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DESIGN EDUCATION | AFRIKA | 4TH INDUSTRIAL REVOLUTION

A systemic framing of the challenges faced in design education during the COVID-19 lockdown

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Abstract

The COVID-19 pandemic has exposed the deep cracks of inequality within the South African educational system (Gustafsson & Deliwe, 2020). The fourth industrial revolution (4IR) has presented a range of new technology applications (Lacy, Long, & Spindler, 2020). These technologies can be leveraged to provide more equal access to the technology needed for remote learning (Du Preez & Sinha, 2020). This paper uses a systemic design approach to reflect on the challenges faced in design education during the COVID-19 pandemic. Student feedback on the online learning experience during the COVID-19 lockdown was reflected on. Observations were organised in themes and then explored using the first step of Namahn and shiftN's Systemic Design Toolkit (Van Ael & Vandenbroeck, 2016). Design thinking toolkits are well-established tools for a design process (Tschimmel, 2012). A systemic design toolkit was chosen as a method that incorporates tools from both Design and System's practice (Vandenbroeck, Van Ael, Thoelen, & Bertels, 2016). The primary aim of this study is to frame the complex systems that contributed to the problems exposed. This inquiry uncovered interlinking issues that exacerbated the challenges of remote learning during the COVID-19 pandemic.

Keywords: 4IR, COVID-19, educational inequalities, mapping, systems

Introduction

This paper illustrates how a systems-orientated approach to Design can be useful in a study that deals with complex socio-technical problems. It does so by presenting my personal account of the challenges experienced by the Multimedia Department at the University of Johannesburg (UJ), during the COVID-19 pandemic. I reflect on the practices that were found to be helpful in mitigating the implications of digital inequality on our students. I have used a Systems approach to expand the framing of the problem context, and by doing so, highlight the systemic nature of design education during the COVID-19 pandemic. I present my experiences during this time and showcase an exploration of Systemic Design tools for *framing a system*, to illustrate how Systems Thinking (ST) can be integrated into the practice of Design.

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Challenges in design education during the COVID-19 lockdown

In March of 2020, the first case of COVID-19 was reported in South Africa. President Ramaphosa declared a National State of Disaster and implemented a national lockdown. From 23 March, until the 30 April 2020, no one besides essential workers was allowed out of their homes. All non-essential industries were closed (Arndt, et al., 2020). Schools and universities were shut, and students living in campus accommodation had to make alternative arrangements (Crawford, et al., 2020). The South African government instituted a five-level alert system. *Level 5* was reduced to *Level 4* in May, *Level 3* in June, *Level 2* in August, and *Level 1* in September (South African Government, 2020). During *Level 5* no students were allowed on campus. This changed during *Level 4* when final year students were allowed back. As can be seen in Table 1, there was a gradual increase of access to campus from 33% of students being allowed back during *Level 3*, 66% during *Level 2*. All students requiring access to university facilities were allowed back on campus during *Level 1* (with spacing limitations).

Table 1: Student access to university campuses mapped to the COVID-19 five-level alert system (South African Government, 2020)

	Level 5	**Level 4**	**Level 3**	**Level 2**	**Level 1**
Alert level timeline:	*26 March to 30 April 2020*	*1 to 31 May 2020*	*1 June to 17 August 2020, 29 December 2020 to 28 February 2021*	*18 August 2020- 20 September 2020*	*21 September to 28 December 2020.*
Student access to campus:	No students allowed on campus	Final year students allowed on campus	33% of senior students allowed on campus	66% of students allowed on campus	100% of students allowed on campus

When the COVID-19 lockdown began, UJ developed a plan for remote learning as all students and staff were required to be off-site during this initial national lockdown. Blackboard was the primary Learning Management System (LMS) used by UJ to deliver online teaching. It is worth noting that over 60% of undergraduate students at UJ are funded by the National Student Financial Aid Scheme (NSFAS). Over and above that, there are also students who fall into the "Missing Middle" category (i.e. Above the income threshold for government funding, but still require financial assistance). Senior academic leaders Motala and Menon (2020), offer insight into the COVID-19 learning experiences faced at UJ. They noted that not all students were afforded the same level of access to the online platforms needed for remote learning. Several factors contributed to this problem, such as limited or no network coverage, lack of a suitable computing device, high data costs, and limited bandwidth. External considerations such as living conditions and psychosocial factors also compromised the COVID-19 online learning experience of many students (Motala & Menon, 2020). The COVID-19 pandemic forced the speeding up of the 4IR journey across UJ, with all faculties and disciplines having to make continuous adjustments to course delivery, bearing in mind digital inequality. Flexibility and agility were essential tools for experimenting with various approaches (Motala & Menon, 2020). The Multimedia Department was by no means unique in this journey, however, like in many other departments, it became apparent that the nature of the discipline contributed to the experience of remote learning.

As a multimedia department, our job is to prepare students for a career in digital media. We equip students with skills for technology-based design. This could take the form of digital content creation (such as video and animation) or the design of digital products and interactive

platforms (such as websites and applications). The course has both a theoretical and practical component. Design is a practice-based discipline and there are practical and technical competencies that students need to master. When the initial COVID-19 lockdown forced all academics online, it was the practice-based modules that were of primary concern. The nature of digital media means that design and technology are completely intertwined. Without access to the relevant technology, many aspects of digital media design cannot be undertaken.

Our department took the strategy of rearranging the curriculum. The idea was that the theoretical course requirements were done during the period that the campus was closed, leaving the technical components to the later part of the year. It was hoped that by that time, students would once again have access to campus facilities and computer labs. This strategy worked well for final year students, as they were allowed back onto campus after a few weeks. However, as the lockdown dragged on it became noticeable that a high proportion of first-year students in our department were not attending online classes and not submitting work. We flagged these students as being "at-risk" of failing the year. As a first-year coordinator, I had the responsibility of communicating with these students. It proved difficult to contact many students. Some students did not seem to have access to their e-mail. There were a few instances where the student's phone numbers were out of service. This highlighted the very real problem of equitable technology access. Our department made a supreme effort to track down as many students as possible and offer them assistance. We wanted to try and understand the barriers to successful remote learning during the COVID-19 lockdown. I had many productive conversations with students, and I noted the re-occurring challenges described. I then took this feedback to our staff meetings, and as a department, we brainstormed possible strategies to deal with the issues discovered.

Systemic design as a tool for reflecting on the challenges of design education during the COVID-19 lockdown

The experience of remote learning during the COVID-19 pandemic held many challenges for Design students in South African universities. As a design educator, I intuitively felt the need to explore the challenges and experiences of this time through the lens of design. The arrival of the 4IR has shifted the traditional notion of an artefact. As things start to become interconnected, artefacts or "things" must be seen as a system of "things" (Holman, Walker, Lansdown, & Hulme, 2020). For this reason, I believe that any design inquiry dealing with interconnected societal and technological issues should be systemic in nature.

Design thinking

Design thinking (DT) is a well-established strategy used in design practice. DT has been popularised within the spheres of innovation and business management. The roots of DT can be found in the meticulous research documented in the *Design Thinking Research Symposium* series. The focus of this forum was to try and understand the cognitive aspects of a design process. DT grew out of a human-centred design (HCD) approach to the process-based methods used for design as a problem-solving activity (Bousbaci, 2008). The practice of DT involves formulating a problem definition and solution proposition (Tonkinwise, 2011).

The notion of *wicked problems* is deeply embedded in DT practice (Buchanan, 1992). Rittel and Webber have been credited for establishing this term in DT (Skaburskis, 2008). The term was originally used to describe the complex, systemic problems found in urban planning. Unlike scientific problems, societal problems are too complex ever to be "solved". Rather they are

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temporarily resolved or “tamed” (Rittel & Webber, 1973). Social system *wicked problems* arise when there are too many stakeholders with conflicting values (Churchman, 1967). Within the practice of DT, it is understood that complicated and multi-faceted problems cannot be solved using a purely scientific method (Churchman, 1967). Complex problems need to be understood in their complexity and solutions must be envisioned and constructed (Buchanan, 1992).

It is clear that complex systems theory (CST) has a strong link to DT. Peter Jones notes that Systemics and Design have had a long-standing but uneasy relationship (2014). The attempt to pull these two fields together has an extensive history. Over the years, various philosophies including pragmatism, critical theory, and phenomenology have blended and influenced design methodologies. Systemics naturally flows as an enriching methodology for practice (Jones, C., 2003). This evolution is acknowledged, yet there is no absolute consensus as to what this interdisciplinary field is called (Jones, 2014). Within this current context, systemic design (SD) practice has emerged as a field of study (Bijl-Brouwer & Malcolm, 2020). SD intentionally brings together ST and DT (Ryan, 2014).

Systemic design

The key differentiating factor in SD is the expanded **framing** of the design situation. ST is used to zoom out and DT is used to zoom in on the problem. SD is well suited to be practised in complex social, political, and highly complex systems such as governance and policymaking (Jones, P., 2014). SD is different from traditional HCD-based DT practice, in that it frames design problems within socio-technical complexity. SD focuses on the complexity of systems and subsystems. The focus is not only on products and services but expands to organisational and policy contexts (Jones, 2014). SD draws on multiple Design methodologies, including generative tools, sketching techniques, ethnographic research, and process reasoning. Systems Theory’s *Action Research* tradition is also employed (Jones, P. & Sevaldson, 2019).

Jones outlines ten shared Systems and Design principles that are highlighted in Figure 1:

- Idealisation
- Wickedness
- Purpose
- Boundary framing
- Requisite variety
- Feedback coordination
- Ordering
- Generative emergence
- Continuous adaptation
- Self-organising.

Jones notes that any design process can be used and that these ten principles are adaptable and should not be seen as a fundamental baseline (2014). The purpose of mapping a design process model to SD principles is to ensure that both Design and Systems principles are equally considered during the design process (Jones, 2014).

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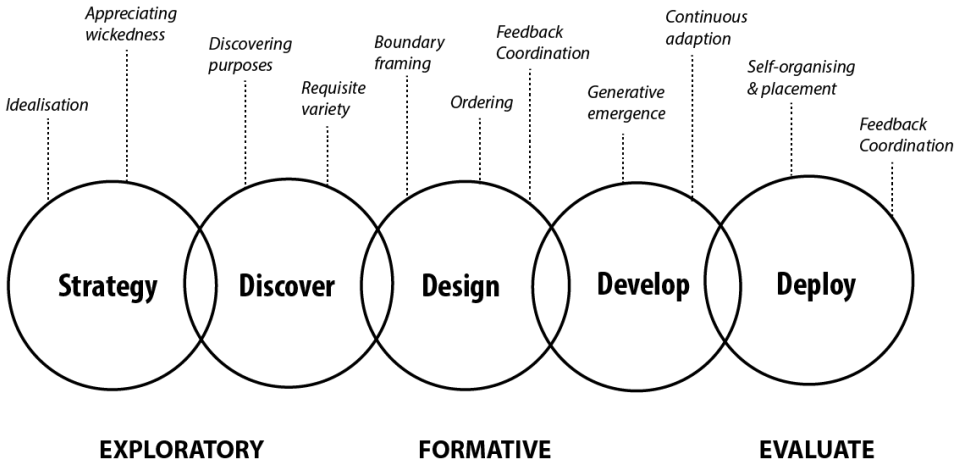

Figure 9: Jones's design principles mapped to design model: Adapted from (Jones, 2014)

One of the successes of DT has been the adaption of its processes into industry practice. This was facilitated by design-based innovation tools and models. David Kelly from Stanford Design School created the five-step DT process of:

- Empathise
- Define
- Ideate
- Prototype
- Test.

Kelly also founded the IDEO company (Denning, 2013). IDEO's famous DT toolkit is available for download and there is even a facilitator version available (Tschimmel, 2012).

SD is a growing form of design practice, as can be seen by the creation of Namahn and shiftN's Systemic Design Toolkit. This toolkit is a codification of the convergence of DT and ST, and comprises seven phases (Jones, P., 2019).

- The toolkit has multiple techniques categorised according to the SD process:
- Framing the system
- Listening to the system
- Understanding the system
- Defining the desired future
- Exploring the possibility space
- Designing the intervention model
- Fostering the transition.

Figure 2 illustrates the seven phases of what I will call the systemic design thinking (SDT) process. The SDT process cycles through ST and DT steps in a toggling fashion. The first step in the model uses ST to *frame the system*.

The intention of this study is not to present solutions to the problems I describe, using DT. Rather SD strategies have been employed to frame and unpack my experiences, observations, and practices our department found useful, during this time.

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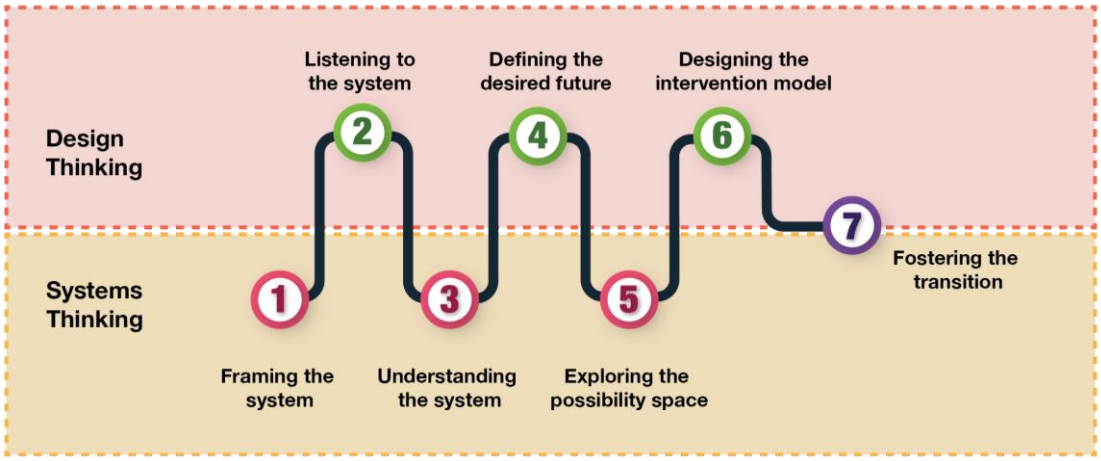

Figure 10: Adaption of the systemic design toolkit (From Jones, P., 2019)

The first phase in the SDT process is to *frame the system*. Noted systems thinker, Peter Checkland[35] argued that prior to defining any problem, an exploration into the problem situation needs to be undertaken and framed from multiple standpoints. He suggests that the tension between what is and what might be provides areas for creative thinking. Comparing different viewpoints of the real-world problem leads to ideas for improvement. He proposes a method called *rich picture*, to describe the richness of "messy" or *wicked problems*. Mapping and sketching tools can be used, though they should not be expressed as a logical process diagram (Williams & Hummelbrunner, 2020).

Geels notes that when it comes to innovation within a Socio-Technical System (STS), innovation occurs through the interplay of dynamics on multiple levels. With this multi-level perspective, a problem context can be addressed by looking at the current modus operandi, then drawing out the long-term trends that will affect the landscape. This prompts conversations about emerging and preferred alternatives (2005). Visualising an ideal future can be useful for addressing problems that relate to 4IR technology, as it points to possible levers that can be used for addressing the problem in innovative ways (Philbeck & Davis, 2018). Stakeholder and actor mapping tools are useful for uncovering the actors in the system, the power and knowledge relationships, and the nuances of the interactions between the actors. A Systems Approach to actor mapping also considers non-human agents that influence the system. Namahn and shiftN have created some canvas tools for framing a system in their SD toolkit (Jones, 2019).

I have used their *rich context* and *ideal(ised) future* canvas tools to visually map, explore and frame the systemic nature of design education during the COVID-19 pandemic.

A reflection on design education during the COVID-19 lockdown articulated through the lens of systemic design.

Framing the system: Rich Context

I have used the SD *rich context* canvas tool to frame the STS context faced in design education during the COVID-19 pandemic. This tool prompts the designer to consider the nature of the current social system and technology landscape and look at what emerging niche initiatives can be used to address the problem innovatively.

35 Peter Checkland developed Soft Systems Methodology (SSM), which persists that there are multiple perspectives within any given situation

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Figure 3 illustrates how the canvas is divided into four categories:

- Institutional structures
- Economic considerations
- Cultural influences
- Human action/behaviour.

These subsystems will always contribute to the messiness of a problem context. The canvas places these subsystems in a circular fashion around a section dedicated to considering long-term trends. Like other wicked problems, design education during the COVID-19 pandemic was influenced by many separate but interconnected subsystems.

Policies that were taken by the **institutional** bodies directly affected the experience of students and lecturers during the COVID-19 pandemic. The university system was affected by power structures including the government, the Department of Education, and the Department of Health. Decisions to close residences and only allow final year students access to campus created a situation where junior students no longer had access to campus facilities.

The broader **economic** structures in South Africa and UJ affected students on a very practical level. Disadvantaged students rely on bursaries to afford their education and learning supplies. NASFAS provided students with a hybrid laptop-tablet. These devices gave the students a means of participating in the online modules. However, these devices were very basic and could not handle heavy design software. Many students from the "Missing Middle", relied solely on their mobile phones to access the learning platforms. Another problem faced by students was the cost of data. Mobile data is expensive in South Africa (Phokeer, Densmore, Johnson, & Feamster, 2016). Remote learning is usually very heavy on data due to video streaming. Added to these problems was the problem of electricity. Not only was load-shedding taking place during the lockdown, but some students had gone home to areas where electricity is intermittent and unreliable.

The **cultural** context also affected students' ability to participate in remote learning. Some students reported family expectations and priorities when residing at home. There seemed to be a culture gap in issues of communication between lecturers and students. This might have stemmed from the lack of face-to-face communication opportunities; however, the possibility of a power imbalance (actual or perceived) was not ignored.

It was noted that certain **actions and behaviours** influenced the student's experience. Informal channels of communication and the responsibilities taken by class representatives (reps) were acknowledged as important practices.

The importance of considering long-term trends was found to be particularly useful when reflecting on the problem context. Visually laying out social and technological trends proved to be highly beneficial for thinking about the solution space. UJ places a strong emphasis on the possibilities the 4IR holds for social innovation in a South African context (Du Preez & Sinha, 2020). Technology products are part of an interconnected system of human and non-human actors. Considering the actors, their relationships, and the tension between the current reality and what could be provided a great springboard for considering niche initiatives to improve the system. The unexpected and sudden nature of the global pandemic did not allow for much preparation time, but long-term trends paved the way for innovative workarounds. In this reflective study, trends that fit into the design education context are 4IR technology such as cloud computing, online learning platforms, open-source software, ubiquitous access to mobile phones and social media platforms.

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Framing the system: Ideal(ised) future

I have used the SD *ideal(ised) future* canvas tool to explore the nature of the challenges that arose for Design students during the COVID-19 lockdown and identify the resources that were and could be used to improve the situation. As seen in Figure 4 the canvas is divided into six boxes. The desired future is considered through six considerations:

- Ultimate goal/purpose
- Desired result
- Driving forces
- Barriers
- Emerging initiatives
- Capacities and resources.

This leads to articulating the design challenge. The purpose of this paper is to reflect on students' experiences during the COVID-19 lockdown and find new methods that will best afford all students the opportunity for quality and accessible design education during and beyond the pandemic.

By thinking about an ideal future, areas for systems improvement became clear. The nature of the COVID-19 lockdown brought to light underlying social inequalities. The nature of design education further compromised disadvantaged students. First and foremost, access to appropriate hardware and software is imperative for successful remote learning. Students need to be able to retrieve the lectures and complete practical assignments. The notoriously expensive Adobe Suite has traditionally been taught by the department. The software is loaded onto the lab computers. Simply moving lectures online via platforms like Teams or Zoom was not practical, as students did not have constant internet access, and relied on costly mobile data. They also needed design software that works on a low-cost device. Flexible learning strategies were necessary to facilitate remote learning. There was a need to promote open communication between students and lecturers.

Section 5 and 6 on the *ideal(ised) future* canvas, showcased in Figure 4, asks a designer to consider other initiatives. This is done by looking for innovations that address the problem in a novel way, as well as by scouting for existing resources that can be built upon. The Digital Divide is a well-known phenomenon in South Africa (Bornman, 2016). Financial Technology (FinTech) innovation has been addressing this issue for many years (Yermack, 2018). Some innovative solutions include providing free data to customers. Leveraging the widespread adoption of mobile phones has proven successful in a South African context (Makina, 2019). Corporate partnerships have also been used to assist in bridging the gap between advantaged and disadvantaged students. Telecommunication companies came to the aid of the University by providing students with 10GB of free data per month during campus lockdowns (Motala & Menon, 2020). Searching for ways this problem has been addressed, found that online learning platforms such as Udacity, do consider access issues native to certain regions. Their LMS provides the option of pre-downloading course content, so students can work even when they do not have internet access (Udacity).

The Multimedia Department looked at other existing initiatives and considered what resources could be leveraged to address some of the issues that arose. We brainstormed our ideas during staff meetings and employed creative problem-solving techniques to find ways of facilitating better and more accessible education during the COVID-19 pandemic.

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Observations and reflections

The practices that proved useful were:

Pre-recorded lectures

A useful technique for migrating the face-to-face lectures to an online platform was to diverge from live Zoom classes. Instead, lectures were made by creating PowerPoint presentations that were converted to low-resolution PDFs. Lectures were recorded in audio-only formats and broken up into smaller lessons. This way files could be downloaded easily and not use up too much data.

Corporate partnerships

At the beginning of the COVID-19 lockdown, students were given three months of free Adobe licenses (personal communication Sept 9). This was helpful for students who had access to appropriate computing devices. Many students were not able to use Adobe software because of the large size of the applications. Contact was made with the InVision company with the purpose of finding a workable alternative. InVision provides a cloud-based web prototyping platform, as well as a full-blown design software package. InVision provided accounts for students valid until six months after graduation (personal communication Oct 1).

Alternative software

Lecturers compiled a list of open-source and free software that could be used as alternatives for practical work. Only, software that is light on RAM or could be used on the cloud was recommended. The list included: (1) GIMP – a substitute for Photoshop, has photo editing, drawing, and painting tools (free to use and light to run, 128MB versus the 4GB that Photoshop requires), (2) Inkscape – free software, similar to Adobe Illustrator, (3) Darktable – free photo editing software (good for photo editing and will handle RAW files, it is analogous to Adobe Lightroom), (4) Pencil 2D – free 2D animation software, including backgrounds, sounds, and camera, (5) Opentoonz – free 2D animation software, (6) DaVinci Resolve – powerful, professional and free video editing software, compositors like After Effects, (7) Olive Video Editor – free video editor, (8) Kdenlive – free open-source video editor, (9) Natron – free compositing software (like After Effects), (10) Audacity – free open-source audio recording and editing software, (11) Visual Studio – free internet development environment (IDE) and (12) Google Docs – an alternative to Office 365, can be used on the cloud. Students found this list very useful, and most students were able to complete their practical work, even when they did not have campus access.

Informal channels and platforms

Since some students were not responding to e-mail or Blackboard communication. Lecturers brought in the class reps to assist in communication. Class reps were often able to contact students when lecturers were struggling to do so. WhatsApp groups were found useful for quick and direct communication. Class reps assisted in adding students to the class groups. Some students had very basic phones and had to connect to the internet via internet cafes. A useful solution was for these students to load an android emulator onto their laptop and view the class chats when they had connectivity. Google Drive was an alternative platform that was used to share files and upload projects.

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Figures 3 and 4 illustrate how I used the SD toolkit for contextualising and broadening the framing of design education in South Africa during the COVID-19 pandemic. Systems framing tools provided insights that showcase the power of combining Design and Systems thinking. The process of *framing the system* uncovered social and technical levers for change that can be expanded upon to create better learning opportunities for students beyond the COVID-19 pandemic. This paper showcases one phase of the seven-phase SD toolkit. Following the entire seven-step process would no doubt prove useful for future research.

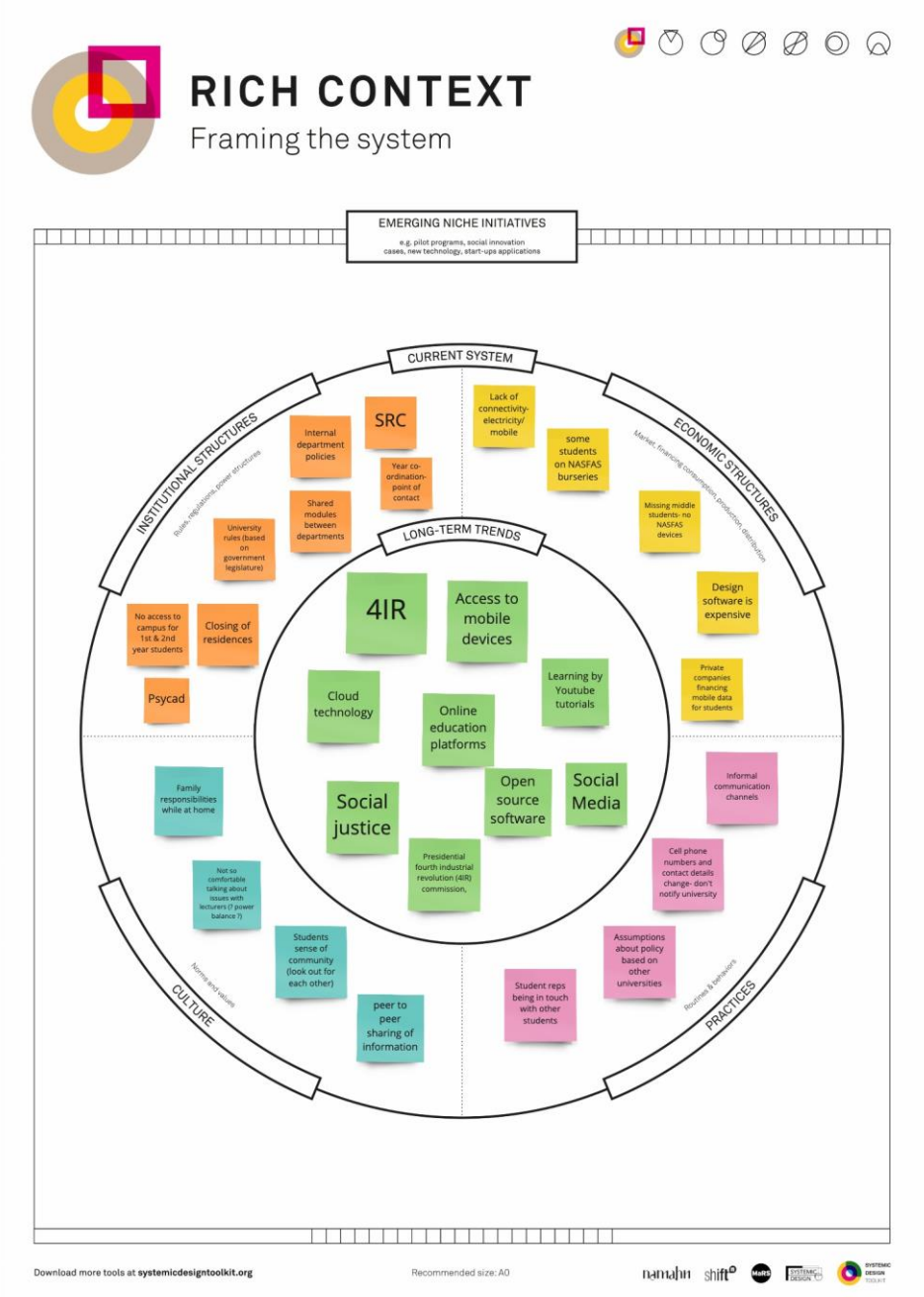

Figure 11: Reflections on design education during the COVID-19 pandemic framed using Namahn and shiftN's rich context canvas tool

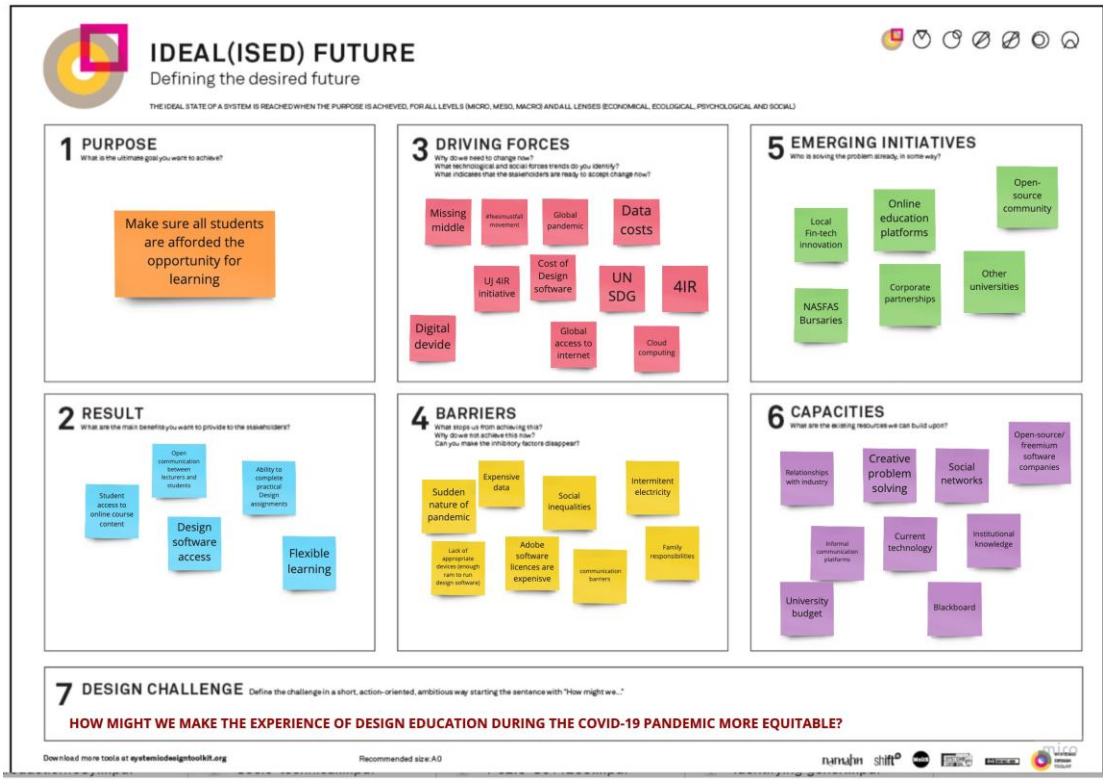

Figure 12: Defining the desired future of design education during the COVID-19 pandemic using Namahn and shiftN's ideal(ised) future canvas tool

Conclusion

At the time of writing this paper, there is still much uncertainty surrounding the COVID-19 pandemic. In South Africa, alert levels are still in flux, and departments must close immediately when an outbreak of COVID-19 cases occur. The vaccine drive had a slow start (Bateman, 2021), and the constant mutations of the virus are cause for concern both locally and internationally (Thom, 2021). Equal access to online design education will undoubtedly continue to be an issue that needs to be addressed and improved on. The outbreak of COVID-19 accelerated the integration of 4IR technologies into design education. Many useful practices were bootstrapped on the fly and should be further considered going forward. The problems that have been described confirm the necessity of taking a systems approach to advancing design education in South Africa within the context of the 4IR era. The exploration of one of the tools used in SDT has exposed how useful a systematic approach to Design can be for thinking about complex *wicked problems* such as the COVID-19 pandemic's effect on accessible education.

References

Arndt, C, Davies, R, Gabriel, S, Harris, L, Makrelov, K, Robinson, S, Levy, S, Simbanegavi, W, van Seventer, D & Anderson, L 2020, 'COVID-19 lockdowns, income distribution, and food security: An analysis for South Africa', *Global Food Security,* vol. 26, pp. 1004-10.

Bateman, C 2021, May 27, 'Slow registration delays South Africa's vital vaccine roll-out', *Mail & Guardian.*

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Bijl-Brouwer, M vd & Malcolm, B 2020, 'Systemic design principles in social innovation: A study of expert practices and design rationales', *She Ji: Journal of Design, Economics, and Innovation,* vol. 6, no. 3, pp. 386-407.

Bornman, E 2016, 'Information society and digital divide in South Africa: Results of longitudinal surveys', *Information, Communication & Society,* vol. 19, no. 2, pp. 264-278.

Bousbaci, R 2008,'Models of man' in design thinking: The 'bounded rationality' episode', *Design Issues, 24*, no. 4, pp. 38-52.

Buchanan, R 1992, 'Wicked problems in design thinking', *Design Issues,* vol. 8, no. 2, pp. 5-21.

Churchman, C 1967, 'Wicked problems', *Management Science,* vol. 14*,* no. 4, pp. 141-142.

Coetzee, A, 2020, in Myers H (ed.), *FW: Access to Adobe CC*

Crawford, J, Butler-Henderson, K, Rudolph, J, Malkawi, B, Glowatz, M, Burton, R, Magni, P & Lam, S 2020, 'COVID-19: 20 countries' higher education intra-period digital pedagogy responses', *Journal of Applied Learning & Teaching,* vol. 3*,* no. 1, pp. 1-20.

Denning, P 2013, 'Design thinking', *Communications of the ACM,* vol. 56, pp. 29-31.

Du Preez, J & Sinha, S 2020, 'Higher education leadership in the era of the fourth industrial revolution', *The Thinker,* vol. 83, no. 12.

Geels, F W 2005, 'Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective', *Technological Forecasting and Social Change,* vol. 72, no. 6, pp. 681-696.

Gustafsson, M & Deliwe, CN 2020, 'How is the COVID-19 pandemic affecting educational quality in South Africa? Evidence to date and future risks', *Insights Briefs.*

Holman, M, Walker, G, Lansdown, T & Hulme, A, 2020, 'Radical systems thinking and the future role of computational modelling in ergonomics: An exploration of agent-based modelling', *Ergonomics,* vol. 63, no. 8, pp. 1057-1074.

Jones, C 2003, 'Theory after the postmodern condition', *Organization*, vol. 10, no. 3, pp. 503-525.

Jones, P 2014, *Design methods for systemic design research*.

Jones, P 2014, 'Systemic design principles for complex social systems', in *Social systems and design*, pp. 91-128 Springer.

Jones, P 2019, *Systemic design toolkit – A brief workshop*

Jones, P & Sevaldson, B *Worlds within worlds*: *Fostering a thriving network in a flourishing field, plenary talks,* Relating Systems Thinking and Design (RSD8).

Lacy, P, Long, J & Spindler, W 2020, 'Disruptive technologies', in *The circular economy handbook*, pp. 43-71, Springer.

Makina, D 2019, 'The potential of FinTech in enabling financial inclusion', *Extending Financial inclusion in Africa*, pp. 299-318, Elsevier.

Motala, S & Menon, K 2020, 'In search of the 'new normal': Reflections on teaching and learning during COVID-19 in a South African university', *Southern African Review of Education,* vol. 26*,* no. 1, pp. 80-99.

Philbeck, T & Davis, N 2018, 'The fourth industrial revolution', *Journal of International Affairs,* vol. 72*,* no. 1, pp. 17-22.

Phokeer, A, Densmore, M, Johnson, D & Feamster, N 2016, 'A first look at mobile internet use in township communities in South Africa'*,* paper presented at the *Proceedings of the 7th Annual Symposium on Computing for Development*, pp. 1-10.

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Reis, N 2020, in Myers H (ed.), *Hi hadassah, new info on free InVision upgrades for your students*

Rittel, HW & Webber, MM 1973, 'Dilemmas in a general theory of planning', *Policy Sciences,* vol. 4, no. 2, pp. 155-169.

Ryan, A 2014, 'A framework for systemic design', *FORMakademisk-Forskningstidsskrift for Design Og Designdidaktikk,* vol. 7, no. 4.

Skaburskis, A 2008, 'The origin of 'wicked problems', *Planning Theory & Practice,* vol. *9*, no. 2, pp. 277-280.

South African Government 2020, 'About alert system'

South African Government 2020, 'About coronavirus COVID-19'

Thom, L 2021, Jan 14, 'COVID-19 mutations spark global concerns', *ABC News.*

Tonkinwise, C 2011, 'A taste for practices: Unrepressing style in design thinking', *Design Studies,* vol. 32, no. 6, pp. 533-545.

Tschimmel, K 2012, 'Design thinking as an effective toolkit for innovation', paper presented at the *ISPIM Conference Proceedings*, p. 1.

Udacity. 'Downloading program content', viewed 4 July 2021, https://udacity.zendesk.com/hc/en-us/articles/360016790251-Downloading-program-content

Van Ael, K & Vandenbroeck, P n.d., 'Towards a systemic design toolkit', *RSD5 Symposium*, OCAD University.

Vandenbroeck, P, Van Ael, K, Thoelen, A & Bertels, P 2016, *Codifying systemic design: A toolki*t.

Williams, B & Hummelbrunner, R 2020, 'Soft systems methodology', in *Systems concepts in action*, pp. 241-261, Stanford University Press.

Yermack, D 2018, *FinTech in sub-saharan Africa: What has worked well, and what hasn't* National Bureau of Economic Research.

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