

Introducing design thinking online to large business education courses for twenty-first century learning

Abstract

Design thinking can be broadly defined as a set of creative skills to understand and problem-solve ambiguous and complex problems, and a practice that places humans at the heart of the design process. Such collaborative ways of design thinking and design-doing are much needed to address twenty-first century challenges such as climate change. Design thinking methodology is well known for teaching and learning in design disciplines, and to a lesser extent, as an innovative problem-solving framework for business education. Typically design thinking has been taught and practised in physical settings and to a lesser extent online. While design thinking is also increasingly practised online, this is challenging at scale in higher education contexts. This case study analyses design thinking activities with educational technologies in a large undergraduate cohort of first-year business students. Eleven students and three teachers were interviewed to ascertain their level of engagement with design thinking with digital tools and to identify common themes that enabled or inhibited such practice. Student artefacts of design thinking are explored and compared to the interview data. Findings indicate that students may develop novice design thinking skills, process knowledge and mindsets in online and remote delivery modes, despite limited experience, technical and time constraints. Broader learning design implications of design thinking constraints in digital practice are discussed to assist educators. It is suggested that higher education adopt and support design thinking, as a subject and practice, more widely.

Practitioner Notes

1. Students find design thinking to be an active, engaging online learning activity.
2. Design thinking may be used as a collaborative problem-solving approach in teaching and learning outside of design disciplines.
3. Novice design thinking skills, mindset and process knowledge may be learnt with limited exposure to design thinking.
4. Online design thinking activities need fewer, less frequent steps in online student groups.
5. Educators need a design thinking mindset to facilitate within the constraints of digital environments.

Introduction

Learning in the twenty-first century is necessarily dynamic and complex, as knowledge is no longer stable and fixed, and no longer resides with elite experts (Koh et al., 2015). New ways of thinking and learning are needed to collaboratively address 'wicked' problems such as climate change that are interconnected and seemingly intractable (Rittel & Webber, 1973). Massive global

socioeconomic changes and the ever accelerating pace of digital growth (Esposito et al., 2018) call for urgent innovation and transformation of pedagogical practice in higher education (Adams Becker et al., 2018). Learning from peers, learning with and through technology is critical for twenty-first century learning and the future of work (Voogt & Roblin, 2012). As such, design thinking has become widespread in contexts outside of its design origins, particularly in business and management (Kimbell, 2011). Design thinking offers a contemporary approach to leading and managing strategic business problems (Dunne & Martin, 2006; Liedtka, 2014). Furthermore, the process of design thinking has been linked to learning through experience, reflecting and abstracting experiments to innovate (Beckman & Barry, 2007). In this paper, design thinking is considered a mindset, skill and process (Wright & Wrigley, 2019).

Higher education practice is also growing more complex, with large classes compelling teachers to adapt to the conditions of these learning environments (Hornsby & Osman, 2014). Social, collaborative, problem-based and cooperative learning pedagogies such as design thinking are more difficult to implement at scale in online spaces (Baldwin, 2018). Typically the practical component of design thinking is facilitated face-to-face, with content or lectures delivered online (Fleischmann, 2021). Few studies investigate design thinking online outside of design disciplines as a student-centred activity in large higher education cohorts (Fleischmann, 2019; Taheri et al., 2018). Hence this study seeks to understand the perspectives of students and teachers towards design thinking online in a large university business course. The overarching research question framing the data collection is:

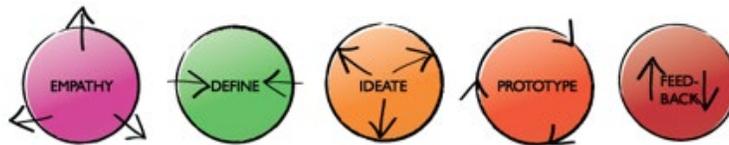
What enables and inhibits the teaching and learning of design thinking skills, processes and mindsets in large online cohorts in higher education?

Design Thinking as a Theoretical framework

At its broadest, design thinking has been described as approaching the world ‘as a designer who intentionally develops or invents novel solutions’ (von Thienen et al., 2018, p. 34). In addition, design thinking entails an empathic mindset of ‘putting people first’ when designing (Brown & Katz, 2011, p. 383), a set of creative methodologies for tackling problems, and a skill to be mastered (Brenner et al., 2016; Koh, 2015). Design thinking is a cognitive style as well as a framework for approaching interdisciplinary problems and issues (Goldman et al., 2012; Kimbell, 2011). A design thinking mindset is suited to untangling ill-defined, ambiguous and non-linear situations, where problems and solutions may co-evolve (Dorst, 2011; Kolko, 2010). Design thinking practitioners are said to adopt a human-centered mindset, which prioritises people’s desires and needs when designing products or services (Brenner et al., 2016). Empathy for all in the design process and an open, curious attitude are central to this design thinking, particularly human-centred design values and practices (Schweitzer et al., 2016).

Figure 1

Design thinking process, Stanford D-School



Arguably the most well-known design thinking methodology originates from the Hasso Plattner Institute of Design at Stanford University (Brown & Green, 2018). The design thinking process begins with learning and empathising with the intended user of the product or service, using these insights about their needs to explore and define problems. Ideas and potential solutions are then generated, selected, refined through iterative cycles, and prototyped so designs may be tested before deciding on the most appropriate solution (see Figure 1). In this sense, design thinking is often

intended as a dynamic, iterative practice with design outputs or artefacts that represent and clarify cognitive processes in practice (Kimbell, 2012).

Design thinking in education

Design thinking is increasingly adopted in higher education contexts to support interdisciplinary and networked learning, and to help students graduate with attributes ready for twenty-first century challenges (Çeviker-Çınar & Demirbağ-Kaplan, 2017; Matthews & Wrigley, 2017). Critical thinking, collaborative and reflective skills, such as design thinking, are needed to navigate the increasing complexity and ambiguity of a constantly changing global environment (Koh, 2015; Razzouk & Shute, 2012).

Research-based constructivist theories suggest that learning socially and thinking critically are more important skills than the mastery of content taught in traditional university models (Jonassen, 1997; Villarroel et al., 2018). Student graduates need to be active and self-directed learners, rather than be 'lectured'; instructivist teaching models where students are expected to consume and reproduce expert knowledge are out-dated (Ertmer & Newby, 2016; Laurillard, 2012). Hence deeper learning approaches, such as project- and problem-based learning, are prevalent in the higher education sector (Baeten et al., 2010).

Design thinking mindsets, processes and skills overlap with active and student-centred learning approaches (Brenner et al., 2016; McLaughlan & Lodge, 2018; Wright & Wrigley, 2019). Teachers may draw on such design processes in the creative problem-solving aspect of designing teaching and learning (Brown & Green, 2018; Koehler et al., 2013). Working in multidisciplinary teams also helps teachers and students make sense of ill-defined educational problems (Bower, 2017). Integrating the design thinking studio experience and problem-based learning on open-ended problems may positively affect student learning (Öztürk & Türkkkan, 2006; Taylor, 2009). Team collaboration in design thinking resembles group work in education, where students learn with and from each other (Haidet et al., 2014; Johnson & Johnson, 2008).

Design thinking skills are also invaluable to teachers as they are expected to design opportunities for students to problem-solve creatively, collaborate in teams, preferably in authentic and situated contexts (Goodyear & Zenios, 2007; Laurillard, 2012). Teachers seek to empathise with, understand, and respond to learner needs through course design, practices that resemble human-centred design (Vanada, 2014; Matthews et al., 2017). The design thinking process may guide collaboration and reflection in curriculum design teams across disciplines to co-create student-centred experiences (Beacham & Shambaugh, 2013). Visualising curriculum and learning outcomes with design thinking principles affords greater clarity and collaboration between team members and subject matter experts in designing online subjects (Davey et al., 2019). Design thinking frameworks place students at the heart of educational design and development (van der Laan et al., 2021).

Design thinking online in education

Research in designing and facilitating learning communities via text-based online discussion forums is well established (Akyol & Garrison, 2013; Laurillard, 2012; McKenney, 2013). Collaborative learning has been associated with the educational use of technology for many years (Beetham, 2013; Bower, 2017), although researchers have challenged conceptions of collaborative online learning as inherently transformative (Hammond, 2017). Nevertheless, digital fluency, collaboratively problem-solving, and adapting to an increasingly automated global economy are key to knowledge work and education (Markauskaite & Goodyear, 2017; McLaughlan & Lodge, 2018). At universities, digital and information dexterity or competence are considered essential student graduate skills (Spante et al., 2018).

Learning about and through design thinking online has the potential to bring together and foster critical thinking, problem-solving and digital competence skills. However, higher education research into design thinking practice in digital student-centred learning environments is still emerging (Beligatamulla et al., 2019). More sophisticated digital whiteboards and drawing technologies that approximate pen and paper have been trialled for virtual design studios for

collaboration (Gumienny et al., 2012), but are still mostly inaccessible for large, mainstream cohorts. Despite technological innovation, the benefits of advanced technologies for collaboration, such as virtual and augmented reality, are yet to be realised in mainstream educational settings (Siu et al., 2018). Yet a growing body of research suggests design thinking has much to offer pedagogically, in and outside of design disciplines (McLaughlan & Lodge, 2018; Welsh & Dehler, 2013; Wrigley & Staker, 2017).

Context

Learning about design thinking is highly relevant to the first-year subject in this study, 'The Future of Business', and core to the University of Sydney's popular Bachelor of Commerce. Students gain foundational business knowledge and critical analysis skills in global challenges such as climate change and sustainability, rapid urbanisation, demographic shifts and exponential technological growth. Traditionally, teachers support students to apply critical, strategic and cross-disciplinary thinking, primarily via the Harvard case method in face-to-face tutorials (Bridgman et al., 2016). Design thinking and entrepreneurial frameworks are introduced later as an alternative innovation toolkit for problem-solving skills (Collinson & Tourish, 2015). In the final assessment, students may choose design thinking as a conceptual framework to analyse challenges and opportunities in business scenarios in a global economy.

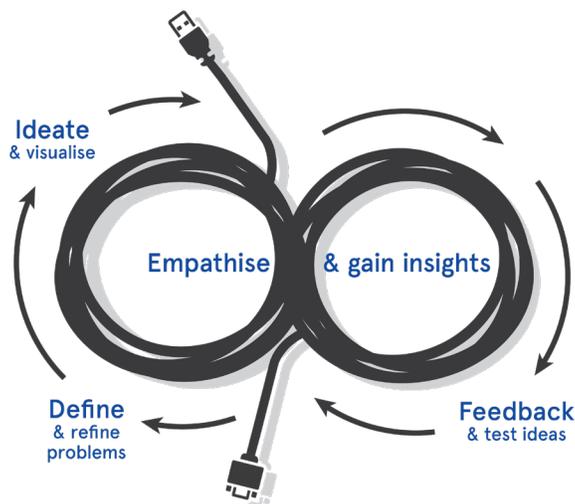
In 2019, re-design and development of the subject were underway before the pandemic forced a shift to emergency remote teaching and the 'digitisation of curriculum' (Crawford et al., 2020). The subject had already been evaluated to identify areas to further engage students online. Subsequently, face-to-face lectures were transformed into shorter self-paced interactive modules as pre-work for the face-to-face tutorial, with multimodal content, activities, and opportunities for social interaction and reflection.

The design thinking tutorial became a workshop where students could practice foundational design thinking skills by designing chairs for each other (Stanford d.school, n.d.). This exercise was chosen so students could concentrate on practising the design thinking process with a common household object, rather than inventing an abstract service or product. For novice learners, a concrete design task reduces cognitive load (Sweller, 2020). Furthermore, as Chen (2021) notes, design thinking is conceptually demanding; working with concrete examples of products may help students in an EFL context to experience such creative and critical thinking processes.

Traditionally, design thinking is practised by small groups in physical studio spaces, and projects are developed over an extended period. This was not feasible in the large cohort of 'The Future of Business', in which students learn and apply many business frameworks across a semester. Nevertheless, introducing students to design thinking in a condensed form was considered valuable, despite the risk of oversimplification (Taylor, 2009). As a result, students were asked to engage in only four stages of the process in the workshop. Prototyping was emphasised as part of the design thinking process in the online module but not experienced in the workshop.

Figure 2

Design thinking workshop process for 'The Future of Business'



Introductory online design thinking process adapted from dschool, Stanford University

However, in the first semester of 2020, the condensed design thinking workshop had to be again reimagined as an online experience, due to the impact of covid19. Despite the easing of lockdown restrictions in the second semester, social distancing measures meant that students who attended campus still interacted via a digital whiteboard, rather than using physical resources. The majority of students collaborated in online workshops to practice design thinking.

Collaboration with the technology needed to be simple and readily available. Third-party software tools in Australia could not be guaranteed access worldwide and relied on students registering individual accounts. Hence, students' design process was mediated by the University VPN (Virtual Private Network), its Learning Management System (Canvas), web conferencing (Zoom) and digital whiteboard technologies (Google Jamboard), which were freely accessible to students studying across the world in remote workshops.

Method

This case study investigates student and teacher perspectives of an introduction to design thinking in a first-year business subject to generate knowledge that may be more broadly used to inform teaching and learning approaches. Participants were asked to describe what they learned or did not learn, in order to analyse the research problems of this specific business context (Yin, 2016).

Data collection

All teachers (n = 5) and students (n = 680) enrolled in the second semester of the subject were invited to participate in the study. Teachers and students self-selected for interviewing. Fourteen semi-structured interviews were conducted two weeks after the online activities and design thinking workshops, using a set of questions approved by the University of Sydney Human Research Ethics Committee (HREC). The eleven participating students were evenly distributed across the five teacher groups. Participant characteristics are summarised in Table 1.

Table 1

Participant characteristics

Students					
<i>Pseudonym</i>	<i>Design thinking experience</i>	<i>Online experience</i>	<i>Workshop delivery</i>	<i>Gender</i>	<i>Background</i>
Ming Mei	No	No	Online	Female	International
Jun	No	No	Online	Female	International
Hui Yin	No	No	Online	Female	International

Hua	No	No	Online	Female	International
Yang	No	No	On-campus	Female	International
Grace	No	No	Online	Female	International
Jennifer	No	Limited	On-campus	Female	Domestic
Sharon	No	No	Online	Female	Domestic
Mia	Yes	No	Online	Female	Domestic
Ray	No	No	Online	Male	Domestic
Justin	No	No	Online	Male	Domestic
Teachers					
Rebecca	No	Yes	Online	Female	
Andrew	No	Yes	Online	Male	
Edward	No	Yes	Online	Male	

Students were asked about their previous experience with design thinking and online learning, and open questions about their workshop experience related to design thinking skills, mindset and process. In addition, students were prompted to reflect on whether their learning could be applied to other situations, and to comment on their designs and how they felt about them. Teachers were asked about their experiences and perceptions of how students generally performed in relation to the design thinking capabilities. Both teachers and students were invited to comment on the most and least successful aspects of the design thinking activities and offer suggestions for the future.

Data analysis

A hybrid coding approach was applied to report and analyse levels of student engagement specifically against design thinking criteria and design-thinking enablers and inhibitors more generally (Fereday & Muir-Cochrane, 2006). Firstly, deductive thematic coding was used to analyse the experiences and engagement with design thinking of students and teachers in relation to the research question (Braun & Clarke, 2006). Participant responses were coded to measure evidence of developing design thinking skills, process knowledge and mindsets, using an adapted version of the ‘Design-led Education Innovation Matrix’ descriptors (Wright & Wrigley, 2019: see Table 2). The matrix was chosen as a design thinking theoretical framework for its relevance to the case study context; it combines business design thinking and education innovation research with twenty-first century learning competencies (Wright & Wrigley, 2019). Three interdependent levels of design thinking that communicate, identify and develop value are described in the matrix. Students in the first level demonstrate novice, exploratory levels of design thinking; in the second deeper metacognitive, communication and collaboration skills (Wright & Wrigley, 2019). The third level, which describes design as intersecting and leading, is beyond the introductory design thinking of this case study. The levels of design thinking were compared by the number of coding references.

Table 2

Adapted design thinking coding levels (Wright & Wrigley, 2019).

Level	0	1	2
<i>Mindset</i>	No change	Communicate the value of human-centred, collaborative thinking in a local context	Practise design thinking values of empathy and collaboration, and prototype solutions for wider contexts
<i>Skills</i>	No change	Use basic design thinking research skills and tools to collaborate and develop value	Practise and reflect on design thinking skills to generate ideas, adapt and collaborate
<i>Process</i>	No change	Follow design thinking processes and identify value	Collaborate to adapt design thinking processes and communicate value

Next, perceptions of online design thinking inhibitors and enablers were analysed across student and teacher datasets to inductively find common patterns and relationships (Braun & Clarke, 2006).

Using NVivo data management software, interview transcript data was constantly compared to formulate themes and the coding scheme outlined in Table 4 (Corbin & Strauss, 2008). Finally, student-generated artefacts were compared with the interview findings to triangulate data where possible (Creswell, 2015). In addition, the artefacts were examined for tangible indicators of design thinking inhibitors and enablers as design thinking emphasises visualisation and embodiment of designs generated through drawings and notes (Kimbell, 2012).

Findings

Emergent design thinking in student learning was evident in most interview discussions, despite the nil or limited exposure to design thinking practice of most participants in this study. A small proportion of participants interviewed did not articulate design thinking process, skill or mindset against the criteria, although they sometimes valued what they learnt about creativity or other related topics. A minority of students interviewed appeared to develop or extend intermediate human-centred, experimental, and collaborative competencies in their practice. Table 2 summarises where interviewees described a design thinking skill level of zero, one, or two in the relevant categories.

Table 3

Design thinking levels expressed in interviews

Level	Mindset %	Skill %	Process %
0 Not demonstrated	16.6	21	16.2
1 Exploring (foundational)	66.7	65.1	78.4
2 Connecting (context adaptive)	16.7	13.9	5.4

No students expressed visionary leadership skills in design thinking, as expected in a first-year undergraduate cohort. However, the majority of student responses indicated foundational design thinking mindsets, such as the importance of interviewing to empathise with each other's needs. Most could also connect their insights to broader applications for future business situations, including market research, product development and service design. Grace reflected that:

We have to change the way we fundamentally feel about how to design a product ... it's really important to get to know what they want rather than just giving them what we think they want... getting to know consumer parts in the design thinking is really critical in the business world.

Many students also articulated the value of design thinking as a problem-solving process to iterate, experiment and prototype solutions for a rapidly changing world. For instance, Sharon thought global issues around politics and climate change could be framed as design thinking challenges, so 'things can constantly be adapted and changed.' Other students such as Ming Mei described design thinking explicitly as combining different perspectives to approach problems afresh. Hui Yin learnt:

Design thinking promotes problem solving ... it's the process of digging deep into why that failed. And taking that failure and just taking those points and putting it into your next move ... It's really a cycle, it's a process.

Foundational design thinking skills such as "information literacy, observation and interviewing for early research stages" were evident in the data collected for this study (Wright & Wrigley, 2019, p.14). Artefacts show students experimenting with available technologies to design in tangible ways, sometimes searching the web for inspiration and images, generating ideas, and communicating insights. Although students interviewed often felt the design thinking process was rushed, all associated it with greater creativity. Pre-conceptions of designing as an artistic talent were sometimes challenged (Chen, 2021). A high level of creative engagement was also evident in some student artefacts.

and impediments to deeper learning experiences are further discussed below under the themes identified in the data, summarised in Table 4.

Learning sequence

Online experiences, particularly when dealing with messy and ambiguous topics, need to be “clear, succinct and broken into manageable pieces of learning” (Cross & Holden, 2020, p. 157). Overall, the workshop and self-paced interactive module's sequencing and instructions were reported as helpful; ‘intuitive’ and ‘a clear guided process.’ Students also appreciated the scheduling of design thinking as a topic and activity after a major assessment, near the end of the semester. While most students praised the engaging learning design, a minority preferred to watch lectures and learn from summarised slides. Self-directed learning in online modules was new to most students (Fleischmann, 2021), and they may have judged the cognitive effort inherent in active learning as overly difficult compared to a lecture’s fluency and ease of consumption (Deslauriers et al., 2019).

Learning by doing

Most students appreciated the workshop as design epistemology, a different type of knowledge and way of knowing than the usual class format (Rowland, 2004; Tsai et al., 2013). Enacting design, ‘learning by doing’, was engaging and rewarding (Goldman et al. 2012). Different students used the words ‘fun’ and ‘hands-on’ several times, and this strong emotional and cognitive engagement helped them learn about design thinking (Tews et al., 2015). The design thinking workshop was perceived as active and creative, using ‘a different part of the brain,’ and a welcome change from the usual case study analysis.

Design thinking was both a novel subject and a pedagogical experience for the participants of this study. Yang described learning by design thinking as ‘unlike other tutorials’ and an ‘innovation of our thinking’ whereby talking with group members, ‘we can get some other ideas which can be used in our own thinking’. Compared to the standard format of studying business frameworks, readings and class questioning, design thinking was ‘less stressing’, even if students like Justin were at first unused to the workshop format, describing it as ‘an odd lesson’.

Interestingly, the student who strongly disliked design thinking attended an on-campus workshop. Jennifer felt it a ‘bit out of nowhere’ to be asked to design a chair, adding she was ‘not really a creative person’. She considered innate artistic ability to be important in design and lacked what Jobst et al. describe as creative confidence (2012, p. 35). Jennifer then described being ‘lost’ in the workshop yet showed design thinking insight by foregrounding mindset and empathy over following process in a rigid way (Schweitzer et al., 2016). That is to say, when asked what she would do differently next time, Jennifer replied:

Because the important part of designing is the empathy part where you think about the person that’s going to use it, maybe just to think deeper about who I’m designing it for, the target audience for the product or whatever it is.

Teacher Rebecca, however, felt that design thinking was too abstract and complex to introduce in a short time, especially when students came to workshops unprepared. She suggested that the online interactive module or a quiz should be mandatory preparation for workshops. Pedagogically, Rebecca considered consistency more important for first-year students, preferring each week to be structured around business case studies with questions that, ‘they need to discuss in a group and then are chosen to present answers.’ Both Rebecca and Edward considered practising design thinking less important than learning and applying business strategy frameworks for first-year students. While business academics acknowledge how influential it is globally, design thinking is a more experiential, practice-based approach that is not easily integrated into traditional curricula such as the lecture-seminar model, which is still the dominant pedagogical model in many large-scale business cohorts in universities (Çeviker-Çınar & Demirbağ-Kaplan, 2017).

Socialising

Another notable theme in interviews was that students enjoyed interaction and discussion as a collaborative knowledge-building activity (Goodyear & Zenios, 2007). Random group allocation in large classes and being 'forced' to meet someone new, as Hui Yin described it, benefitted both shy and outgoing students. Furthermore, communicating over a shared problem was engaging and helped students develop confidence in their creativity, as Cleminson and Cowie (2021) found in their study. For example, in one workshop Hua exchanged WeChat details with a partner, creating a social connection that endured after the activity. In general, students saw the advantages of sharing ideas and collaborating with their peers, with Sharon commenting, 'you feel more of a personal connection to your learning'.

Nonetheless, design thinking with digital tools, was cognitively and creatively challenging (Fleischmann, 2019). Students also needed sophisticated language and group work skills to collaborate via technology to complete the activities under time pressure. Hui Yin described her less than ideal experience in mature philosophical terms:

I did have a little bit of a communication issue with my partner. He was another international student and his language capabilities weren't as smooth. But I think we both tried our best and we managed to get what was best out of the situation. So that was a little bit of a hiccup as well but, you know, I mean it's to be expected when you're working with anybody, be it in school or in the workforce.

A lack of diversity in pairs or group work could limit the richness of the exercise, particularly where there was a lack of leadership (Beckman & Barry, 2007). Students suggested increasing group size for a wider range of critical opinions. Larger heterogeneous groups of students work better in design thinking processes and enable more active learning (Johnson and Johnson, 2008). Students could be involved in the design of the groups, and more adept students with design backgrounds could lead and adapt activities. As teacher Andrew suggested, it may also be important to design groups strategically. Collaboration across disciplines to build inclusive, diverse teams is a feature of design thinking in innovative business scenarios (Schweitzer et al., 2016).

Technology

For students, working on a digital whiteboard enabled visualisation and greater sharing of their ideas, although interacting via a screen and keyboard limited physical, sensory affordances and the shared tactile experience of using pens and sticky notes. Interaction via a laptop instead of drawing meant an absence of freehand movement, which is positively associated with creative, personal expression (Velden, 2021). Even so, students were generally satisfied that they had generated and externalised ideas in visual ways on the digital whiteboard (Siu et al., 2018). Moreover web conferencing and digital whiteboards allowed students to collaborate remotely with peers (Cross & Holden, 2020). Digital artefacts were easily shared via multiple devices, independent of location. Students' visualisations, rudimentary and imperfect, nevertheless enabled them to collectively and creatively imagine future chairs in novice-designerly ways (Kimbell, 2011). Students valued sharing ideas in the workshop, praising each other's creativity (Beligatamulla et al., 2019). Jun summarised students' general sentiment as being 'proud of my design', highlighting that, 'my partner's feedback helped me'.

Students' collaboration on digital whiteboards was externalised in a different way to physical whiteboards and space (Tsai et al., 2013). The digital whiteboard allowed students to easily revert or reinstate previous designs as they refined their chairs and download and juxtapose these designs to create new artifacts, in ways not possible in traditional studios or workshops (Dreamson, 2017). Teacher Edward mentioned that some students returned to drawing after class, and downloaded their products in other workshops to keep them. For student Ray, testing his ideas with others on the digital whiteboard 'reaffirmed the benefit and advantage of feedback and external insights' and that 'you need other people's inputs to be a reality check'.

Technically adept and well-resourced students enjoyed engaging with digital tools. Students like Hua found it easy to draw and present on an iPad while others preferred to draw on paper and upload their chairs as images. Simple, practical enhancements were suggested by students, rather than more sophisticated technology solutions. Digital sticky notes, for example, were perceived as most useful for gathering and grouping ideas. In the artifacts, students often adapted their practice and captured their ideas with text on sticky notes where the drawing tools proved too difficult. Mia, who attended a workshop on-campus, preferred the digital whiteboard to physical sticky notes and drawing, even though she found online drawing difficult:

But for sure the actual vision board that I had going was a lot stronger online than it was on paper because I was able to use Google images of certain sections of chairs that I wanted to incorporate.

For others, drawing with a mouse or trackpad was awkward and occasionally exacerbated by time lags where internet connections were patchy. Other research has similarly found that prototyping and manipulating digital objects in real-time is challenging while collaborating (Siu et al., 2018). In addition, switching between creative design tasks and managing technology places an extra cognitive load on students and may detract from collaboration (Fleischmann, 2019). The minimalist functionality of Google Jamboard as a digital whiteboard may also have constrained some creativity; its canvas size was not large enough to do several sketches or iterations and the drawing tools were simple with few colour options. Despite glitches, technology was not described by students as hindering design thinking activity, as it was in regards to teachers' facilitation, as discussed below.

Facilitation

In terms of facilitation, teachers were most positive about online design thinking when they adapted workshop activities. For example, teachers elicited student responses via text chat and prompted quick feedback via emojis. In some workshops, teachers also actively encouraged students to 'fail' and to 'think big' to encourage students' creativity and changed the timings of activities to accommodate struggling students. This helped students to test their ideas and develop a bias toward action that is important to design thinking. Andrew elaborated:

We can compensate for some of those challenges of having students get a bit lost by having them properly peered and doing a few other things. But I also changed the format. Rather than have them in breakout rooms, I had this front-end and back-end activity in those design thinking steps.

However, the technical facilitation of combining different software at short intervals in large online classes was demanding. Limitations of the web conferencing software hindered teachers' ability to communicate with students in separate group rooms. Teachers had to broadcast frequent reminder messages across all rooms while monitoring students' contribution to whiteboard slides. In online workshops, teachers noticed some students fell behind because they missed teachers' broadcast messages when they had their browsers on full screen to use the digital whiteboard. In workshops on-campus it was simpler to notice groups that might be 'stuck' or benefit from feedback during the various design thinking stages. Edward reported:

The size of the class was really difficult. In a face-to-face classroom it would be easy to keep an overview of what's going on. Impossible to reach all the Zoom rooms.

Andrew ascribed a lack of 'vibrant activity' across the entire semester to the large size of groups in online workshops where teachers struggled to identify and encourage reticent students who might otherwise contribute. In addition, all teachers perceived students to be less engaged in online workshops because of international time differences, exhaustion from pandemic disruption to their lives, and digital inequalities (Williamson et al., 2020).

Although all teachers had either studied online or taught online before to some extent, the pivot to remote teaching was an unexpected and mostly unwelcome shift, and this may have also coloured

perceptions of design thinking activities, which came towards the end of a gruelling semester. Even so, teacher Andrew was 'thankful' to be introduced to the digital whiteboard and has since introduced the technology to colleagues in other subjects, who have also adopted it in their teaching.

Limitations and future research

The authors acknowledge the small sample size of this study as a limitation, and the possible bias from the self-selected sample of participants interviewed. None of the teachers or students in this case study were directly involved in developing the design thinking topic, which was redesigned with a small multidisciplinary team. Co-creating these activities with more teachers and students may have produced a more robust design, and involved a larger and more diverse group in design practice and facilitation in a more meaningful way (Snelling et al., 2019). Further research into students' creative problem-solving strategies in online settings will help refine such design thinking pedagogical approaches (Chen, 2020).

Students and teachers in this study had to contend with the impact of a pandemic, learning remotely from highly individual, physical and material contexts which influenced their ability to interact and learn (Fawns et al., 2019). Teachers alluded to unequal student participation, suggesting that online learners may have been limited by technology and or timezones, beyond design thinking pedagogy. Additionally, most students were from culturally and linguistically diverse backgrounds, another potential barrier to communication and interpersonal relationships in a short timeframe (Dreamson, 2017). Greater forethought and attention is needed to change the practice aspects of design thinking in online settings, especially to factor in more time and flexibility to facilitate a group experience where nobody is left behind. Adapting activities for differing technology levels and internet access is one such future research direction (Williamson et al., 2020).

Implications

Design thinking was introduced in a condensed form as an innovation tool (Liedtka, 2014), rather than a means to produce and share physical prototypes or objects, as practised in design disciplines (Siu et al., 2018). The impact of implementing such introductory design thinking in a large undergraduate cohort has implications for teaching and learning across different disciplines and international contexts, as many are similarly constrained by inexperience, time and technology. Yet despite considerable constraints, the first-year students interviewed learned foundational skills and could articulate design thinking insights. Non-designers typically need more supports, facilitation and time to engage in ambiguous problems across disciplines and silos; Wright and Wrigley recommend three days' immersion in design thinking, for example (2019). Unsurprisingly, some artefacts illustrated superficial engagement rather than deep learning, suggesting students require more time and support to experience the process more fully. Beyond training, teachers also need time and resources if they are to expand design thinking horizons to explore authentic global challenges in an interdisciplinary way. Nevertheless, empathising, collaborating on a condensed design thinking process with online tools; these skills helped large groups of students to begin to ideate, examine and test their assumptions, to refine their ideas further and introduced them to new ways of problem-solving.

Technical constraints were often challenging but not insurmountable. Students demonstrated a capacity to adapt and experiment online, and this flexibility in itself is important for problem-solving (McLaughlan & Lodge, 2018). These findings indicate that investment in the technical improvement of design thinking tools is perhaps less important than leveraging existing technologies to allow students to build design thinking skills, with the aim of connecting to broader networks and authentic contexts outside of their groups and workshops. High-technology workshops may in fact hinder active learning, especially if teachers are less experienced in online facilitation (Nicol et al., 2018). Educational designers or other consultants can bridge gaps in design thinking in online learning with digital tools (Davey et al., 2019).

Teachers' ambivalent attitude to design thinking pedagogy contrasted starkly with the mostly positive perceptions of students interviewed. Teachers may value design thinking when it is better integrated into the overall subject design and more tightly aligned with disciplinary knowledge.

Even so, students and teachers alike increasingly need ‘to think like designers’ to problem-solve in complex learning and work environments (Razzouk & Shute, 2012, 343). Reframing pedagogy as a wicked problem, that can no longer be formulated and solved with deductive logic, calls for a designerly and less well-known teaching and learning approach (Brown & Green, 2018). If higher education is adopts and supports design thinking as *both* subject and practice (Koehler et al., 2013; Koh et al., 2015). Clearer framing of design thinking in education is needed; as an essential mindset, skill and process for future work (Jobst et al., 2012). The discussion has been summarised in Table 4.

Conclusion

This case study highlighted the complex intersection of design thinking expertise, pedagogical and technical demands placed on teachers facilitating online in large business cohorts, outside of design disciplines. While most participants enjoyed the introduction to design thinking, summed up by one novice as ‘it opened my eyes to different ways’, design thinking is inhibited if teachers and students undervalue the process, skill and mindset demanded to flexibly and experientially to learn, solve problems and think differently. As design thinking influence spreads in business and education, so does the need for greater resources, professional development and teacher support in design thinking as a methodology.

Table 4

Design thinking online insights

Enablers	Inhibitors	Suggested improvements
<i>Learning sequence</i>		
Clear and logical structure of content and activity	Content was not detailed enough for some participants	Augment design thinking resources
Strategic scheduling	Transition between activities in workshops was too rapid	Allow more time for design thinking processes online
<i>Learning by doing</i>		
Fun factor	Too little time for the process and abstract complex thinking	Allow more time to explore and to reflect
Hands-on activity	Unfamiliar content and learning style	More orientation to design thinking as pedagogy
Creative content		
Change of style of learning	Perception of lack of rigour	Integrate design thinking into business problems
<i>Socialising</i>		
Meeting new people	Communication difficulties	Establish group norms
Increased social interaction in some groups	Pairs were not diverse enough	Form larger, more heterogeneous groups
Sharing ideas of all students		
<i>Technology</i>		
Externalising ideas on the digital whiteboard	Drawing with a mouse or trackpad	Keep technology simple
Ease of adding web content	Web conferencing software hindered communication from teachers to groups	Encourage student creativity and choice in how designs are represented
Some students preferred online tools to pen and paper	Digital whiteboard limitations	Experiment with other design thinking software

Easy access and sharing of artefacts, independent of location	Cognitive difficulty of managing technology	Consider asynchronous group work where technology is a barrier
<i>Facilitation</i>		
Adapting design thinking in workshops to suit the cohort	Too many pairs/groups for teachers to facilitate and monitor	Factor in more time and attempt fewer tasks
Teacher empathy and encouragement	Managing and switching between multiple tasks and software at short intervals	Upskill in design thinking Recruit students as design partners or leaders

Overall, a significant commitment to design thinking in higher education as both a practice and a subject is critical for grappling with future global and local challenges (Çeviker-Çınar & Demirbağ-Kaplan, 2017). More research is needed to support design thinking as a pedagogy and digital practice to innovate curriculum fit for the complex, networked problems of our knowledge age, powered by rapid technological advances (Koh et al., 2015). To enable design thinking in large online cohorts, universities could practice the same kind of integrative thinking as design practitioners (Dunne & Martin, 2006), to creatively find solutions rather than accept constraints as blockers to learning. As Mia noted:

I think the more able you are to have big goals and be optimistic and be open to so many different possibilities, the better your design is always going to be. Always.

Conflict of interest

The authors declare that there is no conflict of interest.

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