DEVELOPING IDEATION & ITERATIVE DESIGN SKILLS THROUGH HUMAN-CENTRED PRODUCT DESIGN PROJECTS

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ABSTRACT
Understanding human-centred design and developing products for diverse populations are crucial skills for product designers to develop; rapidly acquiring these skills is essential. Many UK undergraduate product design students come from diverse backgrounds acquiring varying qualifications at school/college level which are usually further supplemented by Non-Exam Assessments (NEAs). These preparatory courses provide practical skills and theoretical knowledge but often overlook human-centred design and effective ideation/iteration. First-year students typically have limited experience designing for broader populations, usually designing products for themselves or family members. Early undergraduate education must therefore emphasise researching and designing for diverse population groups by connecting research activities to iterative design processes for continual improvement. This involves considering varying factors such as aesthetics, ergonomics, usability, manufacturability, cost, etc. This paper presents a case study on first-year BSc Product Design (BSc PD) students at Nottingham Trent University (NTU) that engage in two projects in the first 10 weeks of their undergraduate education. The first project involves redesigning a power tool using an iterative design process. Students choose one of three preset user personas and select a power tool (electric screwdriver, detail sander, or jigsaw) to redesign using a human-centred approach. The second project is a cardboard lighting project where students design a light for a home based on a user persona they formulate but are required to focus on diverse living populations. Key findings highlight how the quality of student outputs improve when they develop an understanding of product sectors while empathising with users and identifying their needs using human centred design (HCD) and varying research methods.

Keywords: Design processes, human centred design, ideation, iterative design, project-based learning, power tools, lighting

1 INTRODUCTION
Understanding HCD principles is a fundamental skill for any product designer; this is a core topic/competency that all product design (PD) / industrial design (ID) students need to acquire. Scholars have identified that HCD has potential to contribute to strategic innovation whilst also acknowledging that different HCD methods/activities generate different layers of knowledge [1]. The benefits of HCD are widely accepted as being of upmost importance in both academic (product design / industrial design / design engineering) and industry contexts [2]. Furthermore, researchers have identified that HCD methods have a positive impact within product development in three areas: opportunity identification, design development, and evaluation [2-4]. However, several problems exist, such as i) lack of sensibility and empathy during ethnographic research, ii) miss interpretation of qualitative data when designing a solution, and iii) not being able to ensure that the user will implement the solutions [5]. Therefore, it is important that HCD knowledge/skills are taught within PD projects immediately when entering higher education. Developing these key skills quickly/effectively is essential in any PD student's education. A key challenge that exists within PD/ID education is that many students enter higher education with only a surface level understanding of designing for users. Secondary School level programmes often don't have enough time to explore HCD in any depth, this results in students commonly designing a basic product for a family member or family friend, rather than identifying a real-life design challenge.
UK students regularly enrol on undergraduate PD/ID programmes with backgrounds in Product Design-related A-Levels, BTECs, T-Levels, or equivalent qualifications, often accompanied by Non-Exam

Assessments (NEAs). These preparatory courses are designed to provide students with both practical skills and theoretical knowledge. While these qualifications encourage students to explore the historical, social, cultural, environmental, and economic factors influencing design and technology, and provide opportunities to apply their learning through the creation of prototypes, there is a tendency to overlook HCD. Additionally, the ability to ideate and iterate designs effectively is often not sufficiently taught and integrated into the curriculum. A common observation made during the initial weeks of teaching first-year PD students is that student prior design experiences are often limited to designing products for themselves or family members thus limiting their exposure to tackling problems that go beyond surface level considerations. This trend becomes evident upon examining previous design work. Therefore, it is imperative in the early stages of a PD/ID student's undergraduate studies to emphasise teaching students how to research and design products for users that don't conform to the norm. Additionally, focusing on iterative design as a cyclical process of continual improvement to progress towards concepts and outcomes is a critical skill for design students to integrate into their practice. This is driven by factors such as aesthetics, anthropometrics, ergonomics, usability, suitability for manufacture, material properties, componentry, technical requirements, legislation, and cost.

This paper presents a case study examining first-year BSc Product Design (BSc PD) students at NTU who were tasked with two HCD projects within the first ten weeks of their first-year studies that focus on power tools and lighting. The findings presented in this paper demonstrate how students acquired an understanding of two product sectors while empathising with their users, seeking to understand their problems/needs. We reflect on student feedback, where students often stated that they initially struggled to express their insights/define the users' needs/problems before challenging their assumptions and creating new innovative solutions. We present how we overcame this challenge through the creation of a dynamic design studio environment, where students participated in rotations of breakout sessions and active collaborative learning sessions strategically designed to direct learning in core subjects.

2 METHODS

As part of a ten-week module students study entitled 'Design Fundamentals [6], students undertook two projects i) a three-week power tools redesign project and ii) a five-week carboard lighting project. Within the power tools project, students were required to redesign a power tool using an iterative design process. Designs were not taken through to the final prototyping and testing stage. Students were tasked with choosing one of the given user personas and selecting a power tool from the list of products provided (electric screwdriver, detail sander, or jigsaw), which they were given to disassemble. They were then required to redesigning their chosen power tool to meet the needs of their chosen persona ensuring their design housed all the required components for the power tool they chose whilst considering the space needed for new components they wished to add. The user personas were specifically set up to incorporate conditions such as arthritis, colour blindness, index finger amputation, to ensure the students had to conduct empathic research activities. Students were required to demonstrate an iterative design process through research/sketch development.

Within the cardboard lighting project students were required to design a light through iterative design, following the Double Diamond design process. Their process covered research, design, development through sketching and modelling, and production of a fully resolved final model. Students were tasked with conducting a wide range of research into i) the type of lighting and light they intended to design, ii) a location within a home where the light would be situated/used, iii) a potential consumer/user to design the light for, and iv) develop a re-framed design brief. In addition, the students were provided with a standard light fitting and light bulb and provided the parameters of corrugated cardboard as the construction material. Throughout this project the students were required to show an iterative approach through clear implementation of the Double Diamond design process. Furthermore, their iterative approach was required to cover initial and developmental sketching and sketch modelling to better understand 2D/3D forms and construction before producing the final high quality cardboard model.

To achieve positive student outcomes from the projects, various academics facilitated rotations of SCALE-UP breakout groups/activities (Student-Centred Active Learning Environment with Upside Down Pedagogies), ensuring students were engaged and proactive in project-based learning. Core SCALE-UP principles implemented included backward assessment design, flipped learning, strategic group formation, chunked learning, peer feedback and formative support. A key set of studio breakout group activities focused on design sketching techniques on 2D/3D form generation, ideation/iteration page composition, marker rendering etc. (Figures 1-3). These were also supplemented alongside weekly

design sketching classes. The techniques used were further integrated, alongside project-specific sessions such as rapid research workshops, ideation/iteration workshops, concept generation and sketch modelling. It was crucial to address knowledge generation, core research/design skills, and design qualities/attributes, therefore, students were required to demonstrate an understanding of basic concepts such as form, balance, and proportion in 2D/3D design format, as well as design processes encompassing marketing, aesthetics, ergonomics, manufacturing, materials, and commercial and technical aspects through their design activities; this is evidenced in a previous publication by Siena et al [6].

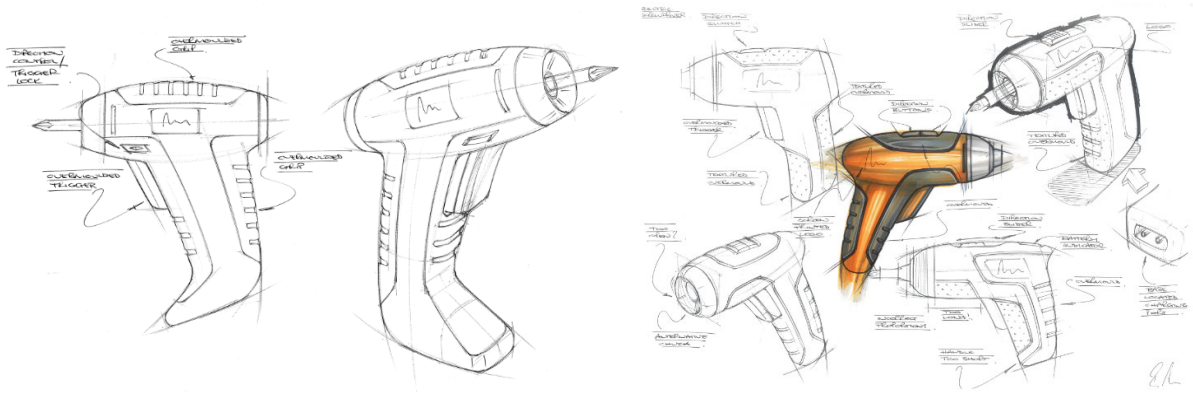

Figure 1. Power Tool Sketch Classes On 2D/3D Views & Page Composition (Credit: Richard Malcolm)

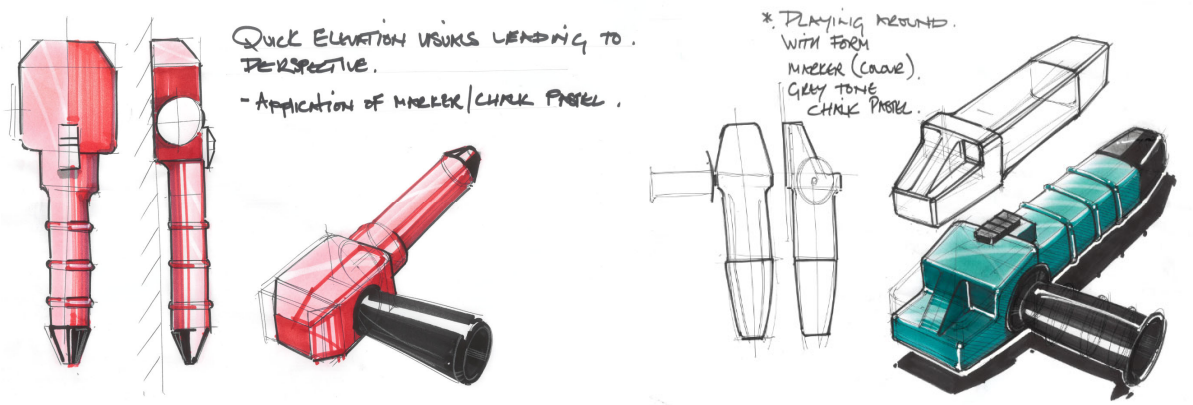

Figure 2. Power Tool Sketch Classes On 2D/3D Elevations, Application of Colour Through Colour/Grey Tone Rendering Markers and Chalk Pastels (Credit: Paul Kennea)

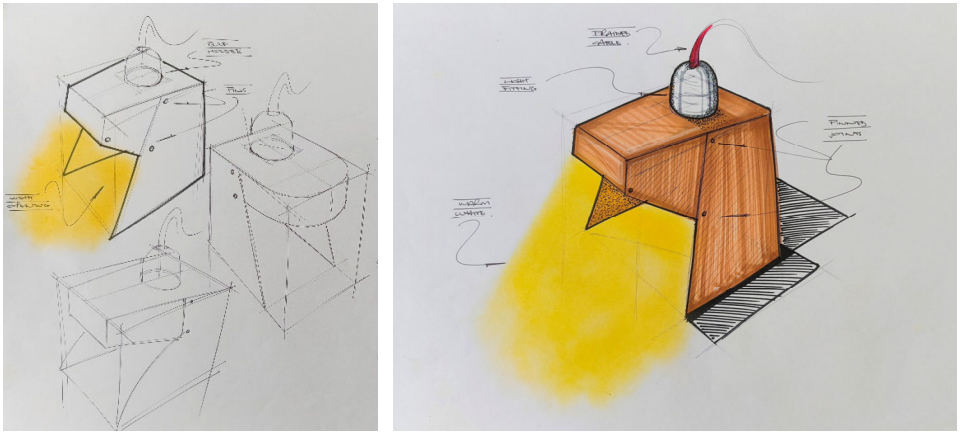

Figure 3. Lighting Design Sketch Classes On 2D/3D Views & Application of Colour Through the Use of Colour and Grey Tone Rendering Markers and Chalk Pastels (Credit: Richard Malcolm)

A critical set of activities within each of the projects included a variety of breakout sessions including store visits, empathic research workshops, rapid research workshops, ergonomic/anthropometric activities, ideation/iteration workshops and rapid model making activities. Store visits were essential to understand the wide variety of room types, light formats and aesthetic considerations. Furniture and homeware department stores across Nottingham City and the wider Nottinghamshire area were visited including Nottingham Lighting Centre, John Lewis, Hopewells, Aura, Dunelm, IKEA, amongst others, in order to complete market research into a diverse range of products and price points. Research from these store visits then linked to the ideation and iteration workshops. Within the rapid ideation and iteration workshops a variety of techniques were utilised including mind mapping, brainstorming, 30 circles, 12 boxes, Crazy 8's, Mash-Up, 3-6-5, amongst others. These rapid ideation techniques were derived from Knapp et al [7], with introductory activities using the methods completed first, before then running power tools and lighting focused ideations/iteration focused activities within the projects.
To review the success or failure of the HCD focussed projects the BSc PD students studying across full time and sandwich routes during the 2023/24 academic year (n=53) were sent a module survey. This module feedback survey covers overall satisfaction, feedback on module teaching, assessment and feedback considerations and module organisation and resources. The post module feedback survey was completed by 64.1% of students (n=34). The anonymised survey was distributed via an in-person studio briefing and powered by the MySay survey platform. Five-point Likert scale questions were utilised with students asked to give testimonials and written feedback via open ended questions.

3 RESULTS

After running the power tools and lighting projects, it was immediately evident that the ideation/iteration methods introduced were threaded throughout the students' submissions. Figure 4 presents an example of a student's power tools project work demonstrating the user of various ideation and iteration methods taught. Across the entire cohort it was evident that compared to previous year groups, the integration of the ideation/iteration methods were consistently used throughout the submitted process documents. Furthermore, the design features integrated into the design work and the use of critical annotations viewed on the sketch work were specifically linked to the user personas. Another positive outcome exhibited in the students' design work was the integration of the techniques to help progress ideas through the development phase of the design process (Figure 5). Not only has this had a positive impact on the overall narrative and progression of the design work, but this positively impacted on the quality of model making produced of the final outcomes (Figure 6).

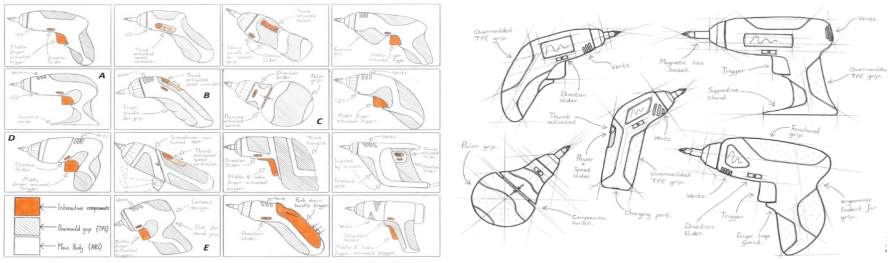

Figure 4. Electric Screwdriver Ideation Sketch Pages (Credit: Matt Ledger)

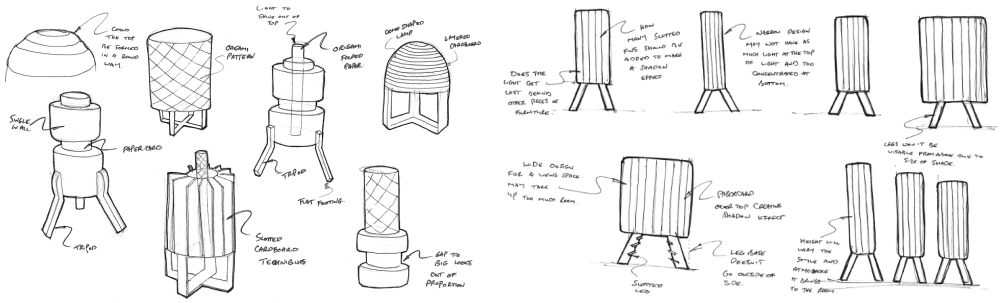

Figure 5. Lighting Project Initial Generation & Development Sketch Pages (Credit: Gavin Jones)

Figure 6. Afterglow – Corrugated Cardboard Free Standing Light (Credit: Gavin Jones)

The quantitative results from the module survey identified several key findings with regards to the quality of teaching, the progression opportunities provided and the satisfaction levels with regards to the development of skills. The module received an overall satisfaction score of 4.25/5, demonstrating a high proportion of students had a high level of satisfaction when engaging with the module and its taught content. Significantly, 95% of students identified that the module teaching staff were good at explaining things, with 5% neither agreeing nor disagreeing, thus demonstrating that the content delivered was perceived to be of high value. Additionally, 95.8% of students agreed that the teaching methods used within the module helped their learning, with 4.2% neither agreeing nor disagreeing. Student commentary also highlighted the usefulness of the ideation/iteration methods taught and structure and dynamism of the design studio sessions. 95.8% of students agreed that the module challenged them to achieve their best work, with 4.2% neither agreeing nor disagreeing. Moreover, 90.8% of students stated they understood how the completed module/projects link with the rest of their course, with 9.2% neither agreeing nor disagreeing. Notably, 100% of students stated they were satisfied with the teaching quality from the module/projects, and 100% of students stated they understood how the module/projects helped them develop skills and knowledge relevant to the subject discipline. Finally, 95% of students identified that the classes/sessions delivered helped them prepare for the assessment of their work.

The qualitative results presented below are a small selection of student feedback/quotes that have identified several key outcomes as result of undertaking the module/projects. Student feedback identified that the module was an effective introduction to their course, with new skills being introduced at an acceptable pace. The iterative design methods/processes taught, particularly in the power tools project, were appreciated by students who identified how this helped them understand the design process but also the role ideation/iteration activities play in development of final designs. The use of rapid ideation of sketch models was also valued, ensuring students were able to prioritise speed/diversity of ideas over the quality of the outcome when exploring and conveying initial ideas/developments. The structured approach of the module/projects was praised for building skills progressively, encouraging deeper thinking, and providing valuable insights into the sector. Additionally, the workshops on iterative design, one-to-one development sessions, and modelling support were deemed extremely helpful. Overall, the module was deemed enjoyable and met students' expectations of a product design course.

I enjoyed the iterative process to develop my power tool into a final design in the through iteration project. Having tutorials is a good way of gaining insight into progression.

I like how we did rapid ideation of sketch models because it taught me that it doesn't matter how good quality my models are if they get the idea across and prioritise speed over quality when it comes to sketch models.

The module/projects have been very helpful in introducing us to the course with each project introducing new skills at a reasonable pace, along with that, the module has been very enjoyable to take part in and was what I expected in what a product design course is.

I like the structure of the module/projects and how it builds up your skills. Classes allowed me to think deeper about my work and gave me insight into my field.

The fact that we are taught "how" to design is extremely helpful, i.e. the workshops on iterative design, the one-to-one development and the modelling support.

4 CONCLUSIONS & RECOMMENDATIONS

This work addresses a critical gap in first year PD students' knowledge by emphasising HCD in the early stages of their higher education journey. The delivery of HCD principles and ideation/iterative design processes to first-year BSc PD students at NTU highlights the importance of early exposure to designing for diverse user groups, which is often overlooked pre-university. This case study demonstrates how students can develop empathy and a deeper understanding of user needs through structured design projects, by examining a variety of product sectors, and empathising with user needs. The requirement for students to redesign a power tool for a specific user persona with specific needs highlights the real-world application of these skills. By completing the power tools project and gaining an understanding of HCD, this has allowed students to successfully create their own design brief for the lighting project which often explores a diverse range of users from varying backgrounds and locations. By creating a dynamic design studio environment, featuring breakout sessions and collaborative learning, this provides valuable insights for PD/ID educators to create a working environment that encourages learners to co-create. Based on our findings, our key recommendation are as follows:

1. **Emphasis on Empathy & Ergonomics:** Introduce students to the concept of empathic research early in the design process. Creating empathic research and ergonomic workshops will encourage students to understand and relate to the needs, challenges, and experiences of diverse user groups through user research and persona development.
2. **Hands-On Projects:** Incorporate hands-on projects that require students to apply HCD principles to products that they can relate to initially. For example, task them with redesigning everyday products for specific user personas with unique needs, whether this be accessibility, disabilities, cultural differences etc.
3. **Iterative Design Process:** Teach iterative design processes as a cycle of continuous improvement to emphasise the importance of prototyping, testing, and refining designs based on user feedback, and not just settling with one of the first ideas that are created.
4. **Collaborative Learning:** Promote a collaborative learning environment where students can work in teams, share ideas, and provide constructive feedback. At NTU we have done this by embracing SCALE-Up and creating studio environment that keeps students engaged allowing them to explore various aspects of design, including vocational skills/traditional academic skills.
5. **Focus on Real-World Applications:** Use real-world case studies, live projects, competition briefs to illustrate and contextualise the importance of HCD.
6. **Feedback and Reflection:** Encourage students to seek feedback from peers, tutors, and potential users; setting up opportunities to seek feedback helps promote a culture of reflection where students can critique and analyse design decisions based on their experiences.

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