




Modes and Methods of Making

Pushing Design Creativity by Using a MakersLab as a Form of an Incubator to Foster Future 4IR Developments

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Introduction

The MakersLab (standing for maker's laboratory) bridges the various socio-economic and gender development gaps by playing with experimental methods grounded in the Afrikan¹ continent. This fosters better access to all students, decolonising the design world through critical thinking and making in using meaningful collaborative engagement. The MakersLab is situated in the Greenside Design Center (GDC), a private higher education institution which was established initially as an Interior Design College in 1987. The GDC has since grown to include graphic design and multimedia degree courses and is located in Greenside, a suburb in Johannesburg, South Africa, which has grown with businesses and restaurants over the years. The Makerslab was designed in 2021 in order to bridge the 4IR knowledge gap within the school. The school's approach bridges gaps in a multi-disciplinary learning pedagogy concerned with human-centred design. For the past

1 I make use of the letter 'K' within Afrika as part of the ongoing academic discourse on the subject and misspelling of the word from colonial times that used the Germanic 'C' instead of the vernacular 'K'. Matebeni and Pereira (2014:7) emphasise, "the need to *reclaim* our existence and being in this continent."

30 years, the GDC has prided itself on being at the forefront of design creativity, pushing theoretical, technical, and creative boundaries. One of the core values in the pedagogical approach is teaching students how to empathise and understand user needs. This approach embraces a human-centred methodology which means “believing that all problems, even the seemingly intractable ones like poverty, gender [in]equality, and clean water, are solvable” (IDEO 2015:9). This research attempts to contribute to the body of shared knowledge and practices in the fields of Design Thinking, Interior Design and the emerging Fourth Industrial Revolution (4IR) in higher education. This paper aims to discuss the MakersLab as a metaphorical space for incubation whilst fostering change within curricula across the GDC. Here, academic staff develop the intersections between design thinking and making in a dynamic non-linear approach in order to produce new modes of critical thinking and awareness that respond to cultural and social identities in post-Apartheid South Africa. As Jordan and Lande mention, “The act of making is to make real ideas, but often with the aid of rapid prototyping tools or other technology. It matters less what the creation actually is but more so the act of creating and building an artifact” (2016:1439). The act of making and doing is beneficial to engage directly with public and private partnerships to promote collaborative and inter-school learning, allowing learning to occur outside the borders of the school.

The objectives for the MakersLab are to re-centre and foster change within the existing curriculum whilst disrupting traditional learning, to further develop design thinking in parallel to 4IR processes and to interrogate what it means to be a visionary site for learning and innovation. Here these processes include but are not limited to digital fabrication, digital literacy, and artificial intelligence (AI). Schwab mentions that 4IR “is not only about smart and connected machines and systems. Its scope is much wider. It is the fusion of these technologies and their interaction across the physical, digital, and biological domains that make the Fourth Industrial Revolution fundamentally different from

previous revolutions” (2016:19). The importance of making the necessary shifts and changes comes with revising the syllabus in relation to the school’s curriculum to produce more research from within the MakersLab. This is to cultivate new ways of thinking (paradigm shifts), skills, and developing a material culture to create a holistic design production with the aid of design thinking from within the school and across courses. It goes without saying that developing the necessary skills is of importance for the trajectory of the school. Marwala (2019) further points out that in order for 4IR to be successful in its application and functioning, it “requires an understanding of interdisciplinarity, an ability to work across silos through ecosystemic thinking, and an ability to embrace risk.” The school is no stranger to risk-taking and has taken this by funding its own MakersLab. Here this space facilitates placing innovation and making at the forefront as a prime objective, together with determining where gaps in institutional thinking and research are (Xing & Marwala 2018:14) dialectical and exciting opportunity which can potentially transform society for the better. The fourth industrial revolution is powered by artificial intelligence and it will transform the workplace from tasks based characteristics to the human centred characteristics. Because of the convergence of man and machine, it will reduce the subject distance between humanities and social science as well as science and technology. This will necessarily require much more interdisciplinary teaching, research and innovation. This paper explores the impact of HE 4.0 on the mission of a university which is teaching, research and includes innovation.

Methodology

This paper uses a qualitative research approach, where a “form of inquiry supports a way of looking at research that honours an inductive style, a focus on individual meaning, and the importance of reporting the complexity of a situation” (Creswell & Creswell 2018:41). This research employs a semi-structured questionnaire (see Appendix A) which collects data using an online capturing form and was sent out to nine staff

and 29 second- and third-year interior design (ID) students. Here the responses were captured and the data analysed in order for it to be coded and themed. “The researcher keep[s] a focus on learning the meaning that the participants hold about the problem or issue, not the meaning that the researchers bring to the research or that writers express in the literature” (Creswell & Creswell 2018:258). To analyse the data, it is collected using a combination of narrative and phenomenological design approaches. Here narrative research studies the lives of the participants and intersects this data with a phenomenological research inquiry which captures the essence of their lived experiences (Creswell: 50). This questionnaire sought to understand current demographics amongst staff and students and to understand how the MakersLab is cultivating engagement and usage within the space. This data is important to ensure that the school’s visionary focus democratizes learning and interrogates the underrepresentation of existing gender and social gaps in the country. The school, in this regard, is a private higher education environment where the author teaches across multiple years and courses.

In keeping with Creswell and Creswell’s transformative paradigm, the respondents to my survey included students and staff who were gender, racial and ethnic minorities; indigenous and postcolonial peoples; and members of the lesbian, gay, bisexual, transsexual, and queer communities (2018:46-47). The GDC is an educational institution that accommodates a diverse group of social identities that align with this transformative paradigm methodology. Being a genderqueer person, an academic, and a designer focused on spatial thinking practices has contributed to my capacity for engaging in a transformative paradigm methodology. I can understand and participate in the lived experience of individuals who come from marginalized and minority backgrounds with identities at the intersection of race, gender, and social backgrounds. I am attuned as to how to navigate spatial boundaries with a sensitivity to identity. It is through my personal, embodied, non-binary,

ontological, and epistemological approach that “I”, the researcher, engage and participate with a level of self-reflexive observation. This self-reflexivity is essential to encourage advocacy in the MakersLab environment, which is an incubator for change and promotes participation.

Transformations and Revolutions

Design thinking is used as a pedagogical methodology within the school. It uses an iterative and non-linear process for problem-solving, meaning that “there is no single, right, absolute answer; there are multiple solutions, some perhaps more optimal than others” (Pressman 2019:7). This process has been used by many creatives in literature, science, and art. Within the school, design thinking has been modelled within four key stages, which seek to investigate, interpret, ideate, and iterate. The design thinking process “begins with an immersion in the unique circumstances of the problem” (Pressman 2019:13), where students empathise with the problem at hand. The design thinking process, as seen in Figure 2.1, is non-linear and allows ideas to circumnavigate through the various stages, to advance thinking, problem-solving and perhaps returning to an initial concept before advancing with gathered insights and information to advance the design. It is through this process that innovation is conceptualised.

The school’s own transformation and revolution have created other creative spaces and introduced new programmes and courses which promote critical thinking and engagement across all courses. The introduction of game design and virtual reality pushes these design boundaries as they respond to the modes of digital fabrication and the built environment. Academic and author Brené Brown mentions, “unlike evolutionary change, which is incremental, revolutionary change fundamentally transforms our thoughts and beliefs” (2015:41). Whilst the alignment of the courses with the 4IR movement is relatively new to the school, it is pushing these boundaries in this research in order to connect and collaborate in creative industries. The term revolution is often associated with politics, however, within the purpose of this research,

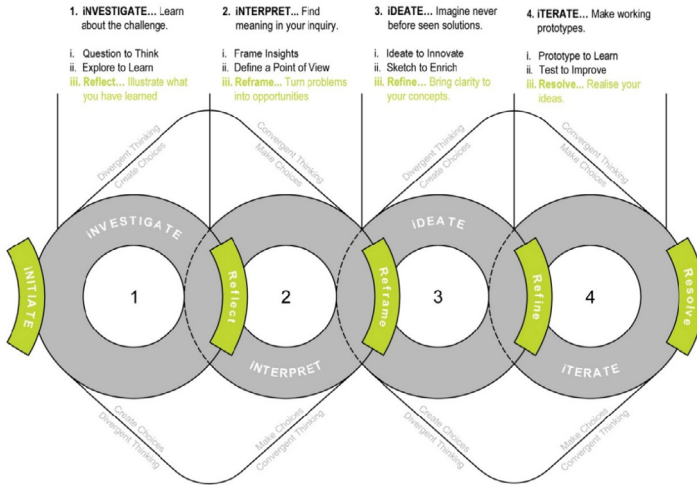


Figure 2.1: Design thinking process (Templer n.d.).

a revolution is more reflective, such as the celestial term suggests, “the act of moving in a circular course” (Harper n.d.). The GDC’s revolution aligns itself particularly to the same design thinking process shown in Figure 2.1 and that of iteration. It is a process of moving, thinking, making, and reflecting on the problem before advancing the conceptual idea. A revolution in the school requires staff to be reflective and to understand what challenges exist and how the necessary changes can be made to align itself to that of the act of making, something that is productive and results in “innovation and competition” (Xing & Marwala 2018:12) dialectical and exciting opportunity which can potentially transform society for the better. The fourth industrial revolution is powered by artificial intelligence and it will transform the workplace from tasks based characteristics to the human centred characteristics. Because of the convergence of man and machine, it will reduce the subject distance between humanities and social science as well as science and technology. This will necessarily require much more interdisciplinary teaching, research and innovation. This paper explores the impact of HE 4.0

on the mission of a university which is teaching, research and includes innovation which echoes that of the 4IR. The MakersLab fosters this innovation using the metaphor of an incubator space that promotes much-needed design visibility and creativity.

The MakersLab

The MakersLab is a compact, 61m² space that aims to act as an incubator to foster an interdisciplinary design environment. Here innovation, creativity, and exploration are beginning to be stimulated to promote learning and collaboration by the act of making, using design thinking as a driver. The act of making powerfully intersects with design thinking, “making encompasses tinkering with technology” (Jordan & Lande 2016:1438), where design emerges “wholly out of [students’] imaginations” (Jordan & Lande 2016:1439). The MakersLab revolution in the country has been steadily growing since the inception of House 4 Hack in 2011. This drive has fostered other maker spaces to be conceptualised together with educational institutions across South Africa and funding from internal resources or from government (Armstrong & De Beer 2021; Armstrong et al. 2018). These maker spaces grew in popularity up until 2016 and plateaued until 2019, with the advancement in the 4IR discourses. Here the MakersLab at the GDC is aligning itself to the maker space movement however, setting the trend for this type of space in private institutions.

It must be acknowledged that there continues to be work ahead for the MakersLab in order to fully arrive and gain knowledge for the successful operation of this space and how it collaborates and engages as an incubation site for learning and innovation. The MakersLab has the potential to bridge gaps and logical overlaps with other resources, such as working together with the library and printing facilities. This scalar approach, linking with existing resources internally whilst also looking outward to facilitate community collaboration, will be beneficial and perhaps accelerate the learning production (Armstrong & De Beer 2021). Using the metaphor of an incubator, similar to that of business incubators, this

must be seen as a tool to aid and develop critical and creative thinking as a resource for developing problem-solving in areas of design education. This process therefore fosters growth and opportunities for interdisciplinary exchanges to disrupt current practices. This process promotes the democratisation of learning which is critical in creating change and rethinking how knowledge is traditionally taught.

Through the aid of rapid prototyping models in projects, the iterative process of design thinking allows for artefacts to be created and seen as part of the design process. A second-year interior design (ID2) student mentions the successes of the MakersLab that additional “learning [occurs] from what you design. The MakersLab shows exactly what you designed and not just the idea of something ... this helps to fix future mistakes and teaches us what our limits are.” This process is valuable for students to acknowledge the shortcomings and failures in their designs. This is important as this is where the real learning happens, which is the stepping stone for innovation. The MakersLab has two 3D printers, a laser cutting machine, an electrical drill, a router, and band saws. Here students are exposed to various machines and technologies ranging from: 3D software, physical making, Virtual Reality and photography. This exposure to multiple machines facilitates and democratises learning. Understanding that digital fabrication technologies “generally fit into four main categories: cutting, subtraction, addition, and formation” (Dunn 2012:88) allows students to think spatially and interpret their designs in a thoughtful and provocative manner. These technologies are to upskill students and provide them with the digital literacy required to operate and produce designs and “therefore provide dynamic, critical and analytical modes of inquiry” (Dunn 2012:120). As Iwamoto mentions, “digital fabrication, in particular, has spurred a design revolution” (2009:4) which the lab already sees with the production of various 3D printed designs by ID2 students, as seen below in Figure 2.2.

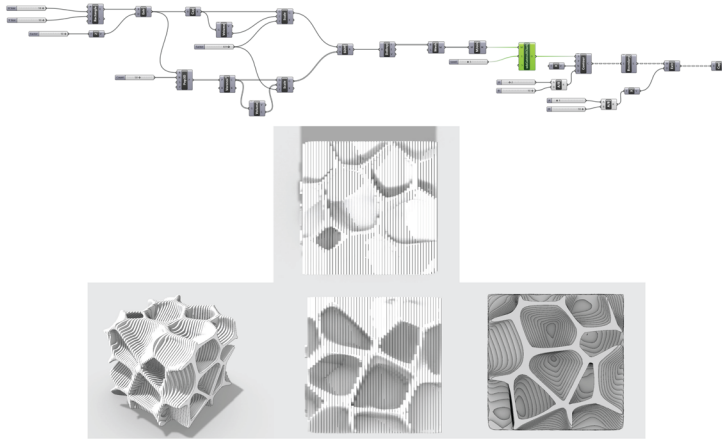


Figure 2.2: 3D-modelled design using Rhino and Grasshopper software programmes by ID2 participant.

Dunn mentions that the “translation of computer-generated data to physical artefact is not a one-way street; processes may be reversed with equipment such as a three-dimensional scanner, or digitiser, which is used to trace contours of physical objects directly into the computer” (2012:6). This speaks clearly to the iterative processes of design thinking and the methodological importance in having digital literacy to facilitate this. It is valuable to note that the ID2 student’s work in Fig 2 taught himself the software to create his design. This learning occurred outside the boundaries of the classroom, however this process facilitated additional learning to other students within the class, incubating and accelerating peer-to-peer teaching and learning. These methods are critical to allow for a holistic approach to digital fabrication, which grows from within the incubator or MakersLab.

The importance of the MakersLab is to ensure that a positive and nurturing learning environment is established, to foster a bottom-up approach to learning about technology, and pushing the boundaries of 4IR is seen as learning together within the school. This is seen with the 2ID student mentioned above. Students are exposed to the complete cycle of design

thinking and push the boundaries with their work with staff. The importance of reflective and iterative or revolutionary processes, as I have mentioned previously, allows for better engagement between staff and students, where “the aim is to involve students in the production of knowledge and research, and discourage passive accumulation of knowledge” (Balkanska 2021:401). This learning format echoes the notion of the MakersLab acting as an incubator, where learning and the production of ideas are developed in parallel or hand-in-hand between staff and students and are “seen as beneficial” (Balkanska 2021:402). This is important because digital fabrication technology and software are as new to staff as to students. This acknowledgement of learning also feeds more broadly into the design thinking ethos of the school, where digital literacy orbits together between student and staff, maximising skills transfer and producing critical thinkers. Here the MakersLab incubator ideology asserts and connects machines, makers and the production of inventors in its process. Students are actively involved within the function and operation of machines in the MakersLab, which bridges and disrupts traditional instructive methods of learning, where students are seen as “active participants” (Marie 2018:30).

The research acknowledges “the underrepresentation of women in design” (Mosley & Bediako 2021:117) and the gender gap within the country as well as on the Afrikan continent. It is essential to note the varying identities which make use of the lab, as seen in Figures 2.3 & 2.4. The MakersLab must be seen as a safe and accommodating space for all to use, irrespective of one’s background. This data is valuable because there is little or no information which shows the accommodation of different groups or communities, such as the LGBTQIA+ community. To acknowledge the minority communities, the school must ensure they are not left behind with the advancement of the 4IR, which must be equitable for all in contributing to reducing social and cultural inequalities within a post-Apartheid South Africa. The space must be democratic and allow for healthy knowledge production and exchanges, echoing Secretary-General of the United Nations, António

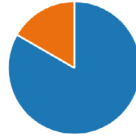
Guterres's statement, "we must deliver on our commitments to support the world's vulnerable people, communities, and nations" (Jensen 2022:2).

The data in Figures 2.3 & 2.4 is particularly valuable and positions the GDC at the forefront of redressing gender inequality and prioritising the development of women in design, with female students outnumbering their male counterparts on the ID courses. Access to the MakersLab is granted to all within the school, however, appointments must be made before accessing the space. The 3D printers and the filament used to print designs are free of charge for their prototypes relating to project briefs. The laser cutting machine is also free of charge to laser cut on, where materials (either cardboard or timbers) are nominally charged for at cost price. This access ensures that students from all backgrounds can make use of the MakersLab without any economic burdens and promotes the use of the machines. Some participants were apprehensive at first because of their unfamiliarity with the digital fabrication process: "I was nervous to use any of the machines because I thought something might break or something bad would happen to [me]" (ID2 participant). However, the introduction of mini-briefs into the syllabus and the implementation of training has changed and facilitated more diverse engagement with the MakersLab (see Figures 2.5 & 2.6). As Andani mentions, "by its very nature, 4IR involves the convergence and intersection of technologies, and it thus requires the ability to bring together capacities, skills, and fields that are not historically connected, and the ability to facilitate failure and innovation" (UJAC-Andani 2021:20).

The school's 10Percent initiative offers staff and students the opportunity to explore the potential of sustainable "designerly" engagements with community needs in a domain that rarely benefits from the work of professional designers. The 10Percent initiative sees ten per cent of the GDC's annual notional teaching and learning time devoted to community-based design intervention projects. This translates into the college "donating" four weeks of formal curricula to community development projects. During this time, class

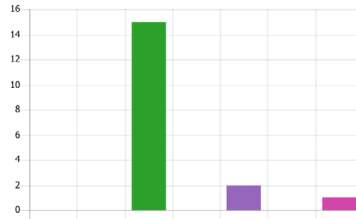
2. What is your gender?

Woman	15
Man	3
Non-binary	0
Prefer not to say	0
Other	0



3. What is your sexual orientation?

Lesbian	0
Homosexual	0
Heterosexual	15
Trans	0
Bi-sexual	2
Queer	0
Other	1



4. Race

Black	9
Coloured	0
Asian	2
White	6
Other	1



structures are disbanded and replaced by inter-level and interdisciplinary design teams representing a mix of expertise, experience, cultural and linguistic backgrounds. The 10Percent initiative speaks to the imperative of South African higher education institutions to include community engagement as a core responsibility (10 Percent n.d.). The global COVID-19 pandemic has reinforced the value of the 10Percent projects over the past two years that have aligned and focussed their attention on the United Nations Sustainable Development Goals (SDGs). In consideration of SDG number 4: Quality Education, it was reported that COVID-19 had deepened a global learning crisis (Jensen, 2022:34). This was seen as a

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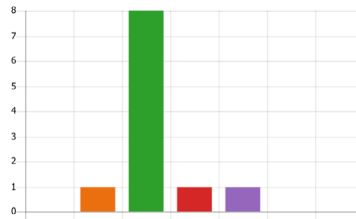
2. What is your gender?

Woman	8
Man	3
Non-binary	0
Prefer not to say	0
Other	0



3. What is your sexual orientation?

Lesbian	0
Homosexual	1
Heterosexual	8
Trans	1
Bi-sexual	1
Queer	0
Other	0



4. Race

Black	2
Coloured	1
Asian	0
White	8
Other	0

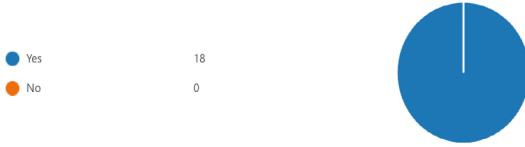


Figures 2.3 & 2.4: Data from the ID2 (left) and ID3 (right) participants.

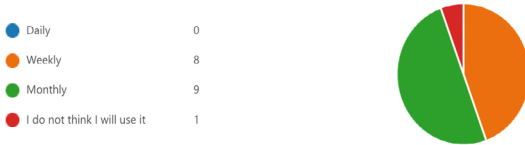
critical and important departure point for problem-solving issues within a post-Apartheid South Africa, whilst also re-centring the Afrikan continent as the point of importance. Projects responded to a vast array of problems, tackling current issues such as vaccines, gender and LGBTQIA+ rights, sustainable water solutions, online education solutions, and ethics of care. These projects have seen various intersecting design approaches tackling heartfelt concerns with communities whilst navigating online learning issues. Projects were encouraged to make use of the MakersLab and digital fabrication processes.

Futures and Beyond: Creativity and 4IR Conference 2022

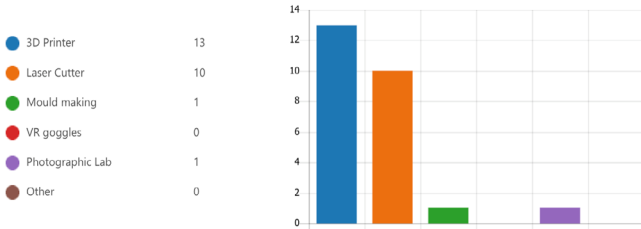
6. Have you used the makers lab?



7. How often do you use the MakersLab?



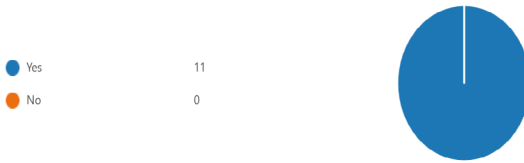
8. What equipment/materials have you used in the MakersLab / GDC? (more than one option may be selected).



Whilst the 10Percent project occurs in one term and engages all departments within the school, I argue that this methodology could be used in a broader setting throughout the year where interdisciplinary learning is fostered and encouraged amongst staff and students. One project in particular, “Missing History: Typography Drives Culture”, realised by design lecturers Juliet Kavishe, Caitlin Paige, and Carla Saunders, serves as a good example, under the premise of SDG number 4: Quality Education. A project such as this

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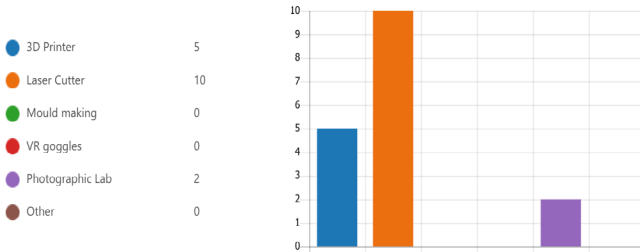
6. Have you used the makers lab?



7. How often do you use the MakersLab?

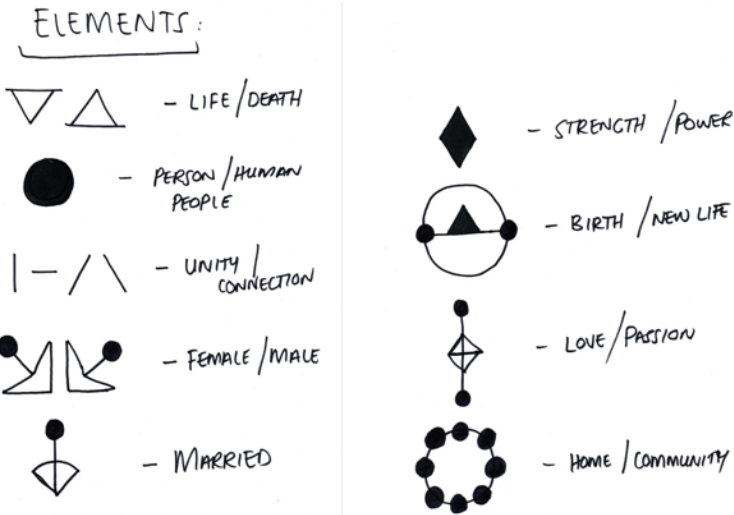


8. What equipment/materials have you used in the MakersLab / GDC? (more than one option may be selected).



Figures 2.5 & 2.6: Data from the ID2 (left) and ID3 (right) participants.

forms a great armature for the school that bridges spatial and “designerly” modes with other courses that further promote interdisciplinary practices. Projects such as “Missing History: Typography Drives Culture” ground both student and staff with real-life issues that further strengthen awareness that align with the SDGs. This project uses language as a tool for knowledge transfer whilst focusing on the writing systems that are being erased on the Afrikan continent. The project sought to create and develop a writing system for several languages in



Southern Afrika: *IsiXhosa, Ndebele, Siswati, Tshivenda, Xitsonga, IsiZulu, and Ubunye*, whilst paying homage to their individual, cultural, and traditional knowledge systems. This inquiry was reminiscent of Afrikan traditional values in history, “looking to the past, to inform the present to hopefully develop a better future” (Kavishe, 2022). The project investigated how written scripts might have been done in the past, whilst considering ideas and concepts on representation, architecture, ritual, beliefs, identity, and culture and how these can be used to inform a new writing system which is symbolic to each language. This project is about the discovery and innovation seeking to uncover the loss of cultural identity in our spoken languages, not only in South Africa but on the continent as a whole. Students were careful not to misrepresent the cultures. They used various modes of making, from drawing and painting, as seen in Figures 2.7 & 2.8, that were translated into the digital fabrication processes to create a type font which



Figures 2.7 & 2.8: Hand sketches (left) and painting glyphs (right) from the 10Percent participants.

was laser cut (Figure 2.9) and could be used as a letter set for printing and reproduction on the school's printing press.

This design thinking process pushed creative and critical thinking, where these conceptual writing systems went through various forms of user testing to showcase an understanding of how these writing systems were constructed. The writing systems are spatialised in the production process, from paper to a physically built artefact, reinforcing the means and ways we engage in understanding the importance of indigenous knowledge systems which have been slowly erased with the implementation of colonial Latin written script. The final individual symbols, as seen in Figure 2.9, were constructed into a sentence read directionally from right to left, "Together we create memories in an environment honouring our state of being."



Figures 2.9 & 2.10: Laser-cut type set of the final design.

Challenges

Whilst the school was pushed online during the COVID-19 pandemic, together with the rest of the world, there is still a need for a tangible material object to see, touch, and experience, as staff participant 1 mentions: “showcasing materials through a camera, especially paper, is not easy. The lighting needs to be perfect, and the resolution needs to be high in order for the students to see what we are discussing.” The pandemic has exposed staff and students to various technical issues, pushing design thinking far beyond imagination. Courses at the GDC rely heavily on the act of making to show the prototyping of ideas through models. However, this did not happen as smoothly in online circumstances. When the school went online, in the beginning students were apprehensive to make models, where making traditionally happened in studio environments under the supervision of academic staff. Staff participant 2 says, “while online environments offer massive potential in its connectedness, I feel we just don’t have the technology yet, required to converse or produce in the way that we are physically used to,” which halts the design thinking process of students and their ability to take ownership of their work. Navigating the insecurities and anxieties of new online spaces limited students’ capabilities and hampered innovation as students worked in digital silos.

The introduction of the MakersLab and its revolution has created a transformation where staff and students are beginning to push technological boundaries. With initiating the use of any new facilities, there will always be unforeseen challenges. However, this has not stopped the act of making or digital fabrication from occurring. Some of the immediate challenges are outlined below:

1. Students do not know what 4IR means.
2. 4IR is not yet fully integrated into the curriculum.
3. The use of the machines is “seasonal”.
4. Dedicated MakersLab technicians are required to facilitate the stream of students needing to make use of the space and machines.

5. There must be access to the MakersLab during all hours of the day.
6. Digital literacy amongst students varies and therefore limits learning outcomes.
7. Online learning environments were rapidly introduced during and post the pandemic.
8. Projects happen in silos mainly because the MakersLab is new.

There are immediate solutions to the challenges above, which are currently being implemented. When referring to point three, where machines are seasonal, this is due to the occurrence of nationwide load shedding. Here, the use of machines – particularly 3D printers – becomes difficult. The 3D printing depends on the model's size and can take anything from one hour to 24 hours to print. The various stages of load shedding dampen the students' designs as models must be shrunk to a smaller size to be printed within the hours where there is no load shedding, as it is difficult to resume printing on the 3D printing machines once the power has gone off. Seasonal refers to the fact that there is more load shedding during the colder months (May-August) as the power demand is greater, as the nation tries to stay warm with electrical heaters. This is an easy fix by installing UPS (uninterrupted power supply) units. However, these are costly, depending on the size of the battery. Concerning points four and five above: as the MakersLab is new, there is no employed full-time laboratory technician, and access is limited and booked through staff members. This creates strain on existing staff members whilst staff perform other academic duties and does not foster mentorship or an open access policy which an incubator is envisioned as. Point six on digital literacy prompts that the necessary training and software can already be introduced from the first-year level of study, although as staff participant 3 mentions, "students and lecturers are always learning". This may have been one of the risks the school has had to undertake, a positive one as it has pushed the innovation and ingenuity of both students and staff.

Conclusion

This paper's aim saw the use of the MakersLab as a space for incubation and fostering change within curricula and to develop intersections between design thinking and making. The MakersLab spatial metaphor of the incubator has allowed for its own revolution to occur where the production of ideas and processes related to curricula needs and functioning of the lab, has stimulated positive and healthy collaboration between staff and students. The MakersLab signifies a noteworthy shift in how we approach design and digital fabrication internally and externally. These approaches are non-linear and require a revolution or iterative process to produce innovative ideas and a material culture embedded with our current society. Dr Zoe Laughlin mentions that "material and process are inextricably linked... Making, in all its gloriously broad variants, is ultimately the relationship between materials and processes" (cited in Burry et al. 2020:4). The act of making, and the accidents and failures that occur, are equally crucial to understanding new ways of thinking and engaging with a design that begins to echo interdisciplinary connections. This can be seen in the success of the "Missing History: Typography Drives Culture" project. The development and growth of the 10Percent project can further build future sustainable communities, where centring the lab in the school as an incubation space grows, develops, and furthers research aligning to the 4IR discourse and how it begins to engage and connect with creative industries. Here, speculative designs can be pushed with the backdrop of sustainable, innovative modes of making that promote further risk-taking and connect to global research.

Immediate challenges are relatively easy to resolve, but do require attention and care by staff at the school. The importance of establishing digital literacy right from the first year to provide the necessary skills and training to students will enable a smoother design thinking approach to digital fabrication in the long run. Facilitating and establishing relationships with public and private sectors outside the school is "to ensure their research programs are aligned to real-world

needs” (Marwala 2019). Maintaining a healthy engagement between staff and student learning, where students are more involved in research and development, is key to the upskilling of both staff and students, an important concern in a world where “career paths are changing fundamentally” (2019).

In the World Economic Forum’s report on the “Future of Jobs”, it placed among the top 10 skills analytical thinking and innovation, complex problem-solving, critical thinking, creativity, technology use, and design and programming (*The Future of Jobs Report 2020:25*). These skills are necessary for the 4IR digital transformation and are critical to teaching and upskilling students already at a higher education level to better equip them with a skill set that will allow them to be a diverse and creative addition to the workforce. The MakersLab is at the forefront of this skills transformation. The school’s own design thinking and iterative process must allow a self-critical and reflective approach to interrogating traditional modes of practice to update syllabi and curricula. The MakersLab is well on its way to fostering future possibilities, and as staff participant 4 says, “I think 4IR and the technology that surrounds it is going to force us [designers] to re-evaluate the practice of design... 4IR technology will let all designers do what we do best – which is to design uninhibitedly – to think and to make...”

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Appendix A: Staff Questionnaire

The survey will take approximately 6 minutes to complete. By participating in this research, you consent to having the data used for the purpose of research. Participation is anonymous.

1. What is your gender?
 - a. Woman
 - b. Man
 - c. Non-binary
 - d. Prefer not to say
 - e. Other
2. What is your sexual orientation?
 - a. Lesbian
 - b. Homosexual
 - c. Heterosexual
 - d. Trans
 - e. Bi-sexual
 - f. Queer
 - g. Other
3. Race.
 - a. Black
 - b. Coloured
 - c. Asian
 - d. White
4. What was your experience teaching online during the pandemic?
5. How has teaching online aided courses?
6. What are the limitations of online learning in terms of making?
7. What does 4IR mean to you?
8. Have you used the MakersLab?
 - a. Yes
 - b. No
9. Have you promoted the use of the MakersLab? Please elaborate.
10. What equipment/materials have you used in the MakersLab/GDC? (More than one option may be selected)
 - a. 3D printer
 - b. Laser cutter

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- c. Mould making
 - d. VR goggles
 - e. Photographic lab
11. What is your favourite mode of technology/method of making to use and why?
 12. Which has been the most beneficial and why?
 13. Have you been hesitant in using the MakersLab? If so, why?
 14. What are the immediate challenges in using the MakersLab?
 15. What have been the successes? Please elaborate.
 16. Do you think using the MakersLab aids student design thinking skills and why?
 17. How are you integrating 4IR within the curriculum?
 18. What does 4IR mean to you and the approach in which you teach?
 19. How is 4IR bridging social and economic gaps within education? Please elaborate.
 20. Do you think learning 4IR technology will better equip students in finding a job in industry when they graduate? Why?
 21. Is there any other information which you would like to include?
 22. Can the researcher make use of photographs taken of yourself during 10Percent project for the purpose of their research only?
 - a. Yes
 - b. No

Appendix B: Second- and third-year interior design student questionnaire

The survey will take approximately 6 minutes to complete. By participating in this research, you consent to having the data used for the purpose of research. Participation is anonymous.

1. What is your gender?
 - a. Woman
 - b. Man
 - c. Non-binary
 - d. Prefer not to say
 - e. Other
2. What is your sexual orientation?
 - a. Lesbian
 - b. Homosexual
 - c. Heterosexual
 - d. Trans
 - e. Bi-sexual
 - f. Queer
 - g. Other
3. Race.
 - a. Black
 - b. Coloured
 - c. Asian
 - d. White
4. What was your experience learning online during the pandemic?
5. Have you used the MakersLab?
 - a. Yes
 - b. No
6. How often do you use the MakersLab?
 - a. Daily
 - b. Weekly
 - c. Monthly
 - d. I do not think I will use it
7. What equipment/materials have you used in the MakersLab/GDC? (more than one option may be selected)
 - a. 3D printer
 - b. Laser cutter

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- c. Mould making
 - d. VR goggles
 - e. Photographic lab
8. What is your favourite mode of technology/method of making to use and why?
 9. Which has been the most beneficial and why?
 10. Have you been hesitant in using the MakersLab? If so, why?
 11. What are the immediate challenges in using the MakersLab?
 12. What have been the successes? Please elaborate.
 13. Do you think using the MakersLab aids your design thinking skills and why?
 14. Do you think learning 4IR technology will better equip you in finding a job in industry when you graduate? Please elaborate.
 15. Can the researcher make use of photographs taken of yourself during training/work within the MakersLab for the purpose of their research only?
 - a. Yes
 - b. No