement of the rings. Through narrations of their physical representations of self, participants highlighted an interplay between using, performing, and/or

enjoying STEM disciplines with being and becoming a STEM professional. In other words, doing STEM was not distinct from being a STEM professional, which is not necessarily the case for some youth (Archer et al., 2010). A second affordance of the tangible objects was that participants utilized their constructions to illustrate and physically point to their positionality within STEM (Davies & Harré, 1990); this notion that "I view myself as an engineer and a mathematician." A third affordance was, in some instances, that participants seemed to position themselves as what they are not in relation to others in STEM, which has been shown to be an important external force or mechanism in shaping one's identity (Bishop, 2012). A fourth affordance was that participants utilized the rings to narrate their "unfinalized" future or designated selves within STEM (Bakhtin, 1984; Sfard & Prusak, 2005). In other words, participants' future STEM identity was narrated as one's career identity (Chope, 2000). Lastly, as implied in the title, a fifth affordance was the use of the tangible objects that provided participants an opportunity to concretely represent an abstract and complex construct.

Affordance 1: Doing STEM and being a STEM professional. The different sized rings provided participants with the capability of physically and verbally expressing how their STEM identity was shaped and was defined by what they do on a daily basis, as well as, but less often, by their perceived cognitive and performance abilities and interests in STEM. For example, the following statement is from Asha, a mechanical engineer with a passion for robotics.

> So I feel that, personally *I am strongest* in the engineering and technology section. I don't, *I'm not as strong* in math, and so it's *smaller*. And *similar* with science. However, at one point *I was a lot stronger* at math. And so I feel like I should be more, this should be a *larger circle*. So basically, this is what I want it to be, not that it is.

As reflected in Figure 3, engineering and technology are represented by the largest ring based on the Asha's ability in these two fields. Mathematics and science are represented by the two smallest sized rings, again based on the Asha's ability or strength in the two disciplines. However, there is a desire to be stronger in mathematics, which is illustrated by the larger circle off to the left of the STEM construction. Thus, this ring is strategically placed away from Asha's current one, indicating a desired being or becoming.

Figure 3. STEM identity representation for Asha.

As an additional example, Jackie, a civil engineer described how she used STEM within her career role.

> I would say for most of mine in STEM, I *use* math a lot. Engineering and technology, they're about the same about in my job. But they *both tie* to the math that I *use*. And I definitely use science the least.

For Jackie, technology, engineering, and mathematics inform one another, as indicated as overlapping rings in Figure 4. One may also consider the layering of the rings in the case, as mathematics is the bottom ring and the largest ring, which is the discipline noted as being frequently.

Figure 4. STEM identity representation for Jackie.

As also represented in Figure 4, Jackie illustrated, and described in her narrative, how science concepts and practices are utilized the least in her career; therefore, she placed a small ring touching her core (e.g., TEM). The ring was also situated at the bottom of her construction, which may or may not be of significance.

Affordance 2: Positionality. Within the various arrangements, some participants represented their positionality within STEM. For instance, as stated by Kendra, "I'm thinking engineering is at the heart of, like, who I am." Note the use "I am," which is identified by Ashforth and colleagues (2008) and Gee (2011) as self-defining oneself as a particular type of person, in this case an engineer. In other words, Kendra is declaring oneness or belongingness to the field of engineering, recognizing herself as having similar characteristics and skills of other engineers (Ashforth et al., 2008). The following participant, Nastasia, used rings to not only position herself within engineering, but also to illustrate her connection to mathematics and technology (see Figure 5). Consider her explanation, "So I would put myself in here, in engineering (*places circle around on top of E*). But I'm also linked to math and technology (*points to rings connected to M and T*). So, that's me, the little one." Here Nastasia identified herself concretely as the small circle on the bottom left, a top of the letter E.

Figure 5. STEM identity representation for Nastasia.

As another example of positionality, consider Figure 6 in which Izabella, an electrical engineering student, is holding a ring above her construction to illustrate her identification or positionality in STEM. “I'd put myself more on the science side and more on the engineering side than on the math or technology side. But it all intersects and you're always dealing with all of it anyways.”

Figure 6. STEM identity representation for Izabella.

Affordance 3: I am… I am not... It was not uncommon for participants to omit a discipline from the representation of their professional STEM identity or include disciplines as remote rings or on the peripheral of the representation (see Figure 7).

Figure 7. STEM identity representation of Rena.

As narrated by Rena, "I use math the least. Mainly because there's other people on my team who use it for me and I just apply it." Here, it can be inferred that although Rena applies mathematical concepts and principles, she did not view herself as a mathematician in relation to other members on her team who use mathematical concepts and principles. This was further indicated by representing mathematics as a smaller ring and by placing it in a position remote to the construction. Therefore, in some instances, participants positioned themselves as what they are not (i.e., "other") relative to others within their own disciplines or individuals within other disciplines (e.g., Chen & Li, 2009; Riedinger, 2015). There is some indication as to how participant's STEM identity was being shaped and informed by the turning mechanism of the kaleidoscope.

Affordance 4: Future STEM self. Within participants' explanation, it was clear how one's STEM identity is fluid and shaped by their courses, projects, or defined role(s) within a particular group, institution of higher education, or company. This was elaborated upon in considering one's ideal and/or predicted STEM identity in the near future and was further illustrated in the shift or change in their representation. Consider Figure 8 in which Clara's current STEM identity is on the left and her ideal future STEM identity is on the right. As one can see, one of the disciplines is missing entirely.

Figure 8. Current and future STEM identity representation for Clara.

As another example, consider the following quote from Melanie, a bio-medical engineering professor.

> Technology, I want to almost do…I feel like I got really behind in technology because it moves so fast. I'm trying to stay on top of it. Young people are helping me stay on top of technology. I'm really hoping that technology swaps with me. *(changes small ring representing T for a large ring)* And I'm kind of trying to grow that.

Here, the participant projects the desire for her future STEM identity to include an increased belongingness or identification in the field of technology.

Affordance 5: Making the invisible visible. As illustrated in several examples above, the use of tangible objects allowed participants to construct and represent an abstract and invisible construct, namely their identity within STEM, as a concrete and visible illustration. These renderings of one's STEM identity are reflective of the object box of the kaleidoscope. Consider the second example in Affordance 2 in which Izabella used a ring to position herself within the construction (see Figure 6) - "I'd put myself more on the science side and more on

the engineering side than on the math or technology side." As another instance, reflect upon Figure 9.

Figure 9. STEM identity representation of Sophie.

Here, engineering is narrated and illustrated as "my core, center self." Mathematics was stated as the bridge that linked and translated engineering to the pure sciences and technology as the field that did all the work for this mechanical engineer. As Sophie concluded, "I can take all of this and integrate it into being an engineer." As a researcher, viewing the construction and representation of participants STEM identity illuminated visual insights that aligned with participant's narration, which may have remained "hidden" or "silent" from my standpoint and viewpoint as a researcher looking from one end of the kaleidoscope to another.

Hindrances

One obstacle of the rings was that participants' construction and narration were void of micro-level (e.g., classroom interactions, Holmegaard, Madsen, & Ulriksen, 2014) and macro-level forces (e.g., race, gender, socioeconomic status; Mendick, 2005) on their professional STEM identity. Second, this approach and/or prompt in general only allowed for a static representation of one's identity as opposed to a dynamic and in-flux representation of one's identification in STEM (e.g., Allen & Eisenhart, 2017; Wood, 2013); similar to the changing images within the object box of the kaleidoscope.

Hindrance 1: External factors. In general, participants in this study did not narrate how external factors such as gender, ethnicity, teacher-student relationships, and/or peer relationships, for example, shaped their STEM identity. What about one's confidence in the disciplines? How might their previous schooling and home life shape their current STEM identity? How might their local community shape their view and beliefs of self as an individual in STEM? What about their previous and current work environment and relationships with co-workers and supervisors? Furthermore, in considering the work of Hazari, Sonnert, Sadler, and Shanahan (2010), as well as Cribbs, Hazari, Sonnert, and Sadler (2015): How does one's perception of how others view them as STEM professionals shape their professional STEM identity? These questions address the turning mechanism of the kaleidoscope. The subjugated narrations focused on external factors could be for several reasons such as the research prompt, the time allotted to participants, and/or the public location of the table at the conference. These potential constraints are illustrative of the viewing tube of the kaleidoscope that limited what I as a researcher was able to "see" in terms of participants' identity in STEM.

On the other hand, for a small number of participants, this did become a space to talk about and illustrate disparities between the number of women and men that enter a field of engineering as research highlights how engineering as a discipline employs more men than women (e.g., NSF, 2017). As stated by Aubrie, an engineering student who was ostracized by a professor for attending the conference,

> So this I would consider everybody in a STEM program. And then being a woman in this field, it's so narrowed down that you need to like stand out more and sort of rise above the crap you're going to face for being a minority.

She illustrated this through a linear arrangement of the five rings from the largest (i.e., "everybody in a STEM program") to the smallest (i.e., "woman in this field"). However, this narration and identity construction was void of her explicit position and identification in STEM. How was being a woman engineer in a STEM program shaping this participant's STEM identity? Therefore, researchers are encouraged to consider specific prompts to elicit this information. For example, I could have asked an additional prompt such as,

> Using these different sized rings, represent how you perceive your colleagues and/or supervisors would identify you as a woman engineer within science, technology, engineering, and/or science, or STEM. Consider the size of the rings and the relationship they may have with one another.

Hindrance 2: Static representation. Contrary to the view of one's identity as dynamic and evolving, the use of the tangible objects, as well as the prompt, did not afford participants an opportunity to represent their changing and shifting professional STEM identity: their past, current, and for some, future selves. This was one snapshot of identity at one point in time and dependent on participants' work- or school-related tasks and activities. For instance,

> I spend all my time in like this engineering and technology. And for me like my whole like work, career, *currently*, is sort of between these two. So it's all about using my engineering to go make products. But those products are all about pushing the brinks of technology.

This response is very much in the here-and-now. One approach to address this hindrance is a longitudinal study in which participants are asked to manipulate the tangible objects to represent their STEM identity at various time points (e.g., end of every week). This could be video recorded and sent to researchers. Participants could also reflect upon their previous identity constructions to examine shifts in their self-identified positions within STEM. This research could potentially highlight moments in which these positionings may lead to a "thickening of identity" (Burke, 2003; Holland & Lave, 2001; Wortham, 2004), the process in which an individual's positionings becomes increasingly united over a period of time to form one's identity and identification as a certain kind of person, and in some cases, "act as self-fulfilling prophecies" (Sfard & Prusak, 2005, p. 19).

Final Thoughts

Grounded in my analysis of data collected from engineers, this paper highlighted the affordances and hindrances of tangible objects (i.e., different sized rings) in unpacking and understanding one's identity in STEM through a kaleidoscopic view of identity. Did the manipulation of tangible objects allow participants to express and physically represent their

professional STEM identity? Yes and no. Yes, the rings allowed participants to narrate and illustrate how STEM was used in their daily lives, as well as their interest and ability in STEM. Participants narrated the manner in which these factors are composing and shaping their professional STEM identity; representing the turning mechanism of the kaleidoscope (e.g., Author, 2015; Cribbs et al., 2015; Hazari et al., 2010). Yet, in general, participants did not narrate how micro- and macro-level factors were shaping and informing their STEM identity. I contend that considering micro- and macro-level factors is applicable to any disciplinary view of identity. These factors can be represented by the various size rings as opposed to S, T, E, and M. Additionally, the tangible objects allowed participants to position themselves within the STEM disciplines and to further illustrate and narrate this position through the various ring sizes and the spatial arrangement of the rings. In other words, participants recognized themselves as a member of a particular category or categories (e.g., technologists, engineer; Davies & Harré, 1990; Harré & van Langenhove, 1991), and in some instances, not as member of particular discipline. These various positioning and sizes are reflected in the object box of the kaleidoscope.

Researchers are challenged to consider how use of tangible objects or artifacts can deepen our understanding of how to understand individual's identity. I expect to build upon this approach to include additional prompts within a semi-structured interview regarding one's identity in science, technology, engineering, and/or mathematics. As noted above, one example includes,

> Using these different sized rings, represent how you perceive your colleagues and/or supervisors would identify you as a woman engineer within science, technology, engineering, and/or science, or STEM. Consider the size of the rings and the relationship they may have with one another.

Additional prompts will focus on using the different sized rings to illustrate how one's sense of belongingness, perceived micro-level (e.g., classroom interactions and macro-level forces such as race, gender, socioeconomic status), confidence, and previous schooling and home life are shaping and informing one's current STEM identity. I am further interested in considering this approach with middle and high school aged students. How might the tangible objects help or hinder how students position themselves within STEM? Will we see differences in terms of gender, ethnicity, and/or religion, to name a few? The use of these tangible objects will also be useful in understanding how individuals of all ages perceive of STEM as shared practices and processes as opposed to isolated disciplines (Moon & Singer, 2012).

Researchers should also consider the pros and cons in terms of the time it takes to collect and analyze the data. Similar to Meo's (2010) consideration of photo-elicitation, researchers should consider if use of tangible objects or artifacts for identity research will be more or less time consuming than other ways to gather data such as traditional interviews (Shields, 2014), video-data or observations (Tan & Barton, 2008), or survey data (Cribbs et al., 2015). However, I contend there is merit in using this technique as a visual method to understand individual's identity as the hindrances highlighted in this paper can be addressed through the prompts, time, and location.

References

Allen, C. D., & Eisenhart, M. (2017). Fighting for desired versions of a future self: How young women negotiated STEM-related identities in the discursive landscape of educational opportunity. *Journal of the Learning Sciences*, *26*(3), 407-436. doi: 1 0.1080/10508406.2017.1294985

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). "Doing" science versus "being" a scientist: Examining 10/11-year-old schoolchildren's constructions of science through the lens of identity. *Science Education*, *94*(4), 617-639.

Ashforth, B. E., Harrison, S. H., & Corley, K. G. (2008). Identification in organizations: An examination of four fundamental questions. *Journal of Management*, *34*(3), 325-374.

Ashforth, B. E., & Mael, F. (1989). Social identity theory and the organization. *Academy of Management Review*, *14*(1), 20-39.

Bakhtin, M. M. (1981). *The dialogic imagination* (C. Emerson & M. Holquist, Trans.). Austin, TX: University of Texas Press.

Bakhtin, M. M. (1984). *Problems of Dostoevsky's poetics* (C. Emerson, Trans.). Minneapolis, MN: University of Minnesota Press.

Birks, M., Chapman, Y., & Francis, K. (2008). Memoing in qualitative research: Probing data and processes. *Journal of Research in Nursing*, *13*(1), 68-75. doi: 10.1177/1744987107081254

Bishop, J. P. (2012). "She's always been the smart one. I've always been the dumb one": Identities in the mathematics classroom. *Journal for Research in Mathematics Education*, *43*(1), 34-74.

Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012). What is STEM? A discussion about conceptions of STEM in education and partnerships. *School Science and Mathematics*, *112*(1), 3-11.

Burke, P. J. (2003). Relationships among multiple identities. In P. J. Burke, T. J. Owens, R. T. Serpe, & P. A. Thoits (Eds.), *Advances in identity theory and research* (pp. 195-214). New York, NY: Kluwer Academic/Plenum Publishers.

Chen, Y., & Li, S. X. (2009). Group identity and social preferences. *American Economic Review, 99*(1), 431-457. doi: 10.1257/aer.99.1.431

Chope, R. C. (2000). *Dancing naked: Breaking through the emotional limits that keep you from the job you want.* Oakland, CA: New Harbinger Publications.

Chope, R. C., & Johnson, R. A. (2008). Career identity in a turbulent world. *Perspectives in Education*, *26*(3), 45-54.

Connelly, F. M., & Clandinin, D. J. (1990). Stories of experience and narrative inquiry. *Educational Researcher, 19*(5), 2-14.

Cribbs, J. D., Hazari, Z., Sonnert, G., & Sadler, P. M. (2015). Establishing an explanatory model for mathematics identity. *Child Development*, *86*(4), 1048-1062. doi: 10.1111/cdev.12363

Davies, B., & Harré, R. (1990). Positioning: The discursive production of selves. *Journal for the Theory of Social Behaviour*, *20*(1), 43-63.

Dutton, J. E., Dukerich, J. M., & Harquail, C. V. (1994). Organizational images and member identification. *Administrative Science Quarterly*, *39*(2), 239-263.

Evans, F. (2008). *The multivoiced body: Society and communication in the age of diversity*. New York, NY: Columbia University Press.

Gee, J. P. (2011). *An introduction to discourse analysis: Theory and method* (4th ed.). New York, NY: Routledge.

Harré, R., & Langenhove, L. V. (1991). Varieties of positioning. *Journal for the Theory of Social Behaviour*, *21*(4), 393-407.

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M. C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, *47*(8), 978-1003.

Hoekstra, H. A. (2011). A career roles model of career development. *Journal of Vocational Behavior, 78,* 159-173.

Holland, D., & Lave, J. (2001). History in person: An introduction. In D. Holland & J. Lave

(Eds.), *History in person: Enduring struggles, contentious practice, intimate identities* (pp. 3-33). Santa Fe, NM: School of American Research Press.

Holmegaard, H. T., Madsen, L. M., & Ulriksen, L. (2014). A journey of negotiation and belonging: Understanding students' transitions to science and engineering in higher education. *Cultural Studies of Science Education, 9*(3), 755-786. doi: 10.1007/s11422-013-9542-3

Horn, M. S., Solovey, E. T., Crouser, R. J., & Jacob, R. J. (2009). Comparing the use of tangible and graphical programming languages for informal science education. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 975-984). ACM.

Hornecker, E., & Buur, J. (2006). Getting a grip on tangible interaction: A framework on physical space and social interaction. *Proceedings of the International Conference for Human-Computer Interaction*. Montreal, Canada.

Ibarra, H. (1999). Provisional selves: Experimenting with image and identity in professional adaptation. *Administrative Science Quarterly*, *44*(4), 764-791.

Inkson, K. (2007). *Understanding careers. The metaphors of working lives*. Thousand Oaks, CA: Sage Publications, Inc.

Johnson, D. R. (2011). Women of color in science, technology, engineering, and mathematics (STEM). *New Directions for Institutional Research, 2011*(152), 75-85.

Kelly, C. A. (2006). Using manipulatives in mathematical problem solving: A performance-based analysis. *The Mathematics Enthusiast*, *3*(2), 184-193.

Krauss, S. E. (2005). Research paradigms and meaning making: A primer. *The Qualitative Report*, *10*(4), 758-770.

Malone, K. R., & Barabino, G. (2009). Narrations of race in STEM research settings: Identity formation and its discontents. *Science Education*, *93*(3), 485-510. doi: *10.1002/sce.20307*

Marshall, P., Price, S., & Rogers, Y. (2003). Conceptualising tangibles to support learning. In *Proceedings of the 2003 Conference on Interaction Design and Children* (pp. 101-109). ACM.

McGee, E. O., & Martin, D. B. (2011). "You would not believe what I have to go through to prove my intellectual value!" Stereotype management among academically successful Black mathematics and engineering students. *American Educational Research Journal, 48*(6), 1347-1389.

Mendick, H. (2005). A beautiful myth? The gendering of being/doing 'good at maths'. *Gender and education, 17*(2), 203-219.

Meo, A. I. (2010). Picturing students' habitus: The advantages and limitations of photo-elicitation interviewing in a qualitative study in the city of Buenos Aires. *International Journal of Qualitative Methods, 9*(2), 149-171.

Moon, J., & Singer, S. R. (2012). Bringing STEM into focus. *Education Week, 31*(19), 24-32.

National Science Foundation [NSF]. (2017). *Women, minorities, and persons with disabilities in science and engineering.* Retrieved from https://www.nsf.gov/statistics/2017/nsf17310/static/downloads/nsf17310-digest.pdf

Ochs, E. (1979). Transcription as theory. In E. Ochs (Ed.). *Developmental pragmatics* (pp. 43-72). New York, NY: Academic Press.

Polkinghorne, D. E. (1988). *Narrative knowing and the human sciences.* Albany, NY: State University of New York Press.

Pratt, M. G., Rockmann, K. W., & Kaufmann, J. B. (2006). Constructing professional identity: The role of work and identity learning cycles in the customization of identity among medical residents. *Academy of Management Journal, 49*(2), 235-262.

Riedinger, K. (2015). Identity development of youth during participation at an informal science

education camp. *International Journal of Environmental & Science Education, 10*(3), 453-475.

Saldaña, J. (2013). *The coding manual for qualitative researchers* (2nd ed.). Los Angeles, CA: Sage.

Sfard, A., & Prusak, A. (2005). Telling identities: In search of an analytic tool for investigating learning as a culturally shaped activity. *Educational Researcher, 34*(4), 14-22.

Shields, T. J. (2014). Identity and learning of mathematics for adult First Nations students. *Journal of Education and Training Studies, 2*(1), 63-72. doi: 10.11114/jets.v2i1.213

Simpson, A. (2015). *Kaleidoscopic view of voices shaping female and male adolescents' dynamic mathematics identity within single-sex and coeducational environments* (Doctoral dissertation). Retrieved from https://tigerprints.clemson.edu/all_dissertations/1532.

Simpson, A., & Quigley, C. (2016). Member checking process with adolescent students: Not just reading a transcript. *The Qualitative Report, 21*(2), 376-391. Retrieved from https://nsuworks.nova.edu/tqr/vol21/iss2/12

Solomon, Y. (2007). Experiencing mathematics classes: Ability grouping, gender and the selective development of participative identities. *International Journal of Educational Research, 46*(1-2), 8-19. doi: 10.1016/j.ijer.2007.07.002.

Tan, E., & Barton, A. C. (2008). Unpacking science for all through the lens of identities-in-practice: the stories of Amelia and Ginny. *Cultural Studies of Science Education, 3*, 43-71. doi: 10.1007/s11422-007-9076-7

Teaching Institute for Excellence in STEM. (2010). *What is STEM education?* Retrieved from http://www.tiesteach.org/stem-education.aspx

Wood, M. B. (2013). Mathematical micro-identities: Moment-to-moment positioning and learning in a fourth-grade classroom. *Journal for Research in Mathematics Education, 44*(5), 775-808.

Wortham, S. (2004). The interdependence of social identification and learning. *American Educational Research Journal, 41*(3), 715-750.

Author Note

Amber Simpson is an Assistant Professor of Mathematics Education in the Department of Teaching, Learning, and Educational Leadership, Binghamton University, Binghamton, NY. Her main topic of concern is the low number of individuals from traditionally underrepresented groups entering and persisting in pathways toward STEM careers. She conducts research on understanding the interplay of voices shaping and embodying individual's STEM identity, as well understanding the role of making in formal and informal educational settings. Correspondence regarding this article can be addressed directly to: asimpson@binghamton.edu.

I would like to thank my dissertation committee at Clemson University, Dr. Megan Che, Dr. Cassie Quigley, Dr. Nicole Bannister, Dr. Diane Perpich, and Dr. William Bridges. I would also like to thank Dr. Adam Maltese at Indiana University for his guidance and support in my research on STEM identity.

Article Citation

Simpson, A. (2018). Making the invisible visible: Affordances and hindrances of using tangible objects in identity research. *The Qualitative Report*, *23*(12), 2973-2988. Retrieved from https://nsuworks.nova.edu/tqr/vol23/iss12/6