Problematising and unpacking the uncertainty of design within technology education.

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ABSTRACT

Technology education is a growing field internationally where developments are being made to conform to new agendas and goals of today's society. The role of technology education is to improve the quality of human life through making meaningful advancements to our lives and the world we live in, which is underpinned by an innate ability that all humans possess, the ability to design. Developing designerly members of society that have strong design capability is identified as being of upmost importance, particularly within education. Fostering designerly students effectively and successfully is a complex domain and is evident within a large literature base, where researchers are trying to understand design, what it should look like in practice, and how it can be successfully developed and fostered within education. Design is a key component within technology education curricula, where teachers and students are required to engage in design tasks and activities in an attempt to foster an ability to design. Design is highly complex in nature and with ambiguity within the literature surrounding the construct of design ability, what defines the design process and what cognitive processes are necessary to design, leaves educators and students in an area of unknown.

In this paper, a theoretical model is presented and utilised to problematise and unpack the uncertainty of design within technology education. The unknown of designing is worse than the problems themselves, which is why this paper offers an initial attempt at identifying these problems through the lens of understanding, teaching, and learning designing. Results offer insight into the complexities and challenges associated with designing in technology education with the aim and objective to identify future research areas.

Key words: Design, Designing, Technology Education, Problematising

1. INTRODUCTION

Technology education, which is considered to be an internationally valued subject area within secondary education curricula (Buckley, 2023), is a growing field of research (Buckley et al., 2022; Williams, 2013, 2016; Xu et al., 2020). Technology is a core element of society where its aim, as defined by Black and Harrison (1986 as cited in Hope, 2013), is "to improve the quality of human life" which partly forms the necessity of technology education. Looking at where technology education stemmed from, specifically within the Irish context at least, it is rooted within vocational education designed in response to local industry needs where craftsmanship values and skills were at the heart of the suite of subjects (NCCA, 2017) . Today, technology education is continuously growing in response to the overarching complexities, goals and values of a technological society relating to, for example, sustainability and technological advancements. Providing an education system which develops learners as valued members of society whom possess key skills and abilities that will be the heart of successful development and progression of today's made world is of critical importance. One of these core abilities that has seen a growing emphasis and treatment within technology education is design, where researchers such as Stables (2008) and Baynes (2008) argue for the necessity to develop design capability and the designerly in young people. Design education has been within secondary level education since the 70s and 80s with its seminal research still with importance and relevance today (Baynes, 2008). The development of design education since then is caused by the necessity to conform to new agendas and goals of this developing world (Baynes, 2008).

Design is a heavily researched area, but this does not directly correlate to an agreed consensus on the treatment of design, how it appears in practice (Alison et al., 2022; Buckley et al., 2020) and even through universal definitions of its many facets. As Baynes (2008), describes where there is consensus is that design is complex, highly specialist and esoteric, and design ability is innately part of every human being. It is also understood that design is integral to the discipline through the means of teaching to and through design (Buckley et al., 2020; Seery et al., 2022). The recent Irish reform of the Junior Cycle (lower secondary level education) has seen an enhanced treatment of design within technology education and these advances can also be seen within the literature situated in the United Kingdom where Spendlove (2017) argues for a greater emphasis to be placed on design. The large body of literature investigating the many facets of design and the development of its position in practice, cannot be mistakenly understood that there is no ambiguity in its treatment in practice (McDyer et al., 2022). Atkinson (2017) discussed that the emphasis on design within technology education syllabi is problematic as there is no common understanding amongst educators of what design is, what it should look like in the classroom and how it should be taught.

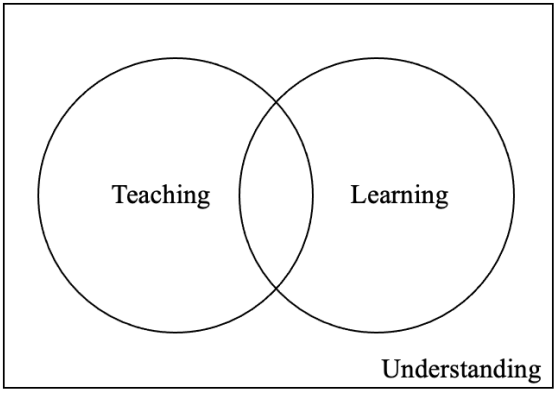
As educators we are preparing our students to be successful citizens for future societies within an unknown – or at least unpredictable – world. Designerly ability has been and will continue to be a core attribute to the advancement of human beings and of our society (Baynes, 2008). With such variance in understanding design, what it should look like in practice and lack of consensus in the definition of its many facets, the question of how we can successfully foster designerly students' merits posing. In response to this question and the associated agenda of qualifying the positioning of design within technology curricula, a theoretical model is presented, designed to support the unpacking of the complexities and intricate nature of designing in education. Through it, we

identify and discuss the problems and challenges associated with designing to support future research. Thus, following this introduction will be the identification and unpacking of key problems as we see them associated with designing in technology education, followed by a discussion where the model will be clarified and elaborated upon based on its intended use. The focal research question which will be explored through the paper is, what are the problems and challenges associated with fostering designerly students within technology education?

2. PROBLEMATISING AND UNPACKING THE UNCERTAINTY OF DESIGN IN TECHNOLOGY EDUCATION

Presented in the body of this paper are the identified focal problems that have been unpacked using one iteration (Fig. 1.) of the theoretical model described fully in Fig. 3. This model consists of three co-related strands which are Teaching, Learning and Understanding. Underpinning this model is the fluid relationship between the three strands, where each of them will have a direct impact on the other two i.e. if a problem was identified in a specific area of learning to design, then this will impact teaching to design which will also impact teachers'/students'/researchers' understanding of design. The discussion section of this paper will clarify and justify the creation and design of this model following these identified unknowns and problems of designing. These challenges and problems discussed have been identified and unpacked through understanding the relevant literature base and supported from the knowledge and experiences of authors in teaching and learning design in the context of technology education at secondary level. These include; what does design look like in practice?, classroom-based problems, complexity of studying design, emerging pedagogies, design studio, varied understanding of design and how can we become better designers?

Figure 1.
One 'iteration' of the theoretical model unpacking design to support the identification of problems and future research activities. This iteration looks through the lens of designing in secondary technology education.



2.1. What does design look like in practice?

Teaching and learning designing is challenging, and this challenge can be amplified by the ambiguity in the definition of design and the varying processes of designing (Stables, 2020). It is understood that design invokes variance in practice (Atkinson, 2017), which concerns its 'teachability' and 'learnability' (Seery et al., 2012). One of the complexities of design is that its construct is synonymous with a breath of perspectives and constructs (Seery et al., 2022) that will see the treatment of design vary amongst contexts, and disciplines. Design is also interdisciplinary, for example, there is product design (Morris, 2016) and engineering design (El Maraghy et al., 2012) to name just two, which by nature will have varying goals and agendas that will foster a contextualised outlook on design for that discipline. The interdisciplinary nature of what could be considered as design within professional contexts is one reason as to why design holds varying interpretations in secondary level, general education, contexts.

What is problematic for technology education within the Irish context is that there is no understanding of what it looks like in practice. There is of course anecdotal understandings and qualitative investigation into how it can be treated (Doyle et al., 2019), but there has not yet been any empirical work which examines how design is treated nationally in a representative and descriptive manner. The unknown is a larger problem than the possible variance itself, and what could be argued is that the unknown must become known in order to progress design within technology education. Additionally, from the understanding that design is interdisciplinary, investigation into the comparison of design within different subjects within the technology suite in Ireland would be necessary to respect the individualities of the subjects and the nature of design. Applied Technology (NCCA, 2018a) , Engineering (NCCA, 2018b) , Graphics (NCCA, 2019) and Wood Technology (NCCA, 2018c) at lower secondary level and Engineering (NCCA, 1983), Construction Studies (NCCA, 1984), Design and Communication Graphics (NCCA, 2007a) and Technology (NCCA, 2007b) at upper secondary level make up technology education in Ireland. Each subject with individual goals, agendas and learning outcomes raising the importance to uncover how design is treated across these subjects.

2.2. Classroom-based problems – design fixation and design feedback

Design fixation, which is the blind adherence to a limited set of ideas (Jansson & Smith, 1991), is a problem found within second level students designing (Schut et al., 2020). Design fixation stems from creative blocks (Schut et al., 2020) and personal and emotional attachment to one's own designs (Baer & Brown, 2012; Schut et al., 2020), resulting in hampered convergent and divergent thinking and ultimately less creative and complete design solutions (Schut et al., 2020). Most commonly, design fixation is found at the end of the design process where 'stereotypical' designs are identified (Nicholl & McLellan, 2007). Schut et al. (2020) has identified and investigated successful strategies to support the identification of fixation early in the design process through conversations and interactions with students, however problems and challenges occur with providing feedback and support to guide students out of fixation.

Epistemic uncertainty is integral to design where designers are working on the extremities of their current knowledge (Schlosser & Paredis, 2007), which raises further complexity to the support and guidance needed when designing. A lot of valuable work has been done where interventions

have been developed and tested where results indicate that implemented design feedback interventions can successfully guide young learners into engagement in constructive feedback dialogues through divergent and convergent thinking (Schut et al., 2022). Feedback conversations should be constructed carefully, as they are sensitive and filled with fragile egos, sensitive identities and insecure learning processes (Schut et al., 2022). Critical thinking is seen as an integral and essential part of technology education (Williams & Stables, 2017) and as Schut et al. (2020) describes critical thinking and critical reflection as a process to limit and mitigate design fixation and essential to the accepting or rejecting of feedback in order to explore its merit without bias (Schut et al., 2022). Schut et al. (2022) has found that feedback is problematic in nature because of the need for students to have a strong critical evaluation skills to balance openness and persistence when met with criticism on their personal design. This challenge provides problems for both students and teachers in overcoming fixation and ensuring the correct guidance and support during the design process.

2.3. Complexity of studying design

Strimel et al. (2020) undertook an investigation into design cognition research to integrate the findings from multiple studies to develop more formal and generalised theories that would provide deeper and more powerful understandings of student design thinking to bridge the gap between research and practice. Findings identify problematic traits of studying design such as the context of the study, the design task itself and the coding schemes using to interpret findings. These constraints on studying design led to varied results and conclusions being drawn which cannot be generalised due to the nature of design. For example, one study found that the most dominant cognitive process when designing was modelling/prototyping, which contradicted another study whose most dominant cognitive processes were analysing and design. Strimel et al.'s (2020) integration and synthesis of these findings found that the first study's design task was to provide a physical prototype as the outcome, where the later study's design task outcome was to produce a conceptual design. This finding identifies that different design tasks afforded different conclusions which evidences the lack of capacity for generalisability and transferability in at least this stem of design research. This emphasises the complexities of studying design and the impact that constraints on the design and implementation of design tasks has on the study's results.

2.4. Emerging pedagogies

Vital to the success of designing in technology education is the development of effective and validated teaching and learning pedagogies that can be successfully adopted into the classroom. There exists a large literature base exploring emerging pedagogies, but even with such an extensive knowledge base, problematic conclusions can be drawn. To support the exploration of this problem, the emerging pedagogy 'Learning by Design' (LBD) will be discussed. LBD is an inquiry-based approach to learning based off two pedagogies that are 'problem-based learning' and 'case-based reasoning' where students learn concepts and skills through their own identification and self-motivated learning and reflection (van Breukelen et al., 2017). Theoretically this approach provides students with rich learning environments where self-directed learning takes place through design tasks (van Breukelen et al., 2017). Van Breukelen et al. (2017) found that students learn just enough for design-implementation and solution outcome

rather than developing a true understanding of the underpinning concepts for intended learning. Identified future research focuses on the interaction with teacher's where the key concepts are explicitly discussed and that the design task is simplified without diluting the key learning. This raises the question whether this possible adaptation into practice dilutes the underpinning value of the pedagogy outlined in the theoretical findings?

What is problematic are the unknown complexities of these pedagogies and the constraints and difficulty in their implementation into practice, moreover, this identifies and emphasises the complexity of teaching designing.

2.5. Design studio

To add more complexity to the teaching and learning of designing is the studio or the environment in which the designing takes place. Chen (2016) investigated the learning problem and resources within the design studio where results found that students rely heavily on interaction and communication with instructors, peers and the internet to solve problems. These interactions are not problematic by design and can provide fruitful guidance (Chen, 2016) but as identified previously these interactions such as teacher-student feedback has its own complexities in order for it to be successful in supporting designing. A negative attribute of using the internet to support the design process was that it was found that students more regularly copied ideas and designs to solve problems, which delegitimised this tool as an effective support mechanism for design, due to students' lack of knowledge and or understanding of its value in supporting their design capability (Chen, 2016). This problem of the incorrect use of teaching and learning tools within the design studio emphasises that within learning to design, the misuse of tools and resource can negatively impact the learning intended.

2.6. Varied understanding of design

The unknown understanding of design and its variance in practice is problematic within the literature and it can be argued that this same ambiguity can be seen in the classroom. Crismond and Adams (2012) stated that young students perceive a design challenge to be a well-structured problem with correct and incorrect answers, so they attempt to solve it immediately. What we see from the literature base is that many researchers identify design to be ill-structured, with a high degree of freedom in its representation, processes and solutions (Jonassen, 1997). The students' interpretation of a design problem is not the problem, but rather the identification of the variance in how design is understood, and whether students understand the role of ill-structured design problems. Well-structured problems support students in applying skills to varying situations of similar degree and context rather than developing their problem-solving or design skills through higher degree tasks which are more meaningful to learners outside of the classroom (Jonassen, 1997). As stated earlier, there is no evidence that identifies teacher's understanding of design with the Irish context, which could provide rich insights into design in technology education

2.7. How can we become better designers?

The final problem identified in this paper, can be argued as being the most complex in nature due to the complexities of the construct of design. Every human being is innately designerly by nature

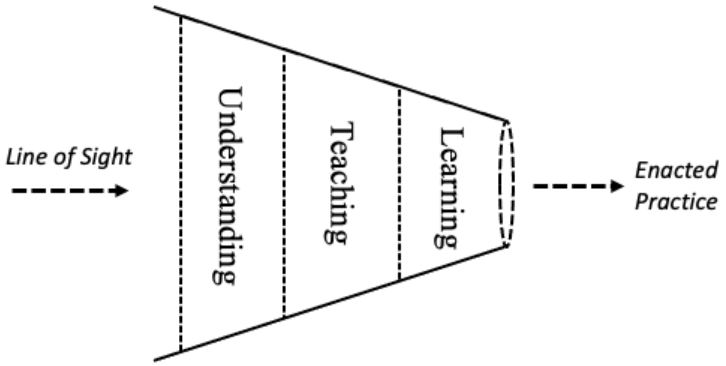
(Stables, 2008) but what is not understood is exactly what is the makeup of being designerly? Design capability has been argued as being the skills, knowledge, motivation, ability to bring future possibilities into reality through thought and action (Stables, 2012). Design competence, has been conceptualised as a social activity, knowledge and information processing, structure building and as a non-verbal process (Dorst, 1995). However, attempting to conceptualise and understand design ability results in questions of such nature as, is there such a construct as design ability? Buckley et al.'s (2020) synthesises of a body of literature with the intention to inform the structural alignment of design ability outlines the multiple complexities to understanding this potential construct. There is ambiguity surrounding the measurement of design ability (Buckley et al., 2020) and so how can the investigation of fostering design ability take place if there is no consensus to its accurate assessment. For instance, if a beginning secondary education engineering class's design task was compared against an end secondary education engineering class's design task, excluding the obvious difference in skill and knowledge base, what would the difference be?

What is problematic with designing within technology education is that there is no universal definition on the construct of design ability, and so challenges the practices of fostering designerly students.

3. DISCUSSION

Presented in Fig. 2 is a graphic representation of the relationship between each of the elements underpinning the model (Fig. 3). Using the analogy of a telescope, looking through the lens (ones perspective) the first element that will be seen is understanding, followed by teaching and finally learning. The funnel shape and linear layout of the elements describes that learning is impacted and underpinned by teaching, which is ultimately fostered from understanding, i.e. one must conceive design, in order to teach towards it, so intended student learning can take place.

Figure 2.
Looking through the 'telescope' to understand the relationship between each strand of the theoretical model.

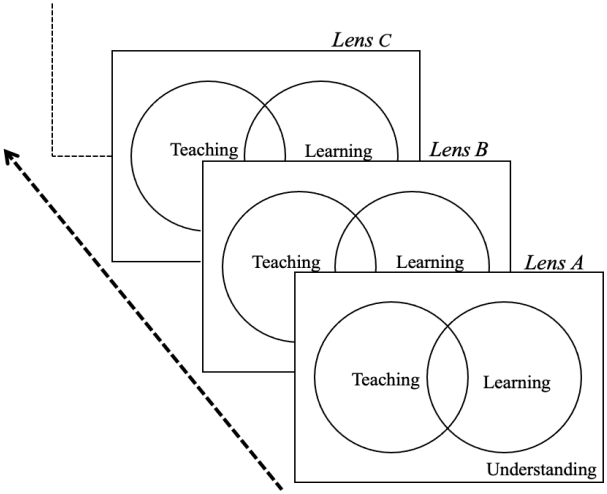


To the fore of problematising the uncertainty of design within technology education in Ireland is the establishment of the theoretical model presented in Fig. 3 and specifically, the use of one specific iteration shown in Fig. 1. This theoretical model was designed and developed through the lens of a practicing engineering teacher where key components to practice were identified and used as elements to the framing of the model. The elements are understanding, teaching and learning. At the core of education is teaching which is underpinned by understanding both within educators' own knowledge base but also that of the literature, ultimately impacting on student learning. What is key to this model and encompasses the complexities of design is that the model will have different iterations depending on the lens in which you look at the model. This is an attempt to interpret the nature of understanding. There is an undetermined number of lenses from which one can view the model that will be dependent on the context of design, the persons understanding and role as a teacher/researcher/student. Practicing teachers' fostering of designerly students in secondary level technology education was the lens, i.e. iteration of the model, used to problematise design in section *2* (Fig.1.). To further describe the value and intended use of this model a short hypothetical vignette will be used describe the nature of understanding, teaching and learning, to provide an insight into how it fostered the identification and unpacking of the problems described in section *2*.

> I am a secondary education engineering teacher in Ireland. To prepare for teaching my students I must become familiar with the subject specifications. Recently the Junior Cycle has been reformed that now sees a new treatment of design within technology education. My understanding and interpretation of the syllabus is that I must develop a learning environment where design application is a core element and students must understand the design process and be creative about forming their design solutions to design challenges. Immediately this challenges my understanding of design, how it is defined, what it looks like in practice, what are the core elements of the design process and what is the most effective pedagogy to foster student designers. I discussed these questions with my colleagues but they teach Graphics, Applied Technology and Wood Technology, which each have different treatments of design. A wide literature base that I am unfamiliar with adds further complexity to selecting necessary pedagogies and tools. I must select and design the necessary assessment strategies to ensure students are developing their designing skills in my class. I have 3 classes of engineering with a wide range of student abilities, skills, knowledge and learning needs, which adds further complexity and challenge to my understanding of design, and specifically what it looks like in my context.

This hypothetical vignette serves as a tool to describe one lens in which design was unpacked using the theoretical model (Fig.3. and this lens' iteration in Fig.1). The lens will depend on the nature and context to which the person is situated within and the complexities of the nature of understanding.

Figure 3.
Theoretical model to support problematising the uncertainty of design underpinned by the interpretation of the nature of understanding, where the lens forms an iteration of the model dependent on the perspective/context that design is being understood.



4. CONCLUSION

This theoretical model presented is a naïve theory based on problematising the uncertainty of design within technology education. This paper is an attempt to describe the complexities of design within technology education and identify the wide literature base that exists. Future research will include investigating teachers' perceptions of their understanding and confidence in fostering designerly students amongst other studies based on the areas discussed.

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