Chen, W. et al. (Eds.) (2017). Proceedings of the 25th International Conference on Computers in Education. New Zealand: Asia-Pacific Society for Computers in Education

Using CSCL to Conceptualize Disability Toward Inclusive Education Design

Christopher P. OSTROWSKI
Werklund School of Education, University of Calgary, Canada
chris.ostrowski@ucalgary.ca

Abstract: This paper presents a framework and design activity to support pre-service PSEs (PSEs) in conceptualizing disability and inclusive education using representations within a computer-supported collaborative learning (CSCL) environment. PSEs often only receive limited or cursory training about disability and how to design for inclusive education. Discourses focus on diagnoses and prescriptive support strategies, which can limit PSEs' ability to effectively support students' needs. I argue PSEs need opportunities to engage with their epistemological and ontological commitments to disability before advancing to considerations for design. Moreover, how PSEs identify in relation to disability can impact their agency in supporting students' needs and how they shape social structures of how disability and inclusion is manifested in their contexts. Framed by Dewey's notion of an aesthetic experience, I propose a design activity where PSEs develop and exercise metarepresentational competencies to individually and collaboratively create, critique, and interpret external representations, such as drawings, imagery, or models of disability and inclusive education. Such representations can be mapped to a digital network and used as mediating artifacts toward collaborative conceptualization of disability. Furthermore, PSEs can draw upon the network to refine, manipulate, and create new representations of possibilities of inclusive education. The network affords the ability for PSEs to democratize their learning and situate their representations, identities, agency, and social structures to see how they collide, converge, and diverge. As noted by CSCL scholars, meaning making does not occur inside the mind and requires external social negotiation of ideas. Combining representational design with CSCL offers a powerful way for PSEs to create socioculturally informed conceptualizations of disability and consider implications for inclusive education design.

Keywords: Inclusive education, representations, disability, teacher education, CSCL

1. Introduction

When an educator is told a student has a disability, what assumptions, approaches, and reactions are triggered? The dominant discourses about disability (Gilham & Tompkins, 2016) focus on diagnoses and prescriptive strategies to manage disabilities. What is missed is an explicit discussion of pre-service educators' (PSEs) epistemological and ontological commitments to disability and how they manifest in designing for inclusive education. Problems arise when PSEs try to design inclusively without engaging in deeper dialogue of what disability might be, what it might not be, and what it could be. I argue opportunities are needed for PSEs' to articulate, represent, negotiate democratize their conceptualizations of disability and how they can affect inclusive education design.

I propose a theoretical framework and design activity to support PSEs in better understanding disability by collaboratively inventing, interrogating, and manipulating representations. I discuss how a metarepresentation design activity (diSessa, 2004) within a computer-supported collaborative learning (CSCL) environment may help PSEs develop more holistic conceptualizations of disability and inclusive education. This representation design activity is framed as an aesthetic experience which is characterized by the transformation of a material into an expressive form, continuity across personal lives and disciplinary perspectives, and an in-depth perception of other's representations (Dewey, 1934/1980). The framework and design activity are situated within the context of a Canadian Bachelor of Education degree program but could be adapted to other contexts, disciplines, and topics.

2. Theoretical Framework

The proposed design activity aims to surface PSEs' assumptions, understandings, and perceptions of disabilities through external representations, and to leverage such representations as entry points into discourses about disabilities and their impact on teaching and learning. I draw on several theoretical perspectives, including inclusive education, metarepresentational competencies (diSessa, 2004); and identity, agency, and social structures (Holland, Lachicotte, Skinner, & Cain, 1998; Shanahan, 2009); CSCL (Stahl, 2006); and aesthetic experience (Dewey, 1934/1980).

2.1 Inclusive Education

Teacher education programs traditionally approach disability from a medical perspective (Gilham & Tompkins, 2016), which addresses support funding and accommodations but not inclusive design. Though well-intentioned, psychologists—by design—focus on diagnoses and individual therapeutic treatments. They evaluate students' strengths and limitations to recommend support strategies based on diagnostic codes (Alberta Education, 2016). Such clinical approaches are a necessary part of supporting student needs but are only part of the solution. Efforts are being made to understanding disability more holistically but are still emergent (Gilham & Tompkins, 2016). There is a touted and accepted vision of inclusion, but a comprehensive training and implementation plan is lacking (Alberta Teachers' Association, 2014). PSEs typically have positive attitudes toward inclusion but much of the training offered is information-based and focuses on policies and procedures without deeper engagement with the topic and PSEs' assumptions (Collins, 2013; Redmond & Lock, 2017; Tait & Purdie, 2000).

In my research (Ostrowski, 2016) and experiences working with students with disabilities, PSEs' assumptions about disabilities are a common barrier students face in having their needs met and being included as productive and valued contributors to learning. Similarly, in a local course about diversity, I observed PSEs struggled with conceptualizing disability and how it affects learning. PSEs often focused on cursory aspects of disability, such as diagnoses and support strategies instead of deeper epistemological perspectives, which caused them to struggle with articulating and operationalizing their concept of disability. If PSEs are expected to design inclusive learning environments and experiences, they need opportunities to articulate, negotiate, and refine the notion of disabilities. It is not enough to approach inclusion based on medical labels of disabilities alone.

Inclusion means embracing the distinct ways of knowing, interpreting, meaning making, and ontological and epistemological perspectives of the world, that students with disabilities may have (Lewis, 2017). As Miele (2017) noted from personal experience and a lifetime dedicated to research and accessibility, inclusion is "far more than…adherence to standards" (p. 6). It is "a design consideration which, in order to be meaningful and effective, must come from a user-centered culture holistically integrated with other critical factors of design and usability" (p. 6). As Seelman et al. (2008), Ostrowski (2016), and others have discussed, much of accommodations and assistive technology are localized at "the body level." That is, they address the specific need of the user to adapt to a fixed environment. Conversely, universal design approaches address accessibility at the system level to be inclusive of a wide range of users. Traditional discussions of disability have adhered to the former in providing support and accommodations for people with disabilities, while leaving the rest of the classroom environment unchanged.

Following a formulaic approach to supporting students may exclude unique ways of learning and knowing. As well, diverse perspectives should be supported with diverse ways to communicate, engage, and express learning. Tools such as language, visuals, and text mediate ontological and epistemological possibilities of how people think and learn. They also dictate human development: "if one changes the tools of thinking available to a child, his mind will have a radically different structure" (Vygotsky, 1978, p. 126). I argue a shift is needed toward inclusion and diverse meaning making as a necessary part of learning. "Inclusion is not primarily a special education, or even an education, issue. It is a fundamental way of seeing and responding to the human difference for the benefit of everyone involved" (Lawarence-Brown & Sapon-Shevin, 2014, p. 4). To reach such perspectives PSEs can benefit from robust conceptualizations of disability and inclusion to effectively support students.

2.2 Metarepresentational Competencies

I suggest PSEs can develop and use metarepresentational competencies (MRCs) to learn about disability and inclusion more deeply. MRCs can challenge PSEs to go beyond sanctioned notions of disability and help them conceive novel approaches to supporting student needs. Metarepresentational competencies are concerned with how students,

- Invent or design new representations
- Critique and compare the adequacy of representations and judge their suitability or various tasks
- Understand the purposes of representations generally and in particular contexts and understand how representations do the work they do for us.
- Explain representations (i.e., the ability to articulate their competence with the preceding items).
- Learn new representations quickly and with minimal instruction. (diSessa, 2004, p. 293)

Conceived in the context of science and math learning, I adapt diSessa's notion of scientists as designers of representations of scientific phenomena to PSEs as designers of representations of teaching and learning experiences. Perhaps the most common educator design activity is lesson planning, which represents more than a list of topics and procedures for a given day. Lesson plans are artifacts of PSEs' ontological and epistemological perspectives melded with prescribed curriculum requirements, and influenced by sociocultural pressures of principals, superintendents, budgets, parents, and students. Simultaneously, PSEs must design ways to accommodate, include, and support students with disabilities among the classroom milieu.

To design for such a complex and emergent system, PSEs must develop an anchored (but not static) understanding of disability and inclusion. MRCs can support this process by having PSEs develop robust representations of disability that can be continually, interrogated, articulated, and refined. Creating and using representations is an integral part meaning making and learning (Azevedo, 2000; Enyedy, 2005; Norman, 1993). Representations are tools to think with and tools to express understanding (Norman, 1993). Exercising MRCs can help PSEs expose blind-spots, bright-spots, and murky aspects of disability and consider implications for inclusive design.

2.3 Identity, Agency, and Social Structures

How PSEs approach disability and inclusion is informed by their identities, agency, and the social structures they work in. According to Shanahan (2009),

- Identity is defined by the requirements, norms and expectations imposed on individuals as a result of their membership and position within a social group
- Structure refers to the underlying principles that shape the normative patterns within social groups
- Agency, on the other hand, refers to each individual's ability to shape the world around them. (p. 45)

These elements impact how PSEs perceive disability and their roles in relation to students with disabilities. For example, if an educator identifies as someone obligated to correct, cure, or fix a student's disability their approach will differ from an educator that views disability as part of a continuum of diversity. This affects an educator's agency in their role in offering supports or advocating for student needs. Likewise, the social structures of schools, communities, and government can strongly influence how PSEs approach disability. PSEs can also shape the structures they work within through advocacy or championing inclusive strategies within their schools and communities.

Complementary to identity, agency, and social structures are figured worlds: "socially and culturally constructed realm[s] of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (Holland et al., 1998, p. 52). Figured worlds shape identity development, where identities "trace our participation, especially our agency, in socially produced, culturally constructed activities" (Holland et al., 1998, p. 40). The worlds are socially produced and dependent on peoples' roles and positions. Figured worlds are always nested, intersecting and overlapping within and among other worlds. Navigating these figured worlds in the physical and observable sense depend on mediational means such as peoples' goals, the constraints and affordances of tangible and intangible tools, and relations of power and authority (Wertsch, 1998).

How PSEs use representations to discuss and collectively engage the topic of disability can be viewed through the lens of discourses and utterances (Gee, 2011). PSEs' approaches to disability

depend on how their representations collide and bump against each other. In Bakhtinian terms, each utterance depends on previous utterances and shapes the utterances that follow (Todorov, 1984). The interplay of these utterances influences how people conceptualize and develop view points of the world (Bakhtin, 1981). Interactions occur through utterances which include two inseparable parts: verbal, the linguistics and vocabularies of language; and nonverbal, the contextual implications such as physical objects, individual knowledge of the situation, and shared evaluations of the situation by the participants (Todorov, 1984).

Together, discourses (utterances), identities, and figured worlds affect how PSEs develop and exercise MRCs. The representations that PSEs design will be influenced by their epistemological commitments, which will inform how they interrogate peers' representations. For example, some may feel pressured to create representations perceived as politically correct or how status quo suggests disability should be represented, which could differ from their actual attitudes and how they manifest inclusive educational practices.

2.4 Collaborative Learning

The metarepresentation activity involves PSEs articulating, discussing, and negotiating the meanings of representations. Articulation and negotiation will be critical in using MRCs to raise students' awareness of their perceptions and epistemological positioning relative to disability and inclusion. Moreover, meaning making is an external process that depends on a person's interactions with sociocultural contexts (Vygotsky, 1978). That is, meaning does not innately form inside the mind and is then externalized by actions and artifacts. Instead, "the meaning fundamentally emerges in the external, observable, intersubjective world of other people and physical objects. The external meaning can secondarily be internalized" (Stahl, 2006, p. 338). For this reason, making meaning of a familiar, yet obscure, concept like disability depends on collaboration to internalize external meanings. Which is not to say students are empty vessels needing to be filled. Rather,

> The practices of meaning making are acts of discourse or interaction; these acts propose, negotiate, display, and define what are to count as the salient features of the setting, the occasion, the social norms. Neither the context nor the meanings are objectively given in advance but are collaboratively constituted or brought in. Artifacts are not simply instruments for conveying independent meanings but are themselves embodiments of meaning. The process of embodying meaning in artifacts mediates or transforms that meaning. (Stahl, 2006, p. 332)

PSEs' representations are artifacts and mediational tools that embody meaning. The collaborative meanings PSEs form, depend on and, are situated within the communal efforts of the group. They are reflective of localized cultures, priorities, and figured worlds. The meanings transcend individualistic views and "cannot be reduced to the sum of independent individual contributions" (Stahl, 2006, p. 344).

2.5 Aesthetic Experience

The proposed framework advocates for teaching and learning as an aesthetic experience. Dewey (1934/1980) described aesthetic as more than something being beautiful or pleasing to look at. Though as Farris and Sengupta (2016), and Kosso (2002) noted, this too is an important part of knowledge development and disciplinary advancement. For example, many physicists would agree there is beauty and elegance in the theories of famous scientists such as Richard Feynman and Albert Einstein because of what the work represents. Those that study such work know how transformational they were—and still are—in understanding the universe. Their theories represent the deep interconnections and coherence of disciplinary knowledge.

From a Deweian perspective, an aesthetic experience is one that is transformative, continuous, and perceptive. It is the clarification of dissonance and part of both creation and consumption. In Dewey's Art as Experience (1934/1980), he described it the context of artistic works, but as he noted, an aesthetic experience transcends disciplinary boundaries. Here, I focus on three aspects of aesthetic experience:

- Transformation: transforming a material into an expressive form
- Continuity: the interconnections across personal experience and disciplinary domains
- Perception: a bodily and emotional connection to an experience

These are relevant to teaching and learning because they democratize teaching and learning. They support PSEs in bringing in their identity, agency, and interests into the learning process to make it personally meaningful.

The goal of continuity is to create alignment between PSEs' lives outside the classroom and disciplinary content. For Dewey (1934/1980), the perceived strength in this continuity dictates the value of such learning experiences. That is, if PSEs cannot see a strong connection between personal life and school, they are less likely to value it. In this context, the goal is to bring relevance and meaning to PSEs about disability and inclusion by encouraging them to draw upon personal experiences in creating and interpreting representations.

Dewey (1934/1980) discussed transformation in terms of an artist transforming paint and canvas into an expressive medium. More than brushing paint on to a canvas, transformation is about taking disjointed or dissonant fragments and molding them into an expressive form. The result represents interconnections and cohesion greater than the sum of its parts, and something that cannot be disassembled into discrete elements. PSEs' representations reflect the essence of their epistemic perspectives, identities, and agency in how they understand disability and inclusion. The representations showcase what is personally meaningful to PSEs.

Perception, is a bodily experience where there is an inner commotion and stirring of an organism between what is known and what is unknown (Dewey, 1934/1980). Dewey used the example of visitors in an art gallery that might admire or enjoy art pieces but experience no lasting impressions or consequences. "An act of perception proceeds by waves that extend serially throughout the entire organism" (Dewey, 1934/1980, p. 53). The intent of the MRC activity is to go beyond merely labelling and recognizing disabilities, toward a deep engagement and interrogation of ideas to form robust conceptualizations. As Dewey (1934/1980) stated, "For to perceive, a beholder must create his own experience" (p. 54). This aspect relates to how PSEs interpret their peers representations and disciplinary perspectives. To perceive, they need to engage at a depth comparable to the creator of the representation in order to form their own experience of it.

Together, transformation, continuity, and perception form an aesthetic, a cohesion of components that are called into action and presence in learning. "That which distinguishes an experience as [a]esthetic is conversion of resistance and tensions, of excitations that in themselves are temptations to diversion, into a movement toward an inclusive and fulfilling close" (Dewey, 1934/1980, p. 56). Moreover, in a classroom context this precludes the need for an aesthetic experience to be visually appealing or beautiful.

The proposed framework extends previous MRC studies by highlighting the roles of identities and social structures in the process. Much of existing representation research has focused on mathematics and science (e.g., Azevedo, 2000; diSessa & Sherin, 2000; Enyedy, 2005), which inherently seldom consider how identities and social structures matter for representations. However, more recently, Halverson (2013) extended this work to examine digital art and considered the relationship between identity and representational practices

3. Metarepresentation Design Activity

The design activity includes five parts based on diSessa's (2004) MRCs and Stahl's (2006) cycles of design within a CSCL environment: design of individual representations, critique and interpretation of peers' representations, collaborative design of representations, networked sharing of representations, and refinement of representations and implications for inclusion. In this section I describe each part of the activity based on a scenario of PSEs within a teacher education program. Figure 1 shows a simplified depiction of this process. In practice, this process is less linear and could include overlaps, and back and forth interactions between elements.

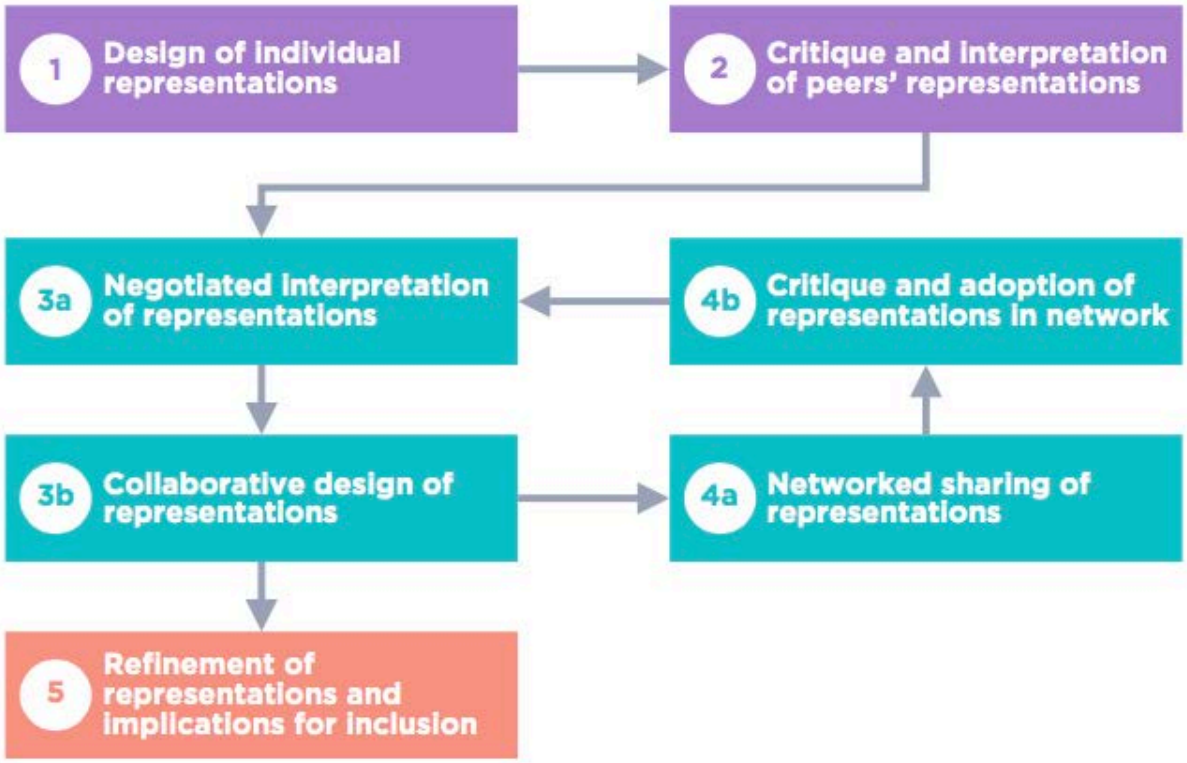

Figure 1. Collaborative design cycle framework.

To help illustrate the framework, I draw upon three studies including the work of Selling (2016) and Azevedo (2000) on using representations in STEM based contexts (see also diSessa & Sherin, 2000; Enyedy, 2005), and Haleverson's (2013) study on digital art to highlight aspects of identity and culture in representations.

Selling (2016) explored how seventh and eighth graders created and used representations as problem-solving tools in an algebra class. The students used representations to construct, reason, justify, and discuss claims about quadratic equations. Over five weeks, student math journals and video data were collected to analyze the types of representations used (tables, verbal, algebraic, graphical), evidence of connections between representations, students' interactions in creating and reasoning with representations, and students' overall representational practices. Teachers gave students different algebra problems and asked students to create representations, link different types of representations, and use representations to solve the problems.

Azevedo (2000) studied ninth graders' ability to create representations of landscapes and geographical terrain. Given a model landscape with various features such as a spherical dome, smooth washboard, dip, and an elliptical mound, students were asked to draw representations of this landscape. The three-dimensional model was meant to simulate what could be seen flying over terrain with various geological and topographical features. The study was motived by the premises that creating and using such representations is a common part of professional practice, and that students seemed to possess substantial constructive resources (prior knowledge) about representing geographic features on paper. The goal was to use to learn about representing landscapes and develop continuities between the representational practices of students and disciplinary approaches. Azevedo (2000) and his colleagues (diSessa & Sherin, 2000) believed in "developing learning activities that engage students' abilities and interests, and which are couched in appropriate material and social infrastructures…[and saw the] process of invention and reinvention as key for developing deeper understandings of the topics at hand" (Azevedo, 2000, p. 444).

Halverson (2013) researched how representations could bridge digital art making and new literacies. She examined how youth created representations that demonstrated understanding. She described the process as a representational trajectory where youth developed a story about the self and considered how different tools afforded the representation of that story. Like the STEM based studies, representational practices are a process of forming an aesthetic where particular features are highlighted

and arranged to convey meaning. Halverson observed and interviewed youth in their creation and use of representations across four youth media organizations. Because the representations were about the participants' autobiographical stories, they were inherently personal and reflective of the participants' identities. As Halverson (2013) found, there can also be tension in the production of representations while travelling along a representational trajectory. Creating a representation requires an understanding of the relationship between the material to be transformed and the intended idea(s) to be conveyed through the representation. Since there may be a disconnect between a person's expressive capacity for a given medium, the proposed framework emphasizes the intended and functional meaning of a representation rather than its visual appeal while still remaining aesthetic in nature.

3.1 Design of Individual Representations

PSEs will design individual metarepresentations using available modes and technology, such as digital or paper sketches, models, imagery, or artifacts. In Dewian (1934/1980) terms, PSEs will transform materials into a form that expresses their perspectives and experiences. The corresponding conceptual resources PSEs use to conceive their representations will also be identified, such as experiencing disability, relatives and friends, media, or courses. By first creating individual representations, PSEs can express their identities, agency, and figured worlds of disability, which supports continuity between their personal and academic lives. Individual representations also give PSEs currency for dialogue during collaboration and mitigates suppression of ideas by more vocal contributors. Creating tangible representations fosters reflexive thinking and requires higher order thinking beyond defaulting to generic definitions of disability (Furberg, Klyge, & Ludvigsen, 2013).

For example, in Selling's (2016) study each student first created an individual representation in their journals and then discussed each others representations with peers in small groups. This gave each student an opportunity to exercise agency in creating an individual and unique representation. Paralleling Dewey (1934/1980), Azevedo's (2000) participants transformed material—paper and drawing utensils in this case—into a representation that expressed the original model. Specifically, the students were told "the representations had to be good enough to aid a hypothetical hiker interested in navigating that terrain" (p. 450). In Dewian terms, this implied a degree of aesthetic was needed to create a stand-alone representation that communicated the various geographical features in a cohesive way. Students were free to represent the model however they wished, which fostered continuity by encouraging agency and drawing upon prior experiences.

3.2 Critique and Interpretation of Peers' Representations

In small groups, PSEs will share their representations, articulate their meanings, critique others' representations, and analyze how representations align and collide. The representations can act as structuring resources (Furberg et al., 2013) to support dialogue and allow reflection on how PSEs' understanding of disability is situated among peers, instructors, and canonical sources: "representations are also resources for analyzing information, communicating ideas, and coordinating interaction in collaborative problem-solving processes" (Furberg et al., 2013, p. 45). With intention, PSEs can begin to perceive (in the Dewian sense) other's representations and develop continuity with their personal lives by forming their own experiences of other's representations. They can consider the similarities and differences of their figured worlds and the possible connections between them.

After Azevedo's (2000) participants created individual representations of a landscape, they shared and discussed their work. In evaluating each others representations, students identified criteria for preferring one representation over another, including preferring representations other than their own. Azevedo (2000) noted students preferred three-dimensional drawings because as one student stated "It looks more natural…something you can relate to," to which another student replied, "It's something you can really identify with" (p. 458). These comments suggest students perceived (or at least started to) the representations by making personal connections to them.

Sharing and discussion of representations can also lead to students modifying their representations, as was the case for students in Selling's (2016) study. Selling noted students often used their individual representations as a tool to explain their thinking to each other and reason about mathematical problems. They also questioned each other's lines of thinking to negotiate their

understanding. Similarly, Halverson's (2013) participants gave oral presentations about their representations and used reflective critique to push their ideas further.

3.3 Collaborative Design of Representations

Prefaced by the interrogation of each other's representations, PSEs will collaboratively create representations and identify the conceptual resources used. The intent is to foster intersubjectivity, where "learning can be construed as the act of bringing divergent meanings into contact, and instruction as the social and material arrangements that foster such negotiation" (Stahl, Koschmann, & Suthers, 2014, p. 490). This process prompts PSEs to critically consider and socially negotiate the epistemological and ontological commitments of their representations. The collaborative representations are also artifacts of collective meaning making that can surpass what an individual could accomplish. The resulting representations will reflect a collective aesthetic that encompasses the graphical elements the group believes are needed to convey their message.

Although Azevedo's (2000) participants only created individual representations, they often discussed and negotiated strategies and criteria for what constituted an ideal representation. Based on these discussions and seeing each other's representations, students refined or redrew their representations. Similarly, the students in Selling's (2016) study worked together to compare different types of representations and make connections between them. They iteratively went back and forth to come up with the connections and create new representations collaboratively. Selling noted the frequent use of "I" and "we" among the students signaling the interchange between individual agency and corroboration in their approaches to solving problems and creating representations.

3.4 Networked Sharing of Representations

Individual and collaborative representations from an entire class will be uploaded into a digital network application. Similar to a mind-map, this can surface patterns of representations and the associated resources. PSEs will then have access to the representations created by all peers and groups. This has several benefits: first, teacher education programs can use the epistemological landscape of PSEs to improve instructional practices; second, PSEs can situate their conceptualizations within their local context and see how representations collide, converge, and diverge; third, the map can be used as a mediational tool to foster further discourses and engagement with the topic; and fourth, it affords more chances for PSEs to encounter diverse conceptualizations of disability than through casual interactions alone. The epistemic landscape of representations reflects a collective aesthetic at a class-wide level. The map can show localized conventions of what is deemed salient in terms of inclusion and disability. It is also a proxy for the range of identities and cultures that make up the local context. The course instructor can then foster continuity by prompting PSEs' to consider relationships between their representations and disciplinary perspectives, as the teacher in Azevedo's (2000) study did in explaining the disciplinary conventions of topographical maps.

3.5 Refinement of Representations and Implications for Inclusion

Using the network of representations, PSEs can draw upon the repository of conceptualizations to refine and manipulate their representations. Among a larger class, such as my local program, the network could include hundreds of representations. Collaboratively, PSEs can leverage the network to create representations of inclusion and implications for design and supporting students' needs. Here, PSEs can look beyond the aesthetic of their small groups and consider how other PSEs' representations compare to their own. Without the artist available to explain their representations, PSE's will be prompted to perceive (Dewey, 1934/1980) other's representations and use them to refine their representations.

For example, the teacher in Selling's (2016) study gave opportunities for students to analyze representations created by another class. Students were tasked with trying to figure out how other students solved problems and their thinking behind the representations. Based on seeing other's representations, the students created "novel but personally meaningful ways to represent an idea. They modified and elaborated on these representations as they used them to make progress on the problem" (Selling, 2016, p. 204). The students also connected different representations to similar problems to see how different methods could be used to solve them. This process required perceptive practices in trying

to understand and make use of other's representations. In other words, they formed their own experiences of other's representations.

In summary, the representation activity fosters an aesthetic experience by having PSEs transform materials into an expressive form, develop continuity between personal experiences and disciplinary practices, and shape their future practices by perceiving other's work (Dewey, 1934/1980). The activity challenges PSEs to consider their identities and roles in supporting students with disabilities and fostering inclusion. Producing representations requires deep engagement and, at times, a sense of internal commotion and uncertainty. As one of Halverson's (2013) participants stated, producers of representations "struggle with that their pieces are about. They struggle with who they are and how they're going to show themselves" (p. 157). Creating representations is a way for PSEs to exercise agency in democratizing conceptualizations of disability and shaping the social structures of what disability and inclusion might be, might not be, and could be. The discourses and interactions can highlight the identities and figured worlds PSEs have and form collectively.

4. Conclusion

This paper proposes using MRCs and CSCL to interpret how disability and inclusion are perceived, understood, and conceptualized by PSEs. Existing approaches focus on diagnosing and prescribing supports corresponding to a diagnosis, which can limit how PSEs understand and support students' needs. The framework extends MRCs as a collaborative process supported by a digital network and contributes to the use of MRCs outside of science and math (i.e., STEM), where it has typically focused. As well, using the CSCL network, conceptual resources can be clustered and the relations between PSEs' representations can show how PSEs traverse between individual and group representations (Stahl, 2013).

The metarepresentation activity aims to raise PSEs' awareness of what disability and inclusion means, and "to represent the complicated relationship between the way they see themselves, the way others see them, and the way they fit into the communities to which they belong" (Halverson, 2013, p. 158). The activity is framed as an aesthetic experience that fosters transformation, continuity, and perception to help PSEs "see more" (Dewey 1934/1980) rather than merely recognizing disability and "grabbing things by their most familiar and convenient handles" (Higgins, 2008, p. 13). An aesthetic experience promotes a democratized learning process that is personally meaningful and that transcends disciplinary boundaries. Through developing and using MRCs to engage with the topics of disabilities, inclusion, and PSEs' and students' identities, PSEs may better understand the challenges and opportunities for inclusive practices. The activity can give PSEs pause to consider more holistic and thoughtful ways of designing for inclusion and valuing diversity.

References

Alberta Education. (2016). *Special education coding criteria*. Edmonton, AB.

Alberta Teachers' Association. (2014). *Report of the Blue Ribbon panel on inclusive education in Alberta schools.* Edmonton, AB.

Azevedo, F. S. (2000). Designing representations of terrain: A study in meta-representational competence. *The Journal of Mathematical Behavior*, *19*(4), 443–480. https://doi.org/10.1016/S0732-3123(01)00053-0

Bakhtin, M. M. (1981). *The dialogic imagination: Four essays.* Austin, TX: University of Texas Press.

Collins, K. M. (2013). A disability studies response to JTE's themed issue on diversity and disability in teacher education. *Journal of Teacher Education*, *64*(3), 283–287. https://doi.org/10.1177/0022487112473155

Dewey, J. (1980). *Art as experience*. New York, NY: Perigee Books. (Original work published 1934)

diSessa, A. A. (2004). Metarepresentation: Native competence and targets for instruction. *Cognition and Instruction*, *22*(3), 293–331. https://doi.org/10.1207/s1532690xci2203_2

diSessa, A. A., & Sherin, B. L. (2000). Meta-representation: An introduction. *The Journal of Mathematical Behavior*, *19*(4), 385–398. https://doi.org/10.1016/S0732-3123(01)00051-7

Enyedy, N. (2005). Inventing mapping: Creating cultural forms to solve collective problems. *Cognition and Instruction*, *23*(4), 427–466. https://doi.org/10.1207/s1532690xci2304_1

Farris, A. V., & Sengupta, P. (2016). Democratizing children's computation: Learning computational science as aesthetic experience. *Educational Theory*, *66*(1–2), 279–296. https://doi.org/10.1111/edth.12168

Furberg, A., Kluge, A., & Ludvigsen, S. (2013). Student sensemaking with science diagrams in a computer-based setting. *International Journal of Computer-Supported Collaborative Learning*, *8*(1), 41–64. https://doi.org/10.1007/s11412-013-9165-4

Gee, J. P. (2011). *An introduction to discourse analysis: Theory and method* (3rd ed.). Florence, KY: Routledge.

Gilham, C. M., & Tompkins, J. (2016). Inclusion reconceptualized: Pre-service teacher education and disability studies in education. *Canadian Journal of Education*, *39*(4).

Halverson, E. R. (2013). Digital art making as a representational process. *Journal of the Learning Sciences*, *22*(1), 121–162. https://doi.org/10.1080/10508406.2011.639471

Higgins, C. (2008). Instrumentalism and the clichés of aesthetic education: A Deweyan corrective. *Education and Culture*, *24*(1), 6–19. https://doi.org/10.1353/eac.0.0020

Holland, D., Lachicotte Jr., W., Skinner, D., & Cain, C. (1998). *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.

Kosso, P. (2002). The omniscienter: Beauty and scientific understanding. *International Studies in the Philosophy of Science*, *16*(1), 39–48. https://doi.org/10.1080/02698590120118819

Lawrence-Brown, D., & Sapon-Shevin, M. (Eds.). (2014), *Condition critical: Key principles for equitable and inclusive education*. New York, NY: Teachers College Press.

Lewis, K. E. (2017). Designing a bridging discourse: Re-mediation of a mathematical learning disability. *Journal of the Learning Sciences*, 1–46. https://doi.org/10.1080/10508406.2016.1256810

Miele, J. (2017). Teaching teachers and making makers. In *Proceedings of the 2017 Conference on Interaction Design and Children - IDC '17* (pp. 5–6). New York, NY: ACM Press. https://doi.org/10.1145/3078072.3078073

Norman, D. A. (1993). *Things that make us smart: Defending human attributes in the age of the machine*. Reading, MA: Addison-Wesley.

Ostrowski, C. P. (2016). *A narrative inquiry into the experiences of university students with visual impairments: The effects of people, institutions, and technology in supporting learning* [Unpublished master's thesis]. University of Calgary. Retrieved from http://hdl.handle.net/11023/3147

Redmond, P., & Lock, J. V. (2017). Do secondary pre-service teachers have what it takes to educate learners with special educational needs? In R. Resta & S. Smith (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2017* (pp. 1051–1056). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).

Seelman, K., Palmer, C., Ortmann, A., Mormer, E., Guthrie, O., Miele, J., & Brabyn, J. (2008). Quality-of-life technology for vision and hearing loss [highlights of recent developments and current challenges in technology]. *IEEE Engineering in Medicine and Biology Magazine*, *27*(2), 40–55. https://doi.org/10.1109/EMB.2007.907393

Selling, S. K. (2016). Learning to represent, representing to learn. *The Journal of Mathematical Behavior*, *41*, 191–209. https://doi.org/10.1016/j.jmathb.2015.10.003

Shanahan, M.-C. (2009). Identity in science learning: Exploring the attention given to agency and structure in studies of identity. *Studies in Science Education*, *45*(1), 43–64. https://doi.org/10.1080/03057260802681847

Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.

Stahl, G. (2013). Learning across levels. *International Journal of Computer-Supported Collaborative Learning*, *8*(1), 1–12. https://doi.org/10.1007/s11412-013-9169-0

Stahl, G., Koschmann, T., & Suthers, D. D. (2014). Computer-supported collaborative learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (2nd ed., pp. 479–500). New York, NY: Cambridge University Press.

Tait, K., & Purdie, N. (2000). Attitudes toward disability: Teacher education for inclusive environments in an Australian university. *International Journal of Disability, Development and Education*, *47*(1), 25–38. https://doi.org/10.1080/103491200116110

Todorov, T. (1984). *Mikhail Bakhtin: The dialogical principle*. Minneapolis, MN: University of Minnesota Press.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wertsch, J. V. (1998). *Mind as action*. New York, NY: Oxford University Press.