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SENSING IGOLI: APPLYING TYPOLOGICAL ACTIVITY SYSTEM MODELS IN THE DESIGN OF INNOVATIVE AND APPROPRIATE URBAN TECHNOLOGIES

While much of the development of 'smart' technologies occurs in the Global North, the logical expectation is that in the near future 'smart' technologies will be implemented across the world. Technology is never value neutral and always carries particular cultural and political assumptions. Ensuring technology is meaningful to people implies that it should acknowledge and support their conceptions and desires. If the particular needs and contexts of local, urban African communities are not recognised, 'smart' technologies, when implemented in urban contexts such as Johannesburg, South Africa (also known as *iGoli* in isiZulu – the City of Gold), may be undertaken in an uncritical and perhaps even detrimental manner.

This paper describes an interdisciplinary project involving fourth-year industrial and interaction design students working in collaborative teams to consider how the emerging 'smart' technologies of the 21st Century, can be implemented in a human-centric manner, particularly in the complex context of Johannesburg. The central conceptual framework that orientated the teams' design thinking was a novel integration of McCullough's Typology of Thirty Situations (TTS) with Engeström's Activity System Model (ASM).

Keywords: smart technology, 4IR, activity theory, urban contexts, Johannesburg

INTRODUCTION

This paper describes an interdisciplinary project involving fourth-year industrial and interaction design students working in collaborative teams to consider how the emerging 'smart' technologies of the 21st Century, can be implemented in a human-centric manner, particularly in the complex context of the inner-city of Johannesburg, South Africa.

If statistical models are correct, one decade from now, there will be nearly 30 cities around the world with more than 10 million inhabitants; with some cities even expanding beyond the 20 million mark (Muñoz & Cohen, 2016, p. 71). It is predicted that nearly 90% of this influx into cities will take place in Africa and Asia (Praharaj, Han, & Hawken, 2018, p. 36).[1] As populations rise coupled with largely stagnant economies, the services and infrastructure in many urban centres struggle to meet the demands and expectations of those living there, resulting in a declining standard of living (Khatoun & Zeadally, 2016, p. 46).

There is therefore an increasing need for cities to respond in innovative and creative ways to these challenges (Snow, Håkonsson, & Obel, 2016, p. 92), one such approach is to make cities 'smarter'. Considering with the finite limit of our planet's resources, economic instability and climate change (Gascó-hernandez, 2018, pp. 50-51; Kitchin, 2014, pp. 1-2) there is no "one-size-fits-all" solution to the variations of contextual complexities facing urban centres. However, from the beginning of human activity, technology has been an important means for people to enact control on the environment in both positive and negative ways (Kline, 2003). To this point, this paper, addresses how the opportunities afforded by 'smart' technology, can be envisioned to provide a positive contribution to urban futures.

'Smart' cities are described as places where digital technology integrates with urban infrastructure, architecture, everyday objects, and sometimes even human bodies to "address social, economic and environmental problems" (Townsend, 2013, p. 15). At a technological level there is a fairly consistent view of what 'smart' city infrastructure includes, however there is less consensus on how the design of 'smart' cities should be approached (Gascó-hernandez, 2018, pp. 50-51; Kitchin, 2014, p. 1). At one extreme is a 'top-down' approach typically categorised as city-wide planning and/or high-level technological implementation (Gardner & Hespanhol, 2018, p. 54). On the

1 While the UN predictions of global population growth (United Nations, 2017) are currently being debated (see Bricker & Ibbitson, 2019), the fact remains that in Africa and Asia numerous mega-cities already exist under extreme environmental and economic difficulties.

other, is a 'bottom-up' community-led, site specific approach characterised by authors such as Greenfield (2017), Townsend (2013), Kitchin (2014), de Waal (2014) and Rose (2015). Much of this discourse is framed in terms of 'the right to the smart city' (Cardullo, Di Feliciantonio, & Kitchin, 2019) which places emphasis on "small-scale or finer grain workings of the city" (Gardner & Hespanhol, 2018, p. 55).

An important acknowledgment at this point in time is that there are no existing 'smart' cities, only cities trying to be 'smart' (Snow, Håkonsson, & Obel, 2016, p. 92). To this end the 'smart' city concept is typically centred on speculative visions of how cities could be.

Thus, particularly for academics, designers, architects and urban planners in the Global South, now is the time to act. Technology is never value neutral and always carries particular cultural and political assumptions (Al-Hunaiyyan, 2009; Bardzell & Bardzell, 2015). Ensuring technology is meaningful to people implies that it should acknowledge and support their conceptions and desires (Krippendorf, 2007) thus, if the particular needs and contexts of local, urban African communities are not recognised, smart technologies, when implemented in urban contexts such as Johannesburg may be undertaken in an uncritical and perhaps even detrimental manner. However, as design practitioners in the Global South, we are in a good position to do something about it.

In reference to the broader framings of the 'smart' city, as interaction and industrial designers, we are principally concerned with preparing our students to design creative and innovative urban experiences at the immediate, embodied scale. Thus, the student project, which is the focus of this paper can be understood as operating within a bottom-up, participatory mode. In this manner it aligns closely with the field of urban informatics[2] and as such can be compared to other research concerned with preparing students for 'smart' city design such as Gardner and Hespanhol (2018) and Caldwell et al. (2013).

However, since much of the existing student work and indeed theoretical accounts of bottom-up smart cities originate from the disciplines involved in the built environment, as product and service designers we sought to establish the effectiveness of working within the broader 'smart' city conceptual setting by firstly, focusing the role of the product within the 'smart' space, and, secondly, orientating the design activity in alignment with theoretical concepts, specifically activity theory, which has been proven to be effective in product design.

2 According to McCullough (2015, p.16) the field of urban informatics seeks to "collect, share, embed, and interpret urban infrastructural and environmental data" whilst emphasizing human-centric priorities such as "urban resilience, livability, and socialization".

The structure of this paper is as follows. **Firstly**, Johannesburg, as the site of the project, will be very briefly introduced. This introduction will be complimented by a short framing of considerations of human activity in contemporary city-making. **Secondly**, the activity theory framework will be introduced outlining fundamental historical and conceptual precedents. In particular, Engeström's Activity System Model (ASM) will be discussed in reference to how, it was adapted in the Typological Activity System Model (TASM) to focus on urban spatial activities. **Thirdly**, the methodology of the student design project is outlined. **Fourth**, the application of the TASM in the student's design process is illustrated and described in a brief examples of work. **Lastly**, in the discussion section of the paper, we critically reflect on the effectiveness of the TASM to enable the students to engage with emerging technologies through a consideration of the embedded social.

SPATIAL AND THEORETICAL CONTEXT

Established in 1886 as the mining town, Johannesburg with an estimated population of nearly 5.6 million,[3] is the largest city in South Africa and its economic centre. Like most cities of its size, Johannesburg is a highly complex city faced with many (often paradoxical) challenges such as poverty and waste; urban sprawl and high-density; slum conditions and gentrification (Ruhiiga, 2017). The focus of the student project was centred on the inner city of Johannesburg characterised by both urban decay and renewal. While Johannesburg was built as an apartheid city and as such has numerous societal issues, the students involved in the project, many of whom live in the city, where expected to engage with their experience of the city. As a city, Johannesburg is a location buzzy with human activity.

The notion of activity as the fundamental unit of human-centric design has an established tradition in architecture. For example, Alexander's (1977) *A Pattern Language* focuses on the interactions between the physical spaces and the way in which they inhibit or facilitate shared societal values and customs (Benyon, 2014, p. 33). Likewise, premised on three categories of activity namely: *necessary*, *optional* and *social* activities Gehl (1987) is concerned with the everyday activities of people and the impact of these activities on urban planning. In contemporary architectural practice these considerations of place have been incorporated into the concept of the *architectural program*, a strategic method

3 The city has a greater metropolitan area with a population of over 10 million (World Population Review , 2019)

which associates the functional requirements of a space with the activities and behaviours that they are envisioned to support (Shepard, 2011, p. 23). One of the ways to focus in on the various human activities that take place in cities is through McCullough's Typology of Thirty Situations (McCullough M. , 2005, pp. 52-57).

McCullough's theory of [activity] typology suggests that the modelling of daily life ensures a cultural sustainability in the urban environment that can be incorporated into the design of place through activity 'types' (2005, pp. 52-57).[4] Activity typology suggests that environments should be perceived not in terms of what they can contain but rather in terms of the possible human activities they can support. Thus, McCullough (2005, pp. 119-120) provides a *Typology of Thirty Situations* as detailed in Table 1. Each element of the typology suggests a situated action that describes the everyday living patterns of a particular category of place (McCullough M. , 2005, p. 118). For example, the situation "Gathering (places to meet)" recognises that in the urban sphere certain environments exist to support the human activity of meeting other people.[5]

While referring to activity, McCullough, as with many other authors from an architectural background, does not specifically unpack the concept of activity. However, in product design, and most notably interaction design, activity is an often-theorised concept[6]. We will therefore briefly unpack the concept of activity in relationship to activity theory.

Activity theory proposes that in order to study subjects and objects the most effective manner to do this is by studying the manifest activity between them (Leontiev, 1978). Therefore, by studying how people act we can arrive at a much more accurate understanding of a person's motivations. "Broadly defined, activity theory is a philosophical and cross-disciplinary framework for studying different forms of human practices as development processes, both individual and social levels interlinked at the same time." (Kuutti, 1995). Originating in Russian psychology through Lev Vygotsky (1982) and his student Alexei Leontiev (1978) it was popularized in Western discourse mainly through its dissemination by Yrjö Engeström (1987). Enegeström's activity model depicts mediated action undertaken by a person (subject/s), towards the solution of a problem (object), mediated by tools (technology), in order to achieve the goal (outcome). This model

4 McCollough's theory is focused on activity, and hence we describe it as activity typology to differentiate it from more generic concepts of typology.

5 Activity typologies are not meant to be regarded as definitive and timeless but should rather instead recognise as a human-centric, emergent situated contributions to institution-building (McCullough, 2005, p. 57).

6 See Rogers' *HCI Theory Classical, Modern, and Contemporary* (2012)

(at work....)
1. Deliberating (places for thinking)
2. Presenting (places for speaking to groups)
3. Collaborating (places for working with groups)
4. Dealing (places for negotiating)
5. Documenting (places for reference resources)
6. Officiating (places for institutions to serve their constituencies)
7. Crafting (places for skilled practices)
8. Associating (places where businesses form ecologies)
9. Learning (places for experiments and explanation)
10. Cultivating (places for stewardship)
11. Watching (places for monitoring)

(at home....)
1. Sheltering (places with comfortable climate)
2. Recharging (places for maintaining the body)
3. Idling (places for watching the world go by)
4. Confining (places to be held in)
5. Servicing (places with local support networks)
6. Metering (places where services flow incrementally)

(at on the town....)
1. Eating, drinking, talking (places for socializing)
2. Gathering (places to meet)
3. Cruising (places for seeing and being seen)
4. Belonging (places for insiders)
5. Shopping (places for recreation retailing)
6. Sporting (places for embodied play)
7. Attending (places for cultural production)
8. Commemorating (places for rituals)

(on the road....)
1. Gazing/touring (places to visit)
2. Hoteling (places to be at home away from home)
3. Adventuring (places for embodied challenge)
4. Driving (car as place)
5. Walking (places at human scale)

Table 1. McCullough's typology of thirty situations (2005, p. 120).

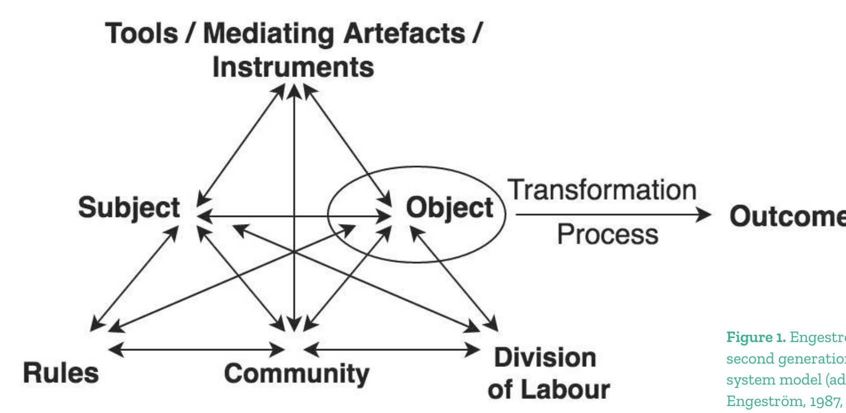


Figure 1. Engeström's second generation activity system model (adapted from Engeström, 1987, p.78).

highlights how cultural and socio-historical factors influence human activity, these factors include conventions (rules), social organisation (division of labour), and the context of the subject's broader society (community).

Activity theory is useful to focus on the operations undertaken in an environment, these then lead into actions, driven by goals, that finally lead to the higher order motivation behind the activity. It is difficult for most individuals to access the emotional motivations behind rational actions, but activity theory provides a means to start with the more rational operations and actions in order to delve into the subconscious of human motivation. As a means to practically engage with the complexity of motivations

AUTONOMY / INDEPENDENCE	Feeling like you are the cause of your own actions rather than feeling that external forces or pressure are the cause of your action
COMPETENCE / EFFECTANCE	Feeling that you are very capable and effective in your actions rather than feeling incompetent or ineffective
RELATEDNESS / BELONGINGNESS	Feeling that you have regular intimate contact with people who care about you rather than feeling lonely and uncared for
SELF-ACTUALIZING / MEANING	Feeling that you are developing your best potentials and making life meaningful rather than feeling stagnant and that life does not have much meaning
SECURITY / CONTROL	Feeling safe and in control of your life rather than feeling uncertain and threatened by your circumstances
MONEY / LUXURY	Feeling that you have plenty of money to buy most of what you want rather than feeling like a poor person who has no nice possessions
INFLUENCE / POPULARITY	Feeling that you are liked, respected, and have influence over others rather than feeling like a person whose advice or opinion nobody is interested in
PHYSICAL THRIVING / BODILY	Feeling that your body is healthy and well-taken care of rather than feeling out of shape and unhealthy
SELF-ESTEEM / SELF-RESPECT	Feeling that you are a worthy person who is as good as anyone else rather than feeling like a "loser"
PLEASURE / STIMULATION	Feeling that you get plenty of enjoyment and pleasure rather than feeling bored and under stimulated by life

Table 2. Sheldon et al. (2010) Top-10 Psychological Needs. This version is based on Hassenzahl (2010 p. 46.)

Sheldon et al's top 10 psychological needs (Sheldon, Elliot, Kim, & Kasser, 2001) are useful as a means to predict why certain human activities take place. As designers, this provides the opportunity to understand the driving force behind action, and therefore design within that desire, as opposed to possibly misinterpreting simple operations or more complex actions as reflecting real needs.[7]

In summary and in order to better situate this project in the urban context, we equate the "object" of Enegström's ASM with McCullough's typology of thirty situations (2005, p. 120), and the "outcome" informed by the 10 Psychological Needs (Sheldon, Elliot, Kim, & Kasser, 2001) to arrive at the TASM. As designers, a product intervention is situated conceptually at the point of the "mediating tool" in the T/ASM, however as opposed to typical use of activity theory in Human Computer Interaction where it is focused on micro or product wide interactions (Kaptelinin & Nardi, 2012), we rather use the TASM as a research tool to frame the overall urban ecosystem as a means to contextualise product and service design.

TEACHING METHODOLOGY

The project commenced with a series of short theoretical lectures that presented the conceptual framework of the project to the students. Major themes presented included: the 4th Industrial Revolution (Schwab, 2016), Floridi's 4th Scientific Revolution (2014), Embodied cognition (Dourish, 2004; McCullough M. , 2005) and Activity theory (Kaptelinin & Nardi, 2012; Engeström, 1999).

Students from both departments were combined into small design teams. Teams were tasked with exploring a particular activity typology in the Johannesburg inner city district using a range of qualitative and quantitate design research methods, framed by the TASM model. This exploration was situated, and people focused. Students were expected to visit their selected spaces throughout the duration of the project and engage with the communities using them.

Once the initial design research was completed, students, again, applied concepts from activity theory to guide their speculative design considerations of future city-making in Johannesburg.[8]

7 The use of Sheldon et al's top 10 psychological needs in the TASM is informed by Hassenzahl's use of it in his 'three level hierarchy of goals' model (2010, pp. 44-46).

8 Concurrent to the theoretical lectures and site visits, students undertook weekly Aurdino programming classes. Aurdino is an Open Source computer hardware and software that provided the students with the skills required to prototype their final designs both in terms of interface and product outcomes.

Student teams, through both independent lecturer engagement and in peer critique sessions, critically reflected on their own design concepts and learning development. At the culmination of the project, the entire process was documented through an electronic publication, which included the final prototype outcomes.

CASE STUDY IDŌ: A SPACE FOR RECHARGING BY NATALIA DELGADO AND RIAN PRETORIUS

In this case study we use one student project as an example of how the TASM was applied over seven-weeks. This is one of nine design outcomes from a project that has been refined over three years.

In the chosen case, using the typology "a space for recharging" as the initial starting point, the design team engaged with community members in Johannesburg in order to better understand their experience of physical health. After engaging with participants (subjects in the TASM), they firstly identified a core set of psychological needs which included: bodily health, self-esteem, pleasure and stimulation (Fig. 2).

Once they had established their object and outcome pairing, their research activities then focused on social approaches to exercise as well as exiting technological support for such activities.

The Idō concept consists of two key products, a wearable watch and a mobile application. Beyond recording biometric data for health feedback, Idō helps to guide movement through the use of integrated sensors to improve technique. Through visual illumination it can sync the users' movements to others, hence creating a shared exercise routine regardless of whether participants are in a shared environment or in the privacy of their own home. Exercises thus become more a more engaging experience, motivating the user to continue with the practice.

Figure 2. Persona Board (Delgado & Pretorius, 2018).

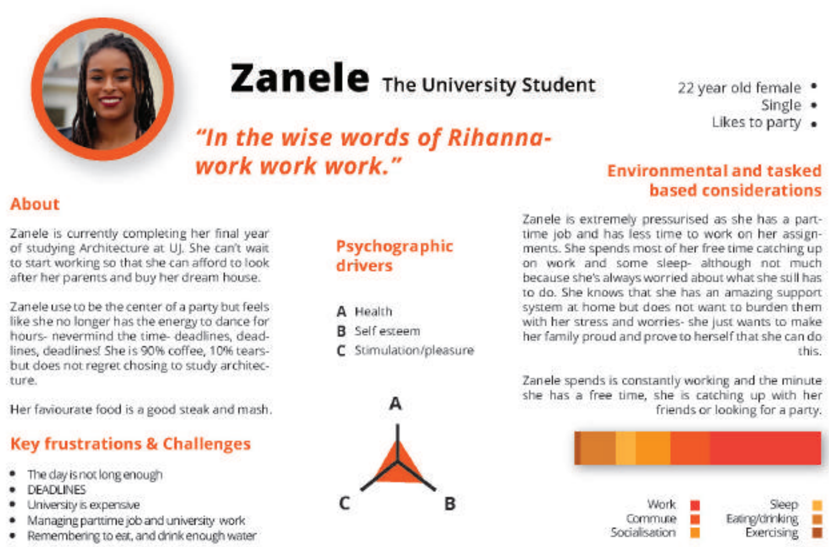
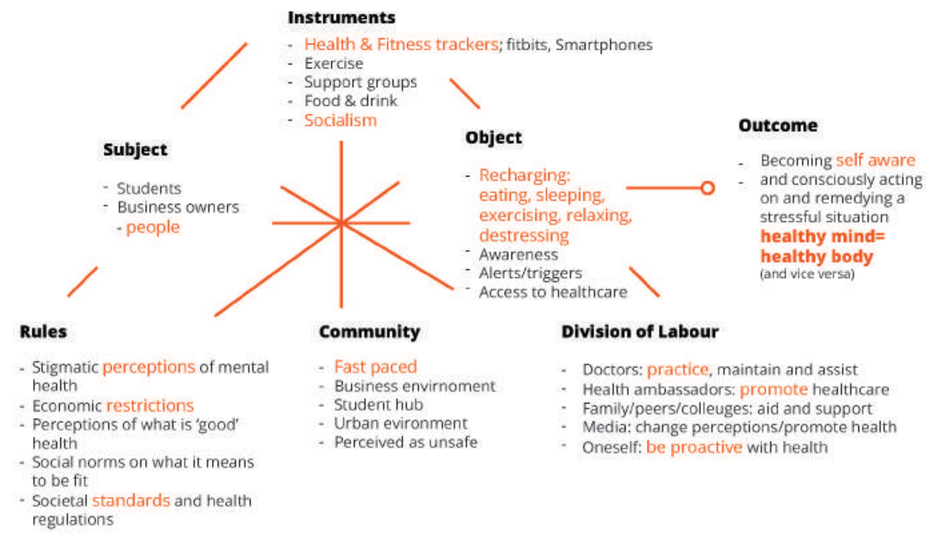


Figure 3. Typological Activity System Model (Delgado & Pretorius, 2018).

Figure 4. Idō visualization (Delgado & Pretorius, 2018).



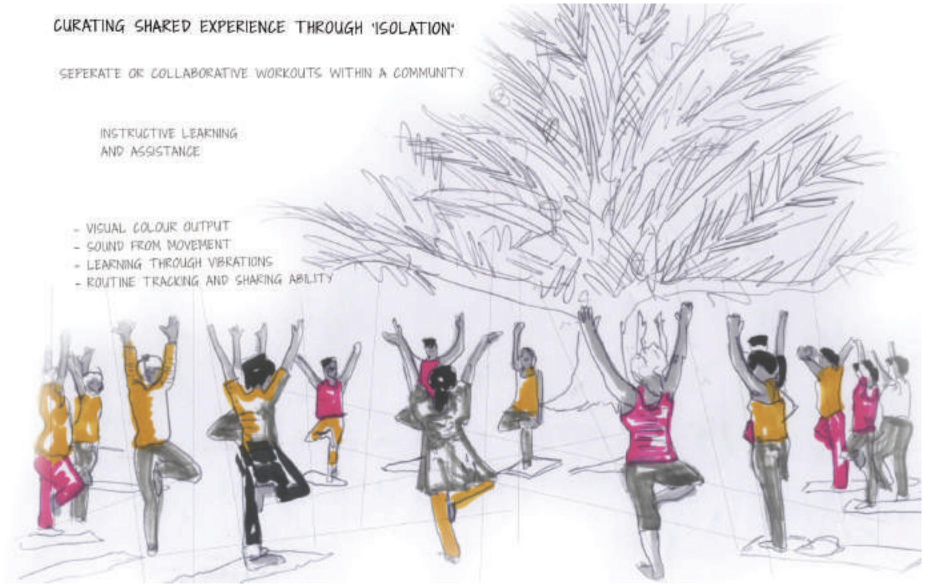


Figure 5. Curating shared experiences with Idō (Delgado & Pretorius, 2018).
Figure 6. Group Interaction with Idō (Delgado & Pretorius, 2018).

Case Study Reflection

Reflecting on our experience working with our students on this project, we found the TASM to be a very useful tool. Firstly, it acts as a visual mapping of research process, which enabled conversation and reflection between students, and, with lecturers. Secondly, it allowed students to structure their thinking and to be generally more strategic in design concept development as it encouraged a focus on peoples' goals (objectives) and needs (outcomes) rather than technological and/or aesthetic specification. Thirdly, it provided a background logic that the students' strategy and ideation could be validated against. Fourthly, it could also be used to systemically speculate on the impact of designerly intervention into a particular urban space. In the sense a change in one of the TASM nodes (typically Tools/Instrument) could be used to predict change in the other nodes. And finally, as evidenced in the provided student example but also true of the other projects, we found the students' concepts to be well-integrated product/service systems. In our previous experience of teaching the same collaborative project we found that students from different disciplines would limit product integration within the knowledge frameworks of their specialisations; whereas we found the TASM enabled better synthesis of design strategy and ideation across the interdisciplinary groups.

CONCLUSION

As design practitioners in the Global South in the post-digital age our students need to be prepared to engage with design approaches that include and integrate computational, physical and spatial domains. Typically, digital and product designers have not explored the spatial realm, however these fields bring their own knowledge with regards to people and technology in an immediate and embodied manner. Activity theory, generally, and the TASM, specifically, help to bridge between product making and urban informatics in a manner that helps students to formulate designerly concepts in a mature and systemic manner.

While we have applied TASM in the urban context only, we believe that it is equally beneficial in its application in the rural context or scaled up to explore more regional contexts. This is an opportunity for future research.

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