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DESIGN EDUCATION | AFRIKA | 4TH INDUSTRIAL REVOLUTION

Developing an educational strategy for emerging technology in design: A case study of the FabLab at FADA, UJ

Denver Hendricks, *University of Johannesburg*

Abstract

Emerging technology is developing at an exponential rate and has a direct impact on design education. This boom in innovation has been dubbed the fourth industrial revolution (4IR). This economic initiative was framed at the 2015 World Economic Forum by Klaus Schwab and has been echoed since 2016 by South African politicians as a government and education policy transformation catalyst to South Africa's struggling economy. Academic scholars are critical about these objectives against the face of high unemployment, poor education and developing foundational skills in South Africa. Educators are confronted with very little support to address this technological development, often leaving design educators with scepticism. Emerging technology can often fall in the realm of being 'hype' and having 'unrealistic expectations' that limit teaching and learning methods facilitated in studios and lecture halls.

Fabrication laboratories are emerging globally as growing sites of innovation and are hands-on creative spaces of production in art, science and engineering that offer exposure to solving real-life problems. In addition, they are being implemented in educational institutions from primary schools up to tertiary education and used to drive pedagogies of the future by teaching twenty-first century content skills and content in emerging technology. Emerging technology offers a wide range of opportunities to enhance education and prepare learners for industries of the future that form part of 4IR.

This paper argues that fabrication laboratories pose a practical and contemporary learning space in addition to the existing current design studios and lecturer halls to aid in the integration of technology into the design curriculum. The author established and currently coordinates a fabrication laboratory at the Faculty of Art Design and Architecture (FADA) at the University of Johannesburg. This paper will discuss the implementation and operations of this Fabrication Laboratory through qualitative data such as the author observations along with feedback from lecturers who are using the FabLab to understand the impact the FADA FabLab has made on design pedagogy. The frequency of use, the types of engagements from lecturers and learners, the average time the learner spent in the FabLab and the types of projects they worked on will be unpacked.

Keywords: *Curriculum, emerging Technology, FabLab, innovation*

Introduction

Fabrication Laboratories are fast becoming alternative democratic innovative educational spaces for learners from primary schools through to tertiary institutions. Fabrication Laboratories are at the centre of emerging technology (ET) in education spaces. They have several benefiting factors such as; contributions to STEM learning (Kajamaa, Kumpulainen and Olkinuora, 2020, p. 372), promoting economic growth and entrepreneurship (Stacey, 2014, p. 222; Schwab, 2016 , p. 32) and, enhancing preparation for learners in the workplace and they expose learners to real-world problems (Dousay, 2015, p. 199). Although Fabrication Laboratories are not only about the latest technology, they are also a space of experimentation and they bring together a culture of shared and self-learning through technology-driven platforms. They foster “collaborative, open and inclusive forms of innovation; decentralised manufacturing; and democratic access to digital fabrication technologies” (Hielscher, 2017, p. 52). Education technology is a term used by academics to describe the type of learning and research associated with ET in the broader knowledge society. Since the first laboratory was established by the Massachusetts Institute of Technology’s (MIT) Interdisciplinary Centre for Bits and Atoms course, fabrication laboratories have developed into grassroots facilities for ‘makers’ known as ‘Maker Labs’ (Stacey, 2014, p. 221; Hielscher, 2017, p. 51). These Laboratories are pitched for entrepreneurs to fill a gap in society to offer services for the design and production of objects, parts and elements. Hielscher (2017, p. 51) had identified 440 Fabrication Laboratories across 60 countries.

Emerging technology (ET) in education

Technology has always had a profound effect on education in general. The last three decades saw the ubiquitous use of the simple calculator, overhead projectors, and computers in schools to make teaching and communication methods easier (Amiel and Thomas C Reeves, 2008, p. 29). Information and communication technology (ICT) has been a foundational mode of education for decades as technological tools to support, enhance and optimise educational networks. Adding to this, the introduction of the internet in education has widened access to learners and has normalised many emerging technologies. Tarling and Ng’ambi (2016, p. 562) recognise “ET’s may be used to achieve deep and meaningful learning experiences “ Academic scholars agree that technology enhances education (Song, 2020, p. 687). Amiel and Reeves (2008, p. 32) draw on the understanding of technology “invention, development, and cognitive deployment of tools and other artefacts” having strong links to the philosophical approach to the education of pragmatism. Tarling and Ng’ambi (2016, p. 561) state that educational spaces will transform the ways we educate. This new landscape will be unfamiliar to how the current educators understand them, and that education is no longer limited to the educator, the books or the curriculum.

ET will help educators to re-conceptualise our modalities of knowledge. It will require a design-based approach. Educators will need to consider a sustainable change. Developing new approaches to knowledge needs to be radically shifted as educators “become that of knowledgeable guide-on- the-side who guides learners as they learn how to interact and work with knowledge” (Tarling & Ng’ambi, 2016, p. 561). Tarling and Ngambi’s (2016) research laboratory brings forth a need to develop a Teaching Change Framework (TCF) that plots out how teachers change sustainably towards implementing technology. The focus is on the scalable innovative practice of teaching with emerging technologies for wider education impact. This is a noteworthy effort to concentrate on responsible and relevant change towards transformative pedagogies. Tarling and Ng’ambi (2016, p. 562) developed a continuum that builds onto Bloomberg's Taxonomy' (Patricia, 2021) skills-based knowledge for ET which, tracks ICT engagement and learning modes (Tarling & Ng'ambi, 2016, p. 562).

The role of technology has been limited to tools and equipment. Amiel and Reeves (2008, p. 32) argue that this has contributed to the misunderstanding of the role of technology in education and that there is an important value being lost. They state that educators need to take up new practices of understanding ET to what they describe as design-based research in technology. Dousay (2015, p. 145) states that we need to recognise the epistemological benefits and that the approach requires a philosophical intertwining of technology in our teaching approaches.

Many academics have elaborated on the definition of technology. In the frame of the emerging technology debate, we must acknowledge the full spectrum of the term to appreciate its capacity and the impact that it has on design education. Therefore, technology is not an item to be used as a product, tool or piece of equipment but instead a systematic process. Song (2020, p. 687) goes on to describe that "technology is a social and cultural construct that concerns what people do with technologies, how knowledge is constructed and shared among people, and how technology use is contextualised within certain social and cultural environments". Amiel and Reeves (2008, p. 31) expands on the definition that goes beyond hardware "Technology is so much more than hardware. It is a process that involves the complex interactions of human, social, and cultural factors, as well as the technical aspects. Second, it requires new directions in research goals, moving away from traditional predictive methods to long-term collaborations based on development goals". With the current explosion of ET being domesticated, we as educators need to shift our concept of technology and rethink what we need to learn, how we need to learn to achieve new paradigms of design thinking in our curriculums. We need to draw on multiple ET's and curate new modalities of learning. Educators need to engage with a variety of new concepts, their purpose and how it applies to our practice and the curriculums we maintain.

Design education

Design education has been disparaged largely for not aligning with ET and exploiting this as a mechanism to add more value and integration to learners' knowledge-building (Venter & van der Wath, 2014, p. 1; Demirkan, 2016, p. 28). To date, it has relied heavily on the classic design thinking skills of the design fields. Design analytical, observation, design, problem-solving, drawing, communication and business skills have largely held the space for design education. For many decades the transferring of these skills have been the normal practice and remain to be core to the teaching of design thinking. Some mainstream teaching methods could fall into the realm of a repetitive and parrot-fashion manner and fall into the paradigm of transmittances (Tarling & Ng'ambi, 2016:562). Conversely, an education that focuses on twenty-first-century technological education falls into the paradigm of being a transformative education where knowledge is conceptualised and is "generative and transformative" (Tarling & Ng'ambi, 2016, p. 562).

Design education has long been ignored and educators are resistant to engage with technology as it defies what design essentially stands for. Hence the idea of technology has been related to a lens through which we see. It has often been seen as a tool and the use of equipment in our curriculums as an extension of our ability to create and make. This brings to light the fact that most design programmes focus on design thinking skills and content, but not enough weight is placed on ET content and skills. With a new emphasis on our conceptual understanding of content and skills in ET, Dousay (2015, p. 18) argues that they are tightly related, and skills need to be given equal attention as content teaching to ensure that we align with twenty-first-century learning.

ET processes can create a sense of despondency due to novelty and can be "over-hyped and insignificant" (Amiel & Reeves, 2008, p. 29). Alternatively, it could be a lack of support or a sense of overwhelming. Amiel and Reeves (2008:30) frame the relationship to technology by educators as "as a process that has implications for how educational technologists conduct research". This important observation could be the reason why some educators are reluctant to take up the technology. Venter and Van de What (2014, p. 1) state that "complexity and innovation in spatial design requires a more pronounced link… eventual technical articulation of design" in a paper which discusses the enhanced hands-on learning technological advances in digital fabrication. Venter and van der Wath (2014) are advocates for educators and learners to have a better understanding of industrial processes and materials in the industry. Venter and van der Wath (2014, p. 1) state that "academic environments share a symbiotic relationship with emerging trends that take influence from technological innovations, social conditions and political shifts'

Actively Integrating ET into design education will enhance design-thinking and aspects of design that previously had less focus. The quality of design education can be augmented by exposing learners to new ways of understanding the complex relationships in design. More technology integration can lead to "substantial changes in social organisation, learner-teacher relationship, and a myriad of other factors that cannot be investigated successfully by predictive research" and "schools can become living laborites in which researchers investigate in real-world settings" (Amiel & Reeves, 2008, p. 35).

Technology in education needs to be treated with consideration to harness the potential of technology by redefining and enhancing the "performance as learners work in partnership ... with a technology" (Tarling & Ng'ambi, 2016, p. 561). Technologies tend to date and therefore require a considerable approach to ET. Impactful events like the internet were received with partial acceptance and contained negative impacts until they became pervasive and part of our daily lives. For design educators to facilitate ET, they would need to position themselves in the centre and understand technology. This means that educators would need to take a more pragmatic approach to their research to build an ET curriculum as opposed to the conventional theoretical methodology. Amiel and Reeves (2008, p. 37) state that dominant research can often be based on "impartial, unengaged" methods.

Educators develop an understanding of contemporary practices in the industry. For example, laser-cutting of materials and large-scale 3D printing is becoming more frequently considered as a form of efficient fabrication in building construction. Architects and builders are employing two-dimensional and three-dimensional strategies on construct aspects and at times entire projects. It is important to emphasise the value and importance of the link to ET and the impact on education. "This link must be informed by technological advances in digital fabrication and should include a deeper understanding of industrial manufacturing processes and the embedded nature of materials" (Venter & van der Wath, 2014, p. 1). Closing the gap between ET and education will create a stronger connection between research and real-world problems (Amiel & Reeves, 2008, p. 29)

FADA FabLab as a case study

In 2018, the author established a fabrication laboratory known as the FabLab at the Faculty of Art, Design and Architecture (FADA) at the University of Johannesburg (UJ). In 2021, the R2m fully equipped facility was completed. The FADA FabLab is a collaborative innovative facility located in the faculty. It is a 250sqm space with a glass shopfront facing the FADA atrium. It is open to all the learners and staff of the institution with a special focus on design fabrication learners and research for educators of FADA. FADA consists of nine departments, i.e. Architecture, Arts and Culture, Communication, Fashion, Industrial, Interior, Jewellery, Multimedia and Visual Art. There are 1400 registered learners at FADA in 2021. The FabLab officially opened its doors in January 2021 and has subsequently run for one full academic year. The current staffing is made up of the development coordinator (the author), who is a lecturer in the Architecture department and the FabLab manager. Several sub-facilities make up the FabLab and are the central preparation area. This is area has three large movable tables that are dedicated to the preparation and cleaning of fabricated models, workshops and exhibitions. The FabLab also has a 3D printing station, graphic station, Virtual Reality corner, laser-cutting room, CNC milling room, a secured small workshop with motorised hand tools, a biology laboratory, storage space and an office which has a two-hundred and seventy-degree view of the facility. It is important to note that a series of educator induction was established to generate an ET culture. This began by inviting all department educators to take a guided tour of the FabLab; demonstrating the facility’s wide range of offerings and catalyse a discussion on the various applications that the design curriculum can pursue. Educators were encouraged to return to their departments to convene and to consider appropriate ET applications within their design programmes. Most of the faculty engaged and attended these sessions.

This paper focuses on the type of ET engagements in the FabLab. The observations intend to establish the nature of the learner’s engagement with the facility. The observations were interpreted and documented. It seeks to establish which learner grouping types are accessing the lab; how they are engaging with space; what their project needs are and how are they are conducting it. Quantitative data was tracked and recorded by the FabLab manager to establish engagement trends. This data is supported by an open-ended questionnaire given to lecturers who engaged with the FabLab. The lecturer feedback establishes the pedagogical value of the FabLab in terms of their learner experience. The paper interprets and reflects on these sources of data.

Findings

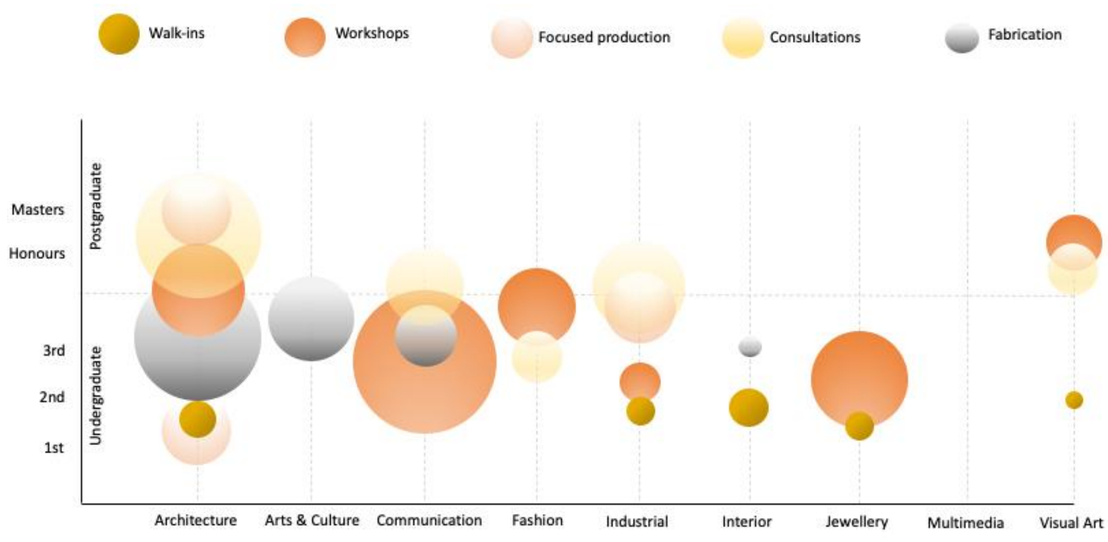

Figure 5: ET engagement with the FabLab

There are five types of ET engagements that were observed.

Firstly, walk-ins: without any prior arrangements, learners walk into the FabLab. There are on average 50 learner walk-ins observed per week with an increase of walk-ins from Tuesday to Thursday, with a constant stream throughout the academic year. These learners are registered in various departments and across all years. However, the majority of walk-ins are undergraduate learners; they make technical enquiries about machine fabrication processes, for example, how to prepare files, which machines are appropriate for certain fabrication processes or the learner purchases fabrication materials. Some learners were not made aware of the FabLab facility, they enter, and walkabout making basic enquiries about the facility.

The second ET engagement with the FabLab is facilitated by the educator with module-specific objectives and outcomes. These engagements were pre-arranged and occupied the format of structured workshops or talks to create awareness of either the facility, 4IR or conducting a specific tutorial. There were 30 formal workshops documented. The most active departments requiring workshops were the Communication, Jewellery Design and Architecture departments. The number of learners in the workshop were between 15 and 45.

The third ET engagement observed in the FabLab was focused on individual production. This group of learners were either worked in the FabLab on practical timber projects for short periods because their briefs required them to use the FabLab for their project- these were predominantly undergraduate learners from the Architecture and Industrial Design Departments, or senior learners conducting parametric modelling on laptops, or senior learners working continuously on a single project which included a combination of machine fabrication and manual work. The latter group of learners developed a stronger pedagogical relationship with the FabLab and the manager.

Consultation is the fourth type of ET engagement. This group of learners were seniors, and they work on one project and are required to invest a significant amount of time to produce the project at a high quality of standard. Their consultation is on average an hour. The FabLab manager is briefed about the project, and he responds by exploring various technical avenues which the learners can pursue. The materials, fabrication methods, modelling, and complexity is thoroughly discussed with possible follow-up consultations to assess and develop the project. There was 200 consultation conducted in 2021 with most of the demographics located in the Architecture, Industrial and Communication Departments.

The fifth and final group of learners include staff and requires little to no physical contact. This group of learners and staff are familiar with the machine fabrication process. There were 530 files received, processed, and fabricated in the FabLab. Most of those files, 355, were architecture senior learner projects, followed by Arts, and Culture, and the Communication Department. The leading machine fabrication was 3D printing. There are two machines; they were printing every day of the working week. The laser cutter and CNC router were producing projects between three to five days per week on average. The drone and the VR headset was booked out minimally for use.

Discussion

The FabLab offers multiple modes of ET engagements for a range of disciplines and year levels. Learners take advantage of that and therefore the lab is preoccupied with all five ET engagements. It forms the matrix of information that enables us to establish the ET engagement patterns.

The broader observation is that although many departments are actively engaging in ET in the FabLab in one form or another, there is a minority group of departments that have low ET engagement. This is attributed to a combination of low programmatic relevance or low educator facilitation and awareness. Learners who are exposed to ET engagements in the FabLab because their educator facilitated the engagement either through workshops or project brief requirements, tend to engage with high motivation. Walk-in learners tell us that there is not enough training and information about working with machine fabrication. In addition, learners responded positively to the workshops, and they are highly engaged. It was also established that senior learners spend more time in the FabLab to conduct intensive medium-term research. They form a stronger pedagogical relationship with the FabLab and the manager. They demonstrated a strong culture of experimentation. Although this is one of the most valuable learning methods in ET, only an insignificant number, four to five, learners are found in this group from the Architecture and Industrial Design Departments primarily in postgraduate programmes. This means that there is no consideration, or desire for, ET yet. With 200 consultations, with most learners being located in the Architecture, Industrial and Communication Design Programmes, this is a clear indicator that postgraduate learners benefit from the technical development discussion of their fabrication methods. Lastly, there is a high volume of fabrication projects received digitally from learners. Printing in 3D is the most common requirement for learners. Learners tend to be implemented laser cutting in fewer volumes and it requires an extensive amount of experimenting. It is more time-consuming.

The FabLab is a neural network of ad-hoc creative activity and most of the workflows in the FabLab require technical assistance because it poses a health and safety risk. Some of the challenges which have surfaced are human resources to expedite the skilled fabrication while consulting learners and dealing with walk-in queries. Trouble-shooting files on the computer before machine fabrication consumes a considerable amount of time. Although a schedule for organised workshops was created for the year, walk-ins and daily machine fabrication are ad-hoc and are challenging to control. The volume of incoming activity is hard to forecast and manage. It has a direct impact on the human resource of the facility.

Four of the educators were requested to provide feedback on their workshop facilitation in the FabLab. The four educators facilitated a structured workshop in the FabLab during the year. The departments were Jewellery (first year), Communication Design (first year), Fashion and Textile Technology (third year) and Architectural Design (third year). Based on a series of questions (Appendix A), the following insights were gained from the lecturers:

- Digital methods are increasing in the respective fields and the lecturers feel that the learner will benefit well and be more prepared for the industry if they are exposed to digital and alternative analogue design methods;
- The projects intend to expose learners to a variety of analogue and fabrication methods.
- Educators have complemented the access to the FabLab and find that the facility is 'extremely" valuable;
- They also complimented that the design of the space structure provides a pedagogical advantage and stimulates and inspired the learners and lecturers.
- Positive feedback was received in regards to exposing learners to new tools, new materials, understanding how materials work and supporting thinking about dimensions in 2D and 3D;
- All lecturers said enquiry based experiential learning does contribute to the way they think about the design curriculum. It makes the curriculum more experimental, opens up learners' minds and increases production quality;

- The FabLab was able to fill a gap in the teaching and learning of skills that are closely related to making; and
- The lecturers will facilitate a wider range of engagements across their departments and will strive to encourage interdisciplinary interaction across the faculty.

In general, lecturers' responses to the questionnaire can be described as exciting, engaging, and complimentary. A larger study over an extended period will examine the quantitative and qualitative multi-facetted impact of the FabLab as an experiential learning model on learners and educators and their performance, comprehension, teaching methods, assessments to produce a comprehensive and extensive understanding.

Conclusion

In this paper, I argue that ET will not be able to solve problems of education inequality, but by developing new modalities of teaching and research in ET we will be able to solve some of the practical and tangible problems which face our country. Although institutions are competing globally for ratings and apply pressure to increase research quality, especially in 4IR, this should not be the reason for design educators to become despondent towards ET. There is real value in transformative pedagogies that can enhance learners understanding of ET content and skills. It will bring education closer to the industry and foster better relationships with spatial design complexity and technical knowledge. To embrace ET will require leadership and an attitude willing to discover new methods, tools, and approaches to design innovation in curriculums.

Accreditation bodies that endorse core design skills, knowledge, and competencies would have to reconsider qualification outputs with a specific focus on technology-related modules in the curriculum. A new conceptual understanding of modules like Computer-aided Draughting would need to be rethought to include ET methods for skills and content. Aspects of fabrication, parametric design, data and design, algorithms, biomaterials, electronics, virtual reality, and augmented reality are aspects of ET that would need to be redesigned into new pedagogical structures to allow new sub-technologies to emerge and old technology to be phased out. However, we need to maintain the core approaches to ET thinking. Problem-solving skills would take on a new approach with new methods and ideas to solve contemporary design-based technical solutions and institutions would need to nurture educators who are inclined to make these changes and invest in modern infrastructures.

The 4IR is a 'primer' for thinking about ET. Although it is high level, strategic and speaks to the positive impact of our economies, it should not be seen as a mechanism to displace poor education in South Africa. It is undeniable that global economies are in neoliberal contexts and that the intention of countries by nature is to compete economically. The context in which 4IR is being presented does very little for design educators and can be viewed as discouraging. We should consider ET for its relevance, its practical intention. Technology has always been at our disposal, some more convincing than others, and it is up to design educators to make sense of its applications. The beneficiaries are our learners, design educators, the departments, and the faculty. By developing this new knowledge, we can advance our society. If design schools want to aspire to offer the best quality in education, they would need to invest in the infrastructure and develop the culture. Creating innovative spaces and programmes to reflect twenty-first-century skills would need to be on the top of the agenda.

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Appendix A

Questions for the FabLab manager

1. Which departments do you service in the faculty?
2. On average how many students do you engage with per day or week?
3. What is the nature of the engagements with students?

4. What are types of requirements and questions do you receive from students?
5. What kind of staff engagements do you have?
6. What role does the FabLab play in faculty?
7. What is the role scale of the role of the FABLAB in the faculty?
8. How does access to the lab help students with their education?
9. How important is access to a lab manager?
10. What is missing from the pedagogical approach in the FabLab?