

**Educational Research for Social Change (ERSC)**

**Volume 11 No. 2 October 2022**

**pp. 39-56**

**ersc.nmmu.ac.za**

**ISSN: 2221-4070**

## **Theorising With Sociomateriality: Interdisciplinary Collaboration in Socio-Technical Learning Environments<sup>1</sup>**

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### **Abstract**

In this paper, we explore the possibilities offered by sociomateriality for academics to engage with complex learning environments. The focus is on a longitudinal design-based research (DBR) study that includes an interdisciplinary, collaborative student project between Information Systems (IS) and Urban Planning (URP) from two different higher education institutions in Cape Town, South Africa. In the project, student groups collaborate to find potential digital innovations for sustainability challenges in their local communities. The aim is to position the student as an active community member with intimate knowledge of local sustainability challenges, and to develop social digital innovations for the benefit of local communities. We apply sociomateriality as a theoretical lens to rethink socio-technical learning environments and propose four pedagogical propositions of relationality, reflexivity, responsiveness, and recognition to guide the pedagogical decision-making when designing complex learning environments. We conclude the paper by mapping student reflections and experiences to the four pedagogical propositions to illustrate how the theoretical sociomaterial elements translate into the learning environment.

**Keywords:** interdisciplinary collaborative learning, sociomateriality, relationality, reflexivity, responsiveness, recognition

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<sup>1</sup>Ethical clearance number, van den Berg: HS21/3/26

Ethical clearance number, Verster: 03/Verster/2021

**Please reference as:** Verster, B. and Van den Berg, C. (2022). Theorising With Sociomateriality: Interdisciplinary Collaboration in Socio-Technical Learning Environments. *Educational Research for Social Change*, 11 (2), 39-56. <http://dx.doi.org/10.17159/2221-4070/2022/v11i2a3>

## Introduction

This paper presents findings from the first iteration of a longitudinal design-based research (DBR) study. A DBR study consists of several phases that take place over a number of years and are generally reported separately. The process of designing and refining the conceptual framework and testing the pedagogical principles during the first iteration of the overall DBR study is discussed. The study was initiated in 2020 when we became acutely aware that our current learning environments were not adequately preparing our students as future professionals for an uncertain and complex world. Moreover, a neoliberal agenda and deeply embedded structures and processes in higher education institutions had little to offer the socioeconomically marginalised, the citizens on the fringes, and the vulnerable. We acknowledge our responsibility as academics to implement values that foreground ethics, sustainability, agency, and social justice. This requires the engagement of students with the complex challenges in their local environments, to acknowledge the local voice, and to act responsibly and sustainably.

Whilst trying to find different approaches to situate the learning within these interconnected, complex realities, we started exploring the intra-action between the social and the technical. We responded to (Allen & Marshall, 2019) and explored sociomateriality as a possibility for action to conceptualise organisational and societal change for sustainability. We position sociomateriality as a theoretical lens for an increasingly complex and interconnected world because of its ontological fusion of social and material relations. To this point, Orlikowski (2007, p. 1437) provided an entrance to exploring sociomateriality by stating that “there is no social that is not also material and no material that is not also social.” Inspired by social theorists, we argue in favour of the ability to move beyond our disciplinary confines to experiment with new ways of thinking and doing in our academic practice. We focus on learning environments and explore how sociomaterial theories of learning might be applied in interdisciplinary and collaborative contexts. Gherardi (2017, p. 48) summarised the complex entanglements we engage with when she proclaimed that “the materialities of bodies, technologies, discourse could not be separated from the society that formed them, and vice versa the social was not external or separate from materialities.”

The format of this paper follows an initial engagement with literature on the topics of interdisciplinary collaborative learning and sociomateriality. The conceptual framework with the four propositions of *relationality*, *reflexivity*, *responsiveness*, and *recognition* is developed in the following section through an exploration of critical literature. The DBR research method was used for the student project (Verster & van den Berg, 2021) that serves as a case to determine how students responded to the learning intervention. This provides the context for a discussion of the results by mapping student responses, experiences, and project artefacts to the four dimensions of the conceptual framework. It is argued that by mapping the student experience, an enriched and practical understanding of a complex learning environment can be offered.

## The Need for Interdisciplinary Collaborative Learning

It has been proven that the cultivation of a collaborative learner-driven environment where students engage with real-life issues, enabled by information and communications technology, gives a sense of purpose and internal motivation and enables students to bring about positive change (Makrakis & Kostoulas-Makrakis, 2021). As educators, we are in a very uncertain and turbulent time that has been

further exacerbated by the Covid-19 pandemic. The quest is for a shift to education for sustainability, to rethink what we learn, where we learn, and how we learn (Makrakis & Kostoulas-Makrakis, 2021). Within this, we are acutely aware of the fundamental social, political, economic, and ecological challenges that shape our society creating complex, wicked problems. In our practices, information systems (IS) students need to develop an acute understanding of the impact of technology on the future whilst urban planners (URP) are instructed in design and the wider implications thereof on society. Consequently, we incorporate multiple perspectives in the learning environment and expose students to complex, wicked problems. The learning environment incorporates interdisciplinary teams working collaboratively, and the ultimate aim is to incorporate transdisciplinary (Nicolescu, 2012) collaborative designs by partnering with multiple stakeholders in local communities.

The complex and interconnected nature of real-life problems requires students to engage in cross-cutting forms of inquiry. Although disciplinary specialisation remains relevant, interdisciplinary inquiry can enable students to work towards the cross-fertilisation of disciplinary and practical knowledge to address complex, interconnected current challenges (Mcmurtry, 2013). The same can be said for the focus not only on interdisciplinary learning but on collaborative learning, where interdisciplinary work can be associated with *collaboration* as opposed to *cooperation*. We understand the difference to be that although both cooperation and collaboration focus on a group working together to reach a shared goal, with collaboration there is no distinction between the contributions of the individuals. Knowledge becomes shared and owned by all. On this point, Herrington et al. (2013) commented that complex real-life problems cannot be solved by working independently.

Overall, within curricula, it is crucial to create the space for students to engage in critical and constructive dialogue by applying multiple perspectives and views (Tassone et al., 2018). Such spaces can enhance collaboration and embrace social and transdisciplinary learning that has the potential to contribute to sustainable transformation in communities. This can facilitate learning to take place intra-actively and thereby distribute the responsibility for learning among all actors in the assemblage (Latour, 2005).

## **A Return to Theory Through a Sociomaterial Lens**

It was clear from the outset of this project, that a purely practice-based intervention for this very complex learning space would not suffice, and that a deep dive into relevant theory was needed to frame the learning intervention. Based on a critical literature review (Fu, 2013; Jesson & Lacey, 2006) in the field of learning for sustainable development, we engaged with several theories that enable the inclusion of multiple actors within the learning space. It is important to acknowledge the importance of transformative learning spaces where communities, institutions, and individuals can engage with sustainability problems and acknowledge the collective voice involved in such transformation (Boström et al., 2018).

This led to the engagement with sociomateriality as a theory that recognises the social or the human realm as well as the material or the nonhuman realm. Sociomateriality does not juxtapose the social and material but focuses on its entangled relationality and ways in which one constitutes the other. Our engagement with the social relates to the students and their own local communities and the situatedness of environmental challenges within their own perspectives, social classes, values, and worldviews. The material encompasses the physical space, locations, and also technology. With sociomaterial perspectives, it is possible to explore how social and material elements come together to engage with complexity in society (Burm & Macleod, 2020).

To make sense of everyday practice, our work involves “inserting oneself” into the situation to better understand the flow of practice (Hultin, 2019, p. 101). Rather than an independent or detached observer of a world who is “out there,” a sociomaterial researcher conceptualises themselves as very much a productive element within the field of analysis. We found this helpful to engage with the complexities of a learning environment. These theories look beyond isolated individuals and view the people, social dynamics, and artefacts with which we interact not merely as backdrops to learning, but as inseparable entanglements (Mcmurtry et al., 2016). We recommend responsiveness to these entanglements on the potential impact of digital technologies and further recognise the effect thereof on marginalised communities. We agree with Feenberg (2012), and acknowledge that social groups could challenge dominant technical codes (Chiasson et al., 2018). This paper does not, however, offer a comprehensive literature review of sociomaterialism because that would require a much longer discussion.

We do, however, summarise that sociomateriality consists of different strands of work such as actor-network theory (ANT; Latour, 2005) and other post-ANT strains such as posthumanism, new materialism, social practice-based theories, spatial theory, and complexity theory. According to Fenwick et al. (2011), the overlapping elements in all these strands are that human activity cannot be separated from material objects, technologies, and settings. There is an intra-acting that occurs (Barad, 2007), with intra-action assuming that entities emerge through their relationship. The interconnected nature of sociomaterialism does not privilege or centre humans above nonhumans but sees them on an ontological similar plane with no preexisting relationships, but constituted through relationships (Leibowitz & Naidoo, 2017). This refers to Barad’s (2007) concept of entanglement, with which we continually engage to be aware of the complexity associated with interdisciplinary collaborative learning.

Furthermore, in sociomaterial perspectives, uncertainty is accepted as part of the process and seen as potential for the emergence of new ways of seeing and being, or new assemblages or combinations of things (Fenwick et al., 2011). The broad banner of sociomateriality presents us with an opportunity to open our thinking about 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 & Orlikowski, 2013, 2014). We adopt a relational ontology (Latour, 2005) that centres relations as more fundamental than entities (Scott & Orlikowski, 2014) and by doing so, we can engage with complexity more authentically.

With a sociomaterialist theoretical positioning, we make an effort to disentangle—to some extent—the highly complex practice of interdisciplinary collaborative learning. This disentanglement is necessary to attempt an understanding of the complex interactions of the social (people) and material (things, including technology) within the learning event. We are also conscious of disentangling, not diluting, the complexity of what Gherardi (2017) referred to as sociomaterial practices.

In summary, we argue that the complex entanglements of an interdisciplinary, and now digital, learning environment require the application and development of collective and sociomaterial learning theories. In this, we attempt to recognise the complex entanglements between the human and nonhuman; devices, objects, digital and analogue texts; spaces and time, to create fluid assemblages of practice (Gourlay & Oliver, 2018).

## **An Assemblage Approach to Engaging Theoretical Concepts**

The development of the four pedagogical propositions in the conceptual framework occurred during the first phase of the study. They are derived from the principles of responsible research innovation (Tassone et al., 2018) and principles of responsible management education (Cunliffe et al., 2020).

The responsible research innovation framework identifies four dimensions, namely, anticipation, reflexivity, inclusiveness, and responsiveness. For each dimension, there are different competencies identified such as the anticipation of possible futures associated with societal challenges and ethical implications thereof; reflecting on ways of knowing, ways of doing, and ways of being related to societal challenges; inclusiveness by involving, communicating, and collaborating with multiple stakeholders in open and transparent ways; and responding to societal challenges by navigating complexity and being flexible to revise and adjust the course of action. The concepts are grounded in education with and for a society where students collaboratively engage with real issues to respond to societal problems to engage with the wider societal and ecological contexts (Tassone et al., 2018).

The purpose of the principles of responsible management education is to facilitate the development of participants who are responsible, ethical, reflexive, and sensitive in their relationships with others and with the world around them, that is, responsible ecocentric professionals as per Cunliffe et al. (2020, p. 299), “through a pedagogy that draws on radical-reflexivity and transdisciplinarity.”

The four pedagogical propositions emerged from our engagement with these concepts in our own learning environments and the entanglements of the socio-technical complexities that we were facing. The application of a sociomaterial lens opens up the possibilities of a collaborative engagement with the social and the material in this space, and positions agency within this complex entanglement. We aimed to bring in the collective voice of multiple actors (and to move away from a linear and overly predetermined understanding of both learning and teaching) to an entangled space where the social and material render each other capable—or incapable.

## **Conceptual Framing of Interdisciplinary Collaborative Learning**

The application of design-based research (DBR) requires researchers to follow a phased approach to designing learning interventions. We have applied a four-phase approach as espoused by Reeves (2006). In the first phase, we identified problems in our learning environments and then consulted with different stakeholders such as fellow practitioners (academics), industry partners, students, NGOs, and local communities—and further supplemented findings with a review of existing literature. During the second phase, we developed a conceptual framework and drafted design principles for interdisciplinary collaborative learning as discussed in this section.

### **Relationality**

Relationality acknowledges that human and nonhuman entities are continually brought into being through relations (Latour, 2005; Orlikowski, 2007; Scott & Orlikowski, 2013, 2014). Instead of assuming that entities, people, and technologies have inherent properties, they are seen as continually performed in a web of relations (Cecez-Kecmanovic et al., 2014). One such example of relationality is found in the focus on the collective in South African society. The complexities of the collective voice and how a community comprises people, their relationships, communal activities, and how communities depend on social relationships and relational structures to both solve day-to-day and long-term problems, need to be understood by our students. We argue that interdisciplinary project teams can assist in understanding the relationality that exists in complex communities.

Relationality plays out in the complex society we live in, and also in the social-technical or sociomaterial relations. The broad banner of sociomateriality presents us with an opportunity to shift our thinking about technology as only being artefacts that influence humans, to a way where we examine and focus attention rather, on the entanglements of the social and the material.

From our engagement with the theory, the following principles that informed our learning environment emerged:

- Awareness of local knowledge.
- The significance of the collective voice.
- Awareness of complexity.
- The relationality between the social and the technical.

### **Reflexivity**

Sociomaterial research takes place intra-actively and the researcher is no longer an independent or detached observer of a world that is “out there,” but part of all aspects of the research projects. For this reason, being reflexive is particularly important in sociomaterial studies. Researchers must continually monitor their study design to allow for a sustained consideration of entanglements between the social and material elements (Burm & Macleod, 2020).

Reflexivity requires a radical shift of the individual in relation to others and their broader society. This form of reflexivity is not done from a detached perspective but recognises our embedded nature within a social and material world. Cunliffe et al. (2020) recognised that we are embedded in our social and material worlds and therefore need to interrogate our place, activities, and responsibilities within our local experience. Students need to develop self-awareness about their own assumptions and worldviews and interpret these in any particular situation. There is further, a need for social awareness and empathy underpinned by ethical reflections. It is important to encourage disruptive thinking to challenge the current status quo and go beyond conventional ways of knowing and doing (Tassone et al., 2018).

The following principles emerged in this context:

- Embed exercises that encourage reflection-in-action (Schön, 1987).
- Instil an ethic of care (Tronto, 2010).
- Disrupt the traditional by using transformative learning to revise frames of references and perspectives (Boström et al., 2018).
- Empowerment.

### **Recognition**

Barad (2007, p. 450) highlighted the issues we should recognise as fundamentally framing our learning and teaching endeavours:

*The possibilities of making a better world, a livable world, a world based on values of co-flourishing and mutuality, not fighting and diminishing one another, not closing one another down, but helping to open up our ideas and ourselves to each other and to new possibilities, which with any luck will have the potential to help us see our way through to a world that is more livable, not for some, but for the entangled wellbeing of all.*

Recognition is engaging with the human and nonhuman relationship within different practices and disciplines, for example, the centrality of the human (URP) and nonhuman (IS). We opened the learning space for multiple perspectives to navigate the complexity of an interconnected world. Furthermore, as we adjusted our fundamental understandings of human and nonhuman knowledge and ways of being in the world, we explored design methods, frameworks, and practices that better address the challenges we face as a planet (Ou Yang, 2016). The following principles emerged for the learning design:

- The value of multiple perspectives.
- The interdependence of the human and nonhuman relationship.
- Create the space for creativity to inspire innovation.
- Recognise context-driven interventions.

### **Responsiveness**

One of the most demanding challenges of our time is to engage simultaneously with both sustainability and social justice issues. Responding, in the local context, to these two issues is considered to be one of the most pressing responsibilities of our students as young professionals. Designing a learning environment with a focus on the proposition of responsiveness is considered not only ideal but necessary for our students to appreciate their social responsibility. For this reason, we incorporated both the Sustainable Development Goals and the United Nations 2030 Agenda as framing mechanisms in the student project (United Nations, n.d.).

Responsiveness manifests in many ways in an interdisciplinary collaborative learning environment, and Sleeter (2011) provided guidance specifically about culturally responsive pedagogies. Being culturally aware is essential in a culturally diverse country such as South Africa, and adds both a rich learning experience as well as a highly complex one. We applied responsiveness in order to cultivate the collective knowing and doing (Haraway, 2016) that is foundational to interdisciplinary work, and also called on sociomateriality to think wider than collective knowing and doing as a human function to include the material. Thus, considering the students, facilitators, discourse, texts, performances, drawing, face-to-face and online coming together in collective knowing, being, doing, making, and co-constructing.

The learning design needs to incorporate the following aspects:

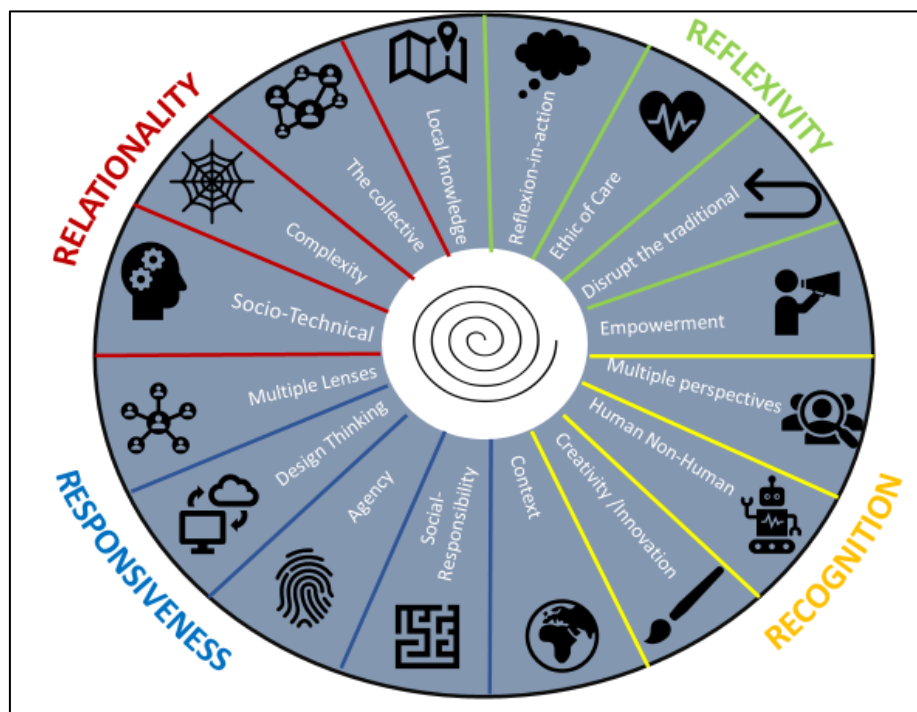
- The value of multiple lenses when reviewing wicked problems.
- Utilisation of a design thinking process in the roll-out of the project.
- Focus on agency through the empowerment of multiple entities.
- Social responsibility.



Figure 1 illustrates the adaption of these principles using a sociomaterial theoretical underpinning.

**Figure 1**

***Four Propositions for Interdisciplinary Collaborative Learning***



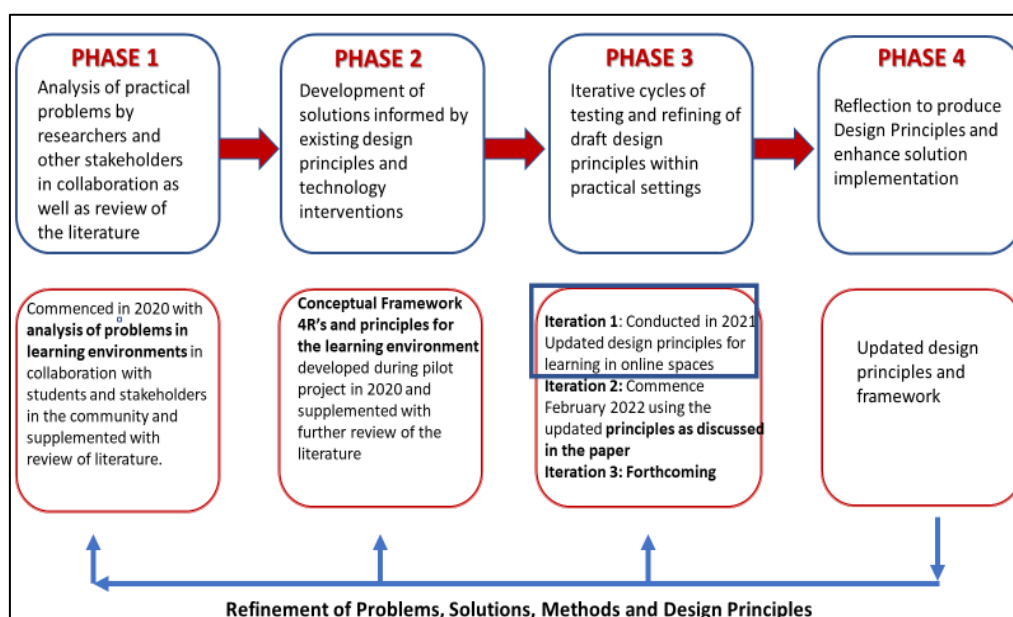
## Research Methodology

The application of design-based research (DBR) as a methodology allows an escalation of the impact, transfer, and translation of education research to improve practice. A DBR study follows a collaborative process in communities of practice that negotiates the study from initial problem identification, through literature review, to the design and implementation of interventions. Design research foregrounds innovativeness, responsiveness to evidence, connectivity to basic science, and dedication to continual improvement (Mckenney & Reeves, 2020).

A DBR study is longitudinal and consists of a collection of sub-studies that are reported separately. In this paper, the process to design and refine the conceptual framework, and testing the principles during the first iteration (as part of Phase 3, in Figure 2) of the overall DBR study, is discussed. As depicted in Figure 2, in the first phase of this DBR study, practical problems in an interdisciplinary online learning environment were collaboratively explored (in a process of collaboration with other practitioners and stakeholders) as well as a review of the literature. The study was initiated in 2020 with the identification of problems in our learning environments and ways of incorporating interdisciplinary collaborative student projects to address systemic problems in communities.



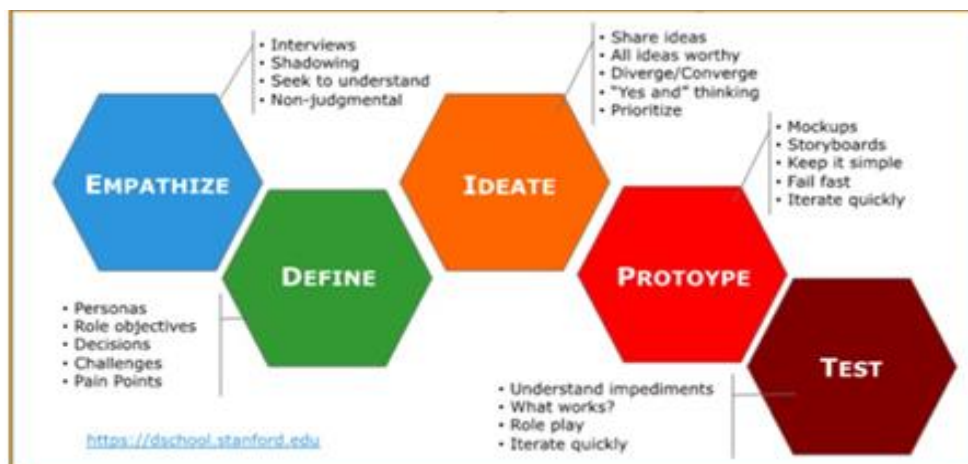
Figure 2

**Design-Based Research Process (adapted from Reeves, 2006)****Design of a Learning Intervention**

The researchers obtained ethical clearance from their respective institutions to conduct research from 2021 to 2024 to enable multiple iterations. Data are collected from online surveys prior to, during, and after each iteration. Furthermore, students are requested to create and update a reflective blog during the semester, which details their experience of working in an interdisciplinary team. Other data sources include project artefacts produced during the roll-out of the student projects. Participation in the study is voluntary, and individual participants are assured anonymity and confidentiality. The identities of students are protected and there are no anticipated risks to participating in the project. During the first semester (February–June) of 2021, 38 students from the honours group in IS collaborated with 21 URP students doing the advanced diploma. Seven interdisciplinary groups were purposively selected. Groups were constituted in a two-phase process: first by letting the IS and URP students choose their own partners in their classes; they were able to draw on their intimate knowledge and experience of fellow students to make an informed decision. The result of this phase was seven groups of three URP students each, and seven groups of five or six IS students. These groups worked independently on identifying and sharing via a poster on GoogleDocs, a single most pressing environmental challenge. The second phase of creating student groups entailed the facilitators consulting the posters and matching similar environmental challenges, thus bringing IS groups and URP groups with similar interests together.

In the learning environment created by the interdisciplinary group project, sociomaterial principles were embraced and groups were actively encouraged to explore the uncertainty that stems from wicked problems such as sustainability and equity. The intra-action between the human, nonhuman, technologies, community, culture, voice, space, and time was examined. We applied Schön's (1987) reflection-in-action approach with students to monitor actions as they are being performed to generate awareness of the intra-actions of the collective. Groups were briefed to follow a design thinking cycle that consisted of a combination of five stages as illustrated in Figure 3.

Figure 3

**Design Thinking Phases (Brown, 2008)**

The project roll-out was as follows:

- Pre-production phase: Collaborative workshop to identify pressing environmental problems in local communities. The workshop was in a blended learning format consisting of Zoom sessions with the IS students where online tools such as Jamboard were used for brainstorming. The URP students collaborated via a face-to-face session. Groups had to identify a single problem and the output was a problem statement informed by a deep dive into the relevant literature.
- Phase 1 (empathise and define): Authentic understanding of the problem from the community perspective was required. The output was interviews with respondents in their communities and the responses were captured as digital stories. From the digital stories, two personas to use in the roll-out of the project were designed by each group.
- Phase 2 (ideate and prototype): The teams were aided to brainstorm ideas during an online session using Jamboard. 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 wider audience consisting of representatives from communities and local government.
- Post-production phase: Reflection in the form of a survey and compilation by the groups of digital portfolios.

### Discussion: Mapping Student Responses/Experiences to the Conceptual Framework

In this section, we consider how students responded to the interdisciplinary collaborative learning intervention in terms of the four propositions. We draw on the students' reflective tasks and project artefacts as sources of data.

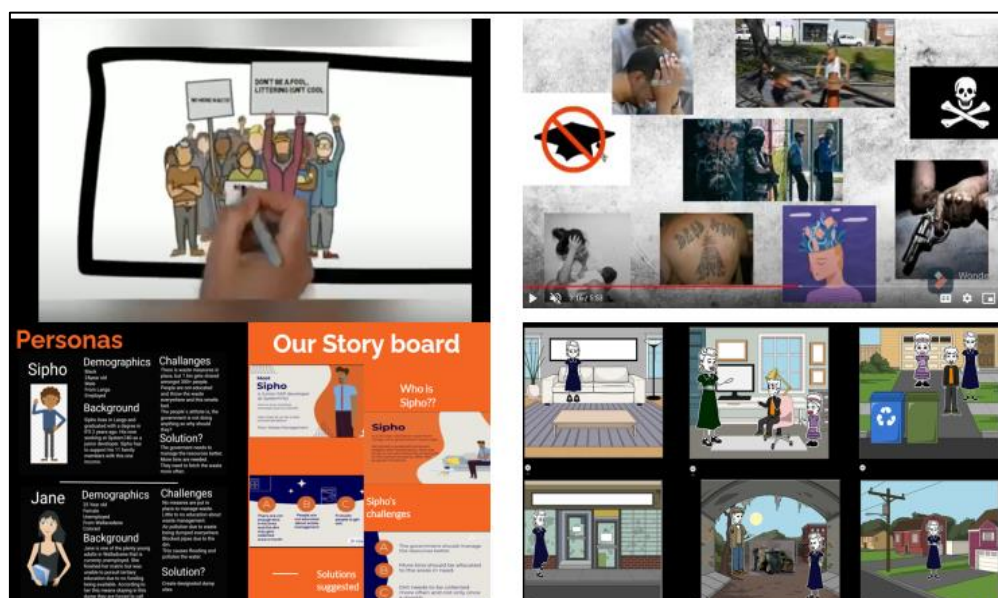
## Relationality

In the framing of relationality, we review the intra-action between the social and technical entanglements that reside in the group's collective and local knowledge. In the design of the learning intervention, the framing needs to occur by not only stressing the problem in a community but also the situatedness of all elements, human, nonhuman, and relational complexities. Due to the intra-action of technology, agency, society, materiality, morality, and ethics, the social and material are inherently inseparable (Orlikowski, 2007).

Student groups were encouraged to pause and explore the interconnectedness of a problem in their community. More time was allocated in the first phase of the project to emphasise relationality via stories and what happens when stories are told (Chiasson et al., 2018). This created the space to explore the problem deeper, which was specifically challenging in the online learning environment. We propose to be excessive with the time allowed for the problem identification and understanding phase of the project. See Figure 4 for outlays of digital stories created by groups.

**Figure 4**

### Digital Stories



Students responded positively to the different perspectives represented by the digital stories for example:

*It made me understand that it is important to involve different perspectives when trying to solve an issue, especially one that affects everyone. I got to learn more through the way the project was structured and gained more insight from the CPUT students, other IS students, and most importantly from the community. (Student 14)*

However, the relationality of an interdisciplinary learning environment was unfamiliar and many students were very uncomfortable at the beginning of the project, for example:

*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 22)*

It was interesting to notice how most of the students experienced the shifts in learning from an in-person to an online environment. These shifts represented the integration of both the social and the technical, for example:

*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 30)*

*I can connect and talk to more people, the online learning has helped me engage more with others. It has also played a part in the fact that without online learning, I would not be as skilled as I am today when using online platforms in order to communicate with others. I think that online learning has broadened the way I learn and the way that I learn. (Student 17)*

*All the participants were aware of the different platforms regardless of our backgrounds. I think to a certain extent it improved the learning environment. (Student 5)*

There were, however, students who felt isolated and needed more scaffolding and initial support:

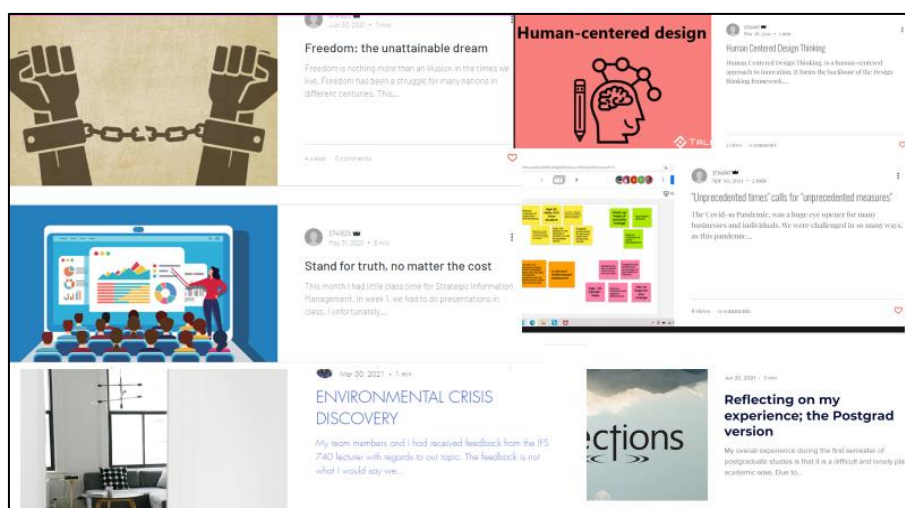
*Some students who did not have access to and were unaware of how to navigate Google Meet or the Drive were excluded from the learning environment until they could get on board. (Group 2)*

## Reflexivity

We encouraged the practice of radical reflexivity (Cunliffe et al., 2020), and incorporated activities where we as facilitators and our students needed to recognise that we are embedded in our social and material worlds and therefore need to recognise our place, activities, and experiences. Students were tasked to reflect on the process individually (in blogs) and as a group in reflective questionnaires. See Figure 5 for examples of extracts from the student blogs on aspects that they reflected on during the semester.

**Figure 5**

### Student Reflections



In the project, students were constantly tasked to better understand their problem area from different perspectives, and to open discussions to allow multiple views. They were tasked to reflect on this and share their learning during the roll-out of the project. Extracts from the students include:

*It made me see that there are many more perspectives than only mine, I always thought that most of us think the same. (Student 5)*

*I learned that it is important to involve different perspectives when trying to solve an issue, especially one that affects everyone. I got to learn more through the way the project was structured and gained more insight from the CPUT students, other IS students and most importantly from the community. (Student 40)*

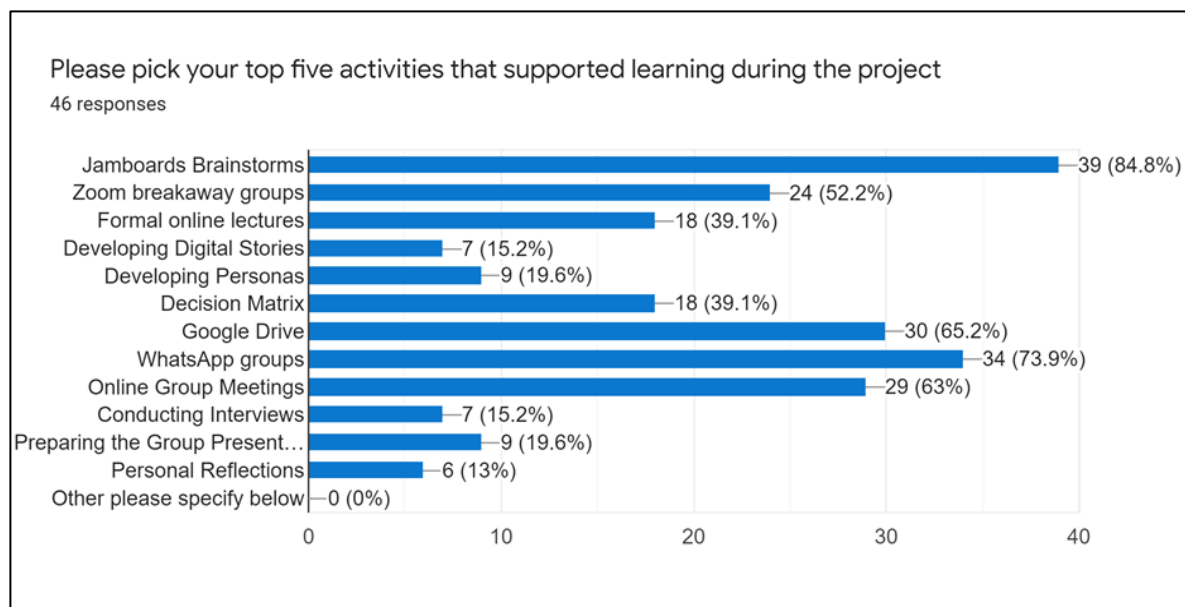
We acknowledge that in future projects, we will encourage more disruptive ways of thinking where students are required to challenge the status quo and go beyond conventional ways of knowing and doing (Tassone et al., 2018).

## Recognition

We found multiple examples of what Barad (2007) referred to as entanglements, involving nonhuman actors in the form of digital devices and online learning artefacts. The students were seen entangled in various ways with print, digital devices, and artefacts throughout the design process. Interestingly, the medium found most conducive by students was the use of brainstorming techniques using Jamboard (see Figure 6). This tool simulates in-person brainstorming and therefore promotes creativity and the simultaneous capturing and recognition of multiple perspectives.

**Figure 6**

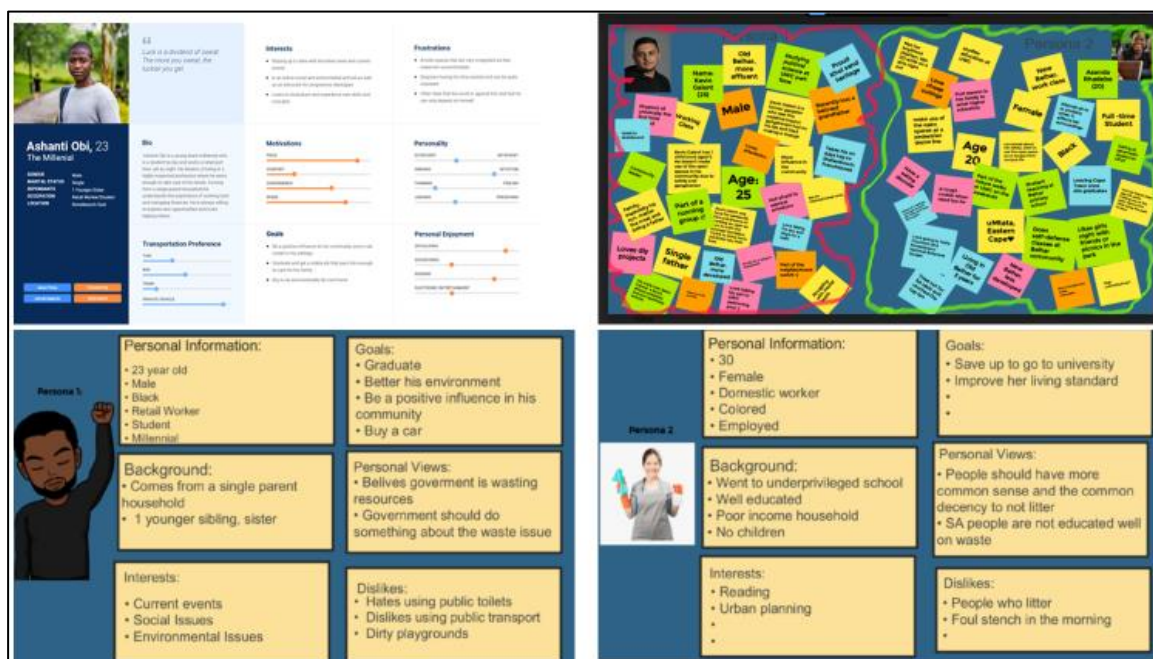
### **Top Five Activities That Supported Interdisciplinary Learning**



Students were highly creative when given the freedom and space in the learning design to develop and represent their community personas, as can be seen from Figure 7.



Figure 7

**Personas**

Students did, however, struggle with several constraints within the learning context as captured by the following quotes:

*A lesson learned when working on a design project is the insufficient time and effort to build the team. We did not have enough time to gel as time is a factor. (Student 21)*

*A project such as this is in constant change, we had to learn to adapt to things not working. (Group 7)*

**Responsiveness**

The quality of responsiveness is portrayed through multiple lenses and agency during the rollout of the design thinking process. We acknowledge that design thinking is traditionally considered human-centred, and as such we concur with observations by (Lake et al., 2021, p. 339) that the process should begin by framing not only the situation but also one's own situatedness:

*This takes place in an iterative exploration of diverse knowledge across space and time. It requires the generation of divergent possibilities and the prototyping of these possibilities (actionable opportunities to enact and test ideas in relationship with others). As an iterative, experimental, relational, and context-responsive process, it leverages these commitments.*

By way of example:

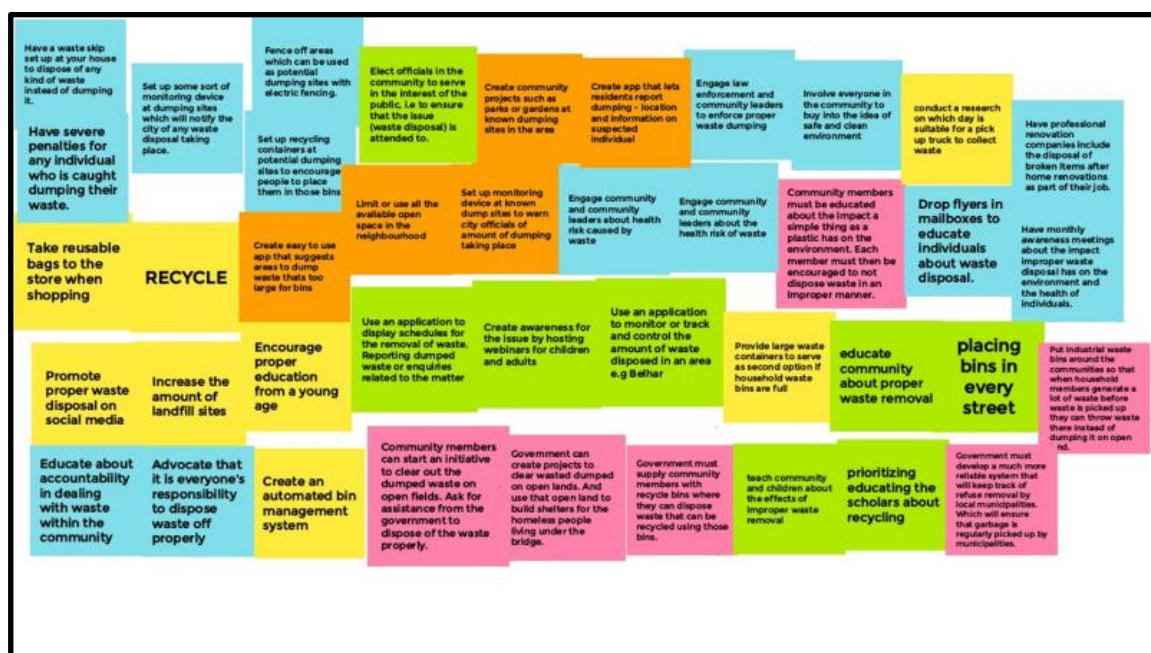
*It broadened my understanding of the complexity of solutions to problems in society in this generation. Given the interrelatedness of the different sciences and ideologies, it is important to approach problems in society by trying to look from and consider multiple disciplines. (Student 3)*

*When working in interdisciplinary collaboration, personal factors that influence collaboration include the span of the group members' interests, competence in one's own discipline combined with a recognition of its limits, a feeling of power, accomplishment and commitment; intellectual openness and flexibility, and trust and respect for teammates with differing disciplinary perspectives. (Group 2)*

A deep, situated understanding of community problems resulted in an extensive ideation phase during the design (see Figure 8). The logic followed here being that the more possibilities considered by the students, the better the chance of resulting in a responsive and context-driven solution.

**Figure 8**

### **Ideation**



### **Conclusion**

In this paper, we highlight problems encountered within our learning environments to adequately prepare our students, as future professionals, for an uncertain and complex world. We adhere to the call that there is an urgent need for new types of innovation that will be both technical and social, and ways to integrate different approaches that allow for the integration of multiple voices.

We discuss extracts from a longitudinal DBR study, and our engagement with sociomateriality as a theoretical lens to disentangle the complexity associated with interdisciplinary collaborative learning. We present a conceptual framework that highlights four pedagogical propositions, namely relationality, reflexivity, recognition, and responsiveness. The four propositions are applied in a learning intervention between urban planning and information systems students who collaborated to find potential digital social innovations for sustainability challenges in their local communities. The data gathered from the student pre- and post-reflections, and project artefacts, are applied to further enrich the four pedagogical propositions and to provide insight into the potential of these propositions to respond to the complex and interconnected world our students, as young professionals, will enter.



Findings confirmed that the focus on relationality highlighted the importance of pacing the learning in a digital environment to compensate for the lack of intimate nuances that occurs during an in-person engagement. Data showed that students easily adapted to an integrated socio-technical learning environment. The second proposition, reflexivity, provided a good grounding for students to engage with the learning interventions and reflect on their experience during the roll-out of their projects. Reflection exercises enabled them to gain a deeper understanding of the problem area and to open up their worldviews to allow for multiple perspectives. The proposition of recognition further focused attention on the importance of creating a space to allow the influences of both human and nonhuman role players to emerge. This facilitated the recognition of multiple perspectives to enhance creativity and innovation. The final proposition, responsiveness, foregrounded the importance of focusing attention on diversity in both the human and nonhuman environments. This resulted in creative and innovative responses to the real-world problems communities experience.

The paper is limited to findings from the first iteration, and further testing and refinement are being conducted and will be reported on in future publications. The objective of the broader study is to explore ways to enhance collaboration, and embrace social and transdisciplinary learning that has the potential to contribute to sustainable transformation in communities.

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