Queering Complexity Using Multi-Agent Simulations

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Abstract: In this paper, we demonstrate how multi-agent simulations of gender and sexuality-based marginalization can help us understand gender and sexual experiences as complex, emergent, multi-level phenomena, which involve dynamic interactions between individuals, groups and institutions. We present Flocking QT Stories, a multiagent-based simulation that illustrates how structural (macro-level) phenomena such as gender and sexuality-based marginalization and resilience can manifest through individual-level interactions between computational agents. We then present illustrative cases from an ongoing co-design study with people with lived or professional scholarly experience of gender and sexuality-based marginalization. Our analysis reveals how participants interacted with Flocking QT Stories through turning (Ahmed, 2006) their attention toward marginalized agents, and engaging in multi-level reasoning (Hostetler, Sengupta & Hollett, 2018; Wilensky & Resnick, 1999) to make sense of the audio stories embedded in the simulation as well as the macro-level, emergent behaviors resulting from interactions between individuals (boids), and between individuals and institutions.

Keywords: multi-agent modelling, complex systems, gender, sexuality

Introduction

In this paper, we demonstrate how interacting and reasoning with multi-agent simulations of gender and sexuality-based marginalization can help us understand gender and sexuality experiences as complex, emergent, multi-level phenomena, that involve dynamic interactions between individuals, groups and institutions. In complex systems, interactions between smaller or individual components of the system give rise to collective, system-level behaviours that are often difficult, counter-intuitive or even impossible to predict simply by thinking about the behavior of each individual component (Holland, 1998; Mitchell, 2009). We offer a complementary approach for designing learning environments to support critical conversations on gender and sexuality that brings together scholarship on queer and trans theories (Ahmed, 2006; Butler, 1990; Lane, 2009) and complex systems education using multi-agent computational simulations (Wilensky & Resnick, 1999; Hostetler, Sengupta & Hollett, 2018). We present Flocking QT Stories, a multiagent-based simulation that illustrates how structural (macro-level) phenomena such as gender and sexuality-based marginalization and resilience can manifest through individual-level interactions between computational agents. We then present illustrative cases from an ongoing co-design study with people who have lived experience and/or professional scholarly experience of gender and sexuality-based marginalization. Our analysis reveals how participants interacted with Flocking QT Stories through *turning* (Ahmed, 2006) their attention toward marginalized agents, and engaging in *multi-level reasoning* (Hostetler, Sengupta & Hollett, 2018; Wilensky & Resnick, 1999) to make sense of the individual, audio stories embedded in the simulation as well as the macro-level, emergent behaviors resulting from between individuals (boids), and between individuals and institutions.

Theoretical background: Synergies between complexity and queer theories

Our theoretical framework is premised on synergies between several foundational constructs proposed by queer theorists such as the heterosexual matrix (Butler, 2006/1990), queer orientations (Ahmed, 2006), as well as Lane's (2009) call for trans and queer studies to engage with a fundamentally more complex, new materialist biology. We propose that both Butler's notion of the heterosexual matrix and Lane's notion of body-becoming can be understood in light of mechanisms of emergence, i.e., how unintentional system-level behaviors emerge from individual-level interactions (Holland, 1998).

For example, Butler's (2006/1990) notion of the heterosexual matrix helps us understand how the hegemonic discursive epistemic practices enacted in our everyday interactions reify heterosexuality as normative. Butler further contends that the everyday reproduction of the "compulsory practice of heterosexuality" (Butler, 2006/1990, p. 208), typically remains hidden from the view of individuals. At the system level, the emergent behaviour identified in this model is represented in the pattern or social practices of disciplining bodies, or the way that bodies are made to "cohere and make sense" within a linear, causal framework of assumed sex-gender-sexuality. Butler (2006/1990) conceptualizes power as discursively produced in interactions at social and institutional levels - not as a centralized power of control - a point echoed by Risman (2004, 2018), who positioned gender as a social structure, in which both

material and cultural (ideological) processes are at work within and across individual, interactional, and macro levels. Lane (2009) further advances the argument for re-positioning gender and sexuality as emergent rather than deterministic. Lane (2009) critiques Butler for emphasizing "the fixity of biological materialities of sex compared with the flexibility of gender" (p. 141). Lane argues that instead of viewing the body as constraining, fixed, and given, we must view the body as a dynamic, transformative process of 'body becoming' (Lane, 2009, p. 141), where social, material and biological aspects of experience interact with each other fluidly.

Along similar lines, Ahmed (2006) argues that queerness is not simply an identity defined by one's desire, but is a lived experience of "the everyday work of dealing with the perceptions of others, with the 'straightening devices' and the violence that might follow when such perceptions congeal into social forms" (p. 107). Further, Ahmed (2006) demonstrates how straightness is not the default or "normal" identity but is also produced. In this way, becoming straight, "as a direction (taken) toward objects and others, is compulsory. In other words, subjects are required to 'tend toward' some objects and not others as a condition of familial as well as social love" (p. 85). Connecting each of these orienting gestures is the way that relationships with people, spaces, and objects are all implicated in the (re)production of cisheteronormativity.

As our discussion so far shows, critical gender and sexuality scholars have positioned the body, the individual, as well as interactions with others and institutions as complex and emergent rather than linear and deterministic. As a corollary, we believe that challenges in public understanding of these issues can be explained in light of conceptual difficulties in understanding complex emergent systems that arise viewing non-linear, emergent processes as deterministic (e.g., Sengupta & Wilensky, 2009; Wilensky & Resnick, 1999). In the context of gender and sexuality, this means that the emergent, fluid nature of gender and sexuality is viewed instead as biologically predetermined. That is, instead of viewing the social, historical and institutional forces and interactions – both implicit and explicit – that shape our gender and sexual experiences and identities – an emergent view – we tend to conceptualize gender and sexuality as an individual "trait", that is predetermined biologically – a deterministic view.

In the literature on complex systems education, such conceptual challenges have been noted as examples of slippage between levels (Sengupta & Wilensky, 2009; Wilensky & Resnick, 1999), which happens when people – experts and newcomers to disciplines alike – incorrectly assign individual-level attributes (e.g., individual cars moving forward) to the aggregate-level phenomenon (e.g., traffic jams moving forward) thereby leading to an incorrect prediction (e.g., in reality, traffic jams propagate in the backward direction). However, a substantial body of research now shows that multi-agent computational models can provide learners with an intuitive pathway for reasoning about emergent outcomes by enabling learners to think like an agent and, consequently, bootstrap their embodied and intuitive knowledge of individual-level actions and interactions (Dickes, Sengupta, Farris, & Basu, 2016; Sengupta & Wilensky, 2009). And finally, although the intersection of critical theory and complexity has received relatively little attention, recent scholarship suggests that multi-agent models can be productively used to unsilence critical conversations about race (Hostetler, Sengupta & Hollett, 2018). Our current work seeks to further expand this field by identifying critical issues in gender and sexuality as a new context for complex systems education and by illustrating how multi-agent computational models can serve a generative and productive computational medium for representing these issues in public settings.

The simulation: Flocking QT stories

In our simulation, there are four types of computational agents: normative and non-normative *boids* or bird-droids (Reynolds, 1987), and two types of *institutions:* normative and non-normative (see Figure 1). Proximity to normative boids and institutions "drains" energy from the non-normative boids, and proximity to other non-normative boids and institutions increases their energy. Each non-normative boid "carries" an audio story - a first person account of gender and/or sexuality-based marginalization and resilience. These stories were recorded by local people who volunteered to contribute a short 2-minute audio narrative of their experiences of gender and sexuality-based marginalization or resilience. All of the boids move according to Reynolds' (1987) flocking algorithm. In Reynolds' algorithm, the rules obeyed by each boid are alignment, separation, and cohesion. Alignment means that a boid tends to turn so that it is moving in the same direction that nearby boids are moving. Separation means that a boid will turn to avoid another boid which gets too close. Cohesion means that a boid will move towards other nearby boids (unless another boid is too close). In addition to these forces that are always in play, when a non-normative boid's story is activated, all the non-normative boids' movements are also affected in part by the frequencies of the audio file. Higher-frequency sounds affect the cohesive motion, lower-frequency sounds affect the separation, and medium-frequency sounds align their directions with neighboring boids. The overall effect is that the movement pattern of the non-normative boids is visually distinct from the normative boids while a story is being played, causing the former to vibrate while they are also flocking. This also helps create a visual contrast between a flock of non-normative boids that are moving together with vibrations, and a non-normative boid that is stagnant because of being isolated from other non-normative boids

and due to being positioned very close to a normative institution that drains its energy. This contrast in movement, we posit, can help orient peoples' attention to representations of marginalization.

People can interact with the simulation by clicking on (or touching) a non-normative boid in order to listen to the story carried by it, which in turn affects the movement of the other non-normative boids based on the rules explained above. They can also use the slider shown in Figure 1 to change the ratio of the normative to the non-normative boids. People's interactions with the simulation are mediated by a facilitator (one of the authors or other members of the research team affiliated with the project). Engaging in conversations with the facilitator as well as with other participants is an important element of people's experiences with the simulation. The audio stories recorded in the simulation include a wide range of experiences of gender and sexuality-based marginalization and resilience, with a focus on everyday interpersonal and institutional interactions. These include stories such as: bisexual erasure in queer and straight spaces, growing up queer in a small town, experiences of homophobia in a Catholic school and other religious spaces, facing limiting gendered expectations for women in male-dominated workplaces, and the influences of hegemonic masculinity in the academy, etc. The narrators are people across a wide range of gender and sexual identities, including people who identify within LGBTQ identities as well as cisgender and heterosexual people — all of whom have experiences of gender and/or sexuality-based marginalization.

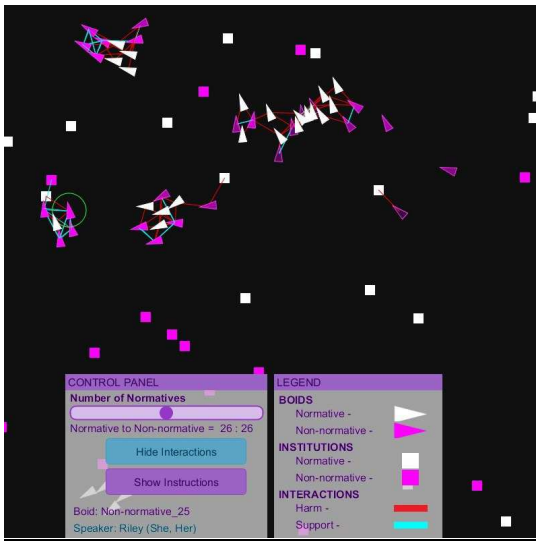

Figure 1. Screenshot of the Flocking QT Stories multi-agent simulation.

Some interesting emergent patterns in the simulation include non-normative boids escaping normative institutions as they find a sufficient number of flock mates, and conversely, getting trapped (i.e., becoming immobile due to losing energy) when they are too close to normative boids and/or normative institutions while being separated from non-normative flocks. These emergent behaviors represent resilience (in the first case) and marginalization (in the second case). Furthermore, as our analysis will reveal, these simulated, emergent representations open up the interpretive space for learners and members of the public who interact with the simulation by inviting them to draw parallels from their own experiences and the experiences shared in the pre-recorded stories carried by the boids, in order to interpret what such behaviors might represent. This is a particular affordance of agent-based models and representations, specifically in contexts that involve critical theoretical issues (e.g., racial and ethnic segregation) (Hostetler, Sengupta & Hollett, 2018). Computational agents can act as *transitional* objects (Papert, 1980), i.e., people can *project* their own experiences onto the agents as they reason about the behaviors of the agents. Building on this idea, Hostetler, Sengupta & Hollett (2018) noted that when pre-service teachers use multi-agent simulations of ethnocentrism, they can engage personally with controversial issues while maintaining sufficient epistemic and affective distance from the discourse.

However, rather than ascribing the epistemic power of this work simply to the protean nature of computational agents, Sengupta, Dickes & Farris (in press) noted that central to supporting such critical discourse using multi-agent simulations is the design of activities that help students productively recontextualize generalized computational algorithms and visual representations. For example, in Hostetler, Sengupta & Hollett's (2018) study, using the Racial Dot Map (which shows residential segregation on a map of the USA) alongside the simulation of ethnocentrism (which relies on a generalized algorithm grounded in Game Theory) was essential for pre-service teachers being able to engage in critical discourse about race and inequality. Similarly, our goal in integrating personal narratives of gender and sexuality with the simulation is to engage the participants (including learners and members

of the public) deeply with first-person narratives of gender and sexuality-based marginalization and resilience while interacting with the Flocking QT Boids simulation. These stories serve as scaffolds for helping participants understand the simulation's emergent patterns of harm and support in the context of gender and sexuality-based marginalization. They also help the participants differentiate the behavior of normative and non-normative boids, given that only the non-normative boids carry stories.

Research question

In this study, we ask the following research question: How do people with lived experience and/or professional scholarly experience of gender and sexuality-based marginalization – ranging from critical gender and sexuality scholars to queer undergraduate students - explain emergent forms of marginalization and resilience through interacting with the simulation?

In asking this question, our research objectives are two-fold: a) to deepen connections between scholarship on complexity education and multi-agent models, and critical scholarship on gender and sexuality; and 2) develop this synergy by centering experiences of gender and sexuality based marginalization across all genders and sexualities in a manner similar to McWilliams' (2016) work to queer participatory action research by fundamentally challenging categories around gender and sexuality.

Methods

As part of an ongoing co-design study with people with lived experience and/or professional scholarly experience of gender and sexuality-based marginalization, we interviewed two groups (dyads) of participants as they interacted with the simulation. The study setting is DigiPlay (Sengupta & Shanahan, 2017), a public walkway located in a Canadian university where visitors can interact with open source, multi-agent simulations of complex systems using 80 inch touchscreens. One dyad of participants, Chuli and Safa, are university level professors and instructors engaging in critical scholarship of gender and sexuality. The second dyad are two undergraduate, university students, Sophia and Chuck, who identified themselves as queer (1). We chose these participants because we were interested in understanding how people with lived experience and people with scholarly experience of gender and sexuality-based marginalizations would make sense of the multi-agent simulation. Our decision to interview dyads of participants who are familiar with each other is based on recent scholarship which highlights the value of conversations with friends for engaging in critical and conceptually challenging discussions, including issues of gender and sexuality-based marginalization (Paré, Sengupta, Windsor, Craig & Thompson, 2019; Takeuchi, 2016).

The videos were viewed individually by each researcher and codes were developed and discussed using the constant comparative method (Corbin & Strauss, 1990; Glaser, 1965). During the first part of this process, known as open-coding, codes were discussed in relation to data. Our theoretical focus was on identifying episodes – i.e., turns of conversations – that involved multi-level reasoning. That is, we were specifically interested in identifying explanations that involved both individual level descriptions - such as personal narratives, and agent-level rules – and interactions between individuals, among individuals and institutions or larger social forces. During the second part of this process, known as axial coding, each code was discussed in relation to others. This process helped us refine themes by identifying the different examples of resilience and marginalization that the participants brought up in their explanations. Overall, two themes emerged in our findings: the use of "turning" (Ahmed, 2006) and multi-level reasoning to identify and explain examples of resilience and marginalization (Theme 1), and multi-level perspectives for extending the simulation in order to deepen our understanding of gender-based resilience and marginalization (Theme 2).

Findings

Theme 1: "Turning" and multi-level reasoning to explain resilience and marginalization

In our first illustrative case, we follow an ongoing discussion between Sophia and Chuck in which they show concerns about the on-screen interactions of a non-normative boid that had become stagnant (Figure 2). The stagnant boid was isolated and seemingly trapped due to its immediate proximity to a normative institution, and distance from other non-normative boids or non-normative institutions. Orienting their attention to the stagnant boids was a common experience for all participants in our data to date (including Chuli and Safa, our second pair of participants). This is an act of *turning* (Ahmed, 2006) or *tending* their attention *toward* a computational representation of marginalization. Sophia frames her observation of these on-screen behaviours by explaining the boid's experience as comparable to being the only queer person in a small town (Excerpt 1).

Excerpt 1: Discussion of effect of small towns on queer people

Turn 1 *Sophia (She/Her & They/Them)*: [Pointing to a transparent, non-normative boid that is not moving with harm lines linking it to a normative institution square and an opaque non-normative boid linking with the transparent boid with support lines] Look at this one trying to get well with the institution draining it and the one best friend.

Turn 2 *Chuck (They/Them)*: Oh, yeah, same with the, like, this one. [Points to another non-normative boid that is stagnant and linked to a normative institution with harm lines] It's been stuck there for like basically the whole entire time. And to help it get better the other purple triangles have to interact with that institution. It's just really hard.

Turn 3 *Sophia*: Well, and the. [points back at a stagnant, isolated non-normative boid next to normative institution] It's also. It's like a small town. It's like it's isolated from every. Like, over here [motions to area with a cluster of normative and non-normative institutions and to an area with a flock of non-normative boids] there's more chance of you running into more people and institutions, but there's like [motions back to the isolated non-normative boid]

Turn 4 *Sophia*: Interesting too, you'd think that when they're that strong [points to large flock of non-normative boids], they could avoid the normative institutions [points to a normative institution], but they're not avoiding them probably because they have to be. They have to participate in them.

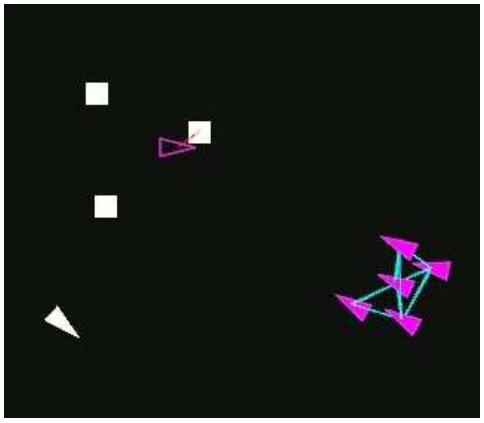

Figure 2. Screenshot of the Flocking QT Stories simulation showing an example of a stagnant non-normative boid (triangle with pink outline) trapped near a "normative" institution (white square).

This interaction demonstrates how Sophia and Chuck make sense of non-normative boids who become "stuck" in institutions. This is a form of multi-level reasoning, because although the participants were focused on interactions between two agents, they also make a connection to a macro-level observation of queer experience - the effect of small towns on queer people, and how difficult it can be to find support to survive. This form of multi-level discourse continues later in their interaction, when Sophia then notices that when non-normative boids are moving together, they can better survive the effects of normative institutions, although they cannot avoid the harm altogether. She connects this phenomenon back to personal experience, asking Chuck about the kind of scenario they would prefer (Excerpt 2).

Excerpt 2: Discussion of queer experiences of collective resilience and isolation

Turn 1 *Sophia:* It's the same here [points to two non-normative boids that are next to a normative institution with harm lines between each boid and the institution and a support line connecting the non-normative boids]. One friend is not enough to combat an institution.

Turn 2 *Sophia*: [Directing question to Chuck] Would you rather be, like, in communities like this where you have more interaction with people but there's lots of harm in it [pointing to large flock of normative and non-normative boids] or in like a small, threesome with no harmful interaction that's like marginalized from society? [gestures with fingers making closing motion to indicate a smaller group]

Turn 3 *Chuck*: [Points to a small flock of all non-normative boids] Yeah, I think that one. [pointing to the small group of three non-normative boids]

Turn 4 *Sophia*: Well, yeah. [both laugh] Like, who wants that one? [check video to see which is indicated] The like five or six geometry shape of total safety. [Gestures to bring hands together, interlocking ends of fingers].

In Excerpt 2, during Turns 1 and 2, Sophia's explanation again provides evidence of multi-level reasoning. For example, in Turn 1, she points to interactions between a small group of agents - two non-normative boids and a normative institution. In Levy and Wilensky's (2008) terms, this is evidence of a *mid-level* observation - as it is in between the individual level (a single boid) and the macro-level (e.g., a large flock). Yet, the power of this mid-level noticing, as Levy and Wilensky (2008) argued, is that these interactions can reveal to the observer important mechanisms that can be used to explain and understand larger scales of complexity. In this case, Sophia, in Turn 1, makes an important inference based on this observation: "One friend is not enough to combat an institution". This is a poignant realization, as Sophia then continues this line of reasoning in Turn 2 as she notices a larger flock and compares the interactions between boids in that flock with her previous observations. She positions her observations in the form of a question to Chuck: Which community would you rather be in? The premise of her question is her observation of the harm and resistance to harm that results from being in a mixed, larger flock, and a hypothetical comparison with a smaller, mid-level flock with only non-normative boids. Chuck responds that they would rather be a part of this smaller, non-normative flock, and as they are responding, such a flock appears in their visual field, to which Chuck points (Turn 3). Sophia then recognizes this new, non-normative flock on the screen as "five or six geometry shape of total safety" (Turn 4). Sophia and Chuck are now in consensus: they would rather see themselves as part of a small non-normative flock, which even though it would be "marginalized from society" (Turn 2), would still keep them safe, i.e., away from harmful interactions that may take place when the flock is larger and contains both normative and non-normative boids.

What is evident from the analysis so far is that Sophia and Chuck have framed the experience of harm in terms of interactions between different types of agents in the simulation: normative boids, non-normative boids, and institutions. This is not surprising given that this was one of the design goals of the simulation from our (the designers') perspective. Sophia then further expands on her understanding of harm by proposing that a new kind of agent - allies - be introduced in the simulation that do not drain energy from non-normative boids. She mentions her idea of this new type of boids because she is concerned for the extremely marginalized and isolated boid that is still trapped near a normative institution (see Excerpt 1, where she first notices the boid). She connects this boid's experience to a story in the simulation, which she also recognized to be her sister's voice. At the same time, Chuck also considers how changing the number of institutions could shape individual and group experiences (Excerpt 3). In Turn 3 (Excerpt 3), Sophia connects an individual story in the simulation (her sister's story) to the boid interaction in the simulation of the isolated boid, and wonders about the extent to which allies could help in this context. She uses her sister's story to hypothesize about how more non-normative boids (or other queer people as explained in the story) are needed for support, and that allies might have a role to play where a non-normative boid (queer person) is isolated in a small town, but that allies may not be able to provide adequate support.

Theme 2: Multi-level perspectives on extending the simulation

Excerpt 3: Introducing allies

Turn 1 *Sophia*: I'd be very interested to see what would happen if you added, like, actual quality allies to this. Like, um, like, 'cuz like, um, I can't remember the pseudonym she used, but my sister talked about being among supportive family [makes hand gesture closing fingers to indicate a small group], but just not having any other queer people. So, it's not like, but the institutions were like this [points to normative institution]. I don't know, it's just like a different combination of like, trying to get her support for her queerness but not having other queer people, but having allies.

Turn 2 *Chuck*: [Points to slider to change ratio of normative to non-normative boids to suggest a slider that would change the ratio of institutions] You mean if we could like up the level of non-normative institutions as opposed to normative ones? In here so like they're all purple?

Turn 3 *Sophia*: Oh yeah, that would be interesting. Or just like human allies too. Like, boid allies that aren't automatically going to drain and do harm. [points to small flock where a normative boid has harm lines draining energy from multiple non-normative boids around it] So, rare. [both laugh] Rare to find true allies, but, um, I wonder if support from an ally would be equally nourishing or probably less. [looks to Chuck] Probably less if her story was indicating. 'Cuz she didn't feel able to be herself despite having some pretty close, strong allies.

In the Excerpt 3, Sophia suggests adding “allies” - a new type of agents - that would represent people who do not themselves identify as queer but are supportive of queer people. Sophia drew from her personal experience - her sister - who also identifies as queer, and talked about the value of being with *a small group* of allies such as a supportive family members (Turn 1). Chuck wondered if this would entail adjusting the ratio of normative to non-normative institutions to represent greater support for queer people by increasing the proportion of non-normative institutions (Turn 2). Sophia followed up by mentioning that she was thinking of introducing human allies - i.e., a new type of normative boids that do not drain energy from the non-normative boids (Turn 3).

Excerpt 4: Introducing Institutions

Turn 1 *Chuli (She/Her):* So, you know, because there is a connection between institutions, people, and ideology. Right, so, you know, how ideology or um, structural discourse gets internalized and so maybe if there are like, I don't know, another shape for ideology or another sort of

Turn 2 *Safa (She/Her)*: Something like a circle, in a different colour. But it takes over. I don't know.

Turn 3 *Safa*: I was thinking like a circle in a different colour or it takes over, I don't know. which is a...

Turn 4 *Chuli*: Yeah, the institution?

Turn 5 *Safa*: Yeah.

Turn 6 *Facilitator*: Okay, so circles that move, are you thinking?

Turn 7 *Safa (She/Her)*: Yeah, 'Cuz I feel like, so, ideologies are like institutions. You have the shape of a circle, like a coloured circle, not a full circle, that goes and you can see like to some extent, interactions with the institution or with the person. It's like a little bit of a portion of it comes over or it takes over and changes the colour of the institution, you know. Maybe something like that.

Turn 8 *Chuli (She/Her)*: I think ideas could change spaces, but you need to have bodies, right, for those ideas to be present. Like, you know, you can have one [facilitator's name] or one [Chuli] and that does only so much. I mean [university name] as an institution is not changing because of our presence because we are not enough. We have our voices, but who's hearing our voices is important. So I think what you have [indicating the simulation] is very powerful in terms of the support network because being heard by other people and having people hear you, you know, at your level. But I, yeah there's something about. So as we change the non-normative, there were more normative boids. Is there a mechanism for normative boids to change colour?

In a similar vein, Chuli and Safa (Excerpt 4) wanted to explore deeper forms of criticality in the form of connections between “institutions, people, and ideology” (Chuli, Turn 1). As Chuli explained in Turn 1, her goal in proposing a new form of agents - ideologies - was to make explicit how “structural discourse gets internalized”. In Turn 7, Safa noted that the process of internalization could be visually represented by interactions between institutions and ideologies, as institutions take on the shape or color of ideologies, and that in turn would have an impact on the movement of non-normative boids around them. For Chuli, ideas are embodied through people and institutions, which in turn should be seen as “networks” of people (Turn 8). She noted that simply having queer presence in an institution does not automatically lead to the institution transforming itself: “We have our voices, but who's hearing our voices is important”, she noted (Turn 8). This is also evidence of *turning* (Ahmed, 2006) attention toward experiences of marginalization, but at the institutional level: Chuli argues that whether or not queer voices are heard within an institution shapes the institutional orientation towards or away from queerness. She suggested that by making such interactions visible, we might better understand the hidden mechanisms through which gender and sexuality are experienced in institutional settings.

Summary and discussion

Overall, we found that both dyads of participants used multi-level reasoning during their interactions with the simulation in order to identify and explain examples of gender and sexuality-based marginalization and resilience. For example, participants positioned harm as an emergent phenomenon that arose from interactions between different kinds of agents in the simulation and reasoned about minimizing harm specifically for the most marginalized agents in the simulation. Participants also proposed changes to the model to reason about adding new types of agents - allies and ideologies - to reason about how individuals, institutions, and ideologies interact to produce emergent behaviours such as institutional and social change, and queer marginalization. In each of the excerpts we reported, it was clear that the participants were *turning* (Ahmed, 2006) their attention toward marginalized agents in the simulation. However, this was not simply an individual-level noticing; the well-being, marginalization and resilience of queer

individuals were clearly positioned in light of interactions with other individuals (e.g., allies), institutions and ideologies. In other words, instead of assuming that these are only individual level experiences - which would have been an example of *slippage between levels* (Wilensky & Resnick, 1999) - participants were able to reason about the interactional and emergent nature of such experiences using the simulation. This in turn illustrates that the experience of taking on a *queer orientation* (Ahmed, 2006) involves thinking about emergence, an experience that is far more complex than re-orienting our attention to an individual, that involves multi-level reasoning. To this end, we believe that our analysis shows that Flocking QT Boids simulation can serve as an effective scaffold for engaging in such reasoning and conversations.

Endnotes

(1) We use the term *queer* in this paper as a short-form to indicate that the participants identify within the LGBTQ+ spectrum of non-normative genders and sexualities. This term, however, may not reflect the terminology that a participant uses to describe themselves and does not necessarily describe their specific gender and sexual identities.

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