

Design education 4.0: technology-driven design futures and the future of design education

Pei, Eujin^a; Kim, Sung Jun^b; Kim, Seongbeom^b; Lee, DaeHun^b; Lee, Seunghoon^b; Self, James^{*b}

^a Brunel University, London, UK.

^b UNIST (Ulsan National Institute of Science & Technology), Ulsan, Republic of Korea.

* jaself@unist.ac.kr

doi.org/10.21606/iasdr.2023.165

Design education has always strived to equip future designers the knowledge, skills, and expertise to work at the intersection of applied technology and the people who use it. The difference for contemporary design is the accelerating pace of technological change. Where previous generations expected to use the same core technology throughout their lifetime, users now and into the future will experience significant change within a generation. We report a project aimed at understanding how design education must change to leverage the opportunity of technology-driven design futures. In an international, collaborative project on the future of design education, we report a comparative audit of education provision at a Korean design department and UK-based design school, both located within colleges of engineering at their respective institutions. We report insights derived from a workshop activity (Design Sprint). During the workshop, faculty and students from the two institutions, together with associated project partners, attempted to address design problems around sustainable futures: with focus upon technology-driven solutions. We finally report some initial insights and recommendations towards the skills and expertise required of the future designer.

Keywords: *design education; design technology; design expertise*

1 Introduction

Higher education needs to equip future designers to work at the intersection between disruptive technologies and people, thereby applying design expertise to identify opportunities for design innovation (Verganti, 2008). This has always been the case. However, the pace and scope of technology-driven change is accelerating and expanding. Consider a few generations past. For previous generations, users may expect to still be using the same or similar technology at the end of life, as they were in younger years (Roser, 2023). For the current and future generations, technologies become outdated and are replaced well within a lifetime.



With the accelerated and increasing impact disruptive technology is having on design practice, our international project between Korean and UK partners aimed to respond to the question: how must design education change? As one example among others, ageing populations across much of the developed world are providing new social pressures and challenges. How might technology be applied through design to support innovative and appropriate healthcare solutions for ageing populations? What new skills and knowledge is required to equip the next generation of designers with the ability to apply disruptive technologies, such as AI (Artificial Intelligence), to help address the future's big challenges?

We present results and insights from an international, government funded project between UK and Korean institutions, and associated partners (Design Council UK, Korean Institute of Design Promotion). We first provide a background by introducing new and disruptive emerging technologies, and how designers have a critical role to play at the intersection between disruptive technologies and end users. Next, we discuss how some design schools are facing challenges integrating technical competencies and traditional design skills. Next, we describe a series of networking activities between participating institutions and associated partners. These activities included the initial mapping of curriculum between the two institutions, with events to explore various aspects of design education futures. Results derived through the education audit report suggested strengths and weaknesses, as well as opportunities and threats in the adoption of technological competencies for the participating institutions. A Design Sprint exercise suggests further possibilities for the adoption of disruptive technologies within future design curriculum. The paper finally draws conclusions, suggesting pedagogic approaches to new design education.

The project investigates the cutting edge of technology-driven education futures. Our aim is to commence work towards the development of design education responsive to and relevant for the future of design. Thereby enhancing design's ability to contribute to address common challenges faced by both Korean and British governments: ageing populations, net-zero carbons targets, and more recently challenges around energy security. Our project thereby aims to mitigate the risks to design education in the UK and Korea in its ability to keep-pace with the accelerating change brought by technology-driven futures. How must design education change to leverage the opportunity of technology to address significant challenges?

In a collaboration between a Korean design department located within a specialised institution of science and technology, and a leading, UK-based design school, located within a college of engineering, we are well placed to examine the interaction between technology and design. Associated project partners also included the Design Council, UK and KIDP (Korean Institute of Design Promotion). As a project still ongoing, we report work-in-progress activities between project partners. In an analysis of design education provision across the two universities, and a workshop to examine interaction between design and technology, we provide initial insights around technology's position and reach within design education, as well as departure points for the further transformation of design education. Therefore, both institutions, and their associated design programs, are uniquely placed to respond to technology driven design futures, with its need to equip future designers with interdisciplinary skills and technical understanding to work at the interface between people and technology. The next chapter introduces potentially new and disruptive technologies that may pose a profound effect upon contemporary design practice.

2 New and disruptive technologies

New and disruptive technologies, such as AI (Artificial Intelligence), are having a profound effect upon contemporary design practices (Kim, Joines, & Feng, 2022). As a result, the skills and knowledge required to drive appropriate and innovative design futures are changing. The COVID pandemic has accelerated the reach of disruptive technologies and their role in people's lives. It has also accelerated the need for change in education to equip future designers with the skills required to innovate at the intersection between people and technology. Previously in the UK, as well as Europe, North America, and later East Asia (including Korea), university level design education followed discipline specific programs of study. Product and Industrial Design, Communication/Graphic Design, and later UI/UX Design and Product-Service and Service Design. While division through discipline-specific knowledge offers opportunity for highly specialised design skills, a discipline-focused curriculum is less able to respond to the paradigm shift now taking place in design practice (Self & Baek, 2016). This is because technology brings increased complexity to design solutions. With complexity will come a greater pressure for a variety of skills and knowledge, cutting across traditional disciplinary boundaries. The ability to work across disciplines is of course challenging. However, the increasing reach of technology, and its impact on our lives, demands it. The designer has a critical role to play at the intersection between disruptive technologies and people. However, to successfully navigate this intersection, the designer requires new skills and competencies (Meyer & Norman, 2020). What these are, and how they may be acquired to position design as the catalyst for innovation between people and technology is the focus of our project.

Design, its role in industry and wider society, is evolving to encompass an increasingly interdisciplinary and expansive skill set and knowledgebase. From the design and development of stand-alone products to experiences, interconnected service-systems, IoT (Internet of Things) enabled devices, and the emergence of AI-driven products-service platforms. Integration of the relevant knowledge and skills in higher education curricula requires exploration of a range of technologies such as modern embedded hardware, open-source software, state-of-the-art platforms democratizing access to AI functionalities, big data analytics, and machine learning. The next section introduces the two main design institutions involved in our project based in Korea and the UK to provide a contextualized background for our work towards design education futures.

3 Educating the future designer

In their seminal work, Archer and Baynes (1977), argue the social and economic importance of design education in primary and secondary schools, stating seven core themes which in some respects still hold true today. The seven themes cover the aims of design education: significance of practical education, encouraging imagination, aesthetic awareness, value of learning through making, creative relationships between designing and making, and the educational purpose design projects. Moving forward Meyer and Norman (2020), recommend that design schools cover a set of core principles, as well as offering advanced courses that would be unique to the school or based on a number of specialties within design. This contrasts with the recent paper by Brosens et al (2023), who echo a similar observation wherein design education needs to adjust itself to 21st century learning objectives that have a greater focus on skills with domain-specific knowledge. In addition, teaching and learning activities should be more student-centred and closely aligned with industry requirements. This is in

line with the observations from Justice (2019) who also proposed a need for more specialization, being more sensitive to culture and embracing new technologies. The paper by Majithia (2017) had previously reported that designers require a different skill set, and in particular moving from specialized subject skills that are the primary outcome of a design education towards lifelong skills. More specifically, Ilhan and Karapars (2019) noted that for the product design curriculum, there is a need to better address the design of digital products due to a changing trend of digital interfaces becoming more prevalent in today's devices.

Differentiation of discipline, justified through specialisation and the tendency to focus on branches of study, has already reached a critical tipping point (Norman, 2010). For the applied field of design, interdisciplinary approaches to curriculum content, with a focus on disruptive technologies are critical to drive and sustain innovation and a creative edge. While many design schools in both Korea and the UK maintain traditional, arts-based approaches, both UNIST Department of Design and Brunel Design School attempt to integrate design education with advances in technology to address bigger societal challenges. Undergraduate and postgraduate programmes aim to educate new cohorts of designers, able to integrate traditional design skills and aesthetic sensibilities, with the opportunities posed by emerging and disruptive technologies.

However, there remain many challenges to the integration of technical competencies and traditional design skills. These include differing worldviews, value systems and working cultures between design, science, and engineering (Self, Evans, Jun, & Southee, 2018). To address these challenges, UNIST Department of Design has implemented various initiatives and curriculum innovations aimed at the convergence of technology and design education. These have included a double-major system (i.e. Design plus one engineering/science field). More recently, UNIST Design developed the Creative Design Engineering Program (CDE), in collaboration with KIDP (Korean Institute of Design Promotion), Korean government ministries and industry partners. The program aimed to provide students an integrated curriculum composed of a design foundation and including engineering and technology elements and competencies.

Currently, UNIST Department of Design is undertaking a project in collaboration with KIDP, MOTIE (Ministry of Trade, Industry & Energy), KAIT (Korean Institute for Advancement of Technology), together with Ulsan-based industry partners. The NTC (New Technology Convergence) program provides students an interdisciplinary design education including core design competencies and technical skills (i.e. electrical and mechanical engineering, computer science). As a further pedagogic strategy, the newly opened UNIST AI Graduate School (AIGS) aims to educate students in artificial intelligence. The school, and institution more broadly, sees AI as key to further industry innovation, providing a platform for both industry-academic engagement and training students able to apply AI technologies to address bigger societal challenges. Brunel Design School also shares a similar approach, where the undergraduate programmes have undergone a major course revision with its first intake now underway. Some of the planned learning outcomes for design graduates are to acquire a better grasp of the use of AI within their coursework. In the next section, we provide further detail of the activities that were carried out in terms of the Education Audit and the Design Sprint to contribute to a better understanding of design education futures.

4 Approach

This section provides an overview of the research activities between the participating institutions and associated partners. As the project is aimed at providing a platform for contact and collaboration, the events and activities were designed to enhance general understanding of existing education provision across UNIST Department of Design, and Brunel Design School. Interactions and related activities provided us with an initial mapping of curriculum, together with events to explore various aspects of design education futures.

The use of a SWOT analysis was employed in the Education Audit; and Action Research was used for the Design Sprint. For the Education Audit, the SWOT analysis served as a framework to evaluate the Strengths, Weaknesses, Opportunities, and Threats in the provision of the design programmes at both institutions. This allowed us to assess internal and external factors, as well as current and future potential. For the second part of the data collection, Action Research by means of a Design Sprint was used to better understand the challenges and opportunities of design education. The use of Action Research is an interactive inquiry process that combines critical reflection and was selected as a data collection method to help gather evidence in a participative and collaborative way through the networking project. By engaging with the cycle of action through the Design Sprint, it allowed us to obtain a deeper understanding of the complex issues within design education and to propose solutions.

To kick-start the data collection process, meetings between partners took place over two overseas trips. In the summer of 2022, a delegation including members of UNIST and KIDP visited Brunel University London for a series of meetings and events. A return trip in November 2022 saw a delegation of Brunel faculty visit UNIST, and Korea's annual national design show and event hosted by KIDP - Design Korea 2022. Prior to these trips, we conducted a SWOT (Strengths, Opportunities, Weaknesses, Threats) analysis of education provision across undergraduate programs across the two institutions.

While we have undertaken various networking activities as part of the project, we will report those with most potential to address our research question around the future of design education. Table 1 below illustrates the two activities we report in the current paper. Other activities and events have been completed, with further meetings planned at the time of writing. However, due to space limitations, we report the two of the most significant meetings to date.

Table 1. Collaborative activities between project partners. Objective & contribution to understanding design education futures.

	Activity	Objective	Contribution
1. Education Audit Report	Analysis of education provision across institutions	Current situation for integration of design & technology	Opportunities & challenges within current provision
2. Design Sprint	Team activity to address a big challenge through design+technology	To understand challenges & opportunities of design+technology	Challenges in the application of technology when designing

Activities 1 and 2 in Table 1 took place at Brunel University London. In the following sections we will discuss the two events illustrated in Table 1. We will provide a general overview of the methods and approach taken for each activity. This will include objective, in relation to our holistic research aims

examining education futures in response to the impact of disruptive technologies. Finally, we will outline insights, including departure points for further work.

5 Results

5.1 Education audit report

We conducted an audit of undergraduate programs across the two partner institutions (Figure 2). The report commenced by contextualising the impact of emerging technology through Rimol's (2021) Hyper Cycle for Emerging Technologies. According to Rimol's model, the adoption of technology proceeds through a synchronic time order, starting at Innovation Trigger, then Peak of Inflated Expectations, Trough of Disillusionment, Slope of Enlightenment, and finally Plato of productivity. Through the report we hoped to examine the stage of adoption (if any) of various technical and technology-related skills, competencies, and knowledge within existing design programs across the partner universities. In particular, the report identified a set of emerging technologies that may have an impact on the designer's future knowledge and expertise. These included, but are not limited to: 4D Printing, AI Augmented Design, Smart Devices, and Immersive Technologies. We wondered to what extent representative knowledge and skill required to work with and apply these technologies was present within the existing program curricula. And, if and to what extent such knowledge and skill was integrated with more conventional design education.



Figure 1: Sample pages taken from Education Audit Report.

In the case of the UK-based institution, we identified three design programs: BSc Product Design Engineering, BSc Design, and BA Industrial Design. For the Korea partner, we examined the single undergraduate BSc Design program. These Product Design programs were identified stemming from

both partnering institutions as a pilot government funded project between UK and Korean universities. The exploration of the curriculum contexts was conducted by adopting and applying a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats). SWOT analysis assesses internal and external factors, as well as current and future potential. Identifying core attributes across the four dimensions of the framework (Helms & Nixon, 2010). For our reported study, the SWOT assessment included the analysis of published materials from both institutions. Further, internal documents related to evaluation protocols, approaches and guidelines were also analysed. We explored curriculum context, learning objectives, and teaching approaches - as described in material published by both institutions. Each year of each programme was evaluated in turn.

5.1.1 Strengths and weaknesses

Depending on which course students take at Brunel Design School, undergraduates can choose to pursue the more technical aspects of design or a design process route. These paths offer inclusive scope to accommodate a wider breadth of student interests and future careers aspirations. In comparison, UNIST Design has one undergraduate design course. This may be the reason the *BSc Design* appears to cover both technical skills and knowledge as well as developing core design competencies such as visualisation skills, design thinking and process. The education at UNIST leans into theory and technical outcomes as evidenced-based design. This is likely the result of UNIST being research based, within a specialised research institution of science and technology. In terms of inclusion of knowledge and skills related to disruptive technology, or its application in design, it is not clear which approach, technical or process, is preferred. Certainly, the BSc programs offered by both institutions incorporate technical aspects.

At first glance, it appears Brunel Design School is stronger in providing process-intensive education. Student design assessments include an emphasis on design process, as well as outcome. This is evidenced by the requirement for submission of project reports as proof of creativity in the design process. In contrast, UNIST Design appears to include course provision related to technology and engineering. Brunel has more design-based modules. For example, it offers DM1700 Design Process and Design Research throughout the 3 years of study. In terms of infrastructure to support courses related to emerging technologies, Brunel has limited facilities. In contrast UNIST may have the intellectual space and facilities to allow the inclusion of emergent technologies due to its context within a science and engineering research institution. Having the required facilities, and access to them, provides students an enhanced opportunity to experience technical aspects. However, it is unclear to what extent students engage either the facilities or expertise related to the science and engineering disciplines located within the same campus. It appears to us that, like other universities, departments are segregated by discipline. While students do have the opportunity to take a major and minor, it is less clear to what extent this knowledge integrates for design students, and/or is applied to their design works. Certainly, project work and learning objective evidence show some integration of design and technical skills. However, it is not until the final year that students apply this to project works - as part of a final year degree project, if at all.

On the other hand, Brunel Design School runs a placement year option for each programme of study. The placement encourages students to learn outside the classroom in an industrial environment and develop their design skills in a work setting. It is unclear if students take the opportunity to embed

themselves in technology-oriented companies as part of this year. It may be an interesting strategy to encourage design majors to spend their placement at a technology-facing industry placement.

At Brunel, students may take technical and technology-oriented courses offered within their own design school including Embedded Systems, Advanced Design for Sustainability, and Human Factors. However, access to electives also depends upon the program students are enrolled: BSc Product Design Engineering, BA Industrial Design & Technology, or BSc Design. Optional courses include: DMCCC5 Advanced Design Innovation, DMCCC6 Advanced User experience and Interaction Design, DMCCC3 Embedded Systems for Product Design, DMCCC1 Product Design Engineering Analysis, Introduction to Robotic, Services Intelligence and AI-based Affective Engineering. While students are limited by access to courses provided by other schools within the college, electives do offer some scope for the acquisition of skills and knowledge around new technologies. Certainly, the education provision at Brunel indicates this. Likewise, UNIST offers a suite of technology-focused courses including Usability Engineering, Interactive Technologies, and Electrical Engineering. While both institutions indicate strength in provision of technology-oriented courses, it is not clear to what extent these existing classes offer competencies at the cutting edge of technologies - i.e. advances in AI, or 4D printing.

5.1.2 Opportunities and threats

Brunel Design School has room to develop its education to include emerging technologies. One way this could be done is in the new first year course: DM 1605 Creative Engineering Practice, where students may be introduced to knowledge of how emerging technologies are involved within the manufacture of designed products. This could also become a required course, where all design students must learn into the integration of design and disruptive technologies. Having a required course on emerging technologies within industry manufacturing would then be both relevant to the holistic curriculum and serve to introduce the significant impact of technology on a particular aspect of design - i.e., technology-enabled change in manufacturing process.

Undergraduate education could pivot toward education in emerging technologies, contextualized within more established pedagogic design themes and agenda. For example, disruptive technologies and design can be considered in terms of environmental implications. Sustainability and design offer opportunities to engage students around the role of technologies and design in addressing significant, world issues. The integration of design and disruptive technology in design education could frame course provision and project works through a sustainability agenda.

Looking at existing curriculum provision as an example of how this may practically work, the course Advanced Design for Sustainability might integrate skills and knowledge around emerging technologies. Embedding technology within existing areas of interest and expertise could stakeholder buy-in for new curriculum provision. The integration of technology could also drive interesting questions to take up as course and/or student project focus. How might emergent technologies scaffold creative solutions to challenges around waste, material sourcing, and transportation or storage?

The Korean institution already has some course provision in emerging technologies. For example, courses such as Introduction to AI Programming, and Interactive Technology. It may be possible to leverage this existing provision to include elements of emerging technologies. For example, 4D

printing, AI or IoT (Internet of Things). Where students have exposure to technologies, they could specialize in 4D printing or other technology in one of the project courses that form the core of the UNIST Design curriculum - Product Design I and II, Creative Design I and II for example.

UNIST is also an institute of science and technology. This should provide enhanced opportunities to incorporate emerging technologies into the curriculum. This is because of the expectation and reality of a design department located among colleges and departments of science and engineering. For example, the existing Interactive Technology course may provide a platform for the introduction of AI technology and its relation to design.

This also depends upon an instructor's expertise, and willingness to adopt material into the course curriculum. Still, existing faculty expertise in computer science, and related course provision, provide a useful foundation for the introduction of emergent technologies into design programs at Brunel. Likewise, UNIST integrates engineering courses within its program, offered by other departments as Design Major electives. To extend this UNIST could require students to take courses from, for example the new School of AI. Taking this further, the institution could explicitly include AI as a component of project outcome requirements for the terminal degree project courses, Creative Design I and II. Bridges between courses may develop where knowledge of emergent technologies, and the skills to apply them to project works, are employed in the final year of the degree program. Again, this may also require careful support from terminal course instructors, and a roadmap and vision for the structured integration of technology and design in student project works. Existing expertise within the department and across the college holds significant potential.

5.1.3 Education audit report: key insights

Both UK and Korean design departments, being located within colleges of engineering, can implement emerging technologies into their curriculum for the future. From this initial analysis of curriculum provision, we think that change is something possible and feasible. We outline three key opportunities, together with related challenges, derived from our audit of educational provision across the two design departments.

First, the integration of faculty knowledge, skills and expertise in adjacent fields, but located within the same college or institution. The challenge here is to facilitate cross department contribution relevant to design. Collaboration between departments at institutional level could be incentivized through strategic programs and/or prioritised in faculty evaluation. Hiring protocols and decision makers can also prioritise objective experience working at interface between technology and design, including expected interdisciplinary competencies of new faculty to help facilitate collaboration.

Second, both Korean and UK institutions already have a selection of technology-oriented classes within the curriculum. This can be used as a scaffold for the introduction of technological knowledge and competencies. The challenge is to identify both instructors and course material of most relevance to designers interested in bridging between users and technology through design - i.e. technology introduced in a way that is relevant to students, that they can identify with, and is also of value to a design education.

Third, provide supervised opportunity for technological skills and knowledge to be applied through project-based learning. Learning through application is nothing new to design. However, the existing studio culture and learning by doing approach may facilitate the integration of technology in design project works. To be successful, this must be done following careful guidance and support. For example, through interdisciplinary teams of supervision on project works. Importantly here is the ability and motivation for faculty from different backgrounds to work together. Strategic investment and guidance at department, college and institutional level is important here.

5.2 Design sprint

As part of a series of activities, the Design Sprint session was attended by delegates from across Korean and UK institutions, and associated partners (KIDP Korea, Design Council UK). The session was chaired and run by the Design Council UK (Design Council, 2023). 25 members participated in the session. Working Groups were divided into teams comprising faculty and student members from each Korean and UK institution. The session took place in one afternoon, lasting approximately four hours. The teams were required to tackle a design challenge through the application of emergent technologies, thereby providing delegates opportunity to integrate design and technology within a design challenge, and to reflect on the challenges of doing so.

The impact of a product on the environment is primarily determined at the product design and development stage. Leaning into the Design Council's Design for Planet initiative (Sommer, Burgoyne, & Cousins, 2021), the Design Sprint introduced design as an opportunity to address environmental problems, such as climate change, with the welfare of the planet as a priority value of design. This opportunity is further scaffolded through three core values: 1) Designing resilient and adaptive products, with communities 2) designing circular economy through regenerative design of natural resources 3) easy and inclusive products & services that support sustainable living.

During the Design Sprint, the session chair introduced example product, service, and strategic design interventions as reference examples. The teams were then asked to address one of three challenge statements:

- Statement 1: Climate change adaptive and resilient products.
- Statement 2: Conserving and restoring natural resources and systems.
- Statement 3: Making it easy and attractive to adopt sustainable behavior.

In addressing the challenge statement, teams were explicitly instructed to apply emergent technologies when exploring, developing and, at the session's conclusion, delivering possible design solution ideas.

5.3 Design to kill the unnecessary

In tackling the three design challenges, Team A discussed 'waste in daily life.' Their holistic idea was to use design and technology to eliminate the unnecessary use of resources throughout the product life cycle (Keoleian & Menerey, 1994). The team focused on waste from online shopping delivery and products thrown out due to broken parts. The group started by outlining sustainability issues within the product life cycle. First, the team attempted to frame the original challenge as follows: Different forms and materials are used for delivery packaging for specific kinds of goods. Second, most consumer goods are limited to obtaining replacement parts if they are missing/broken. After

discussing some personal stories and anecdotes around unnecessary waste in their lives, the team moved to explore some approaches to eliminate or minimise waste. First, the use of reusable packages and bags for delivery and shipping. And second, the use of 3D printers to print broken/missing parts for a product. The manufacturer provides a catalogue of parts with 3D CAD data, and a consumer can later download it and 3D print it to fix up.

Except for the citation of 3D printed replacement parts, the team's engagement with emergent technologies as a driver for both problem framing, and solution ideation was limited. While the team did comprise both a faculty and students with technical expertise, this did not translate into significant contribution to the team's problem framing, solution exploration and identification activities, or criteria applied to evaluating the potential of solution candidates. However, the team did map-out the necessary skills and capabilities within design education around three groups of competencies required to deliver their proposed designs. The first group they termed, design-related skills: design ethics, design thinking, design for policy, design for sustainability, participatory design, social innovation design, and prototyping. The second group was entitled thinking-related: systems thinking, futures thinking, arts, and humanities. The last group the group identified as technology-related: Internet of Things (IoT), artificial intelligence, and 3D printing. While the mapping of skills and knowledge onto future education was interesting, the team's approach also indicated limitations in an informed and critical understanding of technology beyond a common or everyday understanding.



Figure 2: Design Sprint activities in progress.

For example, 3D printing was cited as an opportunity to integrate technology for the benefit of product lifestyle. Skills and capabilities were mapped. While the various design related aspects of the solution were clearly differentiated, citation of technology was more broadly referenced under a single term or idea - i.e. 3D Printing or AI. This indicated that while Team A explicitly considered technology as support for the challenge, including related skills and competencies (i.e. technology-enabled cluster), the role of technology was not clearly specified. While we were careful to include at least one faculty member with expertise in engineering or computer science per team, this did not translate into a significant integration of technology and design within the proposed concept solution.

5.3.1 Redesigning intergenerational household: sustainability & trust

Under the Design for Planet theme Team B targeted senior citizens aged 65 or older. The team discussed what designs may be required to solve problems the demographic faces and what

educational institutions should teach to train designers to provide technology-driven design solutions for an ageing population. The team discussed ideas, and swiftly identified two abstract, high-level challenges: loneliness and reduced mobility. In an open approach to identify core values, the team positioned trust as a broad theme and departure point for exploring solution possibilities. They then identified various solution ideas around intergeneration solutions or green AI (Schwartz, Dodge, Smith, & Etzioni, 2020). Trust was again positioned as an important criterion for assessing the potential of concept ideas, with trust of technology seen as important for the user-group. Team members also cited various key considerations around the concept of technology trust (Technology Communications, Ethics, Sustainability, and UX, Design, IoT, Open Source, Big Data Analysis, and Security). As with the previous team's work, it was interesting to see how engagement with technology, and the types of skills required in its application, was limited to technology's potential relationship to and influence on usability and design experience. This is unsurprising given the group's design expertise. However, it serves to highlight the importance of technical skill and knowledge in the application of technology to drive design. Including how to integrate technical aspects with design, both in design solutions and the skills applied in their generation and development. There may also be a role here for design in its empathic application of technology. That is, considering the role and use of technology in terms of the user's affective response (i.e. the core value, trust). Like Team A, Team B's Design cited the opportunity of various technologies, but with limitations on the scope and detail of technology's integration with the needs of potential users, what competencies are required for integration to happen, or how these skills may be acquired.



Figure 3. Team B's design outcome. Redesigning Intergenerational Households: Sustainability & trust.

5.3.2 Sustainable product cycle

Team C proposed a sustainable cycle of products which aimed to create a closed loop leading from production to consumption. A system that analyses consumer behavior and provides feedback to producers to induce better decisions around optimised production practices for reduced waste. Currently, there is only a production cycle in which goods are designed, manufactured, and distributed to consumers. In the existing manufacture and consumption process, it is not possible to know how goods purchased are consumed and finally disposed of. In the team's proposed design, producers collect data on each product across various dimensions. For example, material type, the period required for decomposition if thrown away, date of manufacture, expiration date, and information

related to the degree and difficulty of recycling. Consumers are then expected to change their behavior through access to this information at point of purchase. Other stakeholders (producers, local and national government, waste disposal) may also benefit from the resulting data. As part of a service system, consumers may make more informed choices on the products they purchase. In addition, companies that produce more recyclable products can obtain benefits such as increased national support and tax reductions. With penalties such as increased tax and reduced investment for companies that produce less sustainable products.

Having outlined their concept idea, Team C then identified two requirements for future learning and one broader theme for education: Systemic Thinking, Technology Literacy and Beyond Communication. Systematic Thinking was described as an expansion of the problem space to include various stakeholders and contexts. In doing so, deeper problems can emerge, leading to more appropriate and/or innovative solutions. Technology Literacy was described as the ability to both understand how technology works and apply understanding in the design and development of creative design solutions. The team positioned Beyond Communication to engage various stakeholders. The result was interesting in its positioning of the two learning aims and one core theme. It was less clear how and where the themes emerged, and their interaction effect with the team's idea of sustainable product lifecycle.

As with Teams A and B above, Team C's concept was not explicitly influenced by technology. While the service was described as technology-enabled, the technical functionality, or viability of the proposed service could not be known or tested. Likewise, the three theoretical concepts for future learning were not well explained or contextualised by reference to technologies, or their function. However, it is interesting to note the solution idea was technology-enabled. Through thinking about the affordances of technology (to record, store and share data on products and their life cycles), the possibility for the design to track the full product life from production to recycling was identified. In design education it may be useful to identify higher-level opportunities for interaction between technology and solution (i.e. tracking product life cycles). Then, identify the knowledge, skills and expertise required to deliver the design opportunity.

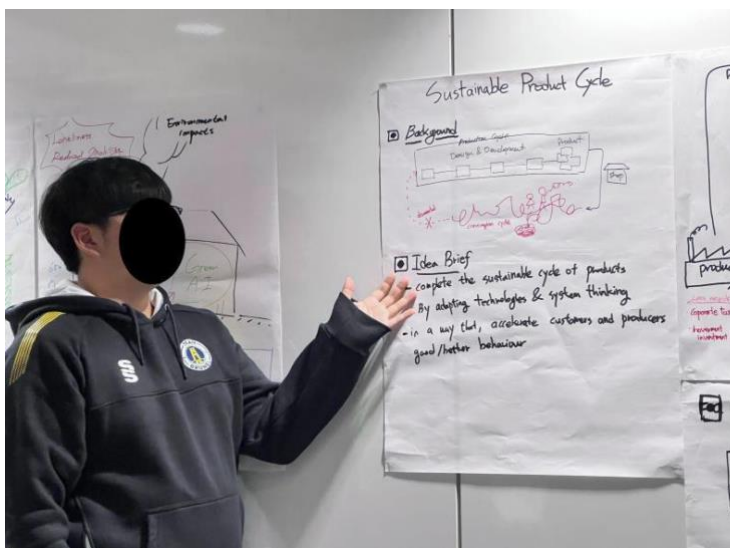


Figure 4. Team C's design outcome: Sustainable product lifecycle.

5.3.3 The 4 Musketeers

Team D quickly focused upon the design process as holding potential to enhance sustainability. The team aimed to create a framework that students could then apply to consider the holistic influence of sustainability throughout the design process. Members identified the issue that product and service providers often cunningly pass-off taking responsibility for the products and services they provide to consumers. Such an example is an accelerating tendency of greenwashing which aims to convince the public that the products they consume are sustainable when really, they are not. This tendency also relates to the private sector's key driver: to increase the sale of products and services, thereby increasing profitability. Greenwashing is a means to this end, rather than a need for sustainable products and services.

The team introduced 4 Musketeers, a framework to guide student and novice designers in considering sustainability subjectively and objectively through a process that included three approaches to sustainable design: Understanding the Interests, Life-cycle Assessment, and Impact Examination (Finnveden, et al., 2009). At the understanding interest stage, the participants put themselves into the shoes of various stakeholders - designer, user, government, and manufacturer each for 10min. By thinking from different perspectives, design students may become more aware of issues, such as conflicts of interest. This stage aims to measure the environmental indicators of designs throughout the entire product life-cycle. From raw material to development, manufacture, transport, storage, usage, and disposal. Lastly, an impact examination stage foresees the probable impact of the products to be designed. The impact is evaluated by comparing key performance indicators (KPI), which later underpin a product sustainability roadmap.

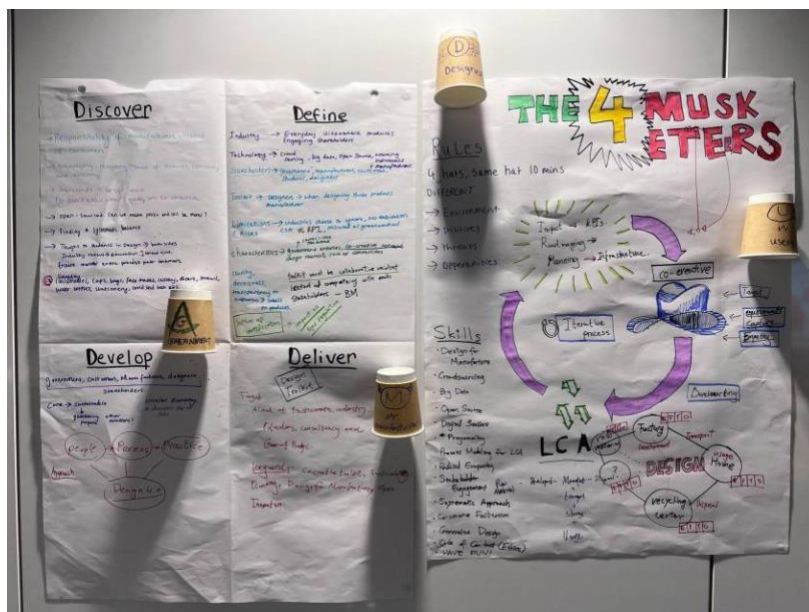


Figure 5. Team D's design outcome: The 4 Musketeers.

The team's outcome evidenced thinking towards application in design education. That is, the group explicitly developed a tool to enhance critical awareness and understanding of sustainability issues in product development processes. Of course, it was beyond the scope of the Design Sprint to test the

potential of Team D's tool. Still, the team's discussions and outcome indicated the importance of systemic thinking for designers around issues of sustainability. Likewise, due to the complexity new technologies bring to future designs, tools to facilitate a broader sweep of related issues may be important for design education as design interventions include various stakeholders, across contexts of use and digitally enabled products and user interactions. We were also interested to see the influence of a team member with experience of developing design tools and methods upon the kind of outcome produced. When considering the integration of knowledge and expertise around emergent technologies within a design curriculum, it may be important to develop tools and methods as enablers in the integration of technology and design. Both instructor expertise in the technology, and those with abilities to develop tools and approaches to the application of technology through design are important here. The next chapter provides a discussion and summarizes the outcomes of this work, suggesting new ideas in design and technology education.

6 Discussion and conclusion

With the accelerated impact disruptive technology is having on design education, an international project between Korean, UK institutions, and associated project partners, aimed to respond to the question: how must design education change? In the current paper we report insights derived from an analysis of undergraduate curriculum provision from two leading design departments in Korea and the UK, both located within colleges of engineering. We also report the result of a Design Sprint activity, undertaken by faculty and student teams comprising members from across Korean and UK institutions, run and chaired by the Design Council, UK.

First, our audit indicated opportunity for both design departments due to an existing infrastructure to support integration of knowledge, skills, and expertise of faculty within adjacent fields, but located within the same college or institution. This is evidenced in course and program offerings by interdisciplinary faculty, both within the department and across college. Students then can acquire technological competencies. The challenge here is to facilitate cross department contribution relevant to design. In a top-down approach, collaboration between departments could be incentivized at institutional level through strategic programs to stimulate collaboration, and recognition in faculty evaluation. Colleges and/or department-level hiring committees can also identify expected interdisciplinary competencies of new faculty to help facilitate collaboration.

Second, both Korean and UK institutions already have a selection of technology-oriented classes within the current curriculum. The result of this is a scaffold for the introduction of technological knowledge and competencies. Including technology-based curriculum. This existing content has the potential to stimulate student interest. The challenge is to identify both instructors and course material of most relevance to designers interested in bridging between users and technology through design. Technology introduced in a way that is relevant and of value to a design education whereby students are interested in application at the interface between technology, and the people who use it.

Third, provide supervised opportunity for students to apply technology-driven design through project-based learning. Learning through application is nothing new to design. However, the existing studio culture and learning by doing approach may facilitate the integration of technology in design project

works. However, to be successful, this must be done following careful guidance and support. This support may be achieved through interdisciplinary teams of supervision on project works. Importantly, the ability and motivation for faculty from different backgrounds to work together will require significant strategic investment and guidance by the institution. This is because both structural and cultural barriers exist within both institutions with regard existing cross-disciplinary efforts. Structural challenges include division between disciplines, and the location of decision-making power, and autonomy between departments or schools within the college. A recommendation is incentivized interdisciplinary initiatives on education. The Korean partner institution is already piloting this approach. Cultural barriers include differences in working practices, disciplinary norms and conventions, and an ability and desire to work across disciplines. However, interdisciplinary education has significant benefits for both faculty and students with respect to acquiring a broader knowledge-base (Self & Baek, 2016).

Insights derived from the Design Sprint activity included the importance of instructor expertise in facilitating the inclusion of technology in problem framing and any eventual solution idea. This may seem self-evident. However, as indicated in the Design Sprint process and outcomes, both individual members' expertise, and willingness and ability to apply expertise to design activity informed the role of technology as represented, and potentially enhancing, creative design solutions. An individual's ability to work at the intersection of design and technology appeared as important as expertise here. For example, while we distributed members with technical competencies between teams, this did not uniformly translate to technology as driver for solution ideas. Perhaps design education must also carefully consider the strategic ability to apply technological knowhow to the design process. For example, the teaching of methods and tools as framework to support the integration of design and emergent technologies. These may work as enablers to integrate both technology and design.

The Design Sprint activity also indicated a limitation in how groups engaged technologies as opportunity to drive design works. For example, Team A explicitly considered technology as support for their design, but the role of technology was not clearly specified. Instead technological opportunity was limited to a general notion of the technology (i.e. how can we use 4D printing?). A deeper knowledge base is required. Otherwise, feasibility of technology function is often an issue between design and the viability of a technology's use or application to drive suggested design solution opportunities. This highlights the importance of technical skill and knowledge in the application of technology to drive design. What skills, knowledge and expertise do future designers require to leverage the opportunity of this or that technology for the benefit of their design ideas? What should the scope of this expertise look like? Perhaps we can focus on design's important role at the intersection between technology and people. From here, consider how much and what, future designer needs to understand about a disruptive technology (i.e. AI).

Our project aims to understand how design education must change to leverage the opportunity of accelerating, disruptive technology. This is not a new question. Since the emergence of the earliest design schools, such as the Bauhaus, established in Germany by Walter Gropius, design education has continued to evolve with a changing discipline. New fields and areas of design have emerged, driven both by a pushing at the boundary of design and the impact of technology. New design disciplines have emerged with new understanding and new technologies: UI/UX Design, Service Design, Human Computer Interaction Design. However, the difference today is the accelerating pace of change. While

the acceleration of technological development continues apace, fundamentally design's purpose of applying technology for the benefit of people's lives remains the same. The question then is how to leverage the opportunity of technology as bridge between people and its use?

In the current paper we have reported on an audit of programme and curriculum content at two leading design departments as well as through the Design Sprint. One in Korea, the other in the UK. Both located within colleges of engineering. And both purporting to integrate design and technology within their course provision. It should be noted that while this research predominantly describes the context of Design Education within the UK and Korea and involving only two institutions, it still provides a good indication that Design Education should change. Future work could involve more Design courses that are not limited to Product Design, but to also consider other Design programmes such as the teaching of Graphics Communication, Architecture, Interior Design, Fashion, etc. We propose three intentionally broad, yet succinct points for Design Educators and Institutions to consider:

- First, identify existing teaching approaches, foundational design skills, knowledge and competences that have worked well.
- Second, consider what needs to change, how quickly, and what fundamentals should remain.
- Third, move with the times by ensuring the relevance of design education, and for designers to be equipped to ensure technology-driven futures continue to be human-centered.

Perhaps there is a contradiction at the heart of this question that will help us to think about the nature and scope of change required. What needs to change, how quickly, and what fundamentals need to remain? To avoid stagnation and eventual irrelevance, there is a need for continued renewal and a pushing at the leading-edge of design education. Even more so today with the increasing speed and reach of disruptive, technological change. On the other hand, we need to identify existing teaching approaches, foundational design skills, knowledge and competences that have served us well in the past and have the potential to continue to underpin design education in the future. The classic contradiction between need for renewal, and ability to identify how change may integrate with what already exists and works well. How must design education change to maintain what works, provide space and opportunity for inclusion of new technologies - associated practices, skills, and knowledge? But at the same time, how can we also identify and leverage the most appropriate/best existing design knowledge, skills, and pedagogic approaches to provide a truly new design education? As our world is influenced by disruptive technologies at greater rates of change, design plays an increasingly important part. Our goal is to move with the times – thereby ensuring both the relevancy of design education, and that designers are equipped to ensure technology-driven futures continue to be human-centered.

References

- Archer, B, and Baynes, K. (1977) The Future of Design Education. Design for Need. The Social Contribution of Design. pp. 126-132: <https://doi.org/10.1016/B978-0-08-021500-6.50030-6>
- Brosens, L., Raes, A., Octavia, J.R. et al. How future proof is design education? A systematic review. *International Journal of Technology and Design Education* 33, 663–683. <https://doi.org/10.1007/s10798-022-09743-4>
- Design Council. (2023). Retrieved March 22, 2023 from Purpose, Vision & Values: <https://www.designcouncil.org.uk/our-mission/purpose-vision-values/>
- Finnveden, G., Hauschild, M., Ekvall, T., Guinée, J., Heijungs, R., Hellweg, S., . . . Suh, S. (2009). Recent developments in life cycle assessment. *Journal of Environmental Management*, 91(1), 1-21. doi.org/10.1016/j.jenvman.2009.06.018
- Helms, M., & Nixon, J. (2010). Exploring SWOT Analysis-Where Are we Now? *Journal of Strategy and Management*, 3, 215-251. doi.org/10.1108/17554251011064837
- Ilhan I.O., and Karapars, Z. (2019) Industrial Design Education in the Age of Digital Products, *The Design Journal*, 22: 1973-1982, DOI: 10.1080/14606925.2019.1594922
- Justice, L. (2019). The Future of Design Education. *Design Management Review*, 30(1), 33–37. <https://doi.org/10.1111/drev.12159>
- Keoleian, G., & Menerey, D. (1994). Sustainable development by design: review of life cycle design and related approaches. *Air & Waste*, 44(5), 645-668.
- Kim, B., Joines, S., & Feng, J. (2022). Technology-driven design process: teaching and mentoring technology-driven design process in industrial design education. *International Journal of Technology and Design Education*, 33, 521–555.
- Lesley-Ann, N. (2022) Designing New Futures for Design Education, *Design and Culture*, 14:3, 277-291. <https://doi.org/10.1080/17547075.2022.2105524>
- Majithia, R.K. (2017) What’s Next in Design Education? Transforming role of a designer and its implications in preparing youth for an ambiguous and volatile future, *The Design Journal*, 20: 1521-1529, DOI: 10.1080/14606925.2017.1352676
- Meyer, M., & Norman, D. (2020). Changing Design Education for the 21st Century. *She Ji: The Journal of Design, Economics, and Innovation*, 6(1), 13-49. [10.1016/J.SHEJI.2019.12.002](https://doi.org/10.1016/J.SHEJI.2019.12.002)
- Norman, D. (2010, November 26). *Why Design Education Must Change*. Retrieved March 22, 2023 from Core77: <http://www.core77.com/posts/17993/why-design-education-must-change-17993>
- Roser, M. (2023). *Technology over the long run: zoom out to see how dramatically the world can change within a lifetime*. From Our World in data: <https://ourworldindata.org/technology-long-run>
- Schwartz, R., Dodge, J., Smith, N., & Etzioni, O. (2020). Green ai. *Communications of the ACM*, 63(12), 54-63. [10.1145/3381831](https://doi.org/10.1145/3381831)
- Self, J., & Baek, J. (2016). Interdisciplinarity in design education: understanding the undergraduate student experience. *International Journal of Technology and Design Education*, 27, 459–480. [10.1007/s10798-016-9355-2](https://doi.org/10.1007/s10798-016-9355-2)
- Self, J., Evans, M., Jun, T., & Southee, D. (2018). Interdisciplinary: challenges and opportunities for design education. *International Journal of Technology and Design Education*, 29, 843–876. [10.1007/s10798-018-9460-5](https://doi.org/10.1007/s10798-018-9460-5)
- Sommer, A., Burgoyne, P., & Cousins, B. (2021). *Design for Planet Festival 2021*. Retrieved March 22, 2023 from Design Council: <https://www.designcouncil.org.uk/our-mission/design-for-planet/design-for-planet-festival-2021/>
- The Fourth Industrial Revolution*, by Klaus Schwab | *World Economic Forum*. (2016). Retrieved March 22, 2023 from The World Economic Forum: <https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab>
- Verganti, R. (2008). Design, Meanings, and Radical Innovation: A Metamodel and a Research Agenda. *Journal of Product Innovation Management*, 25(5), 436-456. <https://doi.org/10.1111/j.1540-5885.2008.00313.x>

About the Authors:

Eujin Pei: Dr. Pei is Reader and Associate Dean for Brunel University London, UK. He is Director for the BSc Product Design Engineering, listed 8th in the UK Complete University Guide 2020 League Table. Eujin is Fellow and Council member of the IED.

Sung Jun Kim: Sung Jun Kim is a doctoral student at Ulsan National Institute of Science and Technology (UNIST), specializes in finding design innovation opportunities using future-oriented design methods at the Graduate School of Creative Design Engineering.

Seongbeom Kim: Seongbeom Kim is a doctoral student at the Graduate School of Carbon Neutrality, Ulsan National Institute of Science and Technology, South Korea. He tries to address design initiatives for sustainability transition with a living lab approach.

DaeHun Lee: DaeHun Lee is taking Master/Ph.D. integrated course in the Design Department at Ulsan National Institute of Science and Technology (UNIST), South Korea. He is interested in the design research and implementation of robots' personality.

Seunghoon Lee: Seunghoon Lee is currently working for Hyundai Motor Company as a Design Strategist. Seunghoon continuously tries to bridge the gap between academic and practical knowledge to jump over different disciplines to expand his contribution to making influencing the world.

James Self: Prof. Self is an Associate Professor of design at UNIST (Ulsan National Institute of Science & Technology). He is also director of the Design Thinking Research Lab, UNIST, and Visiting Academic with Brunel University London. His research interests include design thinking, design innovation, and design education.

Acknowledgement: This project was funded through the UK Research and Innovation (UKRI) Fund for International Collaboration (FIC) UK-South Korea SSH Connections Call. This grant was awarded by the Economic & Social Research Council (ESRC) on behalf UKRI. Grant Ref: ES/W010984/1, and was supported by Korea Institute for Advancement of Technology (KIAT) grant funded by the Korea Government (MOTIE)(P0012725, The Competency Development Program for Industry Specialist).