

Exploring Interdisciplinary Collaborative Online Learning Spaces through Sociomateriality in Cape Town, South Africa

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Abstract: With the rapid adoption of online learning spaces since the advent of COVID-19, more and more calls are being made in higher education to move from emergency remote teaching and learning to appropriate online education. Although much has been written about the designing of online learning from both a technological and pedagogical perspective, limited contemporary literature is available to understand the complexity of interdisciplinary collaborative online learning. This limitation is investigated in this paper that reports on the first iteration of a Design-Based Research (DBR) study. Within this iteration, a qualitative exploratory research design that applies an inductive approach between researchers from Information Systems (IS) and Urban Planning (URP) is discussed. The aim was to develop design principles for interdisciplinary collaborative online learning spaces. This paper reports on the data generated during a semester-long, inter-institutional, interdisciplinary student project that was embedded in co-creating social digital innovations for pressing environmental problems faced by marginalised communities in Cape Town, South Africa. The participants for this study are 38 Honours degree IS students and 22 Advanced Diploma URP students (N=60). Participants, individually and in groups, completed a total of three reflective structured questionnaires using Google Forms during the semester that generated the dataset for this paper. The theoretical framing that underpins this research study is sociomateriality. The attraction to sociomateriality is its ability to not merely shift attention from the human to the non-human but rather a focus on entanglements and the interrelated nature of components that constitute the learning space. This focus on entanglements is needed for an understanding of the complexities associated with interdisciplinary collaborative online learning. Engaging this complex learning space through the data has revealed four design principles namely: (1) creating immersive context-sensitive learning experiences, (2) designing opportunities to collaboratively (co)-construct knowledge, (3) focusing on the intra-action of socio-technical and socio-cultural entanglements and (4) foregrounding relationality as a tool to foster agency. It is argued in this paper that the aforementioned design principles are necessary for developing interdisciplinary collaborative online learning spaces that afford students a complex learning experience. Complex learning is considered fundamental in developing abilities in students to appropriately respond to the myriad 21st-century societal challenges that await.

Keywords: Interdisciplinary collaborative online learning, online learning design, sociomateriality, agency, intra-action, entanglement

1. Introduction and Background

Covid-19 brought with it unprecedented challenges in the teaching and learning space at higher education institutions with a major shift from predominantly in-person to emergency remote teaching and learning. Emergency remote teaching and learning have been criticised for being hurried and pedagogically weak (Hodges et al 2020) and to be replaced by more substantive online learning interventions. A closer exploration of the concept of online learning revealed a significant shortcoming as highlighted by the Networked Learning Editorial Collective (2021, p. 312) "Online learning has always been an awkward term—not least, because, like 'digital', 'distance' and 'virtual', it can obscure the embodied and physically situated nature of learning..... Students live in a complex social-material-digital world".

Although much has been discussed in the literature on the shifts in learning pedagogy (Cubric and Söbke, 2021), fewer scholars are focussing on the sociomaterial aspects of relationality, the agency of technology and the intra-active entanglements within online pedagogy. Sociomateriality (Mousavi Baygi, Introna and Hultin, 2021; Hultin, 2019; Scott and Orlikowski, 2013, 2014; Fenwick, Jensen and Nerland, 2012 and Barad, 2007) and its associated philosophical and theoretical positionings provided the needed recognition of the multitude of complex dimensions within online learning spaces or the "complex social-material-digital world" (Networked Learning Editorial Collective, 2021, p.312) mentioned above. The broad banner of sociomateriality presented the opportunity to acknowledge the interconnected nature of technology artefacts and their influence on humans, and vice versa, to examine how actions and relations are materially constituted in practice (Scott and Orlikowski, 2013, 2014).

The study addresses the research question: *What are the sociomaterial-inspired design principles for interdisciplinary collaborative online learning spaces?* It draws on data from 60 post-graduate students that formed interdisciplinary student teams within the first quarter of 2021. Student teams engaged with local communities to identify pressing urban environmental problems that were framed by the sustainable development goals (SDGs). They followed a design thinking methodology (Brown, 2008) to suggest digital innovations to address the systemic urban environmental problems.

This paper firstly engages theme-specific literature to frame the learning space and thereafter sociomateriality is positioned as a theoretical lens. An argument is made for an analysis of the data with an emphasis on key sociomaterial concepts of agency, intra-action and entanglement. The methodology section provides context about the DBR study and more specifically the interdisciplinary collaborative student projects as part of iteration one of the study. The data were collected - or co-created as is the custom in a sociomaterial context (Pischetola et al. 2021) - from student reflections, researcher field notes and project artefacts. The data exploration concludes this paper with four design principles for interdisciplinary collaborative online learning spaces through a sociomaterial lens.

2. Literature Analysis

The analysis of relevant literature forms part of the DBR process as an element of Phases 1 and 2 (see Figure 1).

2.1 Interdisciplinary and transdisciplinary learning spaces

There is a different approach to studies within a single discipline and those that are drawing from multiple disciplinary stakeholders. A multidisciplinary approach normally gathers contributions from different disciplines without actual synthesis, while interdisciplinarity integrates knowledge from several disciplines (Bernstein, 2015). The integration of perspectives from different disciplines provides a systemic outcome (Lawrence, 2010). The difference between an interdisciplinary and a transdisciplinary approach is the widening of focus to more complex heterogeneous domains that include stakeholders from academia, government and civil society (Lawrence, 2010; Dorst, 2018; Kroeze, Travica and van Zyl, 2019).

Within the academic environment, different professions tend to operate within the confines of their own disciplines leading to deep specialisation within a closed philosophy (Bernstein, 2015). This siloed approach is not conducive to the understanding of complex or wicked problems encountered in an interconnected digital world. Wicked problems transcend a single discipline such as pressing problems around the Sustainable Development Goals (SDGs) that are multi-dimensional and non-linear and should be addressed by a combination of theories and approaches (Kroeze, Travica and van Zyl, 2019). This prompted the engagement with the properties of interdisciplinary perspectives within student projects that explore the complexities of systemic problems within communities. Within the complex entanglements of this environment, further compounded by a switch to online-only learning, the affordances of sociomaterial learning theories were further explored. As a sociomaterial-focus recognise the complex entanglements between the human and non-human, devices, objects, digital and analogue texts, spaces and time, to create fluid assemblages of practice (Gourlay and Oliver, 2018).

Fenwick, Edwards and Sawchuk (2011), affirm that interdisciplinary studies require a shift to the development of collective and sociomaterial learning theories. Within such practices, the emphasis shifts to the collective where social collaborative networks and material artefacts become entangled in knowledge production. The application of an interdisciplinary, project-based approach to teaching and learning is conducive to this mode. Collaborative projects within communities ultimately require a shift from an interdisciplinary to a transdisciplinary understanding that allows for human and non-human entanglements within a complex setting involving multiple actors. To understand the implications of such a collective network, it is necessary to understand the concept of networked learning as situated within the sociomaterial framing of this study. The next section will summarise networked learning within the bigger framing of interdisciplinary collaborative online learning.

2.2 Collaborative, participatory, networked (online) learning

Networked learning researches the complexities that reside in the interconnected nature of “students, teachers, ideas, tasks, activities, tools, artefacts, places and spaces” (NLEC, 2021, p. 313). Deeper engagement with these connections will combat the dissonance that resides in the disconnect between design intent and unfolding learning activities (Carvallo & Yeoman, 2021).

Learning in networks opens up collaboration and collective action in the process of knowledge creation in an unbiased attempt to not privilege any one form of knowledge or learning. There needs to be a strong dependence on relationality that opens up the space for trust and reciprocity to enhance the network’s activities for a larger purpose that matters to the collective. An important part of networked learning is that technology is an integral part of the network to facilitate connectivity (NLEC, 2021). Digital technologies cannot be viewed as tools that will automatically enhance learning for the users (students) but rather as part of the interdisciplinary network of human and non-human actors (Gourlay et al., 2021). As such, we engaged with the framing of our collaborative, participatory, networked (online) learning using a sociomaterial approach. The following section positions the theoretical underpinning of sociomateriality as a way to open the space for human and non-human entanglements.

2.3 Theoretical framing: A sociomaterial approach

In this paper, a sociomaterial position is taken as a relational materialist theoretical stance to frame the complexity and creativity of interdisciplinary collaborative online learning spaces. Notable sociomaterial scholars such as Orlikowski (2007); Scott and Orlikowski (2013) and Hultin (2019) influence and shape understandings of an onto-epistemological position that foregrounds the interrelatedness of the social and material worlds. A shift in understanding is called for because of the contextual changes from face-to-face teaching and learning to an online environment. A need exists to pivot and recognise that experiences for both lecturers and students in face-to-face teaching and learning do not necessarily translate to the online learning space.

Sociomateriality has frequently been adopted as an onto-epistemological framework for various studies as Fenwick et al. (2011) claim, humans should be understood not as holding a privileged status in the world but rather as being part of it. To this point, practice theory (Schatzki, Knorr-Cetina and Von Savigny 2001; Rouse, 2007) and more specifically a posthumanist practice theory (Gherardi in Hui et al., 2017) provides an initial disruptive lens to explore how the dualism between the social and the material may be overcome by considering the practice as the space where complexity and creativity play out. Gherardi in Hui et al. (2017, p. 38) provides a useful understanding by explaining that “the materialities of bodies, technologies, discourses could not be separated from the society that formed them, and vice versa the social cannot be considered external or separate from materialities.” Similarly, Kemmis, Wilkinson, Edwards-Groves et al. (2014, p. 4) caution that people interpret other people within a group or community based not only on face value but their perceptions that are already shaped by “a lifetime of inhabiting the social world.” This needs serious consideration, especially when engaging with a diverse society such as South Africa.

This understanding of practice affords an opening to engage with the complexity of interdisciplinary collaborative learning where the social is made up of differing disciplines underpinned by differing onto-epistemological foundations. Over and above the disciplinary difference, differing socio-eco-cultural backgrounds make up the student body which represents yet another onto-epistemological position. The diversity of onto-epistemology brings with it the potential for conflict and complex engagement in the online learning space but also the opportunity for creative and shared learning and the potential for co-creating a practice. Barad (2007) in Hultin (2019, p. 91) offers that “[a] relational and performative sociomaterial approach operates with a different ontology. Its underlying assumption is that there are no beings, social or material, no subjects and objects, no research and researched. Rather, all assumed actors, entities and categories are understood as relational enactments or material configurations of the world's becoming.”

To formulate a theoretical lens within sociomateriality is a complex endeavour. The work of Mousavi Baygi, Introna and Hultin (2021), is valuable in clarifying the position taken in this paper to focus on “relational enactment” as a move to decenter human actors by advancing attention on “ongoing processes” of phenomena. By “foregrounding the ongoing relational enactments of entities in practices” (Mousavi Baygi et al., 2021, p. 427) the focus shifts not merely from the human to the non-human but rather to the relationality and interrelatedness that typically exist in the background. It is argued that the nature of collaboration exists in this

domain and therefore the focus of this paper is on collaborative enactments. The next section highlights some key elements that constitute the collaborative enactments within the online learning space.

2.4 An understanding of agency, intra-action and entanglement as foundational to sociomateriality

The entanglement of the technical or material and the social can be understood through the notion of constitutive entanglement (Orlikowski and Scott, 2008). Within the context of interdisciplinary collaborative online learning, the ordinary relations between human, material and other elements can be seen as mutually constituted or inextricably related and therefore inseparable (Latour, 2005). Actor-Network Theory developed by Latour (2005), reviews the symmetry between human and non-human elements as actors in a heterogeneous network in which they both have the same power of agency. Therefore, it does not give special privilege to human actors over technologies (or the non-human) but recognises humans and technologies as ontologically inseparable components (Cecez-Kecmanovic, Galliers, Henfridsson et al., 2014).

This assumption allows Barad (2007) to reformulate the notion of agency and in particular to transcend the duality of human versus technological. Barad's conception of agency is the "enactment of iterative changes to particular practices through the dynamics of intra-activity" (2007, p. 827). Intra-action can thus be understood as the "mutual constitution of entangled agencies" (Barad 2007, p. 33). For Barad (2007, p. 33) "the notion of intra-action is a key element of my agential realist framework" where intra-action "signifies the mutual constitution of entangled agencies". This recognises that individual agencies do not precede the interaction but "rather emerge through their intra-action". This would mean that you cannot and should not separate the human and non-human actors in contributing to knowledge creation. There is no prior understanding that is not influenced and shaped by intra-action, stipulating the importance of working within an interdisciplinary environment where there is no discipline-specific knowledge creation but a mutual entanglement of new learning.

The idea of agency opens up possibilities for creating alternative views within an online learning environment. It can be developed and nurtured as an enactment rather than something that someone already has (Norris, 2016, p. 178). This then has the potential to overcome possible inequalities within higher education by considering agency as continuously starting afresh. Mousavi Baygi et al. (2021, p. 440) pose a central question by asking "do they [actors] get to sense and actualise certain possibilities for action?" which foregrounds the empowering ability to consider agency as entangled and inseparable. This is summarised by Ewalt's (2016, p. 139) eloquent statement that "agency emerges from the arrangement-in-relation-to-each-other that is the result of there being a multiplicity of [human and non-human, discursive and nondiscursive] modalities of moving matter." The rapid move under COVID-19 conditions from the traditional face-to-face to online learning and teaching spaces, opens up the possibility of sociomaterial perspectives, specifically, agency, intra-action and entanglement to consider complexity and creativity anew.

3. Methodology

The researchers followed a qualitative exploratory research design that applied an inductive approach to study observations and theories in search of patterns to reach conclusions (Saunders, Lewis and Thornhill, 2019). The application of Design-Based Research (DBR) was deemed to be the most suitable for the larger research study because it encourages collaboration between stakeholders (e.g., researchers, IS and URP students, community members) which is a central premise of the research. Within a DBR study, both new theoretical insights and practical solutions to teaching and learning challenges can be developed (McKenny and Reeves, 2020). Furthermore, the application of DBR is ideal for the research and design of a learning environment in which technology plays a major role, as is the case in this study (Wang and Hannafin, 2005). A four-phased DBR approach as adapted from Reeves (2006) was applied (see Figure 1).

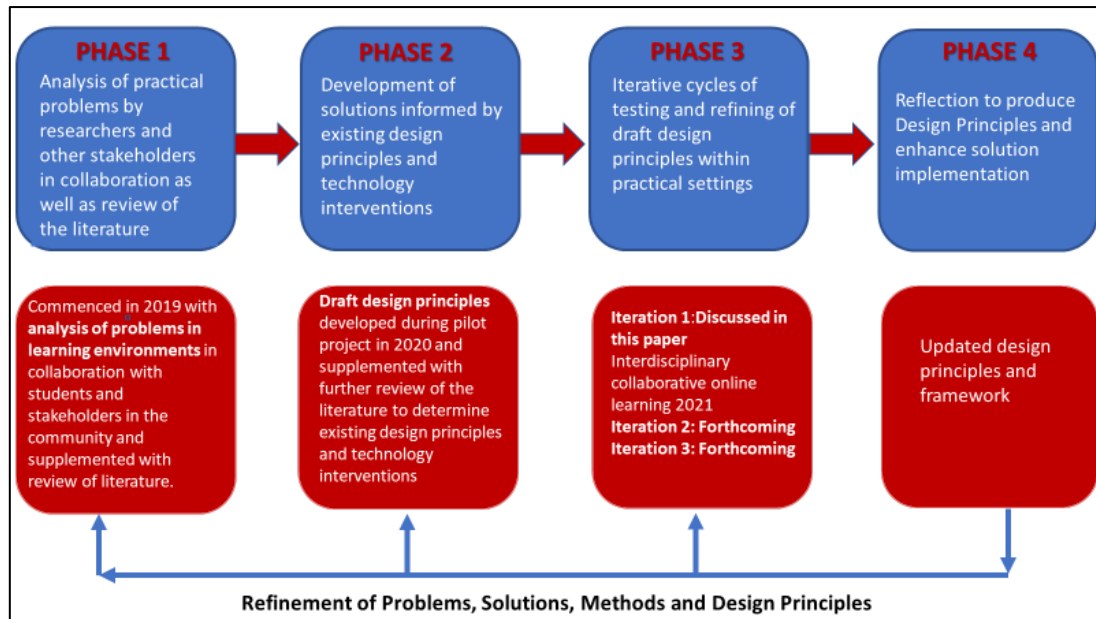


Figure 1: Design-based research phases in blue and the phases of this research study in red. Source: Reeves (2006).

A DBR study is longitudinal and consists of a collection of sub-studies that are reported separately, with this paper discussing the first iteration as part of Phase 3 of the overall DBR study. As seen in Figure 1, in the first phase of a DBR study practical problems within the learning environment are explored in a process of collaboration with other practitioners and stakeholders as well as a review of the literature. The study was initiated in 2019 with the identification of problems in the learning environments and ways of incorporating interdisciplinary collaborative student projects to address systemic problems in communities (van den Berg and Verster, 2020). The consultation and collaboration included a pilot project that resulted in pedagogical propositions and design principles to be continuously tested and refined (Verster and van den Berg, 2021).

The draft principles formulated in Phase 2 were constructed for a blended learning environment and a shift to online-only during the first iteration added more complexity to the learning environment. This presented the problem of how to stimulate interdisciplinary collaboration within an online environment? The shift resulted in a review of theories and as such, the possibilities of sociomateriality were explored by the researchers leading to the research question: What are the sociomaterial-inspired design principles for interdisciplinary collaborative online learning spaces?

3.1 Iteration 1: Interdisciplinary Collaborative Online Student Project 2021

3.1.1 The student project was rolled-out as follows:

- **Pre-Production Phase:** Collaborative workshops to identify pressing environmental problems in local communities. The workshops were in a blended learning format consisting of Zoom sessions with the IS students where online tools such as Jamboards were used for brainstorming ideas within groups of five students each. The URP students collaborated via a face-to-face session in groups made up of two to three students. The themes identified by the individual groups within the different disciplines were used as a guide to form seven interdisciplinary groups. The interdisciplinary groups then identified a single problem within one of their local communities, derived from the broader theme and the output was a problem statement informed by a deep dive into the relevant literature. Table 1 contains information on the group names and the problem areas focused on per group.

Table 1: The range of environmental community problems as identified by student groups.

Group Name	Problem Area
Eco Team	Illegal dumping and mismanagement of solid waste
Eco Warriors	Rapid urbanisation and its pressure on biodiversity
Group 6	Dumping of domestic waste
Removal Approval	Litter and waste at public transport interchanges
System 740	Poor community waste management
Waste Junkies	Improper disposal of urban waste
Water Gate	Water pollution within communities

- **Phase 1:** Empathise and Define: Authentic understanding of the problem from the community perspective. The output was interviews with respondents in student communities and the responses were captured as digital stories. From the digital stories, groups had to develop two personas to be used within the roll-out of the rest of the project (See Figure 2).
- **Phase 2:** Ideate and Prototype: The teams were aided to brainstorm ideas during an online session using Jamboards (See Figure 3). This was followed by a process where teams utilised a decision matrix to determine potential ideas to be prototyped. Prototypes were created and pitched to other groups for feedback.
- **Phase 3:** Test and design. Prototypes were tested by a wider audience and one prototype was selected to be designed and presented to a panel consisting of representatives from communities and local government (See Figure 4).
- **Post-Production Phase:** Individual and group reflections after the completion of the project and the compilation of e-portfolios that showcased the final projects.

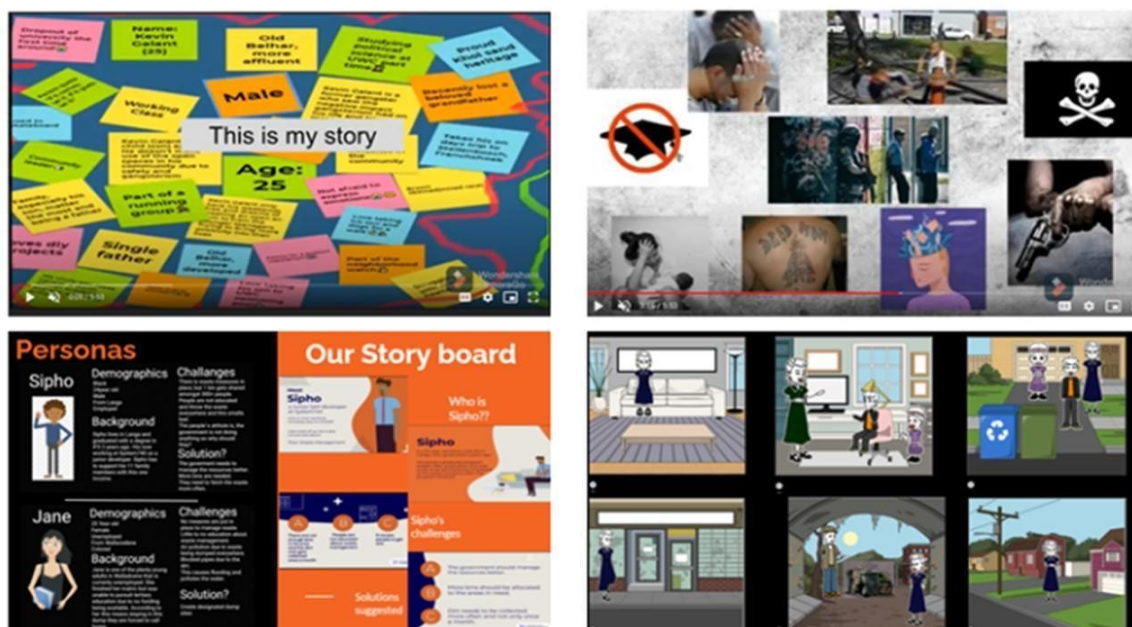


Figure 2: A sample of digital stories and personas that student groups developed to continuously consider the community voice.

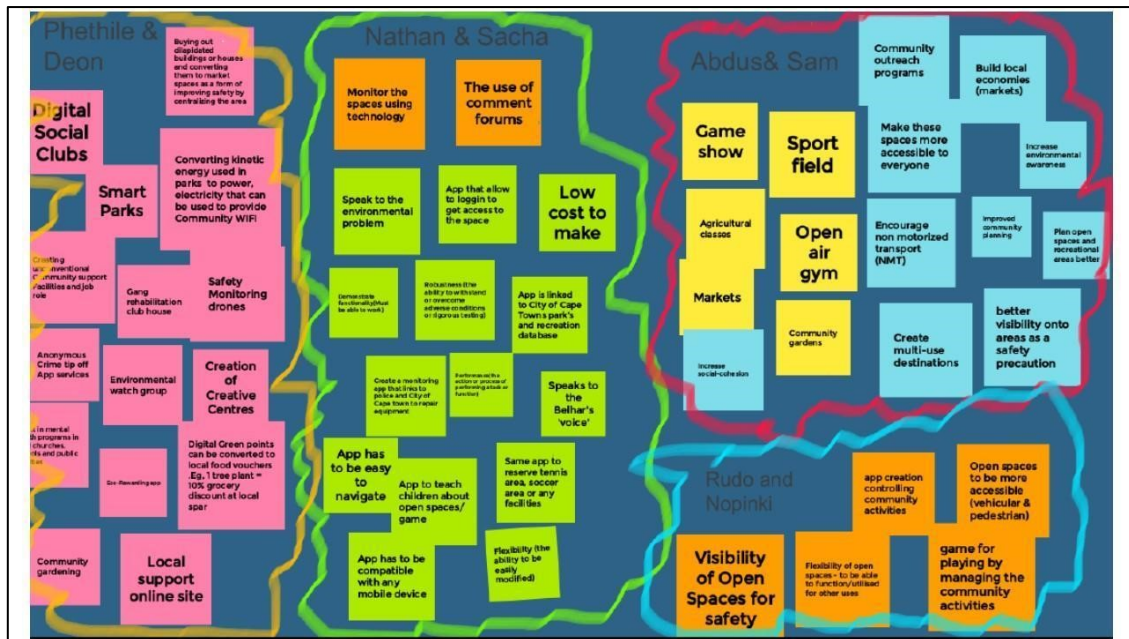


Figure 3: Jamboard with group ideas to co-construct for and with a community.

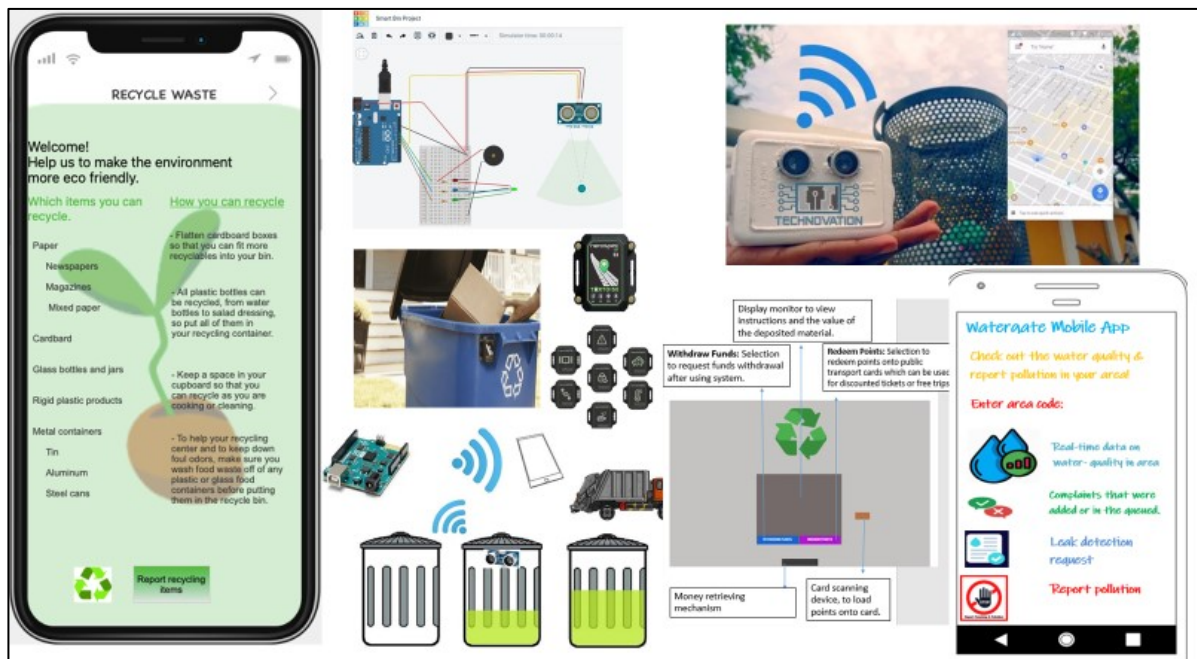


Figure 4: Examples of prototypes developed by student groups.

3.2 Sampling and Participants

The first iteration took place in 2021 during a joint project consisting of 38 students from the Honours group in IS at one university and 22 URP students doing the Advanced Diploma at another university. The two groups represented the full student complement enrolled for these courses. The interdisciplinary group project formed part of the overall learning outcomes and assessments of the modules. Permission to have their findings and reflections, during the roll-out of their group project, included in the data was obtained from students via a signed information sheet that contains details about the study. The participants were students of the researchers and the inclusion of individual findings and reflections in the data was voluntary. Their participation or non-participation had no beneficiary nor negative implications. As such, the researchers applied convenience sampling that included all the students registered for the two modules. Permission and ethical clearance were obtained from both universities.

Table 2: Participation summary

<i>Student Reflections</i>	<i>Before Project</i>	<i>During Project</i>	<i>After Project</i>
<i>Population</i>	60	60	60
<i>Response Rate</i>	87%	83%	85%
<i>Number of URP students</i>	22	18	20
<i>Number of IS students</i>	30	32	31

3.3 Data Collection and Instruments

The researchers participated in the data-gathering efforts and ensured that the data remained as close as possible to the actual events. An access-controlled Google Drive folder was used to store all information gathered from students during the semester. This included:

- A pre-and post-course reflective questionnaire using Google Forms was made up of open and closed questions that tested students' perceptions of the learning environment. The questionnaires were specifically designed to address the objective of the study to test the students' perceptions of interdisciplinary collaborative online learning. The first section tested their perceptions on interdisciplinary knowledge creation, section two focused on the learning environment created, and the third section on collaboration. The fourth section tested students' perception of the development of critical thinking and problem-solving and the final section contained their biographical information.
- A reflective questionnaire on Google Forms about the students' perceptions of the interdisciplinary project during the project activities to reflect on the positive and negative aspects of interdisciplinary collaboration in online environments was a further data collection instrument.
- Field notes and reflections made by the researchers during the project rollout were also consulted.
- Data from the artefacts produced during the interdisciplinary project was also consulted. All course work was saved in folders per group (seven assignments with all responses, comments, artefacts and e-portfolios (See Figure 5).

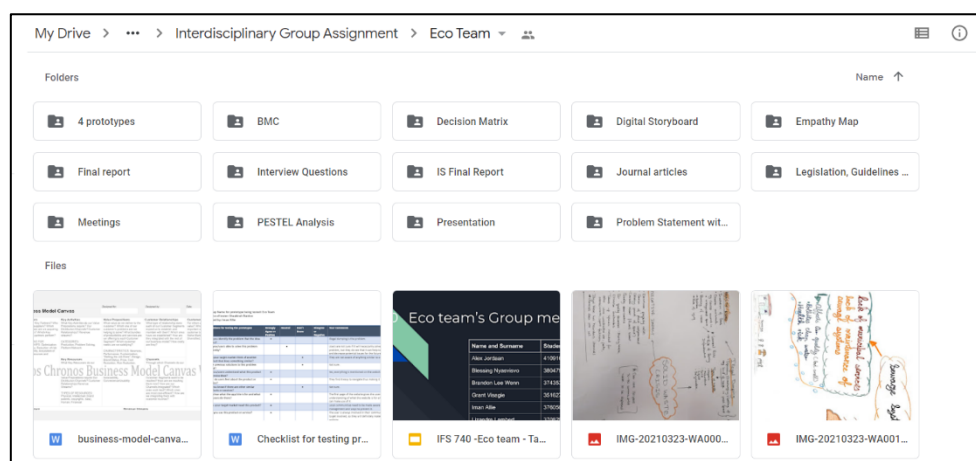


Figure 5: An example of a student group folder in Google Drive.

3.4 Data analysis through sociomaterial concepts

The analysis of findings required “creative and analytical flexibility to support the optimisation of the human and material resources available in ways that remain aligned with the goals of the instruction” (McKenny and Reeves, 2020, p. 90). Within a sociomaterial setting, we shared Hultin’s (2019, p. 92) struggle in this research of “becoming entangled with” the research project “rather than being positioned outside it.” This proved to be especially challenging within the interdisciplinary space where differing positionalities of understanding the world collided.

Researchers are referred to in the first person because they are positioned 'inside' the research event and in line with the sociomaterial approach.

In our engagement with the data sources, our key objective was to focus attention on those manifestations of complex and creative agency and entanglements within the interdisciplinary collaborative online learning space. The interest in agency and entanglements emerged through our reading of sociomaterial theory as positioned by Gaskin, Berente, Lyytinen et al. (2014, p. 849) as the "study of the entanglement of human activities and digital capabilities" to describe a sociomaterial inquiry position. With this in mind, we explore a sociomaterial informed method by drawing on sociomaterial scholars as those "who seek to understand social phenomena as the product of interaction between humans and non-humans" (Moura and de Souza Bispo, 2020, p. 351) and their understanding of a selection of key concepts.

Saunders, Lewis and Thornhill (2016, p. 142) note that the researcher's philosophical positioning represents the "ways of seeing the world and carrying out research." To this point, St Pierre (2014, p. 3) warns "that methodology should never be separated from epistemology and ontology (as if it can be) lest it becomes mechanised and instrumental and reduced to methods, process, and techniques." Being conscious of the limiting nature of predetermining and following a single method, resulted in us following an organic, iterative process of engaging data to ensure a natural unfolding and emergence of meaning. In this organic, iterative process we draw on several key concepts that influenced our engagement with data.

One such concept is offered by MacLure (2013) as 'data that glow' or data hot-spots. In our repeated reading and listening to our data, we sought to tune into those moments of data that 'jumped out at us'. MacLure (2013, p. 228) speaks of data hotspots as data that seem to 'glow' and 'glimmer', which stay in your mind, touch your heart and spark off connections with other instances. Another concept we found useful to think with, is Barad's (2007) 'intra-acting' "which argues that agency is not possessed by individual things or beings, but emerges through relationships" (Verlie, 2020, p. 1266). This concept provides an opportunity to engage with data relationally instead of categorically (Nordstrom, 2013). This means that we are attentive to the relationality and entanglements in the data as it unfolds and evolves.

Because sociomateriality is so deeply rooted in relational onto-epistemology, we propose exploring and engaging with the data by way of 'emergence' as our final concept. Springgay and Truman's (2018, p. 205) concern rings true that "the idea that data is a thing that sits in the world and can be isolated and extricated by a method but as separate from that method is impossible." Letting meaning emerge calls for a move away from the typical measurability of data elements such as coding or affordances. It further shifts focus from verification and recognizable sameness to focus attention on the seemingly insignificant and mundane in the data. Hultin (2019, p. 91) refers to "inviting materiality into" to explain how meaning can be allowed to emerge authentically.

4. Discussion: Sociomaterial-inspired design principles for interdisciplinary collaborative online learning

Due to the fast-changing landscape of ICT, technological innovations now facilitate the interconnection and interaction of large numbers of people, artefacts and organisations. These changes have also impacted Higher Education Institutions (HEIs) and particularly since the outbreak of the COVID-19 pandemic, enforced a move to online learning. The result is that the online learning space has presented new functionality and materiality within the teaching and learning environment for many actors within HEIs. The sudden shift to online learning imposed a review of online pedagogy that prompted a deeper engagement with the social and material entanglements. What was sought in this paper was what Pischetola et al. (2021, p.400) recognised as "a sociomaterial approach might...offer emergent and creative ideas for what might be the future of education and the role of digital technologies within it."

Sociomaterial concepts are not easily quantifiable and provide a way of thinking-with and engaging-with data rather than the more traditional categorising of data in groups of sameness and difference. The datasets are used to understand how sociomaterial qualities of online learning can facilitate interdisciplinary collaboration.

In the data analysis, the sociomaterial concepts of 'data that glow', 'intra-action' and 'emergence' provided the analytical lenses. The following four principles are proposed as considerations when engaging in an

interdisciplinary collaborative online learning pedagogy. A selection of student quotes as well as artefacts are used to illustrate the principles.

4.1 Create immersive context-sensitive learning experiences

It is important to set the context that structural inequalities, societal exclusion and/or poverty are experienced by the majority of our students. The first design principle focuses attention on creating opportunities in the interdisciplinary collaborative online learning space for students to immerse themselves in diverse perspectives and contexts. In an online learning environment, this can be facilitated by opening up the space to experiment with a range of different digital tools to assist group members in authentically expressing themselves. Students groups used a range of tools such as MS Teams, Zoom, Google Meet or WhatsApp for online discussions and could also experiment with tools such as Jamboards or Padlets for brainstorming sessions. These tools were available within the learning management system (LMS) or could be accessed with a Virtual Private Network (VPN) and they did not incur any data charges. Students were encouraged through the above interactive tools to express differing viewpoints and their own cultural understanding of the environmental problems within their communities. The benefits of a context-sensitive learning experience as expressed by students:

It helped me to have a positive mindset and see different perspectives objectively. I realised there are so many more different platforms to reach people and people have vastly different perspectives which relate a lot to their education and upbringing as well as their circumstances (Student).

I got a deeper insight into how people really felt about the problem, what the government was actually doing about it and also [encountered] different ideas that could assist in solving the problem (Student). It broadened my understanding of the complexity of solutions to problems in society in this generation. Given the interrelatedness of the different sciences and ideologies, it is important to approach problems in society from multiple disciplines (Student).

The data also revealed some challenges experienced at the beginning of the project such as the complexity of power dynamics when students are meeting online. In a face-to-face environment, a more structured approach can be introduced by facilitators to ease students into the complexities of an interdisciplinary group project, which is not the case in the online learning space:

At the start, the problem was that not every individual was given an equal footing and some members may overpower others in a virtual setting (Student).

In the beginning, we had a clashing of ideas from the different disciplines, a lack of communication and the absence of some team members due to connectivity issues (Student).

To circumvent the issues experienced at the beginning, the project was redesigned to allow more time to be spent on understanding and formulating the community problem and to enable participation from all students in the groups. Participation through creating, narrating and recording stories from their communities in the form of digital stories and personas, provided students with an opportunity to have their voices heard and to engage with different perspectives.

Higher Education is facing growing uncertainty and complexity that requires creative solutions and new ways of doing and being. This complexity is further amplified by the switch to online learning as a result of the COVID-19 pandemic. There is a growing need to tolerate uncertainty and to function in ambiguous and unpredictable circumstances (Sinha and Sinha, 2020). As such, students need exposure to diverse content, techniques, and views on problems within society that combine multiple knowledge areas (van den Berg and Verster, 2020). Therefore, by designing learning spaces that intentionally create awareness of diverse perspectives and contexts, students are better prepared for the complexity in a ubiquitous world.

4.2 Design opportunities to collaboratively (co)-construct knowledge

For an immersion in diverse perspectives and context to successfully be enacted in interdisciplinary groups, the learning space needs to facilitate a collaborative approach to the co-constructing of knowledge. Within the online space, this requires the use of multiple platforms for engagement, regular peer and facilitator feedback and the pacing of project deliverables to allow enough time for groups to collaboratively consider and incorporate feedback. We used Google Drive with folders for each group that contained the different stages of the project. Student groups were requested to specify the type of feedback they required to be active participants in the learning. Feedback was also provided on each milestone during the project roll-out.

At the beginning of the project, students experienced uncertainty because of the rapid shift to online learning and the additional complexity posed by an interdisciplinary learning environment.

At first, nothing made sense to me and I had no idea of where we were heading with our project. But completing each activity, collaborating with the Urban Planning students, and also having discussions with members of my community gave me a clearer picture of where we are heading. It was quite interesting to see how everything came together and how IS, URP as well as the community could be intertwined to create something really extraordinary (Student).

The feedback provided allowed the team to look through different lenses, angles and approaches to the various [project] stages (Group Watergate).

Online learning is very new to me, so is working from home so I had a lot to adjust to, but it also made it a lot easier to keep in touch with my peers and message them whenever I was struggling with anything related to our assignment (Student).

I also liked the fact that we had small deliverables that build-up to the big project such as using Jamboards the whole time to brainstorm and focus our ideas (Student).

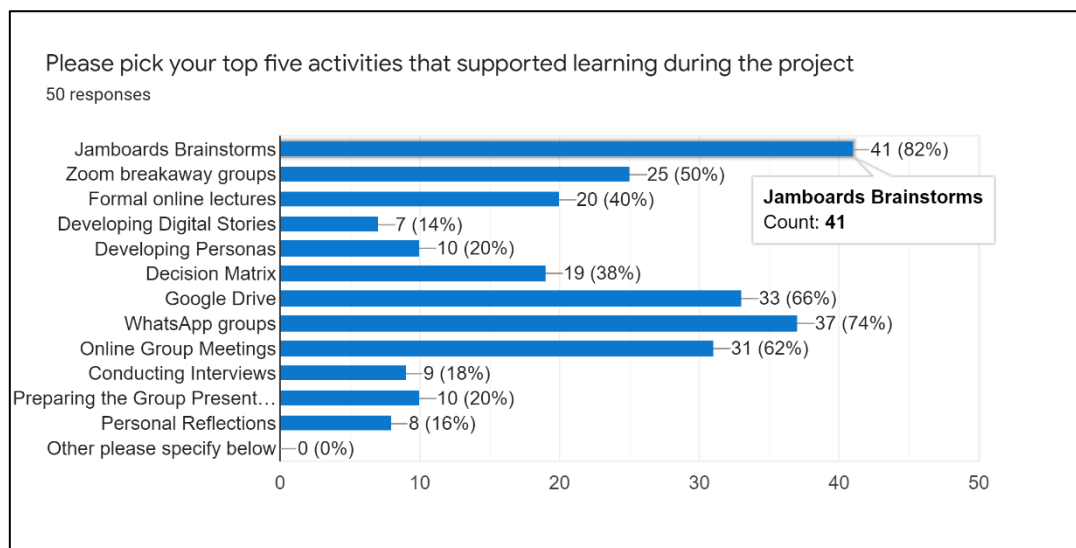


Figure 6: The activities that students regarded as most supportive of their learning. The top 4 - Jamboards, WhatsApp groups, shared Google Drive and Online group meetings - are activities to co-construct knowledge.

To collaboratively (co)-construct knowledge, a space for sharing agency is needed as Sobko, Unadkat, Adams et al. (2020, p. 51) postulate “The key is to neither dismiss nor over-emphasise the role of any actant—be it the instructor, students, or digital tools—but to interrogate the dynamic ways these come together.” The coming together of the actants or what Barad (2007) referred to as “intra-action” enables human and non-human actors to collaboratively (co)-construct knowledge within the online learning space. Moreover, the online learning space needs to incorporate several digital tools to stimulate multiple ways of collaborating and creating group cohesion. Also recognised by both facilitators at the onset of the project and the student groups during the project rollout was the value of offering continuous feedback to provide enough scaffolding that enables students to navigate between the complex and the creative.

4.3 Focus on the intra-action of socio-technical and socio-cultural entanglements

Socio-technical refers to the intra-action between the human and technology within the learning space whereas socio-cultural refers to the complex human and socio-economic-cultural setting. We recognise that both facilitators/lecturers and students are intrinsically linked to their social standing, traditions and beliefs. As such, we created a learning space that enabled the student groups’ time to experiment with and explore different ways of working collaboratively. The focus on experimenting within the learning space created an opportunity for students to develop confidence and strong group cohesion was detected.

The different technologies allowed each student to not only learn from one another but also gave a comprehensive overview of inclusivity through differences in opinions, views etc. (Student).

I enjoyed making use of other technological applications and work ethics such as finding new applications to work together as a group, I have never been involved in such [a] collaboration before. It is exciting to see how well we engage with each other and how we use the knowledge we have acquired and try to use it to achieve the same goal (Student).

How knowledge and agency emerge in complex learning spaces, requires designing with matters of space, time, different digital tools and other artefacts in mind (Leibowitz and Naidoo, 2017). Students were given the freedom to experiment with a variety of digital tools and ways of working as a response to the complexities within their different socio-technical and socio-cultural realities.

Many of the lessons learned were outside an academic perspective, but more on a personal level - learned to accommodate differing cultural-religious social spaces...We also learned that the religious beliefs of people are important. For example, the month of Ramadan for the Muslim students. We had to work around the times of breaking the fast to ensure everyone is available for meetings, for instance (Group EcoWarriors).

People from different backgrounds have very different ways of doing things and different approaches to solv[ing] a common problem (Student).

A further very practical socio-technical consideration, specifically in the South African context, is the added complexity of regular electricity outages referred to as “load shedding” that impacted the delivery of online lectures and student engagements during the roll-out of the project. Furthermore, the cost of data is high in South Africa - South Africa ranks 136th for the average cost of 1GB of mobile data as measured in 230 countries (Cable, 2021). These issues are further exacerbated by the fact that the majority of the students at our two HEIs come from poor and marginalised communities.

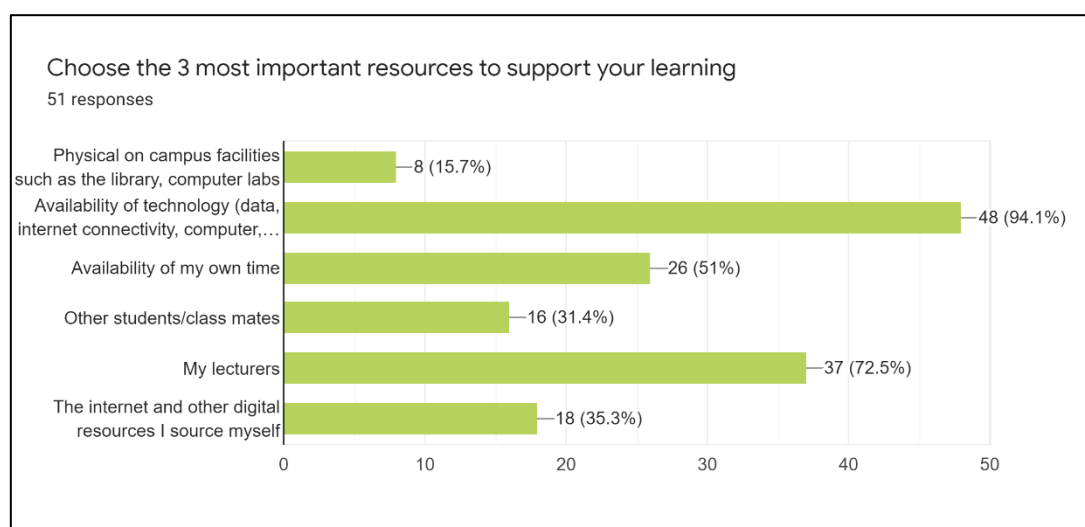


Figure 7: The availability of technology in the form of data, connectivity, devices and digital tools were considered fundamental in supporting student learning.

Some of my group members did not have sufficient data to attend every meeting, some could not connect to any network and this created standstills in some parts of the project (Student).

I consider myself privileged to have working devices and an active internet connection. Some do not have working devices or connectivity which makes it more difficult to be an active student in the online working environment (Student).

Within the context of these ‘impediments’, a sociomaterial turn enabled us to be open to unpredictable flows of action that can cause unforeseen outcomes. Therefore, our focus shifted to the entanglement of students, facilitators and other non-human materials such as Virtual Private Networks (VPNs) in a process of becoming together (Lebowitz and Naidoo, 2017). Students were sensitised to sharing the responsibility of the learning processes and not only the learning outcomes. The idea of ‘learning in the moment’ became important to expose students to new experiences and ways of thinking, acting and co-creating.

One of the things I realised is that non-linear learning is essential to truly understand a concept (Student). I enjoyed the opportunity to express ourselves in a unique way (Student).

The ability to not be as serious as I normally am about work. I feel like I am allowed to explore outside the box and be creative which is fun (Student).

Students recognise the opportunities a non-linear responsive learning experience creates by being creative and flexible and as such provide more openings for students to develop their learning strengths and weaknesses.

We find it useful to think with Kemmis et al. (2014) when they propose “cultural-discursive arrangements” as ways in which to transform our understanding of the intra-action of technology, culture and social opinions. Cultural-discursive arrangements focus attention on the agency that exists within the socio-technical and socio-cultural entanglements and how knowledge cannot and should not be attributed to any one component. This requires an awareness of relationality as discussed in the next section.

4.4 Foreground relationality as a tool to foster agency

Both facilitators have had past success with face-to-face collaborative learning but found the challenge of adapting to an online learning environment daunting when trying to simulate a rich collaborative space. This challenge initiated our interaction with sociomateriality which acknowledges that human and non-human entities are performed and continuously brought into being within a web of relations (Cecez-Kecmanovic et al., 2014). We shifted our thinking about the influence of technology on learning to rather examine the entanglements of the social and the material where learning takes place intra-actively in time and space amongst screens, digital tools, facilitators, students, and other material arrangements. As one student group commented that the “ownership of the learning space was of our own doing and very empowering” (Group EcoTeam).

Designing a learning space that focuses attention on recognising the agency of all human and non-human actors through a relational engagement is complex and time-consuming. Examples of engaging student groups included polls, breakaway groups and brainstorming activities that fostered the relational interplay between the social and material worlds.

Students were able to learn from each other and share already existing skills and knowledge sets, be it discipline-specific, technological or lived community knowledge, and thus created the potential to upskill the whole group. A student reflected on the entangled transfer of skills by stating “this was a steep learning curve, being old school and used to face-to-face lectures and working on hardcopies... I learned so much from the group engagements and other things like the online interviews and apps that we created as a group” (Student). The potential for a relational awareness to have a lasting impact is recognised by a student who commented that “it opened up my mind to so much more and shifted my way of thinking not just for the module but for everything else I do” (Student).

To foster agency within student groups is a highly complex task mainly because of the power dynamics that are at play. Agency is anonymous with empowerment and sharing power in a group. The data revealed this as a major issue with a student commenting on “leadership and power being subverted by the digital space in the way that our group glossed over issues of conflict” (Student). This is a major concern as highlighted by Feldman and Orlikowski (2011, p. 1246) when the authors referred to “power is understood to have both constraining and enabling implications for everyday action”. If students then experience the subvergence of power in the online learning space, it might indicate a lost learning opportunity. Exposing students to the constraining and enabling nature of power relations is central to developing their relations with each other and with the environment in which they learn.

A further challenge to agency that we experienced in this project was the limited voice given to community members because of the lack of technology available at a grassroots level. Students had to rely heavily on their own experiences as community members and only had access to a direct family member or friends because of COVID-19 restrictions as well as the low availability of technology such as smartphones and data to access and capture the community voice. Although students were able to embrace the interdisciplinary collaborative online learning experience and drew high levels of learning from it, they were also aware of one inadequacy in particular: “we missed the embodied experience, being present, and the subtleties you only get from in-person classes” (Group EcoTeam).

In concluding the engagement with data, we refocus attention on the learning space by drawing on Kemmis et al. (2014, p. 4) and their concept of “intersubjective spaces [as] always already arranged in particular ways, so that people receive one another in these spaces in ways already shaped for them by the arrangements that are already to be found there - and sometimes by new objects that are brought there. These intersubjective spaces ‘lie between’ people. They are not mysterious; they are palpable and even tangible.”

Although we agree that these intersubjective spaces are not mysterious, they are in many instances hidden and assumed and as such do not receive the necessary attention when designing interdisciplinary collaborative online learning spaces. Another takeaway from Kemmis et al. is the tension between the “already shaped” quality of the learning space and the freedom of what Mousavi et al. (2021, p. 424) refer to as the “temporal flow of action” to create spaces or pauses for the natural emergence of those learning opportunities that cannot be pre-designed. Here we are thinking of essential learning opportunities such as developing an appreciation for multicultural perspectives or experiencing unexpected creativity and joyfulness.

5. Conclusion

In this paper, sociomateriality provided the lens to unpack the data generated in a semester-long student project to identify design principles that can guide future complex online learning experiences. A theoretical framing through sociomateriality was deemed appropriate as it does not favour either the social (human) or the material (non-human) elements within the online learning space.

The four design principles that were developed in this paper are proposed as a way of engaging with complexity within the interdisciplinary collaborative online learning space. The following is a summary of the main insights from each of the proposed design principles.

1. Create immersive context-sensitive learning experiences by incorporating different interactive tools to open up the learning space to divergent viewpoints and cultural perspectives about problems in communities. The timing and pacing of project deliverables need to be carefully monitored to facilitate continuous and active participation.
2. Designing opportunities to collaboratively (co)-construct knowledge, focuses attention on the agency that both the human and non-human agents have, for example, the activity of continuous feedback. The human actors (facilitators, individual student and student groups, the community members), and the non-human actors (digital tools and artefacts) all have a responsibility to contribute to the feedback cycle's success. This requires the use of multiple platforms for engagement, and the pacing of project deliverables to allow enough time for groups to collaboratively consider and incorporate feedback.
3. Focusing on the intra-action of socio-technical and socio-cultural entanglements by recognising the emergence of knowledge and agency in a learning design that allows for matters of space, time, different digital tools and other artefacts to co-evolve. This provides an opportunity to engage with the full scope of complexities associated with, amongst others, differing technical skills, access to technology as well as the nuances of different socio-cultural backgrounds of group members.
4. Foregrounding relationality as a tool to foster agency, acknowledges that different entities within the learning environment perform within a web of relations between people, tools and the collective activities that take place. This is an exceptionally challenging design principle for the online learning space because of the absence of the embodied-whole person experience. By continuously creating opportunities for human and non-human actors to be put in relation to each other, for example, skills transfer between IS and URP disciplines, empowerment and thus agency is fostered.

It should be noted that the four design principles are not offered as a how-to guide, but rather as a proposed way of thinking about the complex and creative possibilities that exist within interdisciplinary collaborative online learning spaces. That being said, the next iteration of the larger DBR research study will focus on practical ways in which the four design principles can manifest in the online learning space and more importantly how such complex principles can be translated to 21st-century learning skills and objectives.

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