Cape Peninsula
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An exploration of industrial design education in sustainable manufacturing: The case of South Africa, China and Norway.

by

Jacobus Christiaan Vlok

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Supervisor: Dr Alettia Chisin
Co-supervisor: Dr Vikki Eriksson

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DECLARATION

I, Jacobus Christiaan Vlok, declare that the contents of this thesis represent my own unaided work, and that the thesis/dissertation has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed:  **Date**: **2 March 2023**

ABSTRACT

This research study explores how and where Product design can develop as part of a responsive curriculum and reveals the actors that play a role in the social practice of sustainable Product design, post-education. The investigation focuses on how the key areas of sustainability are currently explored in curriculum and learning and teaching practices at three universities situated in South Africa, China and Norway. This exploration gave insights into the current practices but also highlighted the gaps identified. The conclusions offered an argument for a stronger relationship between Product design teaching and the emphasis on all the variables that will influence sustainable manufacturing. The study intended to elucidate current university practices in offering Product design students sound knowledge and skills so that they will be able to change public and industry perceptions after their studies.

The research was motivated as a result of participation in the DesignBRICS project. This project explored various aspects pertaining to sustainability, and sustainable manufacturing was the focus of this research study. The research aimed to identify how sustainable manufacturing is referenced and encouraged in Product design higher education curricula at the participating universities from South Africa, China and Norway.

A constructivist paradigm underpinned this qualitative study, and the epistemological stance was interpretivist. As a project participant of DesignBRICS, the author contributed interpretive concepts from an auto-ethnographical position. In addition, the author's reflections, questionnaire responses from research participants, and literature data were used to inform the research.

The findings identified how sustainability and sustainable manufacturing is currently interpreted and practised at the three universities. The key findings suggest that sustainability and sustainable manufacturing will be best presented and taught through the concept of holistic practice, placing the focus on the development of the key elements of sustainability, namely societal, economic and environmental pillars as all-embracing.

Keywords: Sustainability, Product design, Sustainable manufacturing,

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ABBREVIATIONS AND ACRONYMS

CE	Circular Economy
DfS	Design for Sustainability
GPI	Green Production Innovation
SDGs	Sustainable Development Goals
UN	United Nations
VR	Virtual Reality
WCED	World Commission on Environment and Development
4IR	Fourth Industrial Revolution

GLOSSARY

Word	Definition	Source
Sustainability	Sustainability consists of fulfilling the needs of current generations without compromising the needs of future generations while ensuring a balance between economic growth, environmental care and social well-being	Banco Santander (2021)
Sustainable manufacturing	Sustainable manufacturing is the creation of manufactured products through economically-sound processes that minimize negative environmental impact	United States Environmental Protection Agency (2020)
Autoethnography	Autoethnography is an approach to research and writing that seeks to describe and systematically analyze personal experience to understand cultural experience	Ellis, Carolyn; Adams, Tony E. & Bochner, Arthur P. (2010). Autoethnography: An Overview [40 paragraphs]. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *12*(1), Art. 10, http://nbn-resolving.de/urn:nbn:de:0114-fqs1101108.

The financial assistance of DesignBRICS towards this research is acknowledged. Opinions expressed in this thesis and the conclusions arrived at, are those of the author, and are not necessarily to be attributed to DesignBRICS.

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CHAPTER 1
INTRODUCTION

1.1 Background to the research

In his book Design for the Real World, designer-educator Victor Papanek (1971) criticized Product designers for the deterioration of the environment and unethical practices. Papanek accused Product designers all endorsing trend-driven uselessness, 'useless gadgets', over-packaging, products with a short life span, and significant consumption. Since the publication of Papanek's book, it took 12 years before the Brundtland Commission, also known as World Commission on Environment and Development (WCED), published a report to help nations direct their efforts and goals towards sustainability. The publication presented the most widely used definition of sustainable development namely "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs" (Brundtland,1987).

Van Zon (2002: 1,9,10) stated that sustainability problems have been a constant dilemma throughout human history. The occurrence of problems such as deforestation, salinization, and loss of fertile soil has been present since as early as the ancient Egyptian, Mesopotamian, Greek, and Roman civilizations.

Baldassarre, Keskin, Diehl, Bocken, and Calabretta (2020) argue that the strengthening of industrial activities in a model that does not support sustainable development has and still is causing a disturbing environmental crisis. The study further claims that the intertwining of environmental and social problems has escalated this crisis to a global scale. Baldassarre et al. (2020) present the sustainable design theory which they claim encompasses an extensive body of knowledge on how these environmental and social issues can be dealt with. They further argued that it is not only the rethinking of industrial products and processes, but specifically how organisations operate that can change the model into a more sustainable socio-economic system (Baldassarre et al., 2020).

While the concept of sustainability was deliberated and reflected, the importance of including the concept of sustainability in education became imperative. The drive towards sustainable design education has long been a shared vision by industry and education (Desha &

Hargroves, 2014) and gained support for implementation as a widespread practice in design education. Oke and Fernandes (2020: 2) agreed with this statement but warned that despite the shared vision the education sector has been reluctant to accept and implement technology and sustainability education into the function of teaching and learning.

The urgency of addressing sustainability in Product design education was substantiated when the United Nations (UN) published the framework for Education for Sustainability, at the general assembly in 2019. This framework fed into the UN's Sustainable Development Goals, formulated in 2015. The Sustainable Development Goals contributed to the 2030 Agenda for Sustainable Development that encourages action to be taken to:

> " …strive to adopt a comprehensive, far-reaching, and people-centred set of universal and transformative Sustainable Development Goals and targets, its commitment to working tirelessly for the full implementation of the agenda by 2030" (UNESCO, 2019).

Outlined in the agenda is a commitment to achieve global acknowledgement of the importance of sustainable development, through the delivery of quality education. The framework for Education for Sustainability reaffirmed the commitment made in the 2030 Agenda for Sustainable Development to make certain that all learners obtain the knowledge and skills required to uphold and stimulate sustainable development. With a firm commitment from UNESCO, Product design educators can now engage in a new drive for systemic change in Product design education.

Ramirez (2007), in a worldwide survey, reveals that many tertiary design programmes have included sustainable design as a compulsory or optional component in the curriculum. He further stated that projects in sustainable design studio modules regularly deal with social or environmental sustainability matters but give little attention to the application of design for systemic changes for sustainable businesses and manufacturing. The disparity in the lack of systemic changes for sustainable businesses and manufacturing in Product design curricula led to this study.

Product design shapes the engagement that people have with their environments every day, be it in natural or created spaces. Product design is defined as the professional practice of designing products or services used by millions of individuals every day (IDSA, 2020). The

product or service design process mostly focuses on physical appearance, functionality, and manufacturability. Although designers are often involved in the development cycle, manufacturing processes are not their main concern (IDSA, 2020).

1.2 Towards changes for sustainable businesses and manufacturing

The connection between individuals and the interactions they have daily are dictated by the manufactured objects they engage with in their environments. As such, there is a need to place a continuous and strong emphasis on the sustainable creation and sustainable production of these objects (Bridgens, Powell, Farmer, Walsh, Reed, Royapoor, Gosling, Hall, & Heidrich, 2018). The emphasis on customer experience can be categorized into five general divisions namely, awareness, consideration, acquisition, experience, and loyalty (Duyen, 2021). For future Product designers to design products that focus on each of these five categories, designers should have an awareness and knowledge of how sustainable and responsible design can be unified for each of these categories, and knowledge is predominantly advanced through education.

Education has long been seen to shift patterns and ideas in students (Cappy, 2016; Žalėnienė & Pereira, 2021). Therefore, design education can be used as a means of awareness of the impact and effects sustainable design practices can have on the industry. Placing the design focus on the review of the product life cycle with the commitment to a sustainable approach at each of the stages of the product life cycle should be central to supporting educational and training programs at Design schools. The focus is on design education that supports systemic changes toward sustainable business practices and product manufacturing. Such curricula should include the basic theories and applications of sustainability manufacturing, focusing on ethics, a product lifecycle, and sustainability principles for societal, economic, and environmental benefits (Kishawy, 2018).

1.3 Sustainability and the environment

Sustainability is a belief system (but also a method, practice and theory) that places value on the dynamic balance and symbiotic relationship people have with their environments (Maats, 2016). The relationship refers to in sustainability resembles the same engagement when Product designers design and shape the engagement between people and products. The

methodology used in Product design education should include students' preparedness and awareness of the impact and effects that, not only the design and product, but also the manufacturing processes will have on changes in the environment (Abdul-Waha, Abdulraheem, & Hutchinson, 2003). Addressing climate change (and related problems) is a priority for designers today. As such, it is important to investigate the methods and intensities to which future designers are equipped with the lenses and tools to address these issues.

This study leverages access to institutions through participation in the designBRICS project (2018-2021), an international collaboration focused on sustainability and design between design institutes in BRICS countries, South Africa, China, and Norway. One of the project's key assumptions was the importance of contributing to a new design education that will shift its current focus from designing for societies in affluence to increase their standard of living, which is primarily based on consumption, to a more realistic focus: quality of life (Centre for Design Research, 2021).

The project served as a platform for three scalable modules that were developed under the modules design4futures, design4manufacture, and design4ecology (Centre for Design Research, 2021). The project aimed to assess and develop future design pedagogy and pedagogical frameworks (Centre for Design Research, 2021). The designBRICS programme allowed for the exploration and comparison of content and teaching and learning approaches that relate to sustainable manufacturing and design. This resulted in access to perspectives and practices from both the global north and south in order better understand the current programmes and the inclusion of DfS modules in these.

The designBRICS modules each had their focus and made their contributions to design education in the future. Figure 1.1 illustrates the role of sustainability within each of these modules. The theme of sustainability played the overarching role in the research that contributes to future design pedagogy and pedagogical frameworks. The contributing elements included all three modules namely: design4futures, design4manufacture, and design4ecology. This study only focused on contributions from the module of design4manufacture.

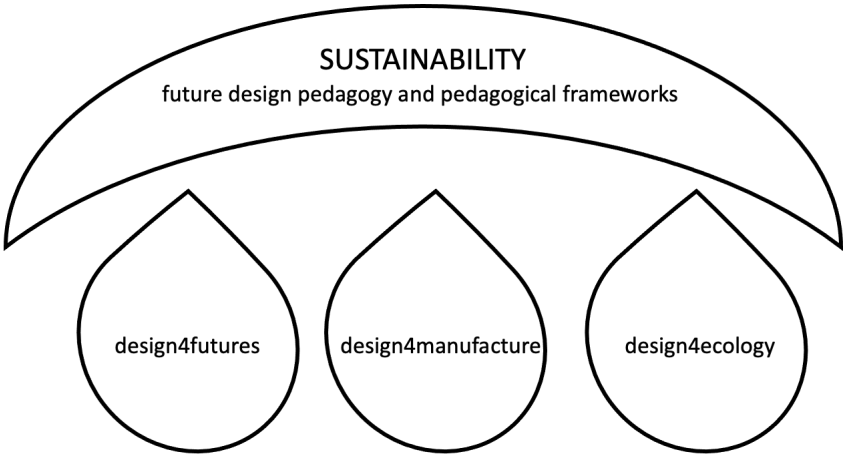

Figure 1.1 designBRICS modules. Author's construct (2021)

The research contributions as part of the designBRICS project illustrated how the three modules relate to a pedagogical focus on sustainable development, and education practice and curricula that support this. This contribution was essential because infusing this awareness and building a broader knowledge base through the higher education curriculum and pedagogy will help students reconceive the role of humans on the planet (Hensley, 2020). This in turn can cultivate reflection, innovation, and integration to tackle the bigger challenges associated with sustainability and sustainable manufacturing (Mensah, 2019). Situated at the intersection of Product design sustainability education, creativity, and manufacturing, this study distinguished itself from other similar scholarship by drawing from inquiry through a literature review, email interviews and reflections in the field of Product design curriculum studies. This study includes personal reflections on my visit to Norway and China as part of the designBRICS project.

1.4 Statement of the research problem

Current Product design and manufacturing practices are often referred to as 'cradle-to-grave' processes, where the start of a product is born through the design and expires when it is discarded and most likely ends up in a landfill (Morone, 2020). Over the years, society has increasingly become aware of the consequences of their actions and had to reconsider the typical linear (cradle-to-grave) practices, to a circular approach. The fact that resources are becoming scarce in an over-populated world, a circular approach to manufacturing has become the new benchmark (Morone, 2020).

As such, the growing awareness of sustainable living and manufacturing in recent years shifted the focus towards building a “circular economy in which end-of-life materials are designed to re-enter the production and consumption cycle so creating a loop” (EMF, 2013:23). This concept has been vocalized for many years by one of the world’s leading experts on sustainable design, Prof. Ezio Manzini (Brooks, 2011). Manzini emphasizes innovative processes in the structure of production and consumption and, more so, the relationship between product strategies and environmental policies from the perspective of sustainable development (Manzini, 2019). Therefore, sustainable development is often referenced with the production and manufacturing of products, the role of products, and Product designers.

However, for Product design as a professional qualification, the starting point for these professions is tertiary education. The lens of a responsive curriculum where a framework of design for sustainability (DfS) and the application of that theory taught at the tertiary undergraduate level in Product design, was explored. This exploration revealed how and where Product design can develop as part of a responsive curriculum and reveal the actors that play a role in the social practice of sustainable Product design, post-education. This importance is highlighted by The School of the Arts and Design of the University of Nairobi, Kenya, where sustainable design is woven into all course modules through engagement with social groups and key informants to further the responsiveness of curriculum to lasting design (Vezzoli et al., 2018).

Rapitsenyane, Moalosi, and Letsholo (2020) mentioned a need for change in the focus of Institutions of Higher Learning which are offering Product design degrees. They considered it imperative to produce designers that are responsive and proactive in addressing the global sustainability crisis to stay relevant in the future (ibid). The Fourth Industrial Revolution (4IR) is rated as the most complex, fast-paced, and global of all the former industrial revolutions (Schwab, 2017, 2018; Philbeck & Davis, 2019; Farrelly, 2018), and with the arrival of Covid 19, technological developments were accelerated. For this reason, higher education programmes offered will need to revise and adapt with more urgency than before to ensure graduates will be ready to harness future thinking to create resilient societies, economies, and ecosystems (Oke & Fernandes, 2020: 10), but within the ambit of the sustainability agenda.

1.5 Background to the research questions

The writings of Papanek and the Brundtland Commission and my experiences as an exchange student in the designBRICS project motivated me to explore more about the differences in the Product design curricula of the participating universities. The participation in the DesignBRICS project also stimulated the investigation into sustainable manufacturing. In the research question, I refer to universities in the countries that I have visited while being part of the DesignBRICS project. As stated in 1.4, sustainable development is often referenced with the production and manufacturing of products, the role of products, and Product designers as such the starting point for these professions is tertiary education. The noticeable differences experienced in each country placed the focus on the awareness and knowledge gained in tertiary education. The questions were developed for a study that can identify if there is a possible need for change, and what that change could entail.

1.5.1 Main question

How is sustainable manufacturing referenced and encouraged in Product design higher education curricula at the participating universities, namely AHO, CPUT and Hunan?

1.5.2 Sub questions

1) How is sustainable manufacturing presented, promoted and or encouraged in the respective curricula at the universities?
2) What are the pedagogical tools used in the curricula to promote a sense of responsibility in carrying sustainable practices from a university setting into the Product design industry?

1.6 Aims and objectives of the study

1.6.1 Aims

- The study only focused on the curricula offered at the undergraduate level, as this is the first point where a practicing professional Product designer could graduate. This study aimed to explore sustainable manufacturing through the lens of Product design and Product design curriculum by exploring cases in the three Universities.

- The study identified the key elements informing sustainable manufacturing within undergraduate Product design practices and pedagogy.
- The study also explored how sustainability in Product design, as a strategic approach, to positive social and environmental change and as a manufacturing practice, is presented to students as an alternative to non-sustainable options, which may allow them to challenge the “status quo”.

1.6.2 Research Objectives

The objective of the study focused on how Sustainable Manufacturing in Product design is presented, promoted, and or encouraged at the participating Universities and to explore the pedagogical tools used in the respective curricula to promote a sense of responsibility in carrying sustainable practices from a university setting into the Product design industry.

1.6.3 Methodological approach

The study used qualitative research methods to make meaning from the data collected**.** Various data collection methods were employed namely a literature review, individual interviews, questionnaires, participant observation, and journaling. A thematical analysis was applied to systematically identify, organise, and find insight into patterns of meaning (themes) across a data set.

1.6.4 Delineation of the study

The scope of the study was determined by focusing on only the three universities that were part of the designBRICS project. Although Product design as qualification is offered all over the globe, this case study focused on the three contributing universities only.

1.6.5 Chapter overviews

This thesis is organized into six chapters to provide an account of the study with a focus on Sustainable manufacturing positioned in Product design education.

1.6.6 Chapter 1

Chapter 1 presents the aim of the study which is to explore sustainable manufacturing through the lens of Product design. The investigation will focus on how the key areas of sustainability are currently explored in curriculum and learning and teaching practices at three universities situated in South Africa, China and Norway. Personal observations done are examined while I was part of the collaborative projects, visiting China and Norway. These observations and journal entries were supported by online interviews with academic staff at all three universities. This chapter also presents the research background, the problem statement, the research questions, the limitations of the study, and the objectives and provides a brief overview of the methodology

1.6.7 Chapter 2

In Chapter 2 I presented the theoretical perspective as it related to this study. I unpacked the theoretical contributions of authors regarding sustainability in the broad term, sustainability in manufacture and the presence it currently occupies in Product design education. I probed the influences of climate-changing factors and sustainable metrics in use. I further deliberated current influencers on sustainability issues such as circular economy, sustainable manufacturing / green production, technology in the Fourth Industrial Revolution (4IR), and learning factories. I validated the connections between data and the literature presented.

1.6.8 Chapter 3

Chapter 3 justified the adoption of an autoethnographic position in the research. While the research philosophy is based on a constructivist paradigm, I also engaged the interpretivist paradigm which is concerned with understanding the world from subjective experiences of individuals. I used meaning making methodologies; interviewing and participant observation, that rely on a subjective relationship between the researcher and subjects. Thereby creating meaning through the interaction of the interpreter, myself, and the interpreted data (Crotty, 1998). The qualitative study will be completed in three stages. Firstly, the engagement and exploration of the literature will inform the relevant questions that will be used in the second stage of the study. This involves the creation and positioning of the questions for the email interviews. The final stage includes the transcription of the data, coding and analysis of the data. The data collected from the interviews are cross-referenced with the latest literature

promoting and advocating sustainability.

1.6.9 Chapter 4

In this chapter, I present the data from the participants and the literature that informed the questionnaire that was distributed to the participants. The data are presented according to the themes identified. I analysed the data from the participants and discuss it according the reviewed literature on sustainable manufacturing. Thereby, I illustrated the relationship between the literature data, the participant feedback and my own journaling and note taking while being part of the exchange programme. I reviewed these data sets against the education requirements identified in the literature. The chapter aimed to link the research intent with the research activities to answer the two research sub-questions.

1.6.10 Chapter 5

As part of the Conclusion and Recommendations Chapter, I presented the findings of the study regarding the original questions. This chapter offer insight into 1) the methodological deductions and focus on the results that were generated through the chosen method. 2) Sustainability and sustainable manufacturing as presented in the Product design programmes. And 3) the auto-ethnographic conclusion. I reflected on the study and presented contributions and possible changes and additions to the Product design programmes.

1.7 Summary

The introduction chapter provided an overview of the current study. It covered the background of the research, the rationale in choosing the topic, the setting of the research questions, the delineation of the research aims and objectives, the adoption of the research methodology, elaboration of the research contributions, determination of the delimitations of the scope of the study, and outline of the organization and structure of the thesis.

CHAPTER 2
LITERATURE REVIEW

2.1 History

In recent years, interest in sustainability is increasingly included in agendas from policymakers to business boardrooms to education. Although the term sustainability has been elevated to a state of high significance, this concept has been used for centuries through the use of such terms in French (durabilité and durable), German (*Nachhaltigkeit*, simply meaning 'lastingness', and nachhaltig), and Dutch (*duurzaamheid* en *duurzaam*) (Van Zon 2002: 20- 22).

The work *Man and Nature* by George Perkins Marsh was first published in 1864 and this marked him as the fountainhead of the conservation movement (Lowenthal 1958: 246, 268). Marsh stated: “Man has long forgotten that the earth was given to him for usufruct alone, not for consumption, still less for profligate waste” (Marsh 1965: 36). His greatest concern was the disruptions humankind caused on earth. He did not want to protect the earth and nature for his good but for the benefit of humankind, a similar approach to the contemporary advocates of sustainable development (Marsh 1965: 36).

Since then, the theory of Sustainable Development appeared in the 1980s (WCED, 1987). During this time the focus was on the coordinated development of the economy, society, and environment, and entered the high-level political agenda. With the arrival of the Fourth Industrial Revolution, Sustainable Development has become a fundamental part of the agenda of governments and companies (Schwab, 2017). Sustainable Development Goals (SDGs) have since permeated academic and research institutions' itineraries around the world and are tied to many related aspects, of which climate change is one (Lye, 2021).

2.2 Design for Sustainability in Higher Education Institutions

Product design as an educational offering has been going through many changes since the introduction of the course (Thomas, 2016). Recently Delaney and Lui (2021) presented their research on the state of sustainability and Design education in the United Kingdom at the International Conference on Design Education. Relevant arguments around sustainability were presented. Recently Delaney and Lui (2021) stated that the aim of sustainability is to

address and satisfy the needs of current generations but with keeping in mind that the need of the future generations should not be compromised. It was further noted that these concerns are important within industry as well and that Product design education can contribute graduate designers that will be equipped with the skills to accommodate sustainability issues as well as demands from industry (Delaney & Liu, 2021).

Wamsler (2020) addressed the matter of including sustainability in design education by means of exploring connections between mindfulness and sustainability. I can be argued that different pedagogical approaches can contribute to the success in finding these linkages (Wamsler, 2020). When considering the pedagogical tools for including sustainability in the curriculum different approaches can be considered. The most recorded were a collaborative approach, a reflective approach, an integrative approach, and an inquiry-based approach. These approaches contribute to strategies that will assist students to work together through think, pair, and share. An integrative approach, and an inquiry-based approach are often revere to experiential learning that is an effective method to engage students in learning by means of doing (Laverie et al., 2022).

Successful teaching in Higher Education can only occur when students develop a sound scholarship of the discipline they are studying in (Healey, 2000). The curricular knowledge, which refers to the goals, purposes and rationale of a course or program cannot be achieved if students do not have the basic knowledge in their subject field to refer to (Niemelä, 2022). Therefore, the sections to follow will focus on the subject specific knowledge that will has bearing on this study.

2.3 Sustainability in context

This study reviewed literature to build a better understanding of the holistic view on the topic of sustainability. The literature review aimed to highlight the various academic influencers, design academics and authors on the topic of sustainability that may contribute to a Product design curriculum underpinned by sustainability.

The term sustainability has been used since the 1980s (Pisani, 2006), but remains a contentious concept. Although sustainable development, as set out by the UN Sustainable Development Goals (UN, 2015) focuses on five contributing areas (Fig 2.1), this study

delimited the possible areas that relate to product manufacturing and may be linked to a Product design curriculum.

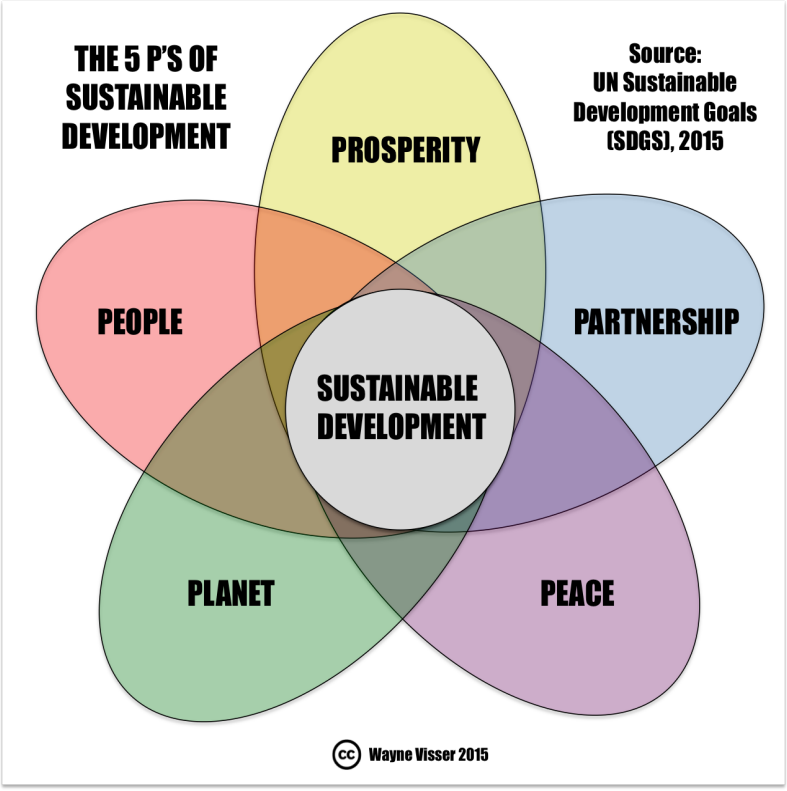

Fig 2.1 5 Ps of Sustainable Development, UN Sustainable Development Goals (SDGs), 2015.

The next two sections namely climate change and sustainable metrics, may not the main focus of the study but were included to build a background toward understanding and placing the more important influencing factors in perspective. The influencing factors that follow thereafter directly relate to the focus on sustainable manufacturing in Product design education.

2.4 Climate change

The Intergovernmental Panel on Climate Change, a body of the United Nations, published a special report on the impact of global warming of 1.5°C above pre-industrial levels (IPCC, 2018: 4). The reports stated that human activities are predicted to have caused approximately 1.0°C of global warming above pre-industrial levels and these levels are likely to reach 1.5°C between 2030 and 2052 (ibid). These climate-related risks will include health,

livelihoods, food security, water supply, human security, and economic growth. The special report also stated that the increase in sustainable development will enable and support fundamental societal and systems transitions and transformations that will contribute to limiting global warming.

Scholarly articles over the past years point out the impact that climate change has on the production and manufacturing environment with a strong focus on waste reduction, energy reduction, and the use of natural resources (Issaoui et al, 2022: Nkhata, 2022; Paprocki, 2022; Balsara et al., 2019; Zhang et al., 2018; Verhoef et al., 2018; Mitchell, 2017). In addition, arguments on the impact of climate change on water resources are endless.

Climate change will affect all parts of human life. It affects all natural systems including the global water cycle. These effects will accelerate the hydrologic cycle and will intensify severe incidents such as droughts and floods (Nazif, 2017; Pickson & Boateng, 2022). The environmental and social impact of climate change has concerned researchers and scientists for many decades, leading to a range of seminal works on the topic as well as a range of metrics to critically evaluate the impact on these dimensions.

These concerns were not ignored and in September 2015 the 17 sustainable development goals (SDGs) were published and accepted at the UN conference. The changing climate can be directly linked to nine of the goals namely;

- GOAL 2: Zero Hunger
- GOAL 3: Good Health and Well-being
- GOAL 6: Clean Water and Sanitation
- GOAL 7: Affordable and Clean Energy
- GOAL 11: Sustainable Cities and Communities
- GOAL 12: Responsible Consumption and Production
- GOAL 13: Climate Action
- GOAL 14: Life Below Water
- GOAL 15: Life on Land.

Since the inception of the SDGs, there has been much deliberation on what will be the best way to implement these goals and make a difference. Education is arguably the best way forward and suggestions such as combining different knowledge systems are potentially one of the most convincing ways forward (Makondo & Thomas, 2018; Kioupi & Voulvoulis, 2019; Chausson et al., 2020).

2.5 Sustainability metrics

Twenty-four years ago, John Elkington (1998) introduced the world to the Triple Bottom Line (TBL). It was acknowledged by other sustainability theorists as a practical, compassionate, and deeply informed piece of work (Hapuwatte, Seevers, & Jawahir, 2022; Slaper, 2011; Hubbard, 2009). They believed that this book provided an informative review of the harsh issues in the world of business and sustainability. Elkington's work was also presented as solutions ready for application (Slaper, 2011). One of the unique features of Elkington's work was the addition of dimensions that traditionally were not deemed measurable namely, social and environmental aspects (Slaper, 2011). Slaper and Hall (2011) clarify the term TBL as a framework that incorporates three distinct dimensions of performance. These dimensions include social, environmental, and financial elements. Since the publishing of the work the TBL commonly refers to the *3Ps*: people, planet, and profit.

Evaluating the rate of sustainability from year to year is considered incredibly hard (Hapuwatte, et al, 2022; .Nature, 2020; Ahmad, Wong, & Rajoo 2019; Escrig-Olmedo, ed. al 2019). Over the decades, researchers and policymakers have been searching to define a measure for evaluating progress on sustainability. Savitz (2006:8) described it best when he stated that TBL: "…captures the essence of sustainability by measuring the impact of an organization's activities on the world ... including both its profitability and shareholder values and its social, human, and environmental capital". Although the TBL concept changed the way governments, businesses and non-profit organizations view and measure sustainability, the challenge was still out to define a standard way of measuring the 3P's, people, planet, and profit (Fernandes, 2020). Even so, the TBL framework created a way for organizations to measure the consequences of their decisions from a long-term perspective.

The fact that the 3Ps mentioned above, do not have a standard unit of measure should be kept in mind when a company want to measure the impact of the TBL. Profits are measured in a monetary value, and this present the difficulty of finding a common standard of measurement across people, planet, and profit. In essence the TBL can contribute by evaluating the environmental matters through valuing the natural resources and assessing the future viability. This process could include energy consumption, water and air quality, availability of natural resources, and managing solid and toxic waste. As for the social

measures, companies should focus on the measures of education, equality and available access to social resources, the health system and the wellbeing of the nation, social capital and the quality of life (Slaper & Hall, 2011).

The United Nations felt the need to set up the United Nations Sustainable Group and has been actively driving a focus on sustainability since then (UN, 2015). In September 2015 they published 17 Sustainable Development Goals (Messerli, 2019: 10), which aim to end poverty and hunger and address climate change. This action has prompted the international community to agree to put measures in place to meet the 2030 deadline. Although the UN publishes a report that rates countries out of 100, the score does not record local-level data and inter-year comparisons (UN, 2020). Whittingham et al. (2022) explored the impact of the SDGs and the impact it has on various firms. Whittingham and his colleagues applied computer-aided text analysis to the study. They reported that:

> *"Results show that, when comparing firms' sustainability reports before and after 2015, increasing alignment was observed with the language of certain SDGs, while alignment did not significantly change for other SDGs. We further analyze these changes across industries, natural resource intensity levels, and geo-institutional contexts, revealing variation among firms based on institutional characteristics that may point to selection priorities and critical gaps as global firms engage with the grand challenges embodied in the SDGs"* (Whittingham et al. 2022).

In 2019 UNESCO developed a different approach to data gathering by constructing a new indicator framework (UNESCO, 2019). The framework for sustainable development goals (SDGs) is based on a score on 209 indicators as well as indicator sets that include 429 specific indicators corresponding to 17 SDGs in three dimensions, i.e., economy, society, and environment. The research team of the United Nations Sustainable Group chose China as its case study (UNESCO, 2019). On the new scoring system, China's overall SDG score showed a significant increase in their overall rating of the country's SDGs within all 31 Chinese provinces. China's government shows awareness of the environmental and social risks of rapid industrialization and the country has built an active community of researchers that is continuously working on improving sustainability (UNESCO, 2019). The report on SDGs further highlighted the importance of action. It also stated that the practicing of SDGs

will contribute to not incremental change but transformation. Not business as usual but business as unusual (UNESCO, 2019)

With the last point in mind, the change in higher education toward implementing the sustainability agenda (Figueiró & Rau et.al, 2015) and sustainable development must also be a transformation rather than choosing incremental change. New curricula should transform the contribution it makes to sustainable development goals concerning the economy, society, and environment (Figueiró & Rau et.al, 2015). From this point of view, the strong contribution towards making a difference in the future through focusing on sustainability shown by the Chinese government makes the inclusion of a Chinese university in this study significant.

2.6 Practitioners and academics who influence the sustainability discourse

The importance of sustainability in Product design education emanates from the fact that the curricula that Product design students are taught represent the approach students are prepared with for industry, and their attitude towards sustainability professionally and in their own lives (Kwagawa, 2007; Stephan et al. 2008; Rieckmannn, 2012; Lozano, 2013 & Figueiró, 2015; Özsoy, 2015; Wamsler, 2020). Cortese (2010) agreed, affirming that universities play a vital role in knowledge creation, and the inclusion of sustainability into curricula will have wide-ranging implications for the global effort in finding sustainable solutions in the future.

Terzioglu and Wever (2021) stated that the existing paradigm of Product design frequently assists the linear system. The same structure that caused the largescale ecological crises. This approach to Product design education has generated the need to rethink the educational offerings in Product design. Loy and Novak (2019) pointed to the fact that although globalization and amalgamation dominated the industry at the turn of the century, the expected homogenization into a world without borders has been shattered with a new determination of nationalism and separatism. New business practices are designed based on a shared economy. With this backdrop, there could be an expectation that Product design education will be entering a period of change itself (Loy & Novak, 2019). Loy and Novak (2019) argued that the existing thinking in the discipline should be challenged, and outdated thinking should be challenged if the discipline wants to make a meaning full contribution to

the industry. It is noteworthy to state that over the last few years there was a new trust towards rethinking the interaction between the 3P's, people, planet, and profit. Although information concerning the Covid pandemic is not part of the study it is evitable not to notice the urgency towards change that has been brought about by the pandemic.

The implementation of systems, such as the circular economy, can offer a positive contribution to the current global ecological problems (Findeli, 2001; Ramirez, 2007 & Andrews, 2015; Velenturf & Purnell, 2021). Education will have to rethink all aspects of the curriculum to present students with enough passion and desire to make a difference in the future through the design of new products. This desire should be met with sufficient knowledge to see the possibilities for change on the micro, medium and macro levels of society, the environment and the economy (Acerbi & Taisch, 2020).

The focus on all levels of society is not a new concept. More than two decades ago Thomashow (1995) outlined the need for ecological awareness and identity. He defined this as an ability to develop an appreciation for all life systems while focusing on the importance of mindfulness. He further encourages the ability to see nature and nurture the ability to be struck by wonder and awe (Thomashow, 1995; Thomashow, 2020).

Kioupi and Voulvoulis (2019) articulate this view differently when they stated that educators and learners should work together to identify constraints and enabling conditions, select the competencies needed, and develop appropriate curricula and pedagogies to pursue the transformation towards sustainable living and ultimately sustainable manufacturing. A well-structured framework for sustainable development will offer an opportunity for rethinking education as a systemic tool for transformative social change (Kioupi & Voulvoulis, 2019).

As illustration the recent project done by the Nottingham Trent University (NTU) Sustainability in Enterprise (SiE) ran a project with their first-year students to work and support local businesses within the greater Nottingham area. The aim was to help improve businesses' environmental performance across four key areas: People, Products, Processes and Premises. A qualitative study reported that students attest to an improved knowledge and a changed attitude towards sustainability. This positive feedback resulted in the course including an intense week of sustainability teaching in the curricula (Siena et al., 2022).

Similarly, the Kingston School of Art at Kingston University, London published research that was aimed at investigating what designers learn, how they learn and where the learning took place. This research was aimed to discover new approaches toward improving sustainability literature amongst senior students (Micklethwaite, 2022). Micklethwaite (2022) included the story told by a course leader, with ten years' experience as a course leader, where he used the students' contributions to illustrate the argument made for a sustainable design pedagogy. Micklethwaite (2022:PG no) reported the key principles of this pedagogy as "(1) sustainability is a social, not just an environmental, agenda; (2) sustainability presents us with 'wicked problems', which have no right or wrong answers; (3) sustainability-directed design practice arises from the sustainability literacy of the designer; (4) sustainability derives from mindsets and worldviews, not just methods and materials; and (5) sustainability is an emergent property of systems, not a quality of products".

Steering students towards knowledge on the levels mentioned above comes with its complications. The concept of education for sustainable development has been viewed as a new educational culture that enables individuals to evaluate their decision-making and behaviour (Adomßent et al., 2014). As such, the focus of higher education institutions and their curricula should, through the implementation of the SDGs, adapt suitable programmes and methodologies (Saitua-Iribar, Corral-Lage & Peña-Miguel, 2020) and introduce Product design projects that will require more and extensive knowledge of different materials, information on ecology, environmental impact scenarios and assessments, biodiversity, business models and supply and value chain functions (Dokter & Rahe, 2021).

The literature is clear that Design for Sustainability and the development of a Circular Economy (CE) cannot be separated (Acerbi et al., 2021; Acerbi & Taisch, 2020; Kopnina, 2020). The next section will focus on the close ties between Design for Sustainability and a Circular Economy.

2.6.1 Circular economy (CE)

The concept of a circular economy (CE) has gained significant traction worldwide. In recent years it became clear that the traditional linear economy of 'take-make-dispose' continued to fall short of meeting sustainable living standards (Triguero et. al., 2022; Geissdoerfer et

al., 2017:758). The present-day understanding of the circular economy and its various applications to the industrial system and the economic system has incorporated various characteristics that draw from a wide range of concepts but share the same idea of closed loops. The close loop system refers to a system where manufacturing processes influences and contributes towards the recycling and reuse of post-consumer products be to put back into the system for recreating new material to be used in a new product. As such businesses can reuse the same materials more than once by conserving the original materials (Winkler, 2011).

Over the years some of the most influential theoretical concepts in this approach are laws of ecology (Commoner, 1971), regenerative design (Lyle, 1994), industrial ecology (Graedel & Allenby, 1995), cradle-to-cradle (McDonough & Braungart, 2002), biomimicry (Benyus, 2002), looped and performance economy (Stahel, 2010), and the blue economy (Pauli, 2010).

In this study the definition of the circular economy, as framed by the Ellen MacArthur Foundation (2013:14), is most appropriate when it states that a circular economy is "…an industrial economy that is restorative or regenerative by intention and design". Comparably, Geng and Doberstein (2008:231) focused on the Chinese application of the concept and described the Circular Economy as the "…realization of [a] closed-loop material flow in the whole economic system". Webster (2015: 16) contributed an appropriate definition of sustainable design and manufacture stating that "…a circular economy is restorative by design, and which aims to keep products, components, and materials at their highest utility and value, at all times". In his doctoral thesis Desing (2021) stated that products and services can be placed at the heart of the economy. He further argues that in the need for companies to keep feeding the excessive consumption of the human, the earth system has been destabilised. To address this concern, he proposed a framework that brings together sustainability and circular economy with the sole focus that the environment will be at the center of all product and service design (Desing, 2021). The implementation of such a proposal will have an insightful impact on education.

Similarly, the seminal work of Diaz et al. (2020) reviewed the impact of sustainable product development of industry in a circular economy. They identified that since the publication of the 17 Sustainable Development Goals (SDG), as published by the United Nations in 2015,

the term CE has been used as a strategic term for many businesses to realign themselves to the 17 Sustainable Development Goals (SDG) (UNITED NATIONS, 2020).

Acerbi & Taisch (2020) investigated the Circular Economy (CE) paradigm as a major contributor towards sustainable manufacturing. In their study to identify the CE principles used in the manufacturing industry, they surmised that there is not one clear definition of Circular Manufacturing or how exactly it is taking place. Acerbi and Taisch (2020) presented a systematic review of the adoption of CE. They discovered that technologies were often used to define or measure Circular Manufacturing strategies. The contributing factors to this deduction are numerous.

Building a clear understanding of the term CE and the different CE strategies is complicated as literature affirmed the view of Acerbi and Taisch (2020) who argued that there is not one clear definition for the concept. Keywords that were identified in the discussions of CE include reuse, closed-loop supply chain, circular design, recycling, cleaner production, waste management, remanufacturing, disassembly, etc. As such the lack of a clear definition for CE highlights the consideration between Eco-Design versus Circular Product design and its fundamental differences (den Hollander et al., 2017)

Eco-Design includes a process of the waste hierarchy, described in the European Waste Framework Directive (EC, 2009). The waste hierarchy prioritizes the preferred option of waste management. These range from prevention of waste, which is the preferred option, to reuse, recycling, and another recovery for example energy recovery, and disposal which is the least preferred option. (Den Hollander et al., 2017). Circular Product design intends to eliminate all waste through reuse and remanufacturing processes (Den Hollander et al., 2017).

The current definitions of prevention, reuse, recovery, and recycling all hinge on the assumption that a product at a certain point in time inevitably will become waste. To distinguish between circular economy and eco-design it is needed to start with a division between the two. The concept eco-design can be defined as a systematic integration of environmental considerations as part of the Product design. This process aims to better the environmental performance of the product throughout its whole life cycle (EC, 2009).

Faber et al. (2005) and De Pauw (2015) refer to eco-design as a comparative approach. They argue that design begins with the situation as is and the problem is identified. Thereafter there will be an attempt to improve the product and solve the problem. “Improvements take place incrementally . . . In contrast to the absolute approach, the focus of this relative approach is not good, but the less bad” (Faber et al., 2005). It is this focus of Eco-Design that was critiqued (e.g., de Pauw, 2015) since designers cannot contribute truly sustainable or circular innovations if the current methods only lead them to optimize what is already there.

In contrast, the concept of CE mimics a closed-loop system (Acerbi & Taisch, 2020). In a Circular Economy the best possible material flow perspective will anticipate resources that have entered the CE to always remain accounted for: before, during, and after their lifetime as useful products (Den Hollander et al., 2017). The flow of the materials, the production processes and the functionality that is involved become real considerations in the design of products.

However, the functionality of a product can be considered insufficient for two reasons. Firstly, often products are deemed redundant and scrapped while still in perfect working order (Oswald & Reller 2011; Bayus 1991). Secondly, products can be temporarily out of order but do not get discarded immediately. A product becomes obsolete if it is no longer considered useful or significant by its user (Burns 2010).

The literature distinguishes different types of obsolescence or reasons for products being discarded. Burns (2010), for instance, discerns aesthetic obsolescence (i.e., products that have become outmoded), social obsolescence (i.e., products that have become outlawed), technological obsolescence, and economic obsolescence. Further examples include logistical and functional obsolescence (Cooper 2010; Bartels et al. 2012; Tomczykowski 2001; Feldmann & Sandborn 2007).

Acerbi et al. (2021) argued that the decisions regarding the life cycle of a product should be taken at the design stage since these important decisions will influence the potential environmental impacts the product might make during its lifecycle. Therefore, the design stage should place focus on the Product design, the processes needed for manufacturing, the technologies and tools used during the manufacturing processes and the management

of the product during use and even after the life cycle has come to an end. In this way, the recycling of the product is designed into the product and the manufacturing processes.

2.6.2 Lean and Green manufacturing

Lean manufacturing or green manufacturing can be defined as a method of manufacturing that minimises waste and reduces environmental impact (Posinasetti, 2018). Environmental concerns in business and the world economy are escalating. The idea of Green Production Innovation (GPI) has grown considerably over the past years. Although selected production companies are already investing in the concept of GPI this is still a less explored topic (Dangelico, Pujari, & Pontrandolfo, 2017: 491). Dangelico et al. (2017) did a study on the sustainability-oriented dynamic capabilities in manufacturing firms throughout Italy.

Lean manufacturing is a manufacturing process that strives to operate without waste and was first used in Japan, particularly in the Toyota Production System (Prasad & Sharma, 2014; Leong et al., 2019). Waste can originate in many places, e.g. in policies, procedures, process and Product designs, and operations, but it only consumes resources without adding any value to the product. The shift of manufacturing in Japan from traditional methods to the lean approach allowed the industry to function at a higher efficiency and in a new competitive way.

While lean manufacturing focuses on the operational aspect, the environmental aspect is symbolised by ‘green’ in this instance (Danish et al., 2022). Green represents ecological sustainability and includes many different concerns in the manufacturing process including waste generation and recycling, air, water and land pollution, energy usage and efficiency (Bhattacharya et al., 2011). Green manufacturing is a method of manufacturing that implements research and process design to minimize waste and pollution. This method supports and sustains a renewable way of producing products that do not harm people or the environment (Prasad & Sharma, 2014). Green manufacturing goals are focussed on conserving natural resources for future generations (Leong et al., 2019) by eliminating the unnecessary use of water, power and resources.

In recent years lean and green manufacturing are used together. The objective behind the phenomenon of the lean-green approach was that it would review all three components of

sustainability simultaneously, i.e., the environmental, economic and social components (Abualfaraa et al., 2020). This combination becomes pertinent, since according to literature (Jakhar et al., 2018; Leong et al., 2019) although lean management affects sustainability positively in terms of sustainable practices related to production and the selection of suppliers, it negatively affects the ones related to logistics. Moreover, Inman and Green (2018) pointed out that although lean practices can have a positive effect on the environmental pillar, their impact is greater when applied with green ones.

2.6.3 Technology in the Fourth Industrial Revolution (4IR)

Since the publication of Professor Klaus Schwab's books called *The Fourth Industrial Revolution* (2016) and S*haping t*he *Fourth Industrial Revolution* (2018), the expectation exists that this technology-driven revolution will bring a new balance to the world that is currently functioning under substantial strain. In the past drivers of change such as globalization, technological advances, and advances in financialization have served humanity well and contributed to economic growth and social progress. Nevertheless, over time these drivers started being entwined to such an extent that it placed people and the planet under strain (Manda & Ben Dhaou, 2019).

The digitally-enabled 4IR has proven to be the fastest period of innovation across the globe (Herweijer, et al. 2018; Oke & Fernandes: 2020; Tang et al., 2020). At the G20 in Germany (2017) it was stated that the 4IR offers great potential to transform, change and realign our economies and societies. This is made possible by the vast underpinning technologies. These include artificial intelligence, robotics, the internet of things, nanotechnology and biotechnology, amongst others. Oke and Fernandes (2020:2) agreed with this statement but warned that despite these innovations the education sector has been reluctant to accept and implement technology into the function of teaching and learning.

According to Farrelly (2018:1), the 4IR will seal the socio-ecological fate within the Anthropocene explaining as far as either exacerbating the world's most pressing challenges or offering a long-term and sustainable solution(s). Farrelly (2018:1) also argues that educators should offer the: "…4IR technologies as cognitive, if not pragmatic devices which students should "think with", develop, draw on, critique, and critically reflect on to improve

global social and environmental conditions". These technologies may include Computer-Aided Design, design for 3D printing, Virtual reality design, and technologies embedded into new workshop equipment, for example, laser technology.

Spaltini et al. (2021) placed the focus on obtaining sustainability through Circular Manufacturing that will impact both the environment and the economy. They described the 4IR technologies as contributing to “smart” factories in the future. These will be computer-driven systems that can operate on decentralized decision-making. The link between 4IR technologies and CM is described as two sides of the same coin (Garcia-Muiña et al., 2018) with a direct link between the concept of the circular ideal and the development of new technologies. The interconnectivity between companies and available resources is undeniable and will contribute to new business models within product manufacturing with a focus on sustainability (Spaltini et al., 2021).

The SDGs placed focus on the environment, the economy and the social environment and therefore the development of new business models with the implementation of new technologies will place the focus on the well-being of the environment, the economy and the social environment (Spaltini et al., 2021). Additionally, the use of 4IR technologies can improve the monitoring of waste, monitor product performances, and contribute to predictive maintenance (Spaltini et al., 2021).

The use of technology through contributors such as the Internet of Things (IoT), Big data, Cloud and Additive manufacturing allows for smart and connected products that allow manufacturers to monitor, control and predict all the stages in the manufacturing processes (Pagoropoulos, Pigosso, & McAloone, 2017). Although there is a strong argument for the collaborative work of the technologies in the 4IR and a circular manufacturing approach, the emphasis should be the translation of the called 6R model towards sustainable manufacturing namely Reduce, Reuse, Recycle, and the additional three; Recover, Redesign and Remanufacture (Jawahir & Bradley, 2016).

2.6.4 Learning factories

The learning factory concept adopts a move from a theoretical, lecture-based concept towards a more active, hands-on, and student-centered approach, thereby ensuring that

problem-based learning becomes integrated into the learning process in a higher education course that adopts this concept (Sackey et al., 2020). Learning factories offer an application-oriented technology and innovation platform. This platform allows research and development until the market maturity of production processes, production technologies, and final products (Tish & Metternich, 2017: 92).

The Learning Factory can be updated to provide the necessary and latest knowledge foundation for manufacturing at any given time. In this way, novel ideas can be exchanged, and new ideas and solutions can be balanced against time and cost that influence real-life decisions (Mavrikios, Georgoulias & Chryssolouris, 2018: 2). The advantage of the Learning Factory approach is the fact that companies often must deal with the latest technologies and know-how of the present day. As such, Learning Factories offer a high potential for innovation transfer (Gärtner & Mark, 2022; Hader e al., 2022; Tisch & Metternich, 2017).

Current practices indicated the inclusion of mostly prototyping. In general, prototyping exercises are intended to stimulate the students' active experimentation with basic training in volumes, composition, and so on. Schaeffer and Palmgren (2017) stated that prototyping exercises were designed to encourage and stimulate students to actively experiment with basic training in volumes, composition, and more. Students are also expected to contextualize the design scope and explore their ideas by experiencing and experimenting with different materials.

The practice of using prototyping in design education has its limitations (Schaeffer & Palmgren, 2017; Petrakis et al., 2019). Students may come to think of their prototype as the final product. This is often true in time constraints where students don't get the chance to do further development and refining to reach the final product (Petrakis et al., 2019). In the event of continuing the process to refine and develop the final product, it is important to keep in mind that this process is time-consuming and often very costly (Toweh, 2019). In true product development, the prototypes often get thrown away in the end.

Riemann et al. (2021) stated that learning factories are, in their physical design, a complex and expensive tool for educational training. Even though there are high-quality learning factory concepts available today, the complexity of the industrial production environment makes the transfer of intended competencies into the operational application situation a

challenging task. He argues that with Virtual Reality (VR), this challenge can be met by adapting the learning environment and personalising the learning layout to the various participants.

VR can be explained as an interactive computer-based simulation of reality (Schwan & Buder, 2006). The use and implementation of VR have seen swift progress over the past decade, especially in terms of device performance. Tisch and Metternich (2017) refer to this proposed approach and state that it should include a systematic approach to developing action-oriented learning factories using VR.

As stated previously, manufacturing faces a rapid change of enabling technologies, tools and techniques, in particular the advancements of Information and Communication Technology (ICT), also known as 'INDUSTRY 4.0'. Therefore, Mahmood et al (2021), stated that there is an elevated need for industrial workers and engineers that should be trained in digital technologies to successfully cope with these changes and new demands. Mahmood et al. (2021) concluded by stating that "higher education plays a vital role and is a major driver in building a skilled and knowledge-based workforce for the next generation manufacturing".

2.7 Holistic sustainable learning

Sustainability has been centered on addressing the needs on a social, economic and environmental level. The objective is to address everyday challenges with an outlook that focuses on all three of these levels. Although sustainability has become an everyday phenomenon in today's higher education (Burns et al., 2018) the need to develop a better understanding of how to teach sustainability has increased. Kopnina (2020) concurs and argues that the focus on the teachings of Sustainability does not take a holistic approach. She further stated that there is little discussion on the topic that debates the need to address the ecological integrity that is important for the future of human and non-human species. The aim of successful education towards sustainable living is based on getting the competencies for achieving transformation (Kioupi & Voulvoulis, 2019).

2.8 Summary

The world is experiencing an environmental emergency that requires explicit efforts in terms of thinking and acting in design. The effects and consequences of the anthropocentric

manner of producing, consuming, and living have grown painfully clear (Tassinari et al., 2020; Manzini & M'Rithaa, 2016; Manzini, 2016). This review detailed the complexity of sustainability and sustainable manufacturing. The purpose of the literature review was to explore the subcategories that contribute towards sustainability. This was done to establish the relevance and implications of these categories on Product design education.

Sustainability was placed in context and the significance of climate change, the motivation for developing a circular economy, and the implementation of green and lean manufacturing were explored. The literature has shown that although there is a strong push to include these concepts in the industry the work has just begun. Thus, highlighting the need for higher education to play a larger part in the campaigning and implementation towards sustainable living.

CHAPTER 3
RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter explains the approach taken for the research and why this was necessary to ensure a clear understanding and investigation of the research problem. By planning the research design effectively and making use of appropriate research methods, it has been possible to explore the current Product design undergraduate programmes at the three universities. Qualitative methods were used to engage with aspects of Product design education, and to identify possible directions that can be used in the curriculum to contribute to the future of sustainable manufacturing (Erickson, 1985; Taylor, 2005). In this chapter, the methodology and research design that was used to investigate the existing courses are discussed. The various measures of the methodology are explained and the advantages of e-mail interviews (Pell et al., 2020) are explained. It further outlines the process of selecting participants in section 3.5, followed by the ethical considerations in section 3.6 and concludes the chapter with section 3.7 explaining the measures and analysis that were applied at the end of the study.

3.2 Research questions

I gathered all data to evaluate the main research question and the two sub-questions:

- How is sustainable manufacturing referenced and encouraged in Product design higher education curricula at the contributing university?
- What are the pedagogical tools used in the curricula to promote a sense of responsibility in carrying sustainable practices from a university setting into the Product design industry?

The research plan and the outline of the methodology were developed to address these questions. The next section will describe the rationale for applying a qualitative approach to the study.

3.3 Research Design and rationale

This study made use of qualitative research methods to create meaning from all research collected and presented. Various data collection methods were employed namely a literature review, individual interviews, questionnaires, participant observation, and journaling. Different research tools were used to support these activities including memos (Chun et al., 2019) as a form of journaling (Tuckett & Stewart, 2003).

The concept of sustainable manufacturing, and the presence thereof in curricula, informed the design and logic of the research. The DesignBRICS project focussed on three main topics. The topics were design4ecology, design4manufacturing and design4futures, and my participation in the designBRICS project was linked to the design4manufacturing module. As such the concept of sustainable manufacturing was the focus during the field trips to AHO University in Oslo and Hunan University in Hunan.

The research questions delineated the main research areas. Once these areas were identified the process of how the research could be done was clarified and outlined as in Figure 3.1.

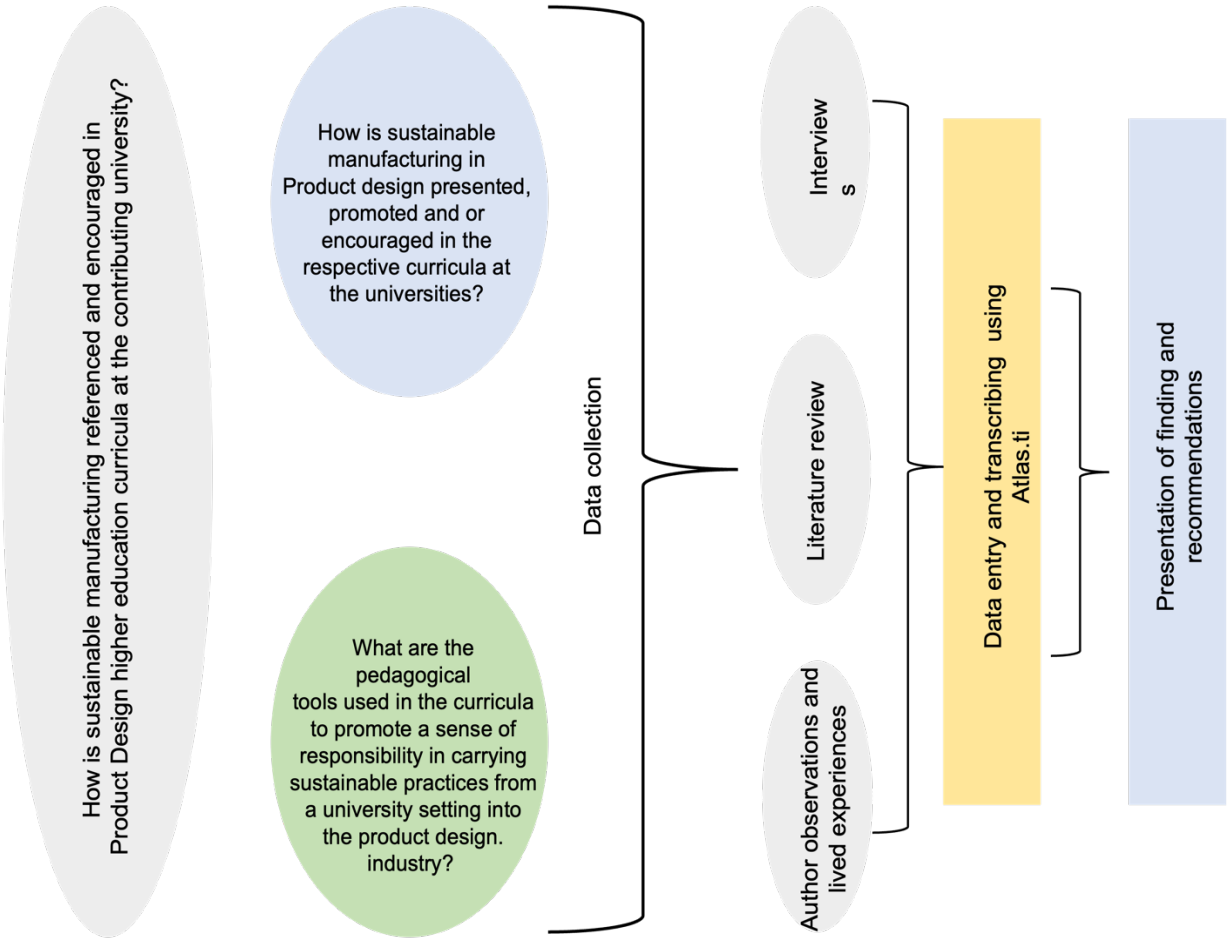

Figure 3.1 Research methodology outline (Author's construct, 2021)

The two sub-questions guided the information pursued from all three data sources namely literature, the academics and researchers that were part of the designBRICS project, and the author's own experiences and journaling. The figure shows that the three areas of data sources constituted the data that was analysed in the Atlas.ti programme to find connections, commonalities, and differences.

Qualitative research methods were used, and Lincoln & Guba (1985) defined this approach as a journey towards 'understanding'. Denzin and Lincoln (2005) further developed this notion with a more descriptive meaning, they defined qualitative research as a multimethod in focus that involves an interpretative, naturalistic approach to the subject matter studied. This sentence does not make sense and needs rephrasing, look it up again and relate it directly to your research method/s. Qualitative research can include a variety of empirical

materials such as case studies, personal experiences, introspective reflections, life stories, interviews, observations, interactions, and visual texts (Denzin & Lincoln 2011). This study made us of interviews, observations, personal experiences, and introspective reflections. This study was motivated by my lived experience (Chisin, 2013) during my Product design studies as an undergraduate and the field trips while visiting universities in Norway and China. As such the research followed an empirical, interactive inquiry approach and by making use of e-mail interviews, evidence was provided that supported detailed and rich descriptions of the defined setting (Dahlin, 2021; Archibald et al.,2019; Braun et al., 2017; Conner et al., 2008). The process of the empirical interactive inquiry is made visible in Figure 3.1

3.4 Research Methodology

Table 3.1 illustrates the data sources for each sub-question, the focus areas, and the data type.

Table 3.1 Research questions with research methods and data types

Research Sub Question	**Focus area**	**Research Method**	**Data Type**
How is sustainable manufacturing in presented, promoted, and or encouraged at three participating universities?	Sustainability related to Product design	Review of Literature	Literature Review
How are the key areas of sustainability currently being explored in curriculum and teaching and learning practices at three universities?	Sustainability	Review of Literature	Literature Review
	Curriculum	Desk research of websites and university databases/curriculum documents interviews	Literature review and document analysis Written responses Google forms and emails
How are the three universities ensuring that students feel a sense of responsibility for carrying sustainable practices in Product design to the industry?	Teaching practices	Interviews	Written responses email interviews
	Curriculum	Interviews with selected researchers and academics of the designBRICS project Participation and reflection using an	Interviews Documentation on curriculum structures Journaling

		autoethnographic approach by reflecting on experiences and data collected in the designBRICs programme.	
	Industry Influence	Interviews Review of Literature	Written responses Using Google forms and emails Literature review

3.4.1 Data collected from e-mail interviews

A qualitative research study has a range of methodological options available for the development of a research design—including electronic research methods (Dahlin, 2021). During the COVID-19 pandemic and in times of climate change, the use of electronic research methods has become even more relevant (Lobe et al., 2020; Teti et al., 2020). Dahlin (2021) recognised that in the current literature on electronic research methods, there are few deliberations on how to use and implement these strategies. Dahlin (2021) further stated that "it is rare to come across guidance for how to develop approaches for, and practically engage in, electronic research methods". Electronic research methods are becoming more recognized as acceptable research methods to be adopted as a methodological approach (O'Connor & Madge, 2017).

In this study, electronic research methods refer to the e-mail interviews I administered asynchronously to seven participants. One advantage of e-mail interviews is that it offers participants time to reflect on the questions and allows time for personalizing their responses (Pell et al., 2020). Ayling and Mewse (2009) pointed to another advantage inherent in this method, in that e-mail interviews are already transcribed. Researchers have also noted that participants that are technologically reachable might respond to emails and other electronic communication quickly (Bowden & Galindo-Gonzalez, 2015; Ingley et al., 2020). The fact that e-mail interviews work well over different time zones proved beneficial and cost-effective. Since I travelled to Norway and China during the designBRICS programme, additional travelling between Europe, China and South Africa was eliminated.

Therefore, participants were interviewed via e-mail due to its flexibility, and the fact that

researchers have illustrated that email interviewing can represent the complexity of social practice on the internet (James, 2016) while allowing respondents to have time to offer responses that are well-written, rich, and informative (Gibson, 2010; Mann, 2016). This semi-structured interview style also allowed respondents to expand on topics and possibly introduce new lines of inquiry.

I used e-mail search and interviews to explore and investigate how an iterative view and approach may offer contributions that may add to the curriculum offered to Product design students, by placing the focus on sustainable manufacturing in the industry (James, 2016). The e-mail interviews were the main primary research method used in the study. The questions posed in the interviews were formulated to include mostly open-ended questions (Bowden & Galindo-Gonzalez, 2015).

The email interviews allowed participants in the study to reply in their own time and the need for face-to-face meetings was eliminated, beyond the first meetings which occurred during the field trips. Fritz and Vandermause (2018) did a study in which they reported the advantages and disadvantages of email interviews (Figure 3.2) with a clear indication that the use of an e-mail interview compensates the face-to-face interview in a satisfactory manner. Where clarification to email questions were sought, Whatsapp and Facetime were useful to connect with participants directly for swift elucidation.

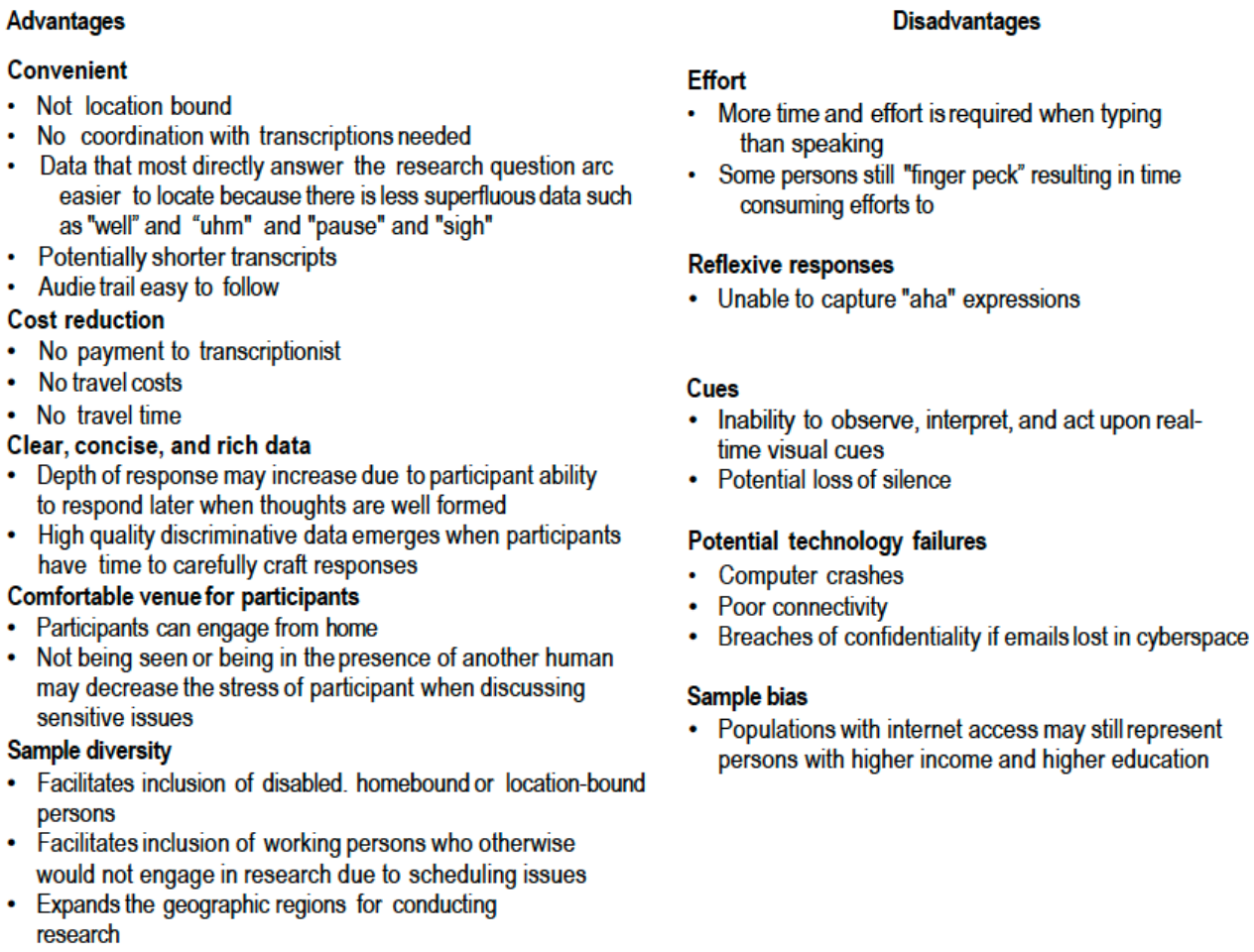

Figure 3.2 Advantages and disadvantages of Email interviews (Fritz & Vandermause, 2018)

3.4.2 Traditional literature review contribution

The literature review process in this study served two functions. Firstly, it informed the background of the study and helped in identifying the research questions that were posed to the participants. Secondly, it contributed to the understanding of the extensive scope that the concept and methods of sustainability embrace (Freitas & Almendra, 2022).

The literature review (Grant et al., 2009) was done to discover contextual considerations for decision-making in the study and the formulation of the questions. The literature was collected using Google Scholar and the database Scopus. These databases proved to be large abstract and citation databases and consist of peer-reviewed literature, books,

scientific journals, and conference proceedings (Nobre & Tavares, 2017). Although the first published work on Sustainable Production Development (SPD) dates to the 1990s, the retrieval process for this study was limited to articles, books, and conference papers published since 2000.

In the quest to find the most suitable literature for the literature review, the following keywords were used:

- Product design
- Design
- Sustainability
- Sustainable manufacturing
- Circular manufacturing
- Circular economy
- 4IR design
- Design technology
- Sustainable education
- Sustainable teaching
- Product design education
- Sustainable pedagogy

The results were scanned for appropriateness by reading the abstract and looking for links to the research questions. This process helped eliminate articles that did not address the research questions or showed any real contribution to the aim of the study.

The literature review was not limited to specific types of publications but was guided by the relevance to the study and the date of publication. Although the concept of Sustainable Production Development (SPD) is not new and can be traced back to the 1990s, the retrieval process was limited to showing the latest contributions since late 2000. The Google scholar search was limited to publications after 2015. The narrative literature review focuses on the contributions that were made since the adoption of the Sustainable Development Goals (SDGs) by the United Nations in 2015.

The decision to focus on publications after this water-shedding treaty did not disregard the

contributions of earlier years. Publications such as Savitz (2006), Ramirez (2007), Stephens et al. (2008), Slaper and Hall (2010), Rieckmann (2012), and others alerted to the need for living sustainably and the important role that education plays to achieve this goal.

3.4.3 Literature and data collection process

This study focused on two main topics namely, sustainability in manufacturing and Product design curricula. The logical approach that was applied to identify the possible literature that would contribute directly to the research questions is presented in Figure 3.3. It outlines the flow process used for identifying the contributing literature. The keywords that were used in both Scopus and Google scholar were sustainability, sustainable manufacturing, green manufacturing, circular economy, technology and 4IR, Curriculum development, pedagogy and learning factories. The searches were limited to publications after 2015.

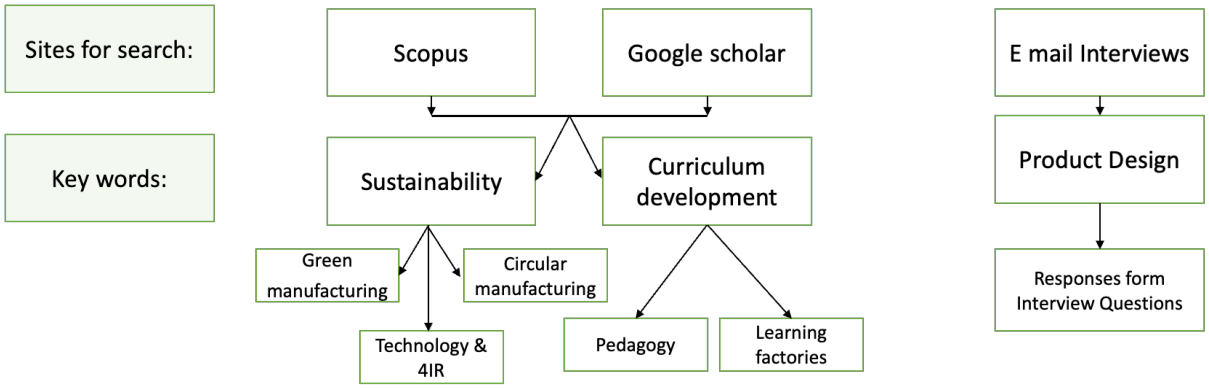

Figure 3.3 Data collecting process (Author's construct, 2021)

In the first search, the results were screened for eligibility in the relation to Product design and/or design education. The next screening process was to focus on the publication titles and abstracts. The areas of focus during the proposal phase of the study helped in the guiding process to identify the relevant contributions. Another selection factor was the availability of the full publications. Due to time limitations, publications that were used in the study were either available online, through the university library services or responses of authors contacted directly.

3.4.4 Autoethnography and reflection

This section of the research represents a highly personalized account of the experiences, observations, complexities, interpretations, and reflections of the time I spent at the two international universities that were part of the designBRICS programme. For this section of the research, I used myself as the subject and the researcher (Chisin, 2013) in the social context of the design4manufacturing module of the designBRICS programme. Through an insider's vantage point, I have recounted and discovered my own experiences using the qualitative methodology of autoethnography (Ellis & Bochner, 2000). While I have visited two vastly different countries and universities, the reflections and introspection I did through the methodology of autoethnography as it relates to the topic of this research, meaningfully assisted in understanding the process of sustainable futures and the need for sustainable manufacturing.

The data emanated from reflexive journaling, my and reflective analysis of my experiences. My notes on experiences, the different observations I made, the complexities, the interpretations I derived, and the final reflections, became the key elements of my autoethnographic contribution to the full data set. Figure 3.4 illustrates some of the summaries I have been collating during the process of analysis.

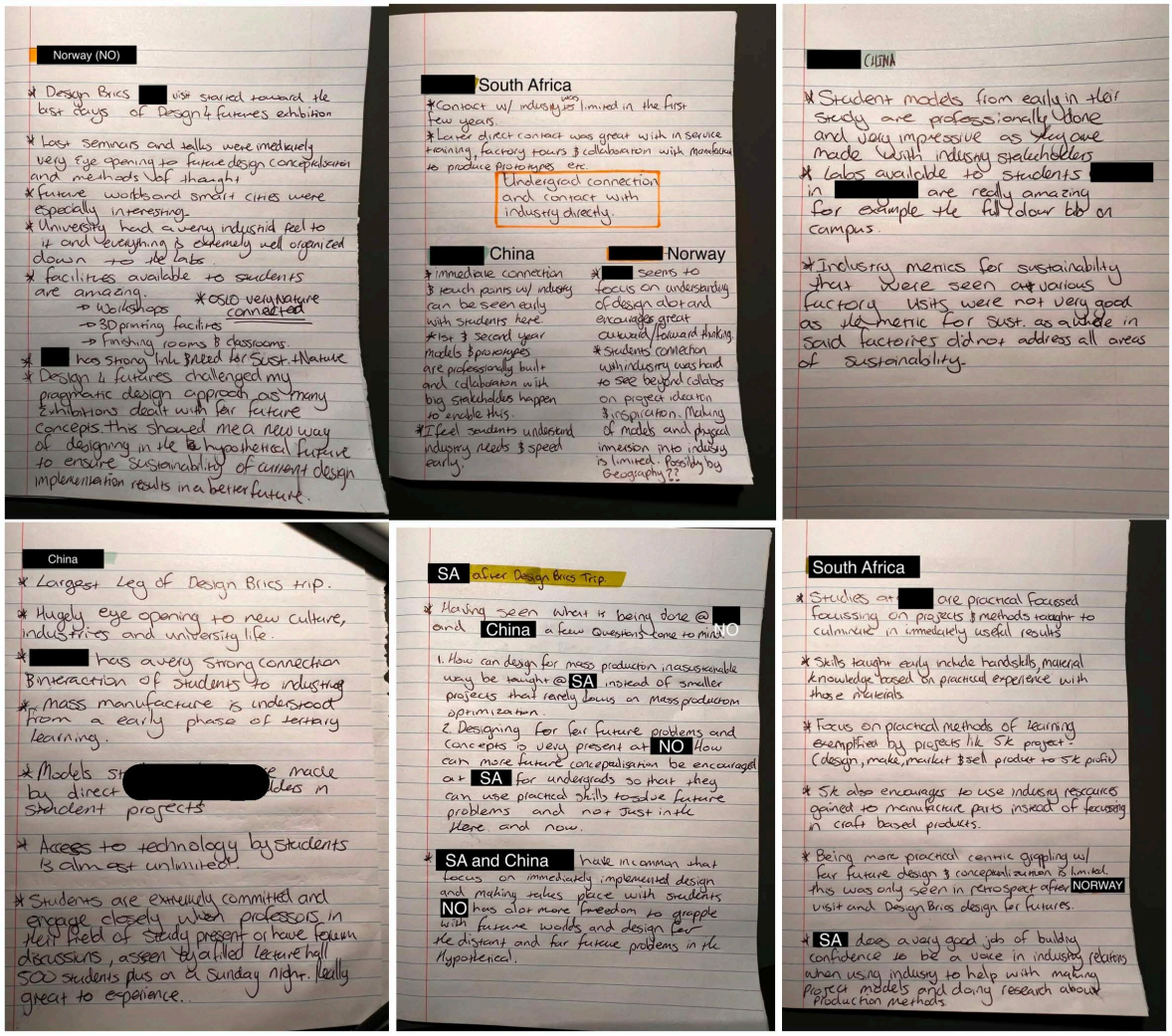

Figure 3.4 Personal notes by Author (June, 2022)

Adding this data to the rest of the data gathered through the email interviews and the literature reviews served to provide insightful understandings.

3.5 Research participants

A purposive sampling method was used for the study (Campbell, 2020). A database, in the form of a list, of the potential academic participants, was created. The aim was to secure a minimum of nine participants. As a participant in the designBRICS project myself, I had access to the list of participants. Since the participants in the Design4manufacturing module were limited to three people in the year of my engagement I had to reach out to participants

and academics who were involved in the previous year. The list included academics and senior researchers that are actively involved in the field of sustainability (either as a researcher in projects like designBRICS or as a lecturer). The purposive sampling method allowed for the identification of participants, at each university, who were best suited for the study (Campbell, 2020).

Although the original intention was to use the feedback from nine participants only seven replied. As part of the empirical inquiry, the participants were coded to ensure the anonymity of their comments and contributions to the study (Table 3.2)

Table 3.2 Breakdown of participants

Participant code	Position/role	Institution
SR1	Researcher	AHO
SR2	Researcher	AHO
AC1	Academic	AHO
AC2	Academic	Hunan
SR 3	Researcher	Hunan
AC3	Academic	CPUT
AC4	Academic	CPUT

Potential participants were contacted via e-mail correspondence and their willingness to participate was established. Three participants from each participating country in the designBRICS programme were invited to participate.

Questions were presented to the participants who could respond in their own time while having time to reflect and give feedback without having a time limit assigned to the interview. After the first contact with a respondent, it was decided that although it was planned as an e-mail interview it would be best suited to structure the questions in a Google form. This was done to eliminate possible shortcomings of the e-mail interview as defined in Figure 3.2 on page 35. All the participants will then be able to answer in their own time and the analysis to identify any gaps in the information can be highlighted in a downloadable spreadsheet. Although possible facetime calls were anticipated this was not necessary.

3.6 Ethical Considerations

This study offered opportunities that I could explore by gathering data from students and educators from the identified universities. The study methodology allowed me to assemble, analyse and code information offered by the participants. As such, correct and ethical procedures had to be taken to ensure that all participants were aware of their rights during the research study.

The study was conducted with adults and no minors were involved. All participants were informed that their participation was voluntary and that they will be able to exit the study at any time. The data collected are stored in the secure online folder and when the study is completed all data will be kept in the university's secure data management system run by Figshare. During the research process access to datasets will only be given to direct participants by assigning rights. This includes supervisors who will be given rights to read, edit and collaborate through the data repositories (Figshare at https://cput.figshare.com). It is not anticipated that the data will be used for any other study or work after this because the data will relate to the current curriculum which will be outdated after five years of storage.

In addition, ethical considerations and clearance were granted by the Faculty of Informatics and Design's (FID) ethics committee and written consent by the Postgraduate Office was obtained, see Appendix A.

3.7 Measures and analysis

In this study, the data collection and analysis were done as a parallel process. The first task was to select the most useful and pertinent literature to underpin the study, all the while reviewing and adding literature as the study progressed. Publications of Master's studies relating to Sustainability and Product Design education and published articles on the topic at hand was the starting point to shape the initial thoughts on the research question. This process helped shape the possible questions that could be presented to the participants of the case study. There was a strong influence of my own experiences as undergraduate students and exchange student that helped frame the questions. The interview data was consolidated, and the transcriptions refined (Dahlin, 2021). Using Google forms facilitated the initial analysis of the information shared by the contributing participants. Although, the process required reading and rereading the data to fully familiarize oneself with the

responses and possible correlations between the answers.

The next step involved coding the transcriptions of all data and labelling concepts and common themes (open coding) explain open coding better (Cho & Lee, 2014). The data from the relatively small group of participants were analysed manually and was not part of the data analysis process of Atlas.ti. The two set were only cross referenced after the final analysis of each set.

At this point, there was information unrelated to the research questions but that was kept for possible future use. Only the data that was deemed relevant and addressed the research questions were used in the next step of analysis.

Data analysis software, Atlas.ti, was used for the coding stage for the publications. Furthermore, relationships among codes (axial coding) were foregrounded. Through this process, the most significant and frequent codes were identified, known as selective coding (Cho & Lee, 2014). At this point, the discovered codes and categories were compared with one another to determine the relationships among the different data types. The relationship identification process allowed me to form a point of view of how core themes and related data can influence the future of curricula. The relationships drawn will explain the process and the pedagogy that can contribute to Product design education (Cho & Lee, 2014).

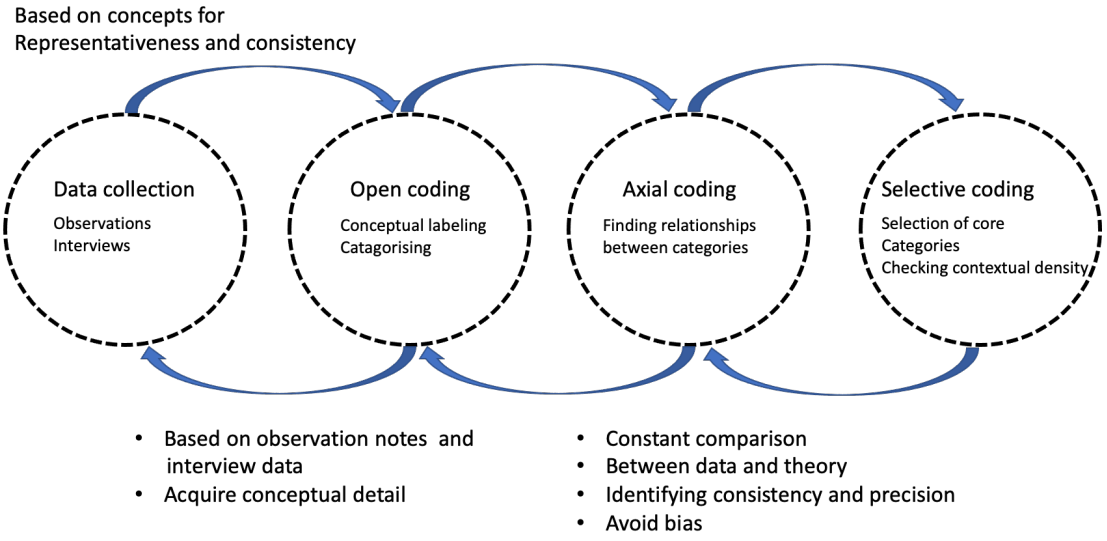

Figure 3.5 Data analysis procedure (Mezmir, 2020))

The research data was uploaded to the data analysis software Atlas.ti. Using Atlas.ti in the data analysis process contributed to making connections between various codes and allowed for finding meaningful associations as illustrated by means of a Sankey image, as shown in Figure 3.6. The Sankey diagram visualizes the flow from one set of values to the other.

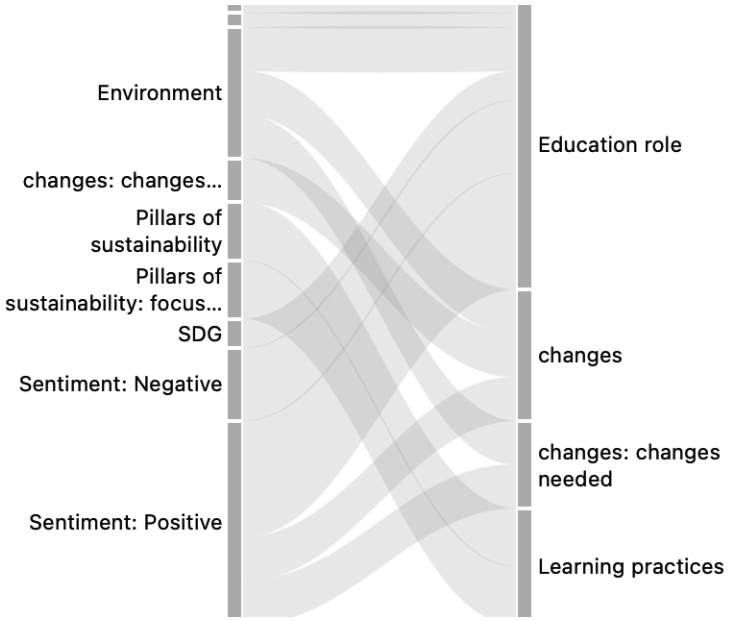

Figure 3.6 Sankey image from Atlas.ti (Authors construct, 2022)

The Sankey generated by Atlas.ti is interactive and allows the user to interact with the links with the move of the cursor on the screen. When placing the cursor on a specific link or value, the programme will highlight the corresponding values or links on the opposite side. In this way cross linkages can be identified.

3.7.1 Data analysis

Before the data analysis could be done all information had to be organized in a way that allows for the thematic analysis that I applied to the study. This allowed me to identify relationships between the sources (Cho & Lee, 2014). Although a narrative analysis seemed like a strong possible choice for the study, the focus of this study was not to understand how the research participants constructed their story based on their own experiences. The study was based on the data collected to build a case study (Teegavarapu et al., 2008) around what was happening in the Global East, Global West and in Africa. Therefore, for the

thematical analysis I applied a computer-assisted qualitative analysis software.
Atlas.ti (Friese, 2020) is a software programme that can be used for the analysis of written data such as interviews and news transcripts, open-ended responses, and similar data sets. See Figure 3.5 for an example. In Atlas.ti (Friese, 2020) a code can be a basic description, a concept, a category, a subcategory, or a wildcard that changes an association in a system (Friese, 2020). The interminable operational possibilities of the software made it a suitable analysis tool for this study. The software itself does not dictate how to use a code but provides this entity as an item in the toolbox (Friese, 2020). This function allows the user to generate own codes to the data as part of the open coding process. As new themes emerge new codes (axial coding) were added until existing codes found new meaning. As the process continued the core categories were defined and the themes started to show more certain context.

The programme allowed for multiple documents to be opened side by side on one screen which assisted in the identification of possible codes in the data (Friese, 20 20). This possibility made the task of cross reading between documents more convenient. Assigning the codes made it possible to organise data in different visual formats (Friese, 2020). The process can be described as resembling building a puzzle; the process of looking for links or patterns in each piece that might link to another piece. If the user discover there are codes that have comparable connections, they can be dragged and dropped to create data segments. Key words generated from the research questions were used for creating codes or tags.

My own reflective notes and the feedback from the research participants were cross-referenced with the computer aided data analysis only afterwards and was done manually. I scanned for similar information that was present in my own work and formed the researcher's reflections.

3.8 Summary

This chapter presented the methodological design used to conduct the research work in this project. The reason for using a thematical analysis was declared. It further described the empirical interactive inquiry approach using email interviews to find rich descriptions of the current practices and to link that with some foundational literature on researchers'

worldviews and theoretical frameworks on sustainability. This was framed within the research questions. The application of a computer-generated software analysis proved to be the more comprehensive option to use in the study. The themes that emerged after the selective coding could be coordinated with the themes that were identified from participants' data. The next chapter will report on the key contributions that emerged from the research process described in this chapter.

CHAPTER 4

PRESENTATION, ANALYSIS AND DISCUSSION OF THE RESEARCH FINDINGS

This chapter is presented in two sections. Section A will present the findings and analysis of the research and Section B will focus on the discussion.

SECTION A
PRESENTATION OF FINDINGS AND ANALYSIS

4.1 Introduction

The study focused on how sustainable manufacturing is referenced and encouraged in Product design higher education curricula at the participating universities, namely AHO, CPUT and Hunan. This chapter presents the data findings,

and analysis of the findings. Firstly, the structured review of the literature on the awareness, adoption and implementation of sustainable manufacturing processes that may be required to be part of a Product design undergraduate curriculum will be outlined and discussed. Secondly, the data from the e-mail responses by Product design academics will be presented. The quotes used in this chapter are reference against the codes presented on Chapter 3.

Participant code	Position/role	Institution
SR1	Researcher	AHO
SR2	Researcher	AHO
AC1	Academic	AHO
AC2	Academic	Hunan
SR3	Researcher	Hunan
AC3	Academic	CPUT
AC4	Academic	CPUT

The chapter will present the outcome after the two data sets were cross-referenced and similarities and differences identified which may form part of possible new knowledge that could be included in the future of Product design education.

4.2 Teaching and learning practices at the three universities

The designBRICS project module Design4manufactiring involved universities from South Africa, Norway and China. The information reflected in this section will present the responses and comments from academics and researchers.

The initial aim was to target three people from each of the institutions that were part of the project. The questions were shared with all participants via a Google form, but after the due date, there were only seven responses. The non-responsive participants were reminded and asked to respond to the request for participation. The following information reflects the input from seven of the nine participants who ultimately participated.

The Google form was structured so that the first part of the questions asked for consent and permission to use the information as part of this study or possible journal publications. Here, one participant did not permit to share the information and the information provided in the responses will therefore not be used for dissemination but rather the information contributed to a greater understanding by the author but is not directly reflected in the discussion that follows.

4.2.1 Students in Product design

As part of understanding the academic input from these institutions, it became clear that although sustainability plays an important role in each programme, it becomes mostly focused on the higher levels of learning and not in the undergraduate phase. Answers that were recorded on the aim of the programme were diverse. Although the recurring message was the need to enrich students learning so that they can develop design capabilities through systems thinking, lateral thinking, developing professional skills and an open mind while being able to do critical reviews of design. Not one of the respondents mentioned awareness about sustainability.

Another fact that was highlighted was the variance in the subject matter on offer throughout all the programmes that were reported on. Often similar design functions were labelled with different names for example *Transform* (AC1) and *Technoform* (AC2). This observation could be assigned to the possible entrance requirements. Three of the six respondents

stated that students were selected on academic results from school as well as a submission of a practical portfolio (SR1, AC1, AC3). The other three pointed to a more fluid selection process but also mentioned prerequisite subjects and credits. This could point to the completion of a Design foundation year which is often the norm in European Universities (Blachnitzky, A. 2011: Morgado, 2010).

The next set of responses, on the expected knowledge of sustainability, did reflect the same message throughout all the responses. None of the respondents expected knew students to have much knowledge of sustainability; however, it was reported that the youth of today know much more about the subject than students entering a few years earlier (SR3). The academics indicated that awareness of sustainability has become a global trend.

4.2.2 The philosophy towards learning and teaching

After considering the typical students that opt to study Product design, the focus shifted toward the philosophy or theory underpinning the offering of the programme. Respondent AC1 mentioned that this is open to the lecturer who will be offering the subject or module. Each lecturer approaches his or her teaching from a personal philosophy. This points towards a very open programme offering where the teaching approach does not include a fixed structure. The most standard answer from all seven respondents was that an iterative design process was applied across all three university programmes. This process allows for continuous improvement on the concept, the prototype and the final product. Experimentation and innovation were rated as an important part of the Product design process by all. Additionally, all seven participants agreed that the most important focus within the programme includes a focus on Product, Service and Systems. Therefore, as students are making decisions during the iterative process they should critically explore and focus on all three aspects: Product, Service and Systems.

When asked to elaborate on the teaching philosophy the responses were in agreement that teamwork plays an important role in the teaching practice of Product design students. The responses also acknowledge the fact that design as an occupation is subject to teamwork. Very seldom design as task stands by itself and therefore the skills and emotional maturity that are required as a member of a team should be a principal focus in the education of a Product designer (AC1, AC2, AC3, SR2).

Two participants stated that students need to have the ability to present ideas as a group and develop collaborative knowledge through experimentation and reflection to help in finding solutions to complex problems (AC1, AC2). This set of feedback is linked strongly to the concept of directing students to think about solutions when sustainable manufacturing is concerned. It is the ability to connect with others that strengthen the journey towards responses. One participant in the survey did mention the importance of acquiring the correct vocabulary within the discipline to be able to complete these tasks according to the expected standard and high quality (AC1).

4.2.3 Curriculum information

Regarding the four pillars of sustainability namely human, social, economic and environmental factors (UNESCO, 2015), participants were asked to explain the inclusion or exclusion of the key area in Design for Sustainability in the Product design curriculum. Although each of the four pillars was framed as separate questions, the overarching message was that the four pillars are equally important. The goal, set out in 2015, can only be achieved when the attention is placed on the interdependencies of all four pillars.

With regards to the 'Human' pillar of sustainability, the respondents agree that the Product design function as presented in the various syllabi is based on the needs of the user. More often today the curriculum points towards human survival and the right to equal treatment of vulnerable groups. Therefore, a design curriculum should have a holistic approach to encompass all aspects of the four pillars (AC1, AC2, SR1, SR2).

One statement emphasizes that in the world everyone strives towards a sustained and inherently long-term sustainable social system (AC1). Society places a high priority on imagining a better future for all and often the projects that students take on as their years' research direction place significance on the human aspect and social systems (AC2, AC3). Although the respondents agreed that all four pillars are equally, it is noticeable that they all perceived the inclusion of the influence on society more important than the influence of economics. Many responses in the feedback mentioned that although economic influences are present it is not a direct part of the curriculum. This is evident in quotes such as "Economic aspects are rarely present in the discourse of the curricula" (AC2) and "If the

design has a holistic approach where the life cycle of the product is considered, economics will play a role but will not be the only thing considered" (AC3). AC3 stated that "All year groups study economics and the impact of design in the economic sphere in a business/ entrepreneurship subject" which shows a disconnect between design and economics within the offering of the subjects. This stance may highlight a possible reason for Product designers not to focus on cost as part of design and that may be associated with being unsustainable. AC3 did refer to the concept of holistic design. This he stated, include notions such as disassembly, recycling, and repurposing that are more in line with sustainable living and manufacturing.

As for the focus on the environment, the responses varied from stating subject names of where environmental issues are placed, to the fact that the environmental issues are part of a holistic approach, to the curriculum and the exploring of materials used. Statements included "Students are expected to look at ecological systems and engage with environmental and local ecological views (AC1), 'This area has been mostly the material explorations and alternative manufacturing tech." (AC2 & SR2) and "Design decisions are based on extensive research and investigation. These decisions, including environment, are part of the process of viewing the developed concept holistically. From the initial seed of the idea to the disassembly, recycling, and repurposing" (SR1). The life cycle of products and services should be environmentally sound, reducing carbon emissions and mitigating the impact of climate change (AC2, SR3). Achieving the environmentally focused outcomes is brought about with iterative design processes, where students design and redesign prototypes until they can meet the required standards expected in the projects.

In the next set of questions posed to the contributors, the differences in the approach towards introducing sustainability and sustainable manufacturing were explored. The question "Express on a scale from 1 to 5 how much of the curriculum content focusses on the concept of sustainable manufacturing (SM)" was presented with answers required for the academic offering from first to third year of studies. Although this is a qualitative study the questions were best posed with a rating on a Likert scale. Figures 4.1, 4.2 and 4.3 show the bar charts for the first, second and third years of study as per the responses where 1 shows very little exposure towards Sustainable manufacturing and 5 a high exposure to the concepts. The bar charts indicate the growing importance of sustainability awareness at level 1 of the studies. As students' progress towards the senior level of studies. In the

narrative responses, the participants did express the need to introduce the concepts of sustainability from year 1. At this level, the participants stated that issues around sustainability will be an introduction and a widening of scope regarding the topic

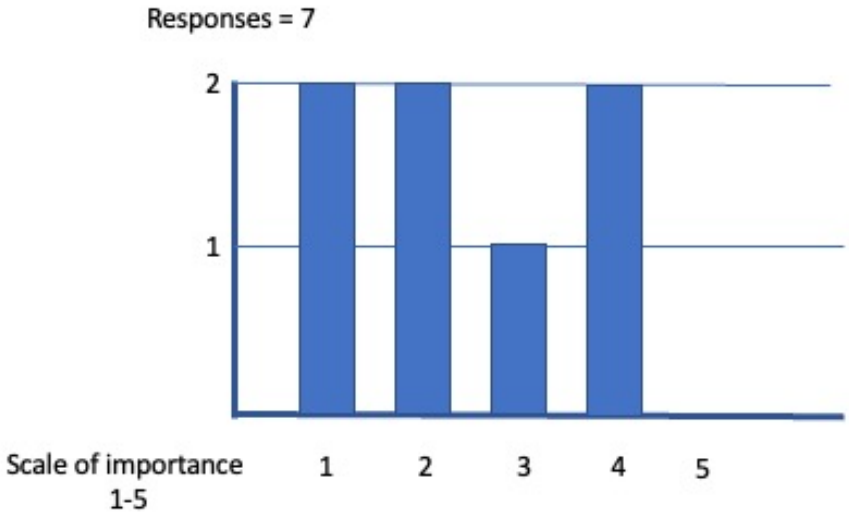

Figure 4.1 Sustainability and sustainable manufacturing awareness in Level one of the studies.

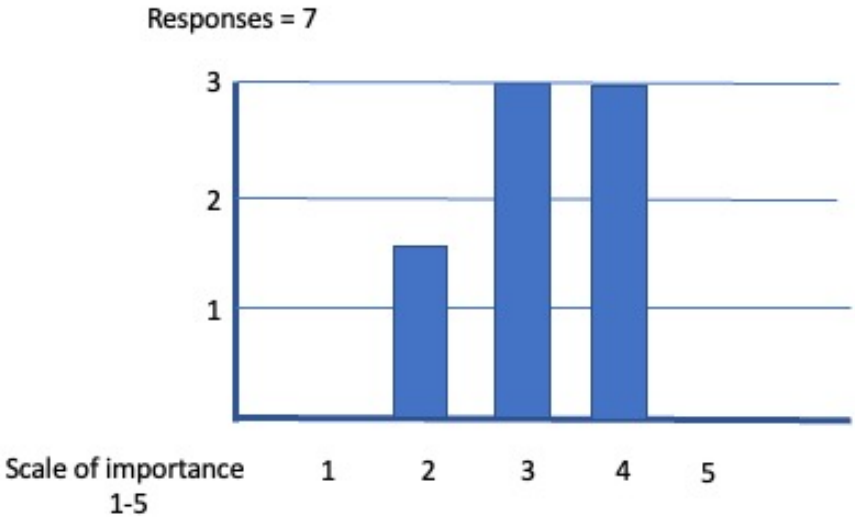

Figure 4.2 Sustainability and sustainable manufacturing awareness in Level two of the studies.

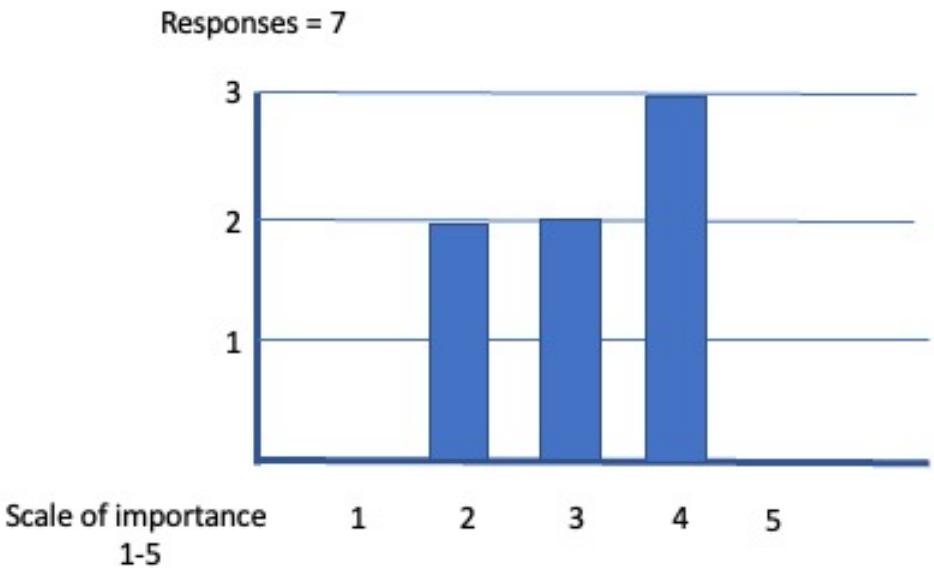

Figure 4.3 Sustainability and sustainable manufacturing awareness in Level three of the studies.

The respondents were unanimous in the fact that all manufacturing as part of sustainability should be reflected in a Product design curriculum with sharing how important it is to minimise the environmental footprint of all products/solutions. Although Figure 4.2 indicates that the first year does not place such a high importance to manufacturing yet. One of the participants (AC1) opted to not score the question but stated that “All manufacturing should be sustainable. This is communicated to students constantly. The next two Figures 4.3 and 4.4, show that the more senior levels start to engage with the concept of sustainable manufacturing in a more concentrated manner. This correlates to the curriculum outlines of the programmes, where the first year of study is explained as a foundational year were students build on general knowledge and skills.

4.2.4 Climate changes and sustainability

Manufacturing globally is inherently linked to Climate Change (WEF,2020). Participants were asked to respond to the importance of future designers having the tools and knowledge necessary to combat the impact of manufacturing on sustainability. Five of the seven

responses were rated but two participants opted for replying with statement.

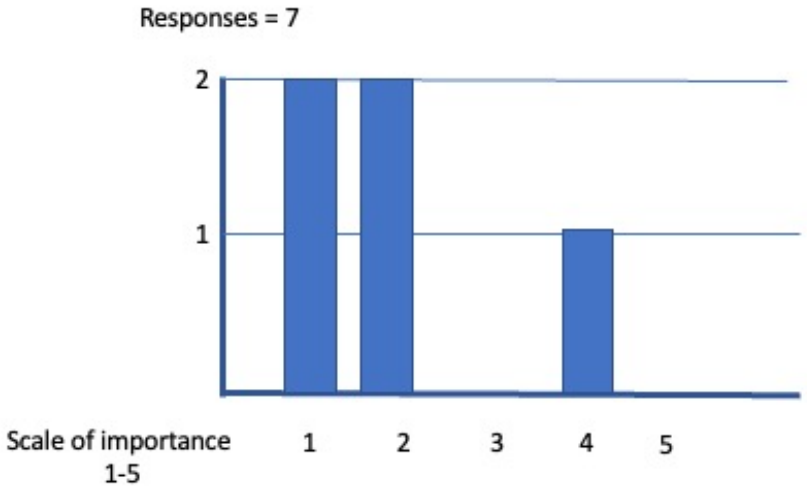

Figure 4.4 Importance of climate change knowledge for Product design students

The two respondents added a comment rather than a score:

> *"Climate change is a complex issue where multiple factors including politics need to be considered. Discussions on what design decisions mean and how they impact the world at large are often discussed. This is part of the holistic approach to Product design" (AC2)*

and

> *"Protohype is largely focused on Climate change as a starting point to tackle discursive and speculative design to formulate future scenarios" (AC1)*

4.3 Pedagogical tools used in delivering the undergraduate Product design curricula

The respondents shared their learning and teaching approaches in various responses throughout the questions that were put before them. The most referenced responses showed that their approach leans on experiential learning, learning by doing and replicating the professional design studio environment. All three universities involve some form of industry learning but no participant indicated that they make use of Learning Factories as such. This means that the students learn aspects of theory, and then apply the principles in practice. They tackle real-world problems to learn creative thinking and apply the iterative design process, underlined with lateral thinking through refining their designs (Mavrikios et al., 2018). AC3 explained that students are assigned social or environmental problems that

is relevant in the year of their studies. An example is the water saving project that was assigned to senior students in 2018 when Cape Town was running out of water supply. Students worked on possible solutions of saving or generating better water supply. AC1 on asked students to come up with futuristic concepts that will make a difference to the environmental crises globally, leaving the project open to focus on any concept of the student's choice.

This is aided by class discussion and critiques where the justification for all decisions is critically and constantly being explored. Furthermore, most responses showed students engaged in group work in most subjects, therefore the teaching methodology is that of learning in groups (AC1, AC2, AC3).

The responses on the use of technology, 4IR/5IR was unexpected. Previously it was stated that the digitally-enabled 4IR has proven to be the fastest period of innovation (Herweijer, et al., 2018; Oke & Fernandes, 2020; Tang et al., 2020) but the responses from the participants shows a different aspect. SR2 said "limited use, except in some cases" and stated "Nothing related, could discuss in the future". Feedback from the Global East produced more related responses. AC2 reported that "These new technologies are introduced and where possible demonstrated and integrated into the curriculum. Technologies like VR, machine learning, rapid prototyping and AI". This feedback correlates with his explanation that students' designs are often manufactured by factories. Whereas AC3 and AC4 reported that the introduction and use of digitally enabled education the Product design curriculum is mostly done in the higher levels of studies such as 4th year or Masters' studies.

4.3.1 Circular economy, green manufacturing, learning factories and the inclusion of Artificial Intelligence

In the final set of questions, the participants were asked to assess the concept of circular economy, green manufacturing, learning factories and the inclusion of AI (Artificial Intelligence). All participants indicated that the concept of a Circular economy and a closed-loop system is present in all the undergraduate programmes. The feedback did however show that this concept features more in the higher level of studies. Instead, the affirmative responses to the awareness and inclusion of green manufacturing were limited. Answers ranged from "I cannot say" (AC4) and "limited" (SR1) to "it reaches 30% of the programme"

(SR2). Seeing that the focus of the study was to understand the impact of sustainable manufacturing in the Product design curriculum, the responses to this question were significant. Green manufacturing and Sustainable manufacturing are often used interchangeably in literature (Inman & Green, 2018) Throughout the responses, product making and prototypes are mentioned, but the significance of sustainable manufacturing processes did not feature as a priority in the teaching and learning process.

Students who do engage in learning in a real live project are mostly placed in industry as part of experiential training. None of the universities has engaged in the creation of learning factories where students learn through briefs or simulated scenarios present in the real world. While being part of the designBRICS exchange, conversations with SR1 and SR2 explained that in most incidences the Product design students will design a new product but will visit factories, mostly in the East to produce these. AC3 did mention that students were send to different types of factories for experience.

Whereas AI has been reported as being introduced mostly in individual projects and on a post-graduate level. It is seen as an add-on tool that students can call on when needed but is not directly written into the syllabus. (AC3 & AC4)

4.4 What does the literature say?

Halliger and Chatpinyakoop (2019) stated that “education that is capable of fostering sustainable values, attitudes and behaviours among the next generation of global citizens is the key to achieving all of the SDGs”. The importance of sustainability being part of Product design education emanates from the fact that the curricula that Product design students are taught represent the channel in which students are prepared for industry, and the attitude towards sustainability they will carry forward and implement in their own lives (Kwagawa, 2007; Stephan et al. 2008; Rieckmannn, 2012; Lozano, 2013 & Figueiró, 2015). Cortese (2010) agreed, affirming that universities play a vital role in knowledge creation and that the inclusion of sustainability into curricula will have wide-ranging implications for the global effort in finding sustainable solutions in the future. The questionnaire responses show a disconnect between the literature and these statements, since there was no definite pedagogy that was applied for teaching sustainability, nor consistent content which covered the focus on human, social, economic and environmental factors in the curricula (AC1,

AC2).

Using the data coded in Atlas.ti, Figure 4.5 was developed to present the close interconnectedness that will be needed to understand and apply concepts of sustainability in the educational environment. The four perspectives are not all-inclusive but have been derived from the literature review and the participants' responses. The responses focused on the fact that the world humans live in, is complex and there are considerable differences between continents.

Figure 4.5 Perspectives needed for understanding sustainability. (Authors construct, 2022)

However, acknowledging differences across the globe, the three universities that were part of the designBRICS project are nevertheless all in agreement with Du Pisani (2007) when he discussed living conditions and how they changed over the centuries. He refers to the work of Alfred Russell Wallace who published a book called *Our Wonderful century* in 1898. Wallace dedicated a chapter on the plundering of the earth in which reference was made to the damage done by the "reckless destruction of the stored-up products of nature and regarded the unlimited extraction of coal, oil, gas and minerals, and the exploitation of the rain forests as an 'injury done to posterity' Van Zon (2002)". The literature revealed that this unethical plundering is still present and may reflect on the differences in ethical living outlooks from one country to the next (Kallianiotis, 2021; Forsyth, 2020).

The Organisation for Economic Co-operation and Development (OECD, 2021) predicted that the continent of Africa is home to the fastest-growing urban population in the world, with African cities expected to be home to an extra 950 million people by 2050. As such, with more than half of the world's population ending up living in cities in the next few years, urban and metropolitan areas will play an important role in accelerating the global uptake of renewable energy sources – particularly in continents with similar living conditions such as in Africa (OECD, 2021). More education focuses on the integration of the economy and social living conditions are required as to create a wider awareness of how the environment will be impacted by the social behaviour and the race towards wealth.

A holistic perspective of knowledge, which may result from an improvement in education, and was identified from the data (AC1, AC2, AC3 & AC4). The reviewed data pointed to the fact that education should contribute to the possibilities that the interconnectedness between people, the planet and profit can be viewed and debated with considerations such as short, medium and long-term outlooks and influences (Baldassarre, 2020; European Commission. 2020, Adomßent, 2014). This proved to be 'contamination' with service and system-oriented design are often encouraged and fostered, therefore the human area is very much explored, although never explicit as criteria". AC2 is in agreement by stating "It should be a holistic approach where the total lifecycle of the product is taken into account".

4.5 Circular Economy (CE)

McDonough (2014) defines the process of design as a critical step because it is the first point that indicates the human intention, and this suggests the role the product and the manufacturing thereof will play towards a circular economy. It is estimated that up to 80% of the environmental impact of a product is determined at the design stage (European Commission, 2009; European Commission, 2020). The concept of a circular economy is of great importance for manufacturers in all industries because it allows them to align their objectives to the 17 Sustainable Development Goals (SDG) as published by the United Nations in 2015 (UN, 2020).

A Circular Economy (CE) paradigm, as a theme, was present throughout the literature review. Academics agree that knowledge of the CE is a means to promote sustainability. AC1 explained that CE is introduced through mini projects and integrated as part of digital manufacturing, but often become part of 'Protohype' as well. AC3 stated that "Circular Economy is often a discussion point when doing iterative design consultations where lateral thinking helps investigate more appropriate solutions". Whereas SR2 and AC4 indicated a stronger of CE only on a more senior level of studies.

Literature on how the 17 sustainable development goals have been implemented or incorporated into the Product design curriculum was infrequent (Freitas & Almendra, Terzioglu & Wever, 2021; Žalėnienė & Pereira, 2021; Wansler, 2020; Loy & Novak, 2019; Figueiró & Raufflet, 2015). Acerbi and Taish (2020:11) define CE as *"the concurrent adoption of different CM strategies, which enable to reduce resources consumption, to extend resources lifecycles and to close the resources loops, by relying on manufacturers' internal and external activities that are shaped to meet stakeholders' needs".* The literature drawn on supports Acerbi and Taish (2020) that the CE includes cleaner production, disassembly, remanufacture, reuse, recycling, servitization, resource efficiency, waste management, industrial symbiosis, and closed-loop supply chain and reverse logistics. This terminology should be part of the new language a Product design student learn. The answers given by the participants were not specific enough to determine if the sharing of a vocabulary list is part of the learning material or if student learning these in the process.

A comprehensive vocabulary can help future Product designer be aware of the fact that decisions taken at the design stage of a product are most important. These decisions will influence the environmental impact that the product will have in the future (Laurenti et al., 2015). The effects can stem from the choice of the correct product adoption, production materials, production processes used, energy use and correct disposal by customers at the end of the product life.

4.6 Summary

The results show that Product design education is presented in a holistic approach across all three universities. The data did indicate that the learning and teaching approaches have slight differences, but all three universities place strong emphasis on teamwork. Interesting

facts were that none of the participants scored the inclusion of economics as a high importance. It was mentioned economics does play a part but is not seen as a vital influence during the iterative process of designing products. The deduction made directs towards learning through experimentation rather than fitting an economical mould. Although no use of learning factories was reported all three universities make use of industry placements through incorporating visits into projects.

The data collected from the participants did show some anomalies. In reported texts all participants placed significance on a focus on climate change but in scoring the importance of climate change four of the seven participants scored it less than 50% important.

SECTION B

DISCUSSIONS

4.7 Introduction

During the course of study various themes were identified. The aim was to explore the inclusion of Sustainable manufacturing in Product design curricula at the three participating universities. The data and the responses from the questions indicated that a more holistic approach toward the concepts of Sustainability and Sustainable Manufacturing is needed.

4.8 Focus on Product design

The programme called Product design is offered in various forms across countries around the globe. Different names and different subject contents are used for building each of the programmes. Ultimately, they all serve to develop students to enter the industry and create products. The participants in this study and literature pointed to the fact that education towards sustainable manufacturing should start with a holistic approach (Velenturf & Purnel, 2021; Participants AC1, AC2, AC3, 2022). A student should be able to place him/ herself in a role which forms a whole. Taking ownership of their actions in dealing in a social, economic or environmental capacity is required (Den Hollander, 2015; Participant AC3, 2022).

Another aspect that was prominent in the literature (Den Hollander, 2015) and the respondents' feedback was the idea that a greater focus should be placed on the

environment. The life cycle of a product and the environmental cost that is inherent in the manufacturing process is of concern. There is a call for manufacturing and services that is environmentally sound and will not contribute to a negative impact on nature or the climate (Den Hollander, 2015; Ramirez, 2007).

These arguments bring to light that the curriculum offered in Product design is far-reaching and does not only focus on the obvious in the syllabus.

4.9 The roots of Sustainable manufacturing

Student exposure to manufacturing was vastly different in each of the participating universities of the three countries. This is visible in the manner the three modules of the designBRICS project were divided amongst the participating universities.

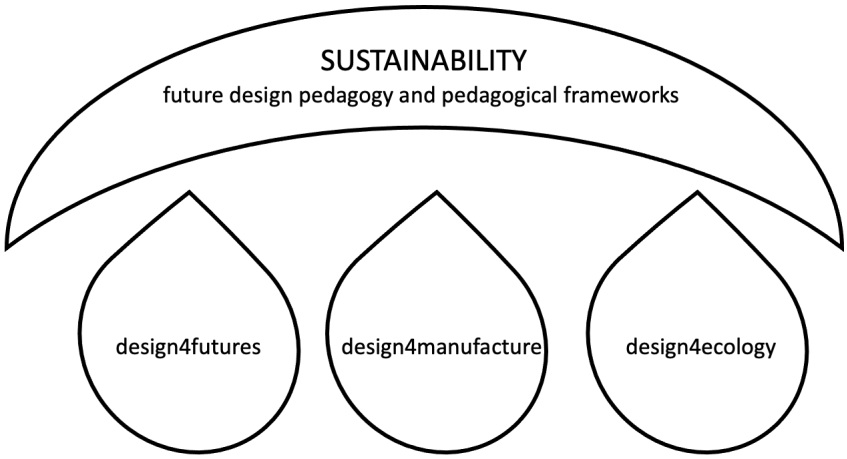

Figure 4.6 designBRICS modules. Author's construct (2021)

The Norwegian university offered the design4futures module, the Chinese university the design4manufacturing and South African university the design4ecology.

As part of the exchange project, I experienced the manufacturing for sustainability at each off the universities as follows. In China, students experienced and understood mass production at an early stage of their studies. They also outsourced production during their studies, whereby the prototypes they developed will be manufactured in industry. Students are close to many industrial plants and manufacturing in many different forms are easy to access. As part of the designBRICS exchange programme we as students moved between three major cities with access to the best possible equipment and plants in the industry.

I experienced a close relationship between the universities and the production industry. This contributed to the understanding of mass production at an early phases of Product design studies. The use of technology is also valued as a contributor towards designing toward sustainability. The negative side of this approach is the fact that the focus on sustainability does not feature in a strong way due to the mass production outlook.

The Norwegian university's approach was based on ecological principles in step with the SDGs around sustainability (AC1). The university placed huge importance on designing for sustainable futures. The focus is understanding design with a resounding focus on forward thinking. The engagement with production plants is not noticeable since design with forward thinking and experimentation and prototyping plays an important role in the learning process. This pedagogical approach fosters critical thinkers that have a strong focus of problem solving for future and current ecological and social challenges. The pedagogy is mainly attentive to experimentation and only to apply technology when needed. The adverse side of this approach is that often the designs may need major readjustment for mass production. Although projects that are completed for innovative advances are not too concerned about mass production.

Students in South Africa learn through practice and doing. The feedback from the participants concurred that the pedagogical approach in education is to promote a generalist direction in the field of Product design. Undergraduate students start by building a "toolkit" of knowledge and skills on which they can build in the next two years of studies. This includes hands skills, knowledge of different materials and use of industrial machinery. Students design and produce their own products or they engage with small production companies. AC3 stated that students do include sustainability as concept and the projects are often related to the current big challenges experience in the country, such as drought, and lack of electricity supply. The pedagogical approach also includes soft skills that can be used in projects that focus on community and social challenges. The product design industry is small in relation to countries such as China therefore the entrepreneurial skills of these students are encouraged. Choosing the entrepreneurial direction however, can have an adverse effect on the focus on sustainable design and manufacture.

I stated these points to illustrate that although the focus or the approaches differ, the ability to make a difference by promoting a sustainable outlook, will rest with the individual. As

such, the pedagogical tools that are used for informing students will need attention. Students need to be exposed to the context of sustainability for them to develop a full and holistic view of where and why Sustainable Manufacturing plays an important role in a Sustainable Future. Other than the already known knowledge and skills that are shared with Product design students, empathy, environmental and social awareness, and ethics need to be part of the pedagogical stances for the future.

4.10 Teaching strategies

The concept of learning factories was explored, and it proved to be a valuable strategy for teaching Product design. Placements in the industry for the development of products took place in different formats (SR1, SR3, AC3, AC4). Industry exposure has shown to be an important part of the learning of a Product design student. The data does not unanimously address the best strategy for teaching Product design at these universities. Possible future considerations for teaching strategies are:

- Collaboration and reflection of students (Laverie et al., 2022; Wamsler,2020)
- Exploring ecological and diverse perspectives (Dokter & Rahe, 2021)
- Learning through experimenting and through community involvement (Cappy, 2016; Brooks, 2011)

4.11 Pushing the boundaries

As part of personal reflections on my experiences during the DesignBRICS student exchange, I noted the difference between the structured projects I was used to and the freer and more future-forward projects that I have engaged in at the other two universities. Encouraging students to push the boundaries in their designs and product concept while linking them to sustainable manufacturing can contribute to critical thinking while keeping sustainability in mind.

Offering projects that can be open and futuristic will challenge the student to explore more and apply their knowledge of new technology and 4IR to come up with innovative solutions. In the digital age, this may contribute to self-exploration and self-learning where lecturers will facilitate forward-thinking and pioneering developments and concepts.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This research study explored how sustainable manufacturing is referenced and encouraged in Product design higher education curricula. In this study, the research focus was defined by the interaction I had with international universities while participating in a student exchange programme namely the designBRICS project. I actively engage in the module design4manufacturing and this led to the development of the research study. The study aimed to explore and develop an understanding of the Product design curricula regarding the practices, encouragement, and teaching of sustainable manufacturing at each of the participating universities. This exploration gave insights into the current practices but also highlighted the gaps in current practices. The conclusions offered a convincing argument for a stronger relationship between Product design teaching and the emphasis on all the variables that will influence Sustainable manufacturing. The study intended to elucidate current university practices in offering Product design students sound knowledge and skills so that they will be able to change public and industry perceptions after their studies. The research study explored literature premises that formally reviewed additional academic input. In this final chapter, I briefly highlight possible limitations of the research and propose areas for future exploration that might offer greater insights into curriculum development for sustainable futures.

5.2 Revisiting the aims of the research

The research initiated an enquiry into sustainable manufacturing through the lens of Product design and Product design curriculum, aimed to build a picture of the current practices at higher education institutions offering Product design as a programme. The research followed an empirical interactive inquiry approach using a qualitative method to explore sustainable manufacturing within Product design practices and pedagogy. This was outlined by the main research question that asked in what why sustainable manufacturing was referenced and encouraged in Product design higher education curricula at the participating universities. The literature (Wamsler, 2020; Vezzoli, 2018) verifies that Product design programmes at higher education institutions have little choice but to prepare the future designers to place focus on sustainability and the recovering of the sustainable resource of the earth.

Additionally, the study differentiated the current inclusion of sustainability in Product design programmes as a strategic approach that may contribute to positive social and environmental change and/or the current inclusion of sustainable manufacturing practice that may point students to alternative, sustainable options through which they can challenge the “status quo”.

5.3 Teaching practices supporting Design for sustainable manufacturing

The study aimed to ascertain the teaching methods and philosophies that are current practice in Product design programmes. A qualitative method was used as a research approach to find keywords and directions to form questions that were designed to obtain relevant responses from the participants in the study.

The study highlighted the fact the current teaching practices place higher importance on the holistic view of design and often lean towards understanding processes and placing the focus on the aesthetic, rather than placing the focus on sustainability. Although most respondents mentioned the fact that sustainability is not a principal focus in undergraduate studies. The programmes in China and Norway offer far more choices in post-graduate studies and students then have the option to focus purely on sustainability.

The results pointed to the fact that Product design as an academic programme in South Africa will need far more consideration concerning the scope and possibilities when planning future Product design curricula.

5.4 Contributions to knowledge

This research set out to define the current state of Product design in the three identified universities. The findings validated the fact that including the focus on sustainable manufacturing is fundamental knowledge that Product design students should acquire while studying. The studies also highlighted the notion that the concept of sustainable manufacturing does not stand alone. It is integrated into the bigger concept of sustainable living and should be incorporated into the curricula at the undergraduate level on only the meta-level. Further development of sustainable practices as part of the curriculum should

be considered for the post-graduate levels. The study also suggests that the concept of sustainability should be introduced as an elective for students to choose from within the syllabus.

It further identified that the manufacturing industry may not be ready to change operations to accommodate sustainable manufacturing as it would be presented in academia. The industry focus is mostly on the economic side of the business and will still need time to embrace the concept in the future.

Lastly, the study suggests various teaching and learning approaches, such as explorative studies and a focus on the circular economy that may contribute to the readiness of both students and lecturers to embrace the manifestation of sustainability as a holistic concept and part of the Product design curricula.

5.5 Limitations of the research

As with most research projects this thesis is not comprehensive. The research question was defined before Covid and therefore the Covid repercussions impacted the study. The research was to be conducted over a defined time, the designBRICS exchange. The time had to be adjusted due to Covid. Further to this, I relied on academic input from the participating institutions, therefore the studies were limited to their views and responses. Other limitations of the study are:

- The timeframe did not allow to include student perceptions on the awareness of sustainable manufacturing in the curriculum
- The research was delineated to the DesignBRICS project, which limited the scope of inquiry to wider survey
- Significant insights into the student briefs and project plans were not shared

5.6 Autoethnographic viewpoint

Being a practical and hands-on person, I have found the writing of the thesis challenging. However, I did realize how significant the critical analysis of information is to open one's mind and to help with making meaning. My experiences during the exchange study visit to

China and Norway, and the research for the thesis emphasised a new awareness of how urgent the need for Sustainable living has become. Product design education through relevant projects and applicable pedagogy can share the message of sustainability and contribute towards the awareness of sustainability in both industry and society.

Reflecting on my international visits together with the questions, feedback and the scholarly articles formulates a similar conclusion. Product designs students can become future ambassadors for driving sustainable future, sustainable manufacturing and promotors working towards the suitability of the eco system.

5.7 Directions for further research

1. Further investigation into this topic may be done in the future and possibilities include:
2. The impact of Smart technologies on the Product design curriculum
3. Produce a broader study with more universities
4. Complete a narrative study with Product design students and their engagement with sustainability in their curriculum
5. To do a study with Product design alumni to establish their experiences of sustainable approaches in the industry.

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APPENDICES INCLUDED

Appendix A: Questions and responses

Appendix B: FID Ethics Approval

Appendix C: DMP

Industrial design education for sustainable manufacturing: An explorative case study of product design curricula in South Africa, China and Norway.

Thank you for participating in this research study conducted by Christiaan Vlok 215053613, from the Faculty of Informatics and Design, at the Cape Peninsula University of Technology (CPUT).

I hope to learn about your perspective in my research field which will focus on the product design curricula offered at the undergraduate level at your university, as this is the first point where a future practicing professional product designer can graduate. This study aims to explore sustainable manufacturing through the lens of product design and Product Design curriculum: The case of three different Universities. Question types will include multiple choice, yes/no, Likert scale indication/ open-ended questions. These form part of my MTech: Industrial Design – research project. The study is supervised by Dr Alettia Chisin from the Department of Applied Design
chisina@cput.ac.za

Ethics clearance has been obtained from Office of the Research Ethics Committee reference number 215053613/2021/34.

The questionnaire/survey will take approximately fifty minutes. Taking part is completely voluntary and you are free to stop participating should you choose to do so. Should you wish to withdraw from the study your responses will be deleted. Please note that responses will remain anonymous throughout the participation process and pseudonyms will be assigned to participants.

Any information that is obtained in connection with this study will remain confidential and comments in text will be linked to pseudonyms. Data will be stored on the CPUT institutional repository, eSango, in line with the research project Data Management Plan, and will be secured with

limited access to the
researcher and the supervisor only.

If you have any questions regarding the study,
data storage, data access control
or data longevity, please feel free to contact me at cvlok2022@gmail.com.

*Required

1. Do you give consent that your anonymous answers to questions and responses, may be used in my Masters thesis work as well as academic journal publications?

   Mark only one oval.

   - Yes
   - No

2. Do you give consent that your written responses from open-ended questions, may anonymously be quoted and analyzed in my thesis work as well as in academic publications?

Mark only one oval.

- ◯ Yes
- ◯ No

General information

These questions are general to the Product Design programme your institution offers.

3. What is the name of the Product Design qualification? *

_____

4. What is the aim of the Product Design qualification?

_____

5. Which subjects and credits in the programme are linked to Design for sustainability (DfS) if any? *

_____

_____

_____

_____

_____

6. How is the selection process for new students managed, if there is such a process? *

7. In your view, with what type of existing knowledge about sustainability do the students enter the Product Design programme at your institution? *

Learning and Teaching

These questions address the Learning and Teaching philosophy and approach in the Product Design programme

8. Is the programme offered with a particular philosophy or theory in mind? If so, can you expand on the philosophy/theory and describe which teaching methods are used to achieve this?. *

9. Please clarify you answer above with reference to the teaching and learning methods for example group work, nomadic pedagogy, field immersion (Freitas & Almendra, 2022; Brailas, 2022). *

Curriculum information

In this section the focus is on the inclusion of Design for Sustainability (DfS) directly or indirectly in the undergraduate curriculum.

10. With reference to the four pillars of sustainability namely human, social, economic and environmental factors (UNESCO, 2015) please explain the inclusion or exclusion of the key area 'human' in Design for Sustainability in the Product design curriculum. *

11. With reference to the four pillars of sustainability namely human, social, economic and environmental factors (UNESCO, 2015) please explain the inclusion of the key area 'society' in Design for Sustainability in the Product design curriculum. *

12. With reference to the four pillars of sustainability namely human, social, economic and environmental factors (UNESCO, 2015) please explain the inclusion of the key area 'economics' in Design for Sustainability in the Product design curriculum *

13. With reference to the four pillars of sustainability namely human, social, economic and environmental factors (UNESCO, 2015) please explain the inclusion of the key area 'environment' in Design for Sustainability in the Product design curriculum *

14. What are the key focus areas of the curriculum? Does the course focus on products, aesthetics, mass production for example or does if offer a more theoretical/conceptual perspective?
Please elaborate on key focus points in the first year of study. *

15. What are the key focus areas of the curriculum? Does the course focus on prod ucts, aesthetics, mass production for example or does if offer a more theoretical/conceptual perspective?
Please elaborate on key focus points in the second year of study. *

16. What are the key focus areas of the curriculum? Does the course focus on prod ucts, aesthetics, mass production for example or does if offer a more theoretical/conceptual perspective?
Please elaborate on key focus points in the third year of study. *

17. Express from 1 to 10 how much of the curriculum content focusses on the concept of sustainable manufacturing (SM) in the first year of study? *

Mark only one oval.

Very little focus on SM

1
2
3
4
5
6
7
8
9
10

Large focus on SM

18. Express from 1 to 10 how much of the curriculum content focusses on the concept of sustainable manufacturing (SM) in the second year of study? *

Mark only one oval.

Very little focus on SM

1
2
3
4
5

Large focus on SM

19. Express from 1 to 10 how much of the curriculum content focusses on the concept of sustainable manufacturing (SM) in the third year of study? *

Mark only one oval.

	Very little focus on SM					Large focus on SM
	1	2	3	4	5	

20. How and in what subjects (if at all) is awareness of SM included or promoted in the design process during the undergraduate programme ? *

21. Do you believe SM is important in Product Design curricula at undergraduate level, and if so, why is this? *

22. Manufacturing globally is inherently linked to Climate Change (WEF,2020) and future designers should have the tools and knowledge necessary to combat the impact of manufacturing when graduating and hopefully making changes in industry toward sustainable manufacturing. Do you agree with this statement? *

Mark only one oval.

	Yes
1	◯
2	◯
3	◯
4	◯
5	◯
	No

23. To what degree, if at all, is Climate Change included in your Product Design curriculum? *

24. To what degree does the curriculum focus on the concept of a Circular Economy (Velenturf & Purnell, 2021) and how is this linked to Design for Sustainability in your programme, if at all? *

25. To what degree does the curriculum focus on the concept of Green production systems as a whole lifecycle, a closed loop, and not only to achieve economic benefit, as described by Tau and Zhao (2016)? *

26. Are Learning factories, as described by Sackey et al., (2020) used in the curriculum in the final year of undergraduate studies? *

27. The use of new and developing technologies such as Augmented reality and Artificial intelligence can be of great use to encourage students today to grapple with future problems (Jeevan et al., 2020). *

To what degree is a focus on 4IR /5IR and Technology included in the Product Design curriculum?

28. Finally, please discuss any methods, theories and philosophies that you currently use in the Product Design curriculum at your University to promote, under the umbrella of Design for Sustainability, critical engagement by students with issues of sustainability. *

Thank you

I appreciate your time and contribution. I will give you feedback once I am done with my study.

Kind regards

Chris Vlok

Student
number 215053616

chrisofthecape@gmail.com

For Research Ethics Committee panel use only				Reference Number:
☐ Approved	☐ Change	☐ Refer	☐ Reject	

Cape Peninsula University of Technology

The Cape Peninsula University of Technology
Faculty of Informatics and Design

FID Research Ethics Committee (REC) – **ETHICS APPROVAL FORM**

1. You may add rows if required, e.g for additional Supervisors
2. Please attach documentation where required. Please answer all questions
3. All post-graduate students and researchers are required to complete this form before commencing with research.
4. Post-graduate students are requested to submit this form together with HDC 1.2 (proposal submission) to the Faculty Research Committee (FRC).
5. Where applicable mark relevant boxes ☐ with an **x =** ☒
6. Replace red text with further description if needed or delete if not.

1: Applicant / Researcher / Investigator:	Title, name & surname: Jacobus Christiaan Vlok	Masters	x	Doctorate	☐	Non Diploma Purposes	☐
Office Telephone: -	Cell: +27 (0)839419342	e-mail: chrisofthecape@gmail.com					
Student/Staff Number: 215053613	Start and proposed end of Study: Start: November 2021 End: May 2022						

2: Supervisor/ Project leader (if applicable):	Title, name & surname: Dr A Chisin	
Office Telephone:	Cell: 073 509 2033	e-mail: chisina@cput.ac.za

3: Project , Thesis, Article Title: as per HDC 1.1

An exploration of industrial design education in sustainable manufacturing: the case of South Africa, China and Norway. Die titel is op HDC en moet vir nou so bly!

4: Project Description: **Gee asb hieronder n summary van jou navorsing – updated soos in gister se proposal**

Main question

How is sustainable manufacturing promoted, encouraged and referenced in Industrial Design higher education curricula in South Africa, China and Norway?

Sub questions

- Why is sustainable manufacturing a critical component of Industrial Design education?
- How are the key areas of sustainability currently being explored in curriculum and teaching and learning practices?
- What is the relationship between current curriculum, and teaching and learning practices in design education, and industry practices for sustainability within each context?

Explained very simply, e-mail interviews refer to conducting interviews via e-mail in an asynchronous manner. This allow the respondents to respond to questions at their own pace and over a longer period of time, rather than the time period typical of traditional interviewing methods. In this research participants will be interviewed via e-mail due to its unobtrusive nature and flexibility.

This research method is deemed most suitable for the fact that researchers have illustrated that email interviewing can represent the complexity of the social practice on the internet (James, 2016) while also allowing participants to offer responses that are well written, dense, rich, and informative (Gibson, 2010; Mann, 2016). This interviewing method is asynchronous and offers the participants time to reflect on the questions and allow personalising of their responses (Pell et al., 2020). Ayling and Mewse (2009) pointed to the advantages inherent in this method, in that email interviews are already transcribed.

The research will make contributions in two parts. Firstly, the result of the study will contribute to the wider literature of sustainability and how it relates to higher education. It will further offer insights from design educators and researchers' perspectives from around the world. The outcome will also present a case study from three participating universities.

Industrial design shapes the engagement that people have with their environments every day, be it in natural or created spaces. The connection between individuals and the interactions that they have daily are dictated by the manufactured objects they engage their environments with. This being said it is important to understand how benchmarks in sustainability in manufacturing can influence education. The study aims to address and investigate sustainability teachings at universities taking part in the DesignBRICS programme namely: Cape Peninsula University of Technology (CPUT), Hunan University, and The Oslo School of Architecture and Design (AHO). The focus will be to investigate the current curricula of each of the participating universities, ascertain the role the local industries play in the university practices, identify the most recent literature contributions in the field, the relationship between current curricula, localised sustainable practices within the industry and current literature related to sustainable product manufacturing. The contribution and possible implementation of this information will allow students at the undergraduate level to be equipped to engage with projects in a way of being considerate of sustainable manufacturing and what is expected to gradually change the status quo and transform current unsustainable norms.

5. Potential for Harm to Participants and/or others:	
Is there any potential for harm: physical, psychological, social, cultural or financial to participants (human or animal) and/or others not directly involved in your study?	☐ Definitely ☐ Possible ☐ Unlikely ■ None
Are there any potential risks to participants and/or the investigator/s?	☐ Definitely ☐ Possible ☐ Unlikely ■ None

The study poses no harm to participants. No potentially emotionally upsetting or disturbing content will be discussed, and the discussion will take place within the framework of the approved proposal. All participation is voluntary. The initial research methods will include online mediated questionnaires and email based interviews. Participants can choose to remain completely anonymous and anonymity will be upheld in the research data presentation of the study. Participants will also have the option to not answer a question if they choose to do so. If a participant opts out of the study at any point, any data recorded from that participant will be excluded from the research and destroyed appropriately. The estimated probability of any harm to research participants or unintentional disclosure of personal details is negligible, since passwords protect all data gathered and participants' anonymity is a priority.

6. Potential for Harm to the Environment:	
Does your research involve any substance, procedure, methods that will directly or indirectly harm the environment?	☐ Definitely ☐ Possible ☐ Unlikely ■ None
The research methods or subsequent contributions do not pose environmental harm. I will be using email interviews for the study, and as per Science Focus magazine (2021) the carbon footprint of one email is 4g which is far less impactful to the environment than that of international travel. thus the study does not pose as a serious threat as air travel would be for face to face interviews.	

7. Selection and Recruitment of Participants:	
This section includes Children/Young people; School children; Mental impairment; Dependent on medical care; Unequal relationships; Institutions; Please note the term recruitment is used here to mean: select, contact and request to participate.	
Will participants be recruited to take part in this research?	■ Definitely ☐ Possible ☐ Unlikely ☐ None
Is there any possibility that any of the participants will feel coerced to take part in this research?	☐ Definitely ■ Possible ☐ Unlikely ☐ None
Are participants in a dependent relationship with the investigator (eg. teacher and student, friends, family)?	☐ Definitely ☐ Possible ☐ Unlikely ■ None
Will participants be offered an inducement to encourage their involvement?	☐ Definitely ☐ Possible ☐ Unlikely ■ None
There will be no payment for the participation in this study. Individuals to be selected or put forward to participate will be lecturers and post graduate students from CPUT, AHO and Hunan University as the study pertains specifically to those universities as well as the DesignBRICS program. Participants may feel obligated to take part however it will be made abundantly clear that participation in this study is completely voluntary and that they may at any point opt out of the study where subsequently no data gathered from that individual will be used in the research.	

8. Informed Consent:	
Will the investigator/s request written informed consent from participants?	■ Definitely ☐ Possible ☐ Unlikely ☐ None

If you answered None please justify why not.
If you answered yes complete and attach FIDs Ethics Consent for Research Participation Form (PISC, FID/REC/C0.2) form available from your supervisor or Ethics Committee secretary (Ms V Naidoo) at 021 469 1012 or fidethics@cput.ac.za.
Informed implies the subject is fully aware of the nature of the study.

During initial project discussions the participant will be introduced to the research methods and study description prior to any questions being asked. Participants will be asked if they give consent for their answers to be included in the study. Contact details for the research will be made available, should participants have additional questions.

For interviews participants will be asked to complete and sign informed consent prior to the interview starting. Participant will be given contact details and a description of the study for them to keep, should they have questions in the future, or if they would like to withdraw their consent.

9. Observations and Records:	
Is it necessary for the investigator/s to make recorded observations of participants (eg. audio, video, photographs or written notes) during this research?	■ Definitely ☐ Possible ☐ Unlikely ☐ None
Data will be preserved for 5 years on the esango facility provided by CPUT. After this time has elapsed all data will be destroyed. Any access granted publicly will maintain the anonymity of the participants of the study. The data management plan outlines how, where and when data will be used and granted access to. Participation and consent forms will also be stored in order to prove willingness to be in the study .	

10. Confidentiality, Privacy and Anonymity:	
Is there any possibility of participants being inadvertently being identified or confidential data being divulged during or after the research has taken place?	☐ Definitely ☐ Possible ■ Unlikely ☐ None
Given that identified institutions will be researched there is a chance someone can work out who they are. No names will be used at all in the research rather codes or pseudonyms. Where specifics are shared that may give away a person's identity the word order if directly quoted will be paraphrased to disguise the contributor.	

11. Deception and Debriefings:	
Is it necessary during the research to deceive participants?	☐ Definitely ☐ Possible ☐ Unlikely ■ None
There is no deception used in the study.	

12. Conflict of interest, including financial involvement:	
Is the research being funded by an agency outside CPUT?	☐ Definitely ☐ Possible ☐ Unlikely ■ None

Is any conflict of interest (including financial gain, vested interest etc.) likely to result from this project?	☐ Definitely ☐ Possible ☐ Unlikely ■ None

13. Organisations other than CPUT:	
Are organisations other than CPUT involved in this research?	■ Yes No
Yes, Although AHO and Hunan universities will be researched for this paper. Individuals will be the participants and the above mentioned Universities do not hold any stake in the outcomes of this research.	

Ensure the Faculty of Informatics and Design Ethics Approval certificate (overleaf) is on its own page as you will need to retain it as proof of clearance.

Cape Peninsula University of Technology

Office of the Research Ethics Committee (REC)

Faculty of Informatics and Design

Ethics Approval certificate

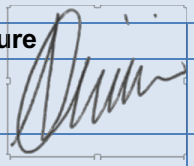
Date:16 September 2021

Applicant Name: Jacobus Christiaan Vlok

Student Number: 215053613

Qualification: Masters of Design

14. Declaration of Investigators			
I/we apply for approval to conduct research. If approval is granted, the research will be undertaken in accordance with the information provided in this application, the protocols described in this application, and any other relevant guidelines, regulations and laws.			
Investigator / Researcher	**Department**	**email**	**extension**
1 J.C. Vlok	FID	chrisofthecape@gmail.com	-

15. Declaration of Supervisor/s (if applicant is a student)			
I/we have read over this application in its entirety and will endeavour to ensure my/our student undertakes his/her research according to all CPUT ethics protocols.			
	Name	**Signature**	**Date**
Supervisor:	DR A CHISIN		September 2021
Co-Supervisor:			

FID Research Ethics Committee comments:	
	Ethics Stamp

An exploration of industrial design education in sustainable manufacturing: the case of South Africa, China and Norway.

A Data Management Plan created using Data Management Planning tool (DMP tool)

Creator: Jacobus Christiaan

Affiliation: Cape Peninsula University of Technology

Template: Cape Peninsula University of Technology

Project abstract:

Product Design shapes the engagement that people have with their environments every day, be it in natural or created spaces. The connection between individuals and the interactions that they have daily are dictated by the manufactured objects they engage their environments with. This being said, it is important to understand how benchmarks in sustainability in manufacturing can influence education. The study aims to address and investigate sustainability teachings at universities taking part in the DesignBRICS programme. The focus will be to investigate the current curricula of each of the participating universities, ascertain the role the local industries play in the university practices, identify the most recent literature contributions in the field, the relationship between current curricula, localised sustainable practices within the industry and current literature related to sustainable product manufacturing. The contribution and possible implementation of this information will allow students at the undergraduate level to be equipped to engage with projects in a way of being considerate of sustainable manufacturing and what is expected to gradually change the status quo and transform current unsustainable norms in design.

Last modified: 07-09-2022

An exploration of industrial design education in sustainable manufacturing: the case of South Africa, China and Norway. - Data Management Plan

DATA COLLECTION

What data will you collect/create?

This study will be mostly a desktop study. Nine participants will be selected. The study will be supported by email interviews with the participants from the selected universities.

Research Sub Question	Focus area	Research Method	Data Type
How is sustainable Manufacturing in Product design presented , Promoted and or encouraged at universities?	Sustainability related to Product Design	Review of Literature Interviews	· Systematic Literature Review
How are the key areas of sustainability currently being explored in curriculum and teaching and learning practices at Universities?	Sustainability	Review of Literature	· Systematic Literature Review
Curriculum	Desk research and Interviews	· Written responses Using Google forms and emails	
How are the three universities above mentioned ensuring that students feel a sense of responsibility for carrying sustainable practices in product design to the industry?	Teaching practices	Interviews	· Written responses to email interviews
Curriculum	Interviews Participation and reflection using an autoethnographic approach by reflecting on experiences in the DesignBRICs program.	· Written information on Curriculum structures	
Industry Influence	Interviews Review of Literature	· Written responses Using Google forms and emails · Literature review	

How will the data be collected or created?

The folders will be arranged according to the following:

Responses from Google forms

The selected participants from the three universities have been approached via email and they will answer the questions via email and there will be no face-to-face meetings.

Responses from emails interviews

Written responses to interviews. the identified lecturers and the three universities were originally selected through face-to-face interviews but due to the lockdown during Covid, this process will be through email only.

Written information from curriculum structures

Existing literature and documents related to curriculum structures will be interrogated in order to explore sustainability related to product design.

Industry influence

Review of the literature

The data will be stored on the CPUT research site Isango powered by Figshare https://cput.figshare.com/ which is a secure database.

DATA DOCUMENTATION AND METADATA

What documentation and metadata will accompany your dataset?

A range of data has been collected for this study, as follows:

- **Metadata sources** related to the field of sustainability research in Product Design in the form of Journal Articles, Case Studies, Research Theses, and online data repositories.
    - Predominantly saved in PDF format, approximately 100 sources were selected after extensive research and literature review.
    - Saved in word format in a secure folder on Onedrive, which allows for long-term storage of the data.
    - Data gathered can be reused in future studies on this topic by the researcher.

- **Interviews with lecturers, researchers, and industry design experts** in order to compile an interrogation of the curricula underpinning the undergraduate programmes at the three universities.
    - All discussions and email responses will be consolidated, coded into themes, and analysed
    - Saved in word format in a secure folder in Onedrive.
    - Data gathered can be reused in future studies on this topic.
    - Industry influences (experts) will be investigated and the literature contributions will be themed and analysed.

- **Email interviews with Product Design experts and a review of the existing literature.**
    - The email interviews will be themed and analysed.
    - Saved in word format in a secure folder in Onedrive, which allows for long-term storage.
    - Data gathered can be reused in future studies on this topic.

ETHICS AND LEGAL COMPLIANCE

How will you manage any ethical issues pertaining to data?

The data will be stored in OneDrive and the eSango drive. Only the researcher and the supervisors will have access to the data for five years.

Data will be collected, managed, and protected according to the Popia act and the DMP of CPUT.

Anonymity

Given that identified institutions will be researched, there is a possibility that non-participants may deduce who some of the participants are. However, no names will be used at all in the research - rather codes or pseudonyms. Where specifics are shared that may disclose a person's identity, particular care will be taken to paraphrase rather than quoting directly.

Conservation of data

Data will be collected, managed, and protected according to Popia and the Data Management Plan of CPUT. All data will be securely stored and password protected using eSango. Data will be preserved for 5 years on the eSango facility provided by CPUT. After this time has elapsed all data will be destroyed. Any data gathered via the research methods outlined in the proposal, will maintain the anonymity of the participants of the study. The data management plan outlines how, where and when data will be used and granted access to. Participation and consent forms will also be stored in order to prove willingness to participate in the study.

Who will be responsible for data management

- The Author has been responsible for all data-related activities e.g. data capture, metadata production, assessing data quality, storage, and backup, data archiving & data sharing.
- The Author has been responsible for ensuring all relevant policies have been respected.

How will the data be shared?

- All data sharing will be done at the direct request of the CPUT.
- The researcher intends to publish this thesis in order to make it available online to the world.
- Should a user wish to access any of the supporting data, it will need to be done via the CPUT, and a formal request made by the CPUT to the Author.
- On request, a secure link will be provided to the user, for the specific data set requested. The user will then be able to download the data set.
- As this thesis is intended to encourage others to explore the use of SRTs in developing softer more ergonomic medical products, the sharing of data is encouraged.
- The Author will request that all data shared be credited to the original creator to ensure that recognition for the data is assigned to the appropriate individual or group.

FID Ethics approval certificate detail

28 October 2021

Jacobus Christiaan Vlok c/o Department of Design CPUT

Reference no: 215053613/2021/34

Project title: Industrial design education for sustainable manufacturing: An explorative case study of product design curricula in South Africa, China, and Norway.

Approval period: 28 October 2021 – 31 December 2022

This is to certify that the Faculty of Informatics and Design Research Ethics Committee of the Cape Peninsula University of Technology approved the methodology and ethics of Jacobus Christiaan Vlok (215053613) for Master of Design.

Any amendments, extensions, or other modifications to the protocol must be submitted to the Research Ethics Committee for approval.

The Committee must be informed of any serious adverse event and/or termination of the study.

Dr Blessing Makwambeni

Acting Chair: Research Ethics Committee Faculty of Informatics and Design

Cape Peninsula University of Technology

How will you manage copyright and Intellectual Property Rights (IPR) issues?

Our findings will be published in peer reviewed Open Access Journals. Therefore there will be no unforeseen copyright and IPR issues.

DATA STORAGE AND BACKUP

How will you store and back up your data during the research?

The data will be stored in OneDrive and the eSango drive. Only the researcher and the supervisors will have access to the data for five years.
No storage on a laptop or hard drive.

How will you manage access and security?

During the research process access to datasets will only be given to direct participants by assigning rights. This includes supervisors who will be given rights to read, edit and collaborate through the data repositories (Figshare at https://cput.figshare.com)

DATA SELECTION AND PRESERVATION

Explain which data should be retained, shared, and /or preserved?

The data will be stored in OneDrive and the eSango drive. Only the researcher and the supervisors will have access to the data for five years.
No storage on a laptop or hard drive.

During the research process access to datasets will only be given to direct participants by assigning rights. This includes supervisors who will be given rights to read, edit and collaborate through the data repositories (Figshare at https://cput.figshare.com)

DATA SHARING

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- As this thesis is intended to encourage others to explore the use of SRTs in developing softer more ergonomic medical products, the sharing of data is encouraged.
- The Author will request that all data shared be credited to the original creator to ensure that recognition for the data is assigned to the appropriate individual or group.

Are any restrictions on data sharing required?

In-case there are such restrictions, the principal researcher may restrict the sharing of data within CPUT repositories (eSango) by giving rights (view only, read, collaborate, edit) to each participant using one of the data repositories.

RESPONSIBILITIES AND RESOURCES

Who will be responsible for data management?

Who will be responsible for data management

- The Author has been responsible for all data-related activities e.g. data capture, metadata production, assessing data quality, storage, and backup, data archiving & data sharing.
- The Author has been responsible for ensuring all relevant policies have been respected.

What resources will you require to deliver your plan?

- No additional resources, equipment, or software has been required in order to complete this research study.
- The Author has provided and paid for all costs related to the capturing, compiling, and analysing of the data.
- Additional financial support was provided by the AHO University of Design in Norway in the form of a funded four week field trip to China in October 2019.

PERSONAL, SENSITIVE AND IDENTIFIABLE HUMAN RESEARCH DATA

Will you be collecting personal information?

No

List all the types of personal/sensitive/identifiable data you will be collecting.

No sensitive or personal data will be shared at any time.

Conduct a benefit/risk analysis to ensure that the benefit of collecting such data outweighs the risk and then motivate why you need to collect such information.

Not applicable

Confidentiality, anonymity, and privacy of human participants.

All first hand data in the body of the thesis has been kept anonymous to ensure direct participants are not identifiable.
Pseudonyms have been used when referring to individuals or their contributions to the research study.

What happens to the information if a participant withdraws from a study?

In the event that a participant wishes to withdraw from this study, it is possible as in most cases the Author has made use of multiple sources. To exclude one would not diminish the whole of the thesis or the findings.
Should such a request arise, the Author will make the adjustments where needed to remove any reference to the participant or their contribution.

After completion of the research, will the information be used for anything else in the future?

No, the data will relate to the curriculum which will be outdated after five years of storage.

Will study participants/groups etc. receive feedback before disseminating the results of the research?

The Author has ensured that all participants understand what their contribution has been to this research study and how the Author intends to use the information/data provided.
No additional feedback will be given before the thesis is published.

Outline your informed consent process and details of the data management plan.

- All participants were given an ethics agreement form to read and sign before they could participate in the study.
- The intention of the Author was clearly stated and understood by the participants when signing the agreement of consent.
- The Author has respected the individual decisions of each participant and restricted the information shared to only that where permission was granted by the participant.
- The security of the information was explained.
- The Author has also confirmed with each participant that their information will not be stored for longer than a period of five years after the date of publication.
- Anonymity was explained, and the use of Pseudonyms demonstrates this.
- The participants understand their right to withdraw from this study and that their contribution to the study would be removed from the thesis and then deleted from Dropbox.
- The participants of this study were all fully informed of their rights and provided the consent needed in order to carry out this research effectively.