Preliminary study of how 21st-Century Skills are developed during a participatory user-centred curriculum intervention at Key Stage 3 in Design and Technology

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ABSTRACT

Whilst designing 'for and with' end-users has been commonplace in the professional design space since the 1970s, there is a lack of research evidence of empathic or human-centred design in primary and secondary education. This paper presents a preliminary study of the 'Solving Genuine Problems for Authentic Users Project' conducted to explore the effect that involving end-users throughout the design process has on students and their outcomes as part of their Key Stage 3 D&T education. Sixteen 12-13-year-old students at a secondary school in England worked in teams of four to with a member of the school catering staff to develop a prototype, aimed towards solving a problem that they identified together. The student researchers utilised agency in the research methods they employed to gain a better understanding of the design context. Data included a pre and post questionnaire to measure students' creative potential which helped to improve an understanding of how empathy, a recognised 21st-century skill, was developed over the course of the study. Other data collected included photographs of student work and the students' field notes. Data was thematically coded to offer a narrative of the findings. This study contributes to the growing understanding of 21st-century skill development in a D&T context, as well as the facilitation of face-to-face collaboration with end-users at an early stage of secondary design and technology education.

Key Words: user-centred design, participatory design, empathy, 21st-century skills, design education

1. INTRODUCTION

21st century life and work require individuals to possess specific skills, often referred to as soft or more recently, human skills, to successfully confront the complex challenges presented by technology and society. So-called 'wicked problems' such as climate change, overpopulation, and rapid technological advancements have emerged, which are complex and 'messy' (Buchanan, 1992; Rittel & Webber, 1973), each demanding a diverse range of skills to navigate successfully. Educators and policymakers around the world are placing a greater emphasis on enabling students to develop so-called 21st-century skills across all phases of education, to ensure that they are equipped to address these challenges (Ananiadou & Magdalean, 2009). With new forms of

artificial intelligence (AI) presently in the spotlight, a shift in the labour market paradigm has motivated policymakers to demonstrate an appreciation for students' human capacity for creativity (OECD, 2019a). Focusing on the development of human creativity alongside the proliferation of AI and other technological advancements, encourages people to embrace the human uniqueness of creating value, reconciling tensions, and taking responsibility (OECD, 2019b). The OECD Skills for 2030 initiative (OECD, 2019a; 2019b) centres around the development of competencies related to cognitive and meta-cognitive skills, social and emotional skills, and practical and physical skills. The design and technology (D&T) curriculum in England is well-placed to develop all of these skills in children and young people, especially in the context of addressing contemporary societal challenges (Morrison-Love, 2022) due to its focus on designing within contexts and responding to problems, enabling students to become socially involved and participate in authentic problem-solving; bringing about hope and change through transformation (Klapwijk, 2017; Morrison-Love, 2017). The national picture in England at Key Stage 3 is bleak and has been recognised by the Design and Technology Association as being a problem for the future of the subject. The Association has released a position paper (2023) highlighting the importance of change at Key Stage 3, capitalising on the development of human skills.

An approach to design that has become increasingly popular in industry is participatory design, which engages end-users as active participants in the design process (Sanders & Stappers, 2008), demanding the application of many 21st-century skills. The purpose of this preliminary research project is to investigate how 21st-century skills are developed when Key Stage 3 students (age 11-14 years) work as designers engaging in a participatory design process, as part of the design and technology curriculum.

'21st-century skills' include creativity, critical thinking, collaboration, communication, and digital literacy and are widely considered as necessary for individuals to adapt to new challenges and opportunities, and to solve complex problems (OECD, 2019a). Creativity, critical thinking, and collaboration form the focus of this project, with empathy being essential in all three. D&T is a subject in the National Curriculum for schools in England (DfE, 2013) which is uniquely placed to develop these skills; it requires students to engage in a range of designing, making, and critiquing activities (McLain, 2023), contributing towards an overarching knowledge of 'design and technology'. It also requires students to utilise skills such as critical thinking, creativity, and communication to solve problems in different contexts, as well as applying technical skills such as manipulating materials and components using tools and equipment.

Participatory design is pertinent to the development of 21st-century skills, as it requires collaboration and communication with peers and users, the development of empathy, and the ability to think creatively in relation to problems and solutions. [cite] Evidence of studies focusing on human-centred or empathic design at primary and secondary school level is scarce (Bosch et al., 2022; Dindler et al., 2020), therefore, this study aims to contribute to and expand upon this emergent body of knowledge by exploring a case study of a preliminary project aimed at facilitating sustained face-to-face interactions between end-users and lower-secondary aged students, towards collaboratively solving an identified problem through designing and making.

2. LITERATURE REVIEW

2.1. 21st Century Skills and Interaction with End-Users

The literature highlights that design education is going through a period of transition (Bakirlioğlu et al., 2016), blurring the lines between design and design research (Shore et al., 2018), revealing the potential of considering user knowledge, human factors, experiences, and interactions in the engagement of participatory practices with end-users and stakeholders. Human-centred design is emerging as a dominant trend (Chmela-Jones, 2017), contributing towards the shift in design education towards a more participatory form of practice (Bakirlioğlu et al., 2016; Shore et al., 2018). The value of involving end users in a participatory design process lies in learning different 21st-century attributes and in producing design outcomes (Bosch et al., 2022).

21st-century skills are featured widely in design education literature, noting social and emotional skills as being particularly relevant in preparing students for navigating working life (Demetriou & Nicholl, 2022; Mitchell & Light, 2018). There is much discourse on the skills of problem-solving, creativity, and empathy within design education, however this tends to lie within the higher education space. In pertinent studies to the focus of this topic and its relation to schools, Bosch et al. (2022) and Klapwijk and Van Doorn (2015) note that the value of involving end-users in the participatory design process is in the students' development of 21st-century skills, especially empathy.

2.2. Empathy and its Relevance in a D&T Curriculum

When empathic design first appeared in business literature in the late 1990s, it was described as a cultural shift (IDEO, 2014). It was then that companies started to realise that only noting customers' responses through questionnaires was not enough to develop successful products (Koskinen and Battarbee, 2009). Whilst this phenomenon was gaining traction in the business world, it too was a key feature of the National Curriculum for D&T in England, beginning in the 1993 National Curriculum "…including some contexts with which they are initially unfamiliar." (DES/WO, 1992, p.24) Although the term 'empathic design' is not explicitly included, the concept itself plays a significant part in D&T Programmes of Study from this point, including in its present iteration. Focusing on the user as a vehicle for the development of other skills and knowledge within D&T has the potential to contribute to the subjects' uniqueness and perceived value.

2.3. Opportunity

To understand a problem fully, students are encouraged to conduct a significant amount of research (Hill, 1998); whilst there are many ways of researching user needs in order to develop an understanding, literature advocates the development of a relationship between students and end-users within problem-based contexts (Jones, 2023). A lack of designer/user contact is a serious limitation to good design because ongoing contact between designers and users allows designers to gain first-hand knowledge from their intended audience (Denton and McDonagh, 2003), however school structures often reduce the likelihood of regular designer/user contact, where the students take on the role of designer within their D&T studies. As a result of a lack of

time and students' understanding of contexts, the design process can be described as being stunted, leading to poorer outcomes (Demetriou & Nicholl, 2022); this is also often the case in the professional design world where designers do not spend enough time experiencing the user's 'world', therefore they may be reluctant to immerse themselves in it, as the activity is not necessarily solution focused (Kouprie and Visser, 2009). This study attempts to address the constraint of time within a school curriculum, providing an opportunity to study the effects of facilitated sustained interaction between students and end-users within D&T lessons.

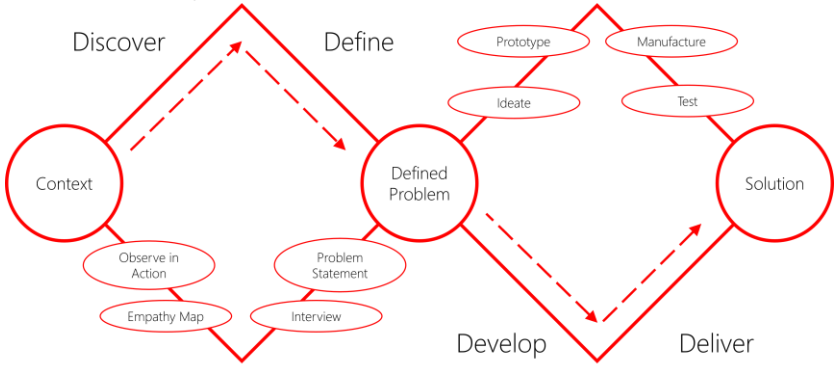
3. METHODOLOGY

This case study was conducted in a secondary school in North-West England as part of students' Year 8 (age 12-13) D&T curriculum. Sixteen students working in teams of four, one teacher-researcher and four members of the school catering staff (end-users) participated in the project. In order to maximise the development of empathy, it was important that the end-users were different to the students themselves. The catering staff were selected for this preliminary study because there are clear differences in age and experience to the students and face-to-face interaction was relatively easy to arrange at regular intervals. I, as the teacher-researcher, present an ethical dilemma in that there is a clear power dynamic between the students and I, therefore the way in which the study was presented to the students in the first session was designed so that it was very clear that the outcomes of the project were the focus of the study, rather than in teaching, learning and assessment, and that the questionnaire was anonymised. For the purposes of school assessment, it was solely the way in which students worked collaboratively that was reported on.

The study began with a self-reporting questionnaire 'The Creative Personality-Potential Composite' developed by Shepard (2019), containing questions relating to problem-awareness, novelty, complexity, sensitivity, non-conformity, independence, flexibility, and fluency. This questionnaire was selected due its validation in a sample of 1076 respondents and its questioning style being suitable for use by children. The above categories based can be attributed to different 21st-century skills; however, its main aim is to measure creative potential, a valid instrument for the purpose of this study. This questionnaire was completed again at the end of the intervention in order to analyse any changes.

The Double Diamond Model (Design Council, 2005) was used as a basis for the intervention design, utilising a range of activities inspired by aspects of the Delft Design Guide (van Boeijen et al, 2020) and The Design Thinking Toolbox (Lewrick et al., 2020), as shown in Figure 1. Participants met on four occasions during the project, first for the students to observe the user in action, second to interview the users, third to present and refine ideas, and finally to test out their prototypes.

Figure 1. Intervention Design



4. 4. DATA COLLECTION AND ANALYSIS

The project was designed to be delivered over twelve 55-minute sessions, however due to teacher strikes, extra-curricular events, teacher training days and bank holidays, this was reduced to a total of eight sessions, thus requiring the students to periodically complete activities at lunchtime. Two of the student participants developed long-term illnesses during the project and were therefore absent and unable to complete it; this also meant that two of the teams of students were reduced to three members for much of the project. Several students were absent in the final lesson, which meant that post-data was not available for all participants.

The design work and practical outcomes were thematically analysed based on developing themes, in addition to an analysis of themes emerging from changes in the pre and post questionnaire.

5. RESULTS

The problems identified by each participant team were varied and well-defined. The solutions they aimed to develop were:

- *Group 1* A way to safely transport cooked pasta from the kitchen to a servery.
- *Group 2* A way to prevent students from throwing metal cutlery in the bin when removing food waste from their plate.
- *Group 3* A way to organise consumables in a café to improve efficiency.
- *Group 4* A way to reduce queues by developing an interactive ordering and collection system.

The pre and post questionnaire highlighted a slight improvement in ‘creative potential’ overall. Interestingly, it was the teams of participants that completed a more prolonged iterative process (Group 1 and 2) that reported more improvement to skills, especially empathy, highlighting the

importance of a prolonged interaction with the end-users. The design work completed by students gave a much more detailed picture of how skills were developed during the process. The outcomes of the four teams are shown in Figure 2-5.

Figure 2: Group 1 Outcome

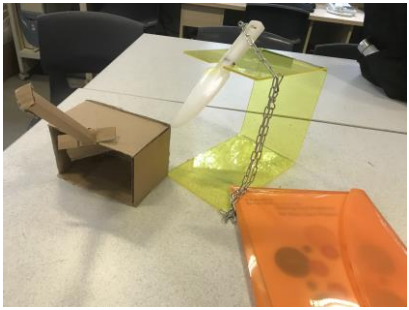


Figure 3: Group 2 Outcome

Figure 4: Group 3 Outcome

Figure 5: Group 4 Outcome

6. DISCUSSION

Whilst the questionnaire led to some interesting results, its suitability for measuring 21st-century skills more generally is limited, therefore a questionnaire designed specifically for measuring these skills would be sought or developed to better understand how these skills are understood and developed by students. In the post-questionnaire, it would have been useful to have some open-ended questions to elicit more detailed responses about students' perceptions of different skills and their experiences of the intervention.

As the teacher-researcher, I was able to reflect on all aspects of the intervention. I was surprised by the confidence of students when interacting with adults they are fairly unfamiliar with; they were able to develop relationships very quickly and their empathy was evident when discussing their interactions and in their design work. As an open-ended project, the participants were able

to define their own problems, however this did prove difficult for some who required prompting. The aim of the project was to develop a functional prototype using materials, components, tools, and equipment, however the versatility of the problems that were defined meant that there was opportunity for participants to pursue more conceptual products. There was a tendency to design solutions that were incredibly ambitious, containing complex electronic and mechanical systems, which led to the need to advise participants on more appropriate ways of tackling the problem, in line with the intentions of the project, which felt limiting and contrived at times. The project lends itself well to designing creative, complex solutions to problems and has the potential to cover many aspects of the National Curriculum, however the intention was also to include the 'make' aspects of the curriculum. There was an ongoing need to intervene and prompt participants, arguably the modus operandi of a D&T teacher, requiring the need to regularly step in and out of researcher and teacher roles.

Students were not confident when generating ideas and tended to become fixated, this phase would need to be developed to support students in generating more varied ideas.

The data collection methods were limiting. There were many interactions, statements and actions that remained uncaptured during the project, therefore in future investigations, teachers would be encouraged to keep field notes to support analysis. Whilst students were encouraged to photograph their journey, many neglected this and then found it difficult to reflect on the development of their prototype later. As the teacher, I was able to witness the considerably increased level of motivation and commitment to their individual projects compared to my ten years' experience of other units of work at Key Stage 3; this is an area that could be explored further.

One of the teams produced a rough prototype for an ordering and collection system (Figure 5) that they would have been unable to make functional, therefore they were tasked with pitching their idea to the school's Business Manager in order to improve the rigour of their experience. On reflection, this should have been a key part of the project for all participants, enabling the development of more skills and providing further opportunities for analysis. In subsequent investigations, students will be required to present their entire design process, narrating the decisions made and obstacles they overcame. The use of video for this phase would be useful to capture as much data as possible.

6.1. Limitations

This study involved a very small sample of participants. Whilst the intention was never to generate generalisable findings, it would be beneficial to expand the study to include more groups of students in the future to increase the rigour and reliability of the study. A lack of field notes from the researcher, as well as a lack of recorded key moments from participants reduced the scope of data considerably, therefore careful planning and consideration to recording ideas would need to be taken. A reflective journal, culminating in a presentation of participants' journeys would mitigate this loss of data and provide further opportunities for analysis later.

7. CONCLUSION

This preliminary research project has demonstrated that there is potential for 21st-century skill development by engaging with authentic end-users. Whilst common at Key Stage 4 and 5, the design of a 'real-world' project such as this is a departure from typical practices at Key Stage 3 D&T and requires further exploration. The project aligns with the ambitions of the Design and Technology Association, whose paper entitled 'Reimagining D&T' (2023) highlights the potential for the subject to be a key aspect of the curriculum to develop human skills, alongside technical expertise. It also emphasises that change is required at Key Stage 3 in England, focusing more on succession from a now-rigorous Key Stage 2 experience and moving away from routine making activities that often culminate in identical 'end-products'.

The contexts provided to students in this preliminary project ensured that there was some familiarity to students, however it would be interesting to investigate whether more open or obscure contexts has an impact on skill development. The *'Solving Genuine Problems for Authentic Users Project'* will be conducted from October 2023 involving 160 students and 40 end-users from within and outside of the school, focusing on solving genuine problems identified collaboratively between students and the end-users.

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