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Interaction with end-users in design and technology education: a systematic review

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Abstract

This paper is a systematic literature review of works focused on user-centred design practices and their potential application in pedagogical contexts in design and technology (D&T) education. It is a response to the increasingly complex demand of allowing students to develop so-called 21st-century skills within a D&T curriculum, which is often constrained by time, resources, and policy restrictions. This review highlights a range of studies that have been completed in various countries and phases of education, which enabled students to develop empathy with end-users whilst designing specifically for (and in some cases with) them. A Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) model was used to extract works published concerning established inclusion criteria. The articles were analysed according to their relation to user-centred design in a formal education setting and categorised based on the focus of each study. NVIVO was used to code the included literature to establish themes and to support analysis. The literature highlights many advantages to students in engaging in user-centred practices, both contributing towards improved design outcomes as well as improved social and emotional skills. It presents a need to further explore user-centred design methodologies in schools, feasibly through the lens of 21st-century skill development.

Keywords

User-centred design, human-centred design, participatory design, co-design, design education, design and technology education

Philosophy, Policy, and Practice

In England, there is a movement towards adopting a supposed ‘knowledge-rich’ curriculum, which has been propelled to the forefront of educational policy, partly due to the introduction of the English Baccalaureate (EBacc) (McLain et al., 2019). It is argued that D&T takes an ‘extremist’ theoretical position towards realism, against the trend (ibid.). The renewed focus on explicit knowledge is evidenced in the most recent GCSE and A Level D&T subject criteria (DfE, 2015a; 2015b). The curriculum is narrowly focused upon examinations, rather than including elements such as creative coursework (Demetriou & Nicholl, 2022), which has a profound effect on D&T and its identity and relevance in the curriculum. Demetriou and Nicholl (2022) warn that a lack of imagination from policymakers regarding the curriculum will lead to a lack of imagination and creativity in students. The shift towards a ‘knowledge curriculum’ thus creates a gap for the development of human skills such as those supported by constructivists and pragmatists.

Pragmatic philosophies such as those developed by Dewey align with the theoretical position outlined by McLain et al. (2019). Dewey claimed that “isolation of subject matter from a social context is the chief obstruction in current practice to securing a general training of mind.” (1916, p.73). D&T aims for students to gain knowledge through reflection and action (Biesta, 2014), established around a deep understanding of context. Some authors describe the learning

experience in D&T as transformative, focusing on 'abstract knowledge' as opposed to the 'concrete'. Reflecting on pragmatism and the transformational qualities offered by D&T, it can be said that learning in D&T utilises past experiences by relating them to current interests and practical applications (Miller, 1985; Hickman, 2001; Morrison-Love, 2017), leading to abstract knowledge. Whilst D&T as a subject could be described as all-encompassing, there is however increased evidence of teachers' biased focus on practical work and potentially routine affairs that offer little value towards knowledge and experience (de Vries, 2005; Nicholl et al., 2013; Nicholl & Spendlove, 2016), which conflicts with the aims of D&T as a rigorous and creative subject outlined in the English National Curriculum (DfE, 2013) and GCSE and A Level criteria (DfE, 2015a; 2015b).

As early as 1938, Dewey expressed a warning on focusing narrowly on English and maths skills without context:

> *"It is a mistake to suppose that the acquisition of skills in reading and figuring will automatically constitute preparation for the right and affective use under conditions unlike those in which they were acquired." (Dewey, 1938, p.47)*

Whilst the EBacc does not exclusively concern English and mathematics, it is acknowledged that the implementation of the EBacc in schools narrows a much broader curriculum into one that is almost exclusively academic in nature, and it is believed to be a major contributing factor to the demise of D&T as a subject (Banks & Williams, 2023; Spendlove, 2023). It is the focus upon abstract knowledge, a unique element of D&T, in which context can be provided.

Links to Industrial Practice and 21st-Century Skills

The literature demonstrates that in the design industry, there has been a shift towards more participatory and collaborative design practices (Sanders & Stappers, 2008) and people, specifically end-users, are included in the design process as partners. Whilst such practices purportedly lead to more successful commercial products, there is significant discourse to suggest that there are many benefits to students undergoing a similar design process from an educational perspective. Human-centred design is emerging as a dominant trend in design education (Chmela-Jones, 2017), contributing towards its shift towards a more participatory form of practice (Bakirlioğlu et al., 2016; Shore et al., 2018).

So-called 21st-century skills include empathy, creativity, communication, and collaboration, which are essential skills required for engaging in human-centred design and can be developed with the support of a design-based education (Carroll et al., 2010; Noel & Liub, 2017; Tellez & Gonzalez-Tobon, 2019). It is in subjects such as D&T that social and emotional skills such as empathy can support the creative process in order to make the students' products real, usable, and meaningful (Demetriou & Nicholl, 2022).

The learning of these social and emotional skills are deemed to be a necessity in 21st-century education (Ananiadou & Magdalean, 2009) and was advocated for in the early 20th Century: "there is no education when ideas and knowledge are not translated into emotion, interest, and volition" (Dewey, 1933, p. 189), but skills such as those listed above have never been focused upon within education as a whole (Ananiadou & Magdalean, 2009) and it can be said that the current focus on 'knowledge' is detrimental, particularly for D&T (McGarr & Lynch, 2017). Earlier, Dewey (1915, p.163) stated that "recognition of the natural course of

development always starts with situations involving learning by doing.", against the trend outlined above. He goes on to claim that "education that associates learning with doing will replace the passive education of imparting the learning of others" (ibid.). Whilst this is certainly not true at the moment, not least due to a renewed focus on knowledge, D&T in all of its iterations have developed a pedagogy centred around learning by doing.

User-Centred Design and its Relevance in D&T

With roots in craft and training for industry-readiness, D&T was recognised as being a foundation subject in the National Curriculum for England and Wales as a consequence of the Education Reform Act 1988. There has been an explicit focus on the 'user' since its very first iteration in 1990, where students' design outcomes should be developed "in response to perceived needs or opportunities, as opposed to being undertaken for its own sake" (DES/WO, 1988, p.4). This is not always the case, as explored in the proceeding sections.

Whilst literature concerning user-centred design within the realm of D&T has been of interest for almost thirty years, it is gaining traction within the field, particularly due to a popularity in design thinking, a cycle aimed at producing innovative solutions to complex problems. Future generations will be faced with many so-called 'wicked' problems (Buchanan, 1992; Rittel & Webber, 1973), intricate and 'messy' problems that are ill-defined and complex to establish the root of, which impact a wide range of stakeholders. Wicked problems, for example, those relating to sustainability, are what the 21st-century workforce must face (Peng & Kueh, 2022), thus generating interest in how 21st-century skills are developed in the classroom, particularly concerning the need for students to consider the needs of a range of stakeholders.

A contributing factor in the growing popularity of user-centred design in primary and secondary school-based research is the fact that D&T in England is in crisis and the future of the subject is very much unknown. The curricular position of Technology Education in schools is fragile (Jones et al., 2013) and this fragility has become more apparent over the tenure of recent governments. As a subject with weaker epistemological roots compared to other subjects such as mathematics, it is viewed by policymakers as being less rigorous (McLain et al., 2019). This, along with other neoliberalist actions, such as the movement towards school-based teacher training and the school reform agenda, namely academisation, is diminishing D&T as a subject and is rapidly becoming unsustainable (Spendlove, 2023). Whilst this belief is certainly bleak, key figures in the D&T sphere claim that if D&T is to remain a foundation subject in schools, then the future 'version' of the subject must adapt to be entirely distinct from other areas of the curriculum (Spendlove, 2023) and encompass the development of 21st-century skills (McLain, 2023) in order to address problems within a wide range of contexts (Banks & Williams, 2023), especially involving creative, critical and emotional dimensions (Nicholl & Spendlove, 2016). It is often the responsibility of D&T departments to develop students' creative and problem-solving skills (Lane et al., 2023), and this prompts the need to explore how the approach to skills such as these may be developed further and contribute to the strengthening of D&T as a subject.

Solving real problems for real people in early key stages has the possibility of presenting a need for D&T to remain as part of the compulsory curriculum to a range of stakeholders, including policymakers.

Rationale for the Study

It is widely established that the design process is not linear and is in fact a cyclical process, however it is argued that teachers often treat design, predominantly making (Mulberg, 1992), or problem-solving, as a series of steps, which does not necessarily affect the students' thinking (McCormick, 2004), therefore they remain in the procedural knowledge space, impeding the development of authentic problem-solving skills (Nicholl et al., 2013; Nicholl & Spendlove, 2016; Demetriou & Nicholl, 2022). As a result of a lack of time and students' understanding of contexts, the design process has been described as being stunted, leading to poorer outcomes (Demetriou & Nicholl, 2022), highlighting that there is still an absence of authentic D&T activities. This provides an opportunity to investigate ways in which students engage in design-based research activities.

Whilst research of empathic or human-centred design at primary and secondary education levels is considerably limited (Bosch et al., 2022; Dindler et al., 2020), this review will focus on how context is provided through a user-centred design methodology at all stages of design education, and how this has been implemented in the classroom as part of curricula in formal design and/or technology education.

The research questions used to frame the review are:

1. What key skills are developed when students are involved in user-centred design activities?
2. What methods are employed to facilitate user-centred design activities in formal education settings?
3. What instruments were used to measure the impact of the interventions?
4. What difficulties were faced when implementing the interventions?
5. If the study has taken place in higher education, how may this translate to D&T in a school?

Article Selection

The study applied a Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) methodology to review how user-centred design activities have been implemented into a D&T curriculum. The PRISMA process has four steps: (1) identifying articles according to keywords; (2) screening of abstract, title, and keywords according to the set inclusion criteria; (3) checking the eligibility of complete articles; and (4) obtaining them. Figure 1 shows a flowchart of the procedure used.

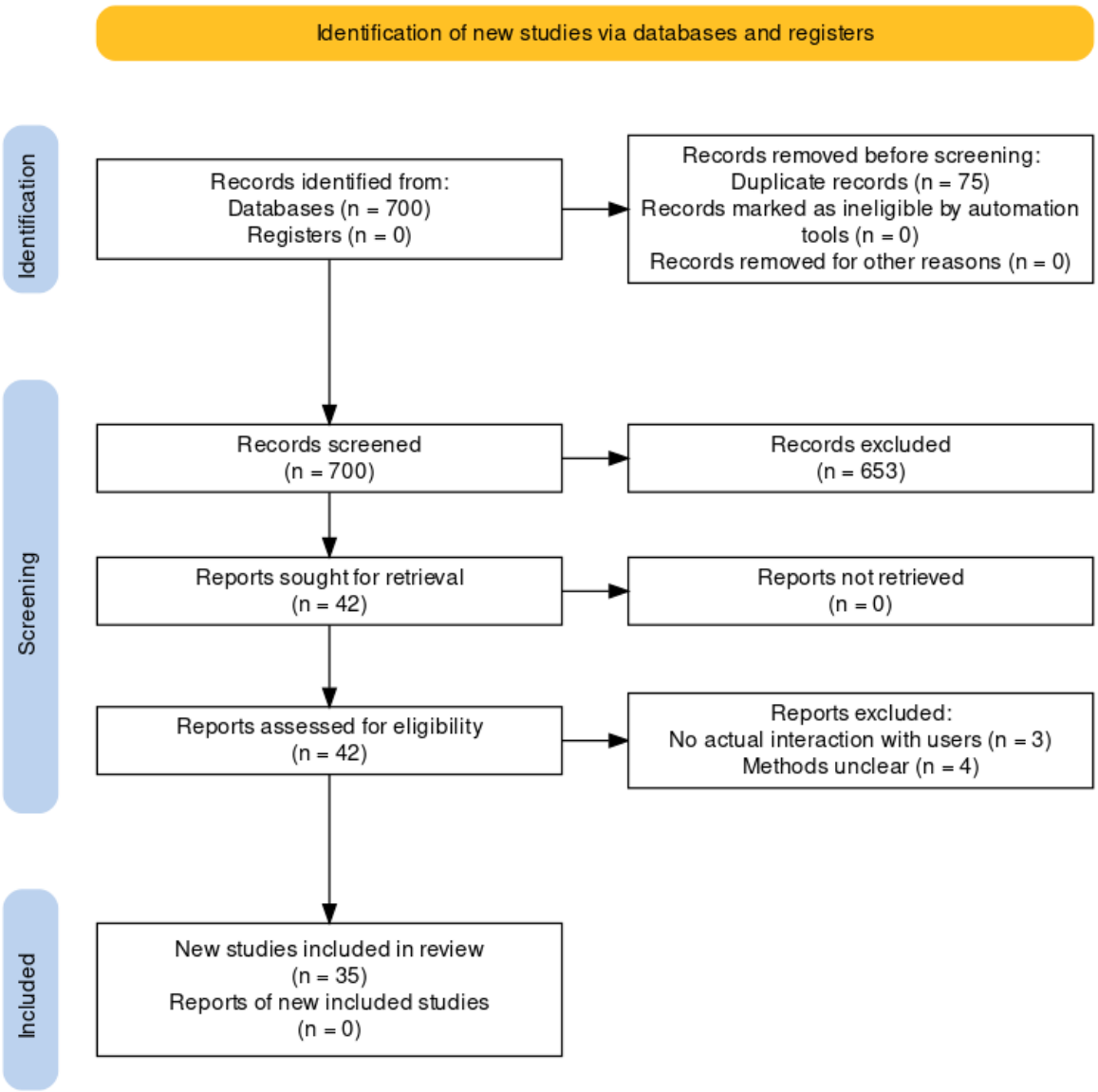

Figure 1 – Article selection procedure (Haddaway et al., 2022)

All types of available data were included in the literature search, with articles screened as being from peer-reviewed journals or conference proceedings due to their increased reliability, as well as being written in English for the purpose of analysis. The two prominent journals within the field of D&T are the *International Journal of Technology and Design Education* and *Design and Technology Education: an International Journal*, these two journals were searched extensively using a set of keywords relating to the field of enquiry. The 'Primo' search engine by Ex Libris was used to search these terms for the *International Journal of Technology and Design Education* and a second search was performed on the *Design and Technology Education: an International Journal* open journal platform. The search terms were 'empath*', 'human', 'context', 'user', 'design thinking' and 'participatory'. Table 1 shows the number of results returned for the criteria, as well as additional criteria used for a wider search of all available material, also using 'Primo'.

Table 1: Key terms used in the literature search

	International Journal of Technology and Design Education and *Design and Technology Education*	*Design and Technology Education: an International Journal*	All databases (including the additional term AND any field contains 'design education'.
'empath*'	n=3	n=11	n=24
'human'	n=33	n=19	'human-centred' n=93
'user'	n=42	n=9	'user-centred' n=36
'context'	n=21	n=84	n=62
'design thinking'	n=20	n=37	n=147
'participatory'	n=7	n=12	n=40
Total	126	172	402

The established inclusion criteria were that each study must involve interaction between students and end-users, either face-to-face or facilitated in another way, and be part of a design curriculum in formal education at primary or secondary level, or in further or higher education. Following screening, n=35 studies were included in the literature review. The included articles were analysed in detail and later categorised based on the research questions.

Findings

All the included studies involved face-to-face or another form of live interaction between students and end-users, with most face-to-face activities facilitated by teaching staff. Of all studies identified, one study related to D&T in a primary school, four to D&T in a secondary school, although one of these studies concerned students from higher education collaborating with secondary-aged special school students (Torrens & Newton, 2013), and the remaining 30 studies related to design education at higher education institutions. A lack of evidence of user-centred studies in primary and secondary schools was also found by authors of articles within the included literature (Bosch et al., 2022; Klapwijk & Van Doorn, 2015). Most of the research tended to be small-scale and was heavily qualitative, presented as phenomenological case studies, describing the user-centred intervention and its impact, whereas a small number of studies were quantitative or mixed-methods and focused on measuring motivation, creativity, or influence on design outcomes. Intriguingly, of all the literature included in the review, the study by Demetriou & Nicholl (2022) utilised the Torrance Tests of Creative Thinking (TCCT) as a standardised measurement tool. The TCCT involves subjects engaging with several creative figural and verbal assessments, requiring subjects to respond to stimuli that can be reliably measured for their creative strengths (Demetriou & Nicholl, 2022). The inclusion of a standardised assessment to measure the effectiveness of an intervention was unique to this study.

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), towards revealing the potential of considering user knowledge, human factors, experiences, and interactions in the engagement of participatory practices with end-users and stakeholders. This is supported by the fact that the included studies in this review took place in

19 different countries, highlighting the worldwide interest in investigating this phenomenon. Most studies took place in England (n=9), Turkey (n=5) and the USA (n=5).

The utilisation of end-users as contributors to the design process was evident in all selected literature. There were references to many different approaches such as user-centred design, human-centred design, participatory design, and co-design; whilst each of these is different, for the purpose of this study, they all require students to engage in contact with potential end-users, which is the focus of this review. There were a wide range of end-users chosen as the focus of each study, ranging from victims of flooding in Bangladesh to stray cats and dogs in Turkey. Some of the studies focused on more than one end-user. Interestingly, of the studies including children, five had a disability, raising the total studies involving disabled users to fourteen, or one-third of all included studies.

All included literature cited that students were required to conduct extensive research to better understand the end-user and their context, which mostly involved observation of and interviews with the intended users. Much of the literature discussed the importance of developing empathy as a way of improving design outcomes.

Several themes were identified from the literature: 21st-century skills including problem-solving and empathy, as well as user-centred strategies implemented, and disability. The literature was coded using NVIVO according to these categories as the themes emerged.

What key skills are developed when students are involved in user-centred design activities?

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). Problems faced in the 21st-century are fundamentally more complex and multi-layered (Kaygan & Yargın, 2019; Kwon, 2018), especially due to human longevity (Peng & Kueh, 2022), thus demanding more skills from design students and designers (Dhadphale & Wicks, 2022; Mitchell & Light, 2018). Designers, compared to the general population, can approach problems differently and bring a fresh perspective to multidisciplinary teams by using empathy, user centred techniques, co-design methods and making skills (Zitkus et al., 2020). The skills of problem-solving, creativity and empathy were repeatedly explored in the selected literature.

Exposure to Real-World Problem-Solving

Involving students in 'real world' problems is not a new idea (Zitkus et al., 2020) and neither is involving end-users in the process (Nicholl et al., 2013). Much of the literature discusses the importance of problem-solving in the current climate and beyond, particularly the need to provide students with ‘problem-solving’ contexts, especially in higher education (Powell & Underwood, 2018; Wormald, 2011), which is the domain in which 86% of the selected studies took place. Hill (1998) and Peng & Kueh (2022) describe the complexities of understanding problems and stress that design education can play a part in teaching an effective problem-solving mindset through designerly thinking. It is through design that fundamental problem-solving skills can be developed, particularly focusing on finding problems, leading to innovation (Wormald, 2011; Zitkus et al., 2020). Problem-finding skills, an aspect of problem-solving, which was the focus of many of the included studies, meant students were required to find a problem for themselves as a result of their research, rather than a problem being presented to them,

leading to more effective learning and confidence (Emmanouil, 2015; Hill, 1998). This supports the earlier assertion that students must be prepared to work within wicked problems that are ill-defined and convoluted, despite that it is acknowledged there is no 'solution' to a wicked problem as further problems are likely to be identified as part of the proposed solution (Peng & Kueh, 2022). The literature suggests that problems cannot be solved with a particular type of thinking, and it is up to the student to decide upon the best way of approaching such complex problems by selecting from a wide range of skills, depending on the design context, rather than approaching a problem in a prescribed manner (Gibson, 2016; Williams Goodrich, 2019).

To understand a problem fully, the literature encourages students to conduct a significant amount of research, particularly through joining conceptual and procedural knowledge, as well as utilising thought and action, to reflect on design possibilities (Hill, 1998). Whilst there are many ways of researching a need, in order to develop an understanding, all literature supports the development of a relationship with end-users within real problem-based contexts. It is accepted that when researching a specific problem, more problems arise, creating a more complex situation for the student (Wormald, 2011), as is typically the case when engaging with complex problems (Peng & Kueh, 2022).

In a pertinent study to the focus of this review and its relation to schools, Klapwijk & 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. 21st-century skills are a feature in a wide range of the 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 a need for a broad base of cross-disciplinary knowledge and skills, particularly those related to emotions (Demetriou & Nicholl, 2022; Kwon, 2018), for students to successfully solve complex problems and adopt an improved approach to problem-solving.

The Development of Empathy

Mitchell & Light (2018) claim that empathy began to be a feature in design-related literature around the late 1990s when companies realised that to design better products, they needed to be more attuned to their user's needs. Empathy is a core attribute of a designer (Bosch et al., 2022), yet there is some debate as to what empathy is (ibid.) and as a result, there was a range of tools highlighted in the selected literature for measuring empathy, according to the school of thought on empathy that the authors place themselves within. Definitions of empathy vary from an empathy where there is an understanding of another's perspective, to an empathy where similar feelings are experienced (Demetriou & Nicholl, 2022). The teaching of empathy has not been widely adopted due to a lack of frameworks available for educators to use (Mitchell & Light, 2018), perhaps due to the evidential lack of agreement on a universal definition of empathy.

All of the selected studies found that students engaging with end-users developed greater empathy, although the study by Conradie et al. (2017) found that engagement with end-users did not affect the design outcomes of a group of students. The authors hypothesised that this would not be the case, nevertheless, a quantitative methodology led to the finding there was no statistically significant difference between the design outcomes of intervention and control groups. It is worth noting that the findings of this study are very much the exception compared to the other selected studies; user involvement generally has a positive influence on design

outcomes Conradie et al. (2021), with almost all studies supporting this claim. The study by Conradie et al. (2017) concerned design outcomes only, whereas the majority of the other studies measured the impact on students or educators, and in some cases, alongside design outcomes.

Much of the literature highlights the importance of empathy as a key skill for designers, as well as a useful aim in education, especially for preparing design students to develop empathy when problem-solving in the future, (Mitchell & Light, 2018), in addition to reducing egotistical design responses due to a lack of empathy with others (Chmela-Jones, 2017; Demetriou & Nicholl, 2022). Cummings et al. (2014) cited an undergraduate design activity whereby students would design for aliens, in an attempt to remove any preconceptions or misunderstandings based on the student's understandings or experience, emphasising the important role empathy plays in designing authentic products based around user needs.

Designers must have knowledge of and be able to develop empathy with the people they are going to design for (Klapwijk & Van Doorn, 2015), they found that as a result of developing empathy with elderly people in their study involving primary-school-aged-children, the students gained new knowledge about the people around them, developed a respect for a diverse group and were more attuned to the needs and wishes of the end-users, which led to more effective design solutions. The embedding of empathy within the design process is the formula for fostering creativity and leads to more successful design outcomes in D&T (Demetriou & Nicholl, 2022).

The Emergence of Disability as a Focus

One-third of the selected studies focused on users with disabilities. A bias towards 'extreme users' or the softer term 'lead users' was unsurprising given that the approach to involve very specific users with increased needs and diverse experiences, and who are motivated to find solutions (Conradie et al., 2017) may be more likely to engage in such projects. The aim of the selected literature was for students to design with end-users; if the end-users were very similar to the students, then as the literature suggests, the students would not develop their skills as much as they would if the end-user was unfamiliar. Empathy was a key skill discussed in each of the studies concerning disabled users. Engaging with elderly people, especially in nursing homes, was a common context in the literature. Many elderly people are likely to have disabilities or difficulties in completing daily tasks, therefore the rationale provided above also applies to this context. Due to the fact much of the literature employed qualitative methods, it is difficult to establish whether engaging with disabled users is more effective than engaging with people without disabilities, however, it does highlight that more empathy is required to design for these individuals, developing 21st-century skills more widely and deeply, potentially developing a need for further investigation. Of the studies involving disabled people, none of the studies took place in a school, although the study by Nicholl et al. (2013) involved students designing products for young children with asthma, which is arguably not classified as a disability per se, however, it did encourage students to consider the needs of users who are markedly different to themselves.

What methods are employed to facilitate user-centred design activities in formal education settings?

To answer the second research question, all articles were analysed based on how the students interacted with end-users.

The involvement of users in the design process is widely taught and advocated, both in industry and in design education (Conradie et al., 2021). The selected literature describes the need for face-to-face contact with users to enhance sensibility and awareness of social issues, rather than organising activities such as role-playing (Salazar Ferro et al., 2020) or personas (Conradie et al., 2021). Personas are commonly used within the design process to encourage designers and design students to consider the needs of users; these were often cited in the selected literature, yet the difference between the traditional use of personas and those employed within a participatory methodology (Zitkus et al., 2020) is that they are populated with data collected by the students themselves, thus creating a more authentic resource for design.

Of the many methods used to engage with end-users, including, shadowing, customer journey maps, workshops, visual journals etc., the most common methods were observations, interviews, focus groups, and questionnaires.

There is a growing emphasis on ethnographic and observational research within design (Giambattista et al., 2021; Liem & Sanders, 2013; Shore et al., 2018; Thamrin et al., 2019). Much of the field research conducted by students involved observation of the end-user in their context, talking with them in the form of interviews or focus groups, and co-designing. Some of the selected studies utilised creative methods such as live model-making with the user using Play-Doh or sketching out ideas with the users. In the studies involving animals, the authors felt that empathy was best achieved when observing the animals in their usual environments (Kaygan & Yargın, 2019; Yavuzcan et al., 2019), which led to improved emotional investment in the design project.

Participatory Action Research (PAR) was the chosen methodology used by Salazar Ferro et al. (2020) when working with architectural students in Colombia, and Kwon (2018) in the USA, to improve the effectiveness of the interventions in cycles, rather than case study which is the principal methodology across the selected literature, describing the intervention that has taken place. Both Salazar Ferro et al. (2020) and Kwon (2018) highlight the need to view the interventions in cycles where students reflect on thought and action when interacting with end-users and develop ongoing design work.

Broadly, the process that students went through across all of the studies was to observe, understand, ideate, develop, and evaluate/test, which is a common approach to the design process across many educational institutions and in industry, however, the literature suggests that the observe and understand phases are typically less emphasised in education. The factor that was different to the accepted norm is that the studies sought to include the user at all stages of the process so that they were able to have an input in the product's development and provide feedback, as well as immersing themselves in the user's context and an emphasis was placed on gaining a much deeper understanding of the user and their needs and desires. A range of design process models were cited across the literature, predominantly the Double Diamond Model (Design Council, 2005) or variations of this, followed by design thinking models

produced by the d.School at Stanford University and at IDEO, a commercial organisation where empathic practices are firmly established in an industrial context.

What instruments were used to measure the impact of the interventions?

Questionnaires and interviews tended to be used to help analyse the impact of the interventions in the selected literature. Questionnaires were often given to the students at the end of the intervention to measure their perception of its effectiveness, although some studies gave students questionnaires more often. Some studies also required teaching staff to complete questionnaires relating to their perception of the effectiveness of the intervention. Relating to empathy, Klapwijk & Van Doorn (2015) cite that in all previous empathy studies in schools, researchers have analysed data taken from questionnaires, interviews, design work and field notes, which was also the case in many of the selected studies following a qualitative case study methodology.

Each of the studies in the selected literature had a different focus, for example, to what extent did user interaction have on the motivation of students or to what extent was creativity developed as a result of engaging with end users, nevertheless, questionnaires remained to be the most common method of measuring impact, usually alongside other instruments as outlined above.

Some studies utilised video recordings of activities to support analysis, although most of them did not. The study by Demetriou & Nicholl (2022) employed the Torrance Test of Creative Thinking (TTCT) as a way of measuring the impact of their intervention, alongside interviews to support their analysis.

What difficulties were faced when implementing the interventions?

The studies highlighted some challenges faced by researchers when implementing their interventions or faced by students when conducting their user-centred activities.

It is acknowledged that there is some difficulty in collecting data at the beginning of the process and students are often keen to start designing without gaining a rich understanding of the user's needs first. Gaining the data in the first instance can also be challenging. Authors cited the logistical challenges of recruiting end-users (Yalman & Yavuzcan, 2015), particularly if there are ethical implications, such as those studies centred around people with disabilities or in healthcare settings. The studies engaging with patients tended to interact with healthcare professionals as an alternative (Chmela-Jones, 2017; Zitkus et al., 2020) or used test rigs or simulations to support their design development, however, those studies that achieved ethical clearance were able to work with end-users directly. Some studies cited that a way to avoid undergoing a more intense ethical approval process is to approach the study from a service improvement angle (Godbold et al., 2019), which reduced the need for full ethical approval. One difficulty highlighted was students' ability to synthesise such a large amount of data collected during their fieldwork, and some students, given the extent of the data collected, found it difficult to know what to share with consumers later on in the process. In the study by Lee et al., (2019), feedback was sought online via social media which was text-based, which students found difficult to interpret, consequently supporting that face-to-face contact with end users could be seen as more effective.

When working with animals as end-users, students needed to understand that they may not be able to meet their true needs based on a lack of understanding. Students who took part in animal-based projects found the task challenging due to its non-human focus, which was different to the practice they were more familiar with.

Some of the studies involved other parties, alongside end-users, such as manufacturers. This posed the issue of bias due to students being influenced by the other parties, rather than focusing solely on the end-users. Some of the contexts were complex, such as those in hospitals, and students found it difficult to find problems to focus on due to a lack of expertise and experience in the field, this implication is an important factor to consider if user-centred activities were planned for younger students in schools, as a lack of understanding would lead to even more difficulties at that level.

The majority of studies in the included literature were undertaken in higher education where class sizes are considerably larger than in schools. Some authors described the difficulties with implementing user-focused activities when working with large groups of students. This is a factor that would have less of an impact in a school due to smaller class sizes, although, Klapwijk & Van Doorn (2015) found that the researcher worked at times with a small group of four children, whereas teachers will in general work with the complete class. This has the potential to make facilitation more difficult, yet not as difficult as it could be in higher education settings.

Klapwijk & Van Doorn (2015) also found that while end-users provided a rich description of their experiences, the students only tended to write a short number of words, which led to a lack of understanding later. They recommended that interviews were to be undertaken in pairs in future, with one of the students documenting the responses whilst the other asks the questions. They also found that storytelling was lacking, and the students tended to rigidly ask the questions they wanted to know more about regarding activities. If students were more aligned with storytelling and its role within a semi-structured interview, then this would have improved the process of creating a persona to work with during the ideation phase; a further factor to consider if implementing such activity within a school.

The purpose of all included studies was to explore the effect of involving end-users in the design process. Some of the users within the studies were more familiar to students, such as people their age or a dog which they may have experience with already, however, some of the users such as those who were visually impaired or suffered from a chronic illness, were likely to be very different to that of the students, thus offering a more diverse perspective using their experiences, potentially evoking a more empathic response from the students. Whilst the alien nature of engaging with these kinds of users was the aim of some of the studies, some students found it difficult to engage with them and were not forthcoming during the process, due to cultural or language differences (Boess & Lebbon, 1998; Peng & Kueh, 2022), highlighting that if the user is vastly different to the student, then this has the potential to inhibit learning.

Implications for Practice in D&T

The final research question relates to how practices in higher education may translate to D&T in schools. This section will also concern the findings and future implications from studies conducted in primary and secondary schools.

Implications for D&T in Schools

There is an appreciation that a focus on the 'user' is explicitly featured in the English National Curriculum (Kaygan & Yargın, 2019; Klapwijk & Van Doorn, 2015; Nicholl et al., 2013) at all key stages. It is imperative that students conduct in-depth research on the user (Klapwijk & Van Doorn, 2015; Nicholl et al., 2013) to maximise success in the design process. As early as Key Stage 1, teachers must provide students with contexts that are closely related to their own, including research on users that the pupils are closely related to, e.g., "their grandparents, house pets or the butcher next door." (Klapwijk & Van Doorn., 2015, p.154). It can be argued that authentic learning in D&T can only be possible when pupils develop local and specific knowledge of the people they are designing for (Nicholl et al., 2013), therefore the social and emotional skill of empathy is required, igniting, and infusing the creative process for pupils (Demetriou & Nicholl, 2022), consequently leading to improved outcomes. A lack of involvement in the inclusion of end users within participatory design (or indeed user research more generally) is evident in the literature, highlighting that without exposure to end-users, students build models of understanding context and products based on their previous experience as a user (Kaygan & Yargın, 2019), inhibiting empathy and its influence on the development of products, therefore schools are encouraged to pay more attention to this as a way of allowing students to develop empathy (Bosch et al., 2022; Demetriou & Nicholl, 2022; Nicholl et al., 2013). Bringing users into the design process is feasible for small-scale projects (Dong, 2010), and even short immersive experiences can have a large impact on students' understanding of design (Cummings et al., 2014), further supporting this opportunity available to schools.

Nicholl et al. (2013, p.930) explain, in the context of policymakers' desire to include user needs in the D&T curriculum that, "it is participating in the authentic social practice(s) of engineering design that links D&T to the real world", similarly in the Netherlands, pupils' activities should mirror the activities of professional designers and scientists according to Klapwijk & Van Doorn (2015). It is evident that design curricula are inspired by industrial practice in many other countries according to the included literature, with much of it focusing on how design education emulates industrial practices, not only to prepare design students for industry (in the case of higher education) but in the development of wider, 21st-century skills. There is a need for future studies on how community-based participatory and empathic practices can be implemented in formal education (Bosch et al., 2022), with an aim that students complete certain tasks to feed implicit learning goals within the process, further addressing the problem identified by Nicholl et al. (2013) in that students were not exposed to an authentic user context in the schools they studied, leading to poorer outcomes for students.

The literature highlighted that schools often reduce levels of student creativity and problem-solving by designing activities in such a way that they are narrow or prescribed (Kimbell, 1994; Hill, 1998; Nicholl et al., 2013; Demetriou & Nicholl, 2022). The fact that this attitude towards pedagogy within D&T is still present over an almost thirty-year period is surprising. When students work very prescriptively according to a narrowly defined design or problem brief, this guides decision-making which leads to predictable, often pre-determined outcomes (Gibson, 2016), which is also present in design education within higher education (Thamrin et al., 2019). Denton & McDonagh (2003) suggest the use of focus groups in schools in order to provide such an opportunity to engage with potential users, an early suggestion in the journey towards a participatory approach outlined in the selected literature. Noël (2016) concluded that design

education must be based on real needs and people, prompting a potential to explore this phenomenon in future research.

Implications for Design Education

Research is a vital aspect of all design work, both inside and outside of education, whilst this is fundamentally important in the development of effective products, it also has a secondary value in developing the young designer's understanding of products and the social context of their use (Denton & McDonagh, 2003), providing a clear rationale for the need of authentic research by students within D&T curricula.

Many of the included studies commented on the effect that engaging with end-users had on student motivation and confidence (Bakirlioğlu et al., 2016), whilst these increased in many of the studies, this was not always the case (Chmela-Jones, 2017; Yavuzcan et al., 2019). Many studies refer to the students' excitement when involved in such activities, especially during those between students and end-users. This is echoed by Hill (1998) in her study of technological problem-solving in a secondary school in Canada, who found that when activities are set in the context of authentic world problems and real human needs, exciting possibilities emerged for students and design education more generally. Many students within the included studies found that this 'real' interaction was the most meaningful way of designing for 'real' people, compared to other methods employed in previous projects such as the use of basic personas, providing a similar opportunity for pupils in schools.

Numerous studies conducted in higher education emphasised how important the students felt their interactions with end-users were, with some explaining that this was the first time they had the opportunity to work with end-users (Salazar Ferro et al., 2020), and provided them with the experience necessary to be successful when working in the field. Several studies concluded that students changed their attitudes as a result of the interventions, towards being more open-minded and focused more on lateral thinking.

Participatory practices are a relatively recent phenomenon in some areas of higher education, depending on the locations of institutions (Salazar Ferro et al., 2020) and the design discipline taught (Thamrin et al., 2019), as well as a belief from industry that education is not supporting human-focused opportunities (Shore et al., 2018), yet, it must be acknowledged that there is now an established body of knowledge in this area on which further research could be built, not least within schools.

Conclusion

This study has emphasised the fundamental link between the act of designing and the pursuit of improvement, not least for the experience of users. The relationship between designer and user is essential in improving the value that users place on products and services.

The literature has demonstrated that there is an established body of knowledge concerning students engaging with end-users as part of the design process. It also highlighted that there is a need to explore user-centred design further, particularly in schools, and there is much to learn from the studies completed in higher education. Whilst there is a broad consensus on the design process and where end-users may fit into it, there is little literature concerning an authentic user focus in D&T in schools, therefore presenting an opportunity to explore this further.

Whilst there are clear barriers to enabling students to design with and for people, especially those with disabilities, the gains from working with a wide range of people are distinctly apparent. The skills of creativity, empathy and problem-solving surfaced in much of the selected literature, providing a considerable rationale to base further research on the development of 21st-century skills through an authentic user focus within D&T in schools.

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