

# The use of design thinking in non-design contexts – a journey and experience

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Design thinking is gaining momentum for developing solutions to issues in many areas, eg, health, education and business management. It is seen as a tool for improving creativity, addressing complex or wicked problems and a method for promoting interdisciplinary working among students and professionals. In this paper, we focus on the experiences of four academics on their design thinking journey as part of a European project. This aimed to share design thinking skills and processes for peer training and application with non-design student cohorts. Important is the fact that none of the participants are trained designers. The four have been participants, facilitators and teachers and been subject to and used design thinking tools and techniques in a variety of contexts, together and individually. By reflecting on these experiences and drawing out lessons learned the paper argues that design thinking is useful in a non-design context and has become well enough defined to be applied by people whose background is not design. The paper concludes with some key factors in delivering design thinking workshops for the future as well as identifying areas for further research.

**Keywords:** *design thinking, interdisciplinary working, divergent, convergent*

## 1 Introduction

This paper is based on the experiences of four people who have been involved in a pan European project, 'DT.UNI – Design thinking approach for an interdisciplinary university'. The project is part-funded by the Erasmus+ programme and is led by the University Maria Curie Skłodowska, in Lublin, Poland with partners from seven other European countries: Bratislava, Germany, Iceland, Italy, the Netherlands, Portugal and the UK (see [www.umcs.pl/en/about-the-project,13514.htm](http://www.umcs.pl/en/about-the-project,13514.htm)). Throughout this paper, the project is referred to as DT:Uni.

The main aim of the project is the stimulation of interdisciplinary work in higher education (HE) institutions. This is considered as a means of equipping the next generation of workers with problem solving skills whereby they become the producers, not just consumers, of knowledge.

DT:Uni is proposing to achieve its aim by instilling design thinking methods in three interlinked HE groups: academics; HE managers and students. This will be achieved through a number of international workshops held across Europe, as well as the development of workbooks and case studies relating to the implementation of design thinking in HE. The project suggests that design thinking will enhance the level of interdisciplinarity among participants by improving their abilities to think in a divergent, creative and designerly way. It should also develop their abilities to introduce the design thinking approach into the teaching and learning environment of 'non-design' courses. In the project, design thinking focuses on and is empathetic with the user as well as enabling divergent and convergent thinking. It is viewed as a method for solving complex or 'wicked' problems. In short, the DT:Uni project is about facilitating processes, experiences, experiments and reflective practice with a focus on design thinking methods rather than designerly thinking skills.

The project comprises international workshops that train academics and managers in design thinking techniques and tools. Participants are then obliged to hold local multiplier events, where they train their colleagues in a similar fashion. The project also includes local workshops and innovation bootcamps for students. Winners from the local bootcamps will attend an international bootcamp for students to be held in Poland towards the end of the project.

The workshops are supported by the development of various materials such as handouts, programme guidelines for trainers and task descriptions based on real-life challenges. There will also be an e-book of case studies to demonstrate best practice in design thinking and interdisciplinarity as well as teaching materials. It is intended that these materials are tested through the workshops.

Thus, the overall rationale of the project is to 'train' people in design thinking who then take the principles back to their institutions to implement for groups of students, academics and management staff. The first international workshop was held in Dresden in April 2018 and organised by Technische Universität Dresden. This paper considers four people who took part in that workshop and explores their individual and joint experiences post the workshop. The participants had different levels of design thinking experience from expert to novice and a range of backgrounds encompassing environmental studies, game design, entrepreneurship, business studies and project management.

## **2 Literature review**

To help us contextualise our own experiences and findings, our review concentrates on recent work that relates to using design thinking in the HE context. While still a relatively new and evolving field, the benefits of using creative thinking approaches in HE seem to be supported by evidence from action research and pedagogic studies (eg, Bennett et al., 2015; Blanco et al., 2017; Wrigley & Straker, 2017; Mosely et al., 2018; Pohl et al., 2018; Tu et al., 2018). Design thinking has also captured interest in secondary level education (eg, Aflatoony et al., 2017; Cook & Bush, 2018) and teacher training with the need for educators to be innovative and creative in their facilitation of learning (eg, Norton & Hathaway, 2015; Henriksen et al., 2017).

The study by Mosely et al. (2018) is probably closest to our own focus. Their research built on work conducted as part of two Masters projects, with case studies in Brisbane (Australia) and Utrecht (The Netherlands) where one-off 2-2.5 hour informal design thinking workshops

were held for undergraduate students. The authors focus on critically appraising how the level of design knowledge and experience by facilitators/tutors impacts on teaching design thinking to students from a range of non-design based disciplines with a view to establishing “what level of design expertise facilitators require to educate non-design students” (Moseley et al., 2018: 177). They also considered the complexity of the ‘problem’, or design challenge, and how this may have to be adjusted to the level of familiarity by students with design thinking type approaches and their willingness or ease to ‘change’ the mindset from ‘traditional’ (linear) towards creative thinking.

While a relatively small sample, the research found that designerly thinking by design-based tutors pitched the delivery and analysis of design thinking processes and outcomes at a ‘higher’ level compared to facilitators who were classified as design thinking novices. Reflections and comments of the latter focused mainly on design thinking methods and processes, whereas facilitators trained in design paid attention to how design thinking approaches will coach students in designerly thinking and mindset change – moving from a discussion-based approach to a more creative, experimental and innovative thinking approach. Limitations of the study were the very short design thinking ‘educational’ sessions and it was felt retrospectively that a half or full day workshop would be ideal.

The distinction between design thinking (or design science) and designerly thinking (or design as a discipline) has been made clearly (eg, Cross, 2001; Mosely et al., 2018). While designerly thinking is firmly rooted in the design profession and courses, design thinking has evolved for and within non-design based contexts. Importantly, there appears to be a further contrast between the two, namely design thinking being explicitly group based and usually interdisciplinary whereas designerly thinking tends to be largely focused on the individual. We found this an almost hidden part of many papers and this element proved of particular interest and relevance in our own research. For example, Tu et al. (2018: 2649) highlight “the purpose of interdisciplinary collaboration” and worked with groups of 3-4 students. Similarly, Henriksen et al. (2017: 150) emphasise the importance of viewing the challenge from “multiple perspectives”.

Attention is paid in various case studies and by a range of authors to what extent designerly thinking is something that can be acquired ‘quickly’ and outside design practice and studies. It appears that the popularity of design thinking has shifted attention away from ‘designerly thinking’ as a ‘trait’ and that it should be more usefully understood as a habit of mind or approach (Cropley, 2016; Baaki et al., 2017; Henriksen et al., 2017). Stables (2008), for example, argues that educators should facilitate the development of design capabilities (which could be argued to include doing, thinking, experimenting) at all levels of education (rather than being the sole domain of ‘designers’). This then highlights the need to probe more into the ‘robustness’ of approaches and integrity of design thinking processes rather than simply jumping on a bandwagon.

Different models of and guidance for design thinking exist. For example, the Stanford guide (Doorley et al., 2018) and IDEO’s Design Thinking for Educators’ Toolkit (IDEO, 2013) in North America and the Design Commission (2011) in the UK. The DT:Uni consortium also will publish an online design thinking manual. In our research we draw on five stages (define challenge, explore, create/ideate, prototype, evaluate) as part of a double-diamond approach emphasising the need for phases of opening up (diverging) and closing down (converging) as part of the design thinking process (see, eg, Shapira et al., 2017). The importance of

opening up and closing down has also been made in other fields such as participatory processes as part of deliberative democracy (Stirling, 2008). With the emphasis of design thinking to address 21st century complex social, economic and environmental challenges, the connection to social-ecological literature beyond design seems also very relevant and is reflected in the range of fields of design thinking applications (eg, Cahn et al., 2016; Eckman et al., 2016; Mummah et al., 2016; McGann et al., 2018; McLaughlan & Lodge, 2019).

### **3 Methodology**

Our analysis is based on reflective practice of the workshops we attended and/or organised. All workshops were based on the same model of design thinking and used a set of prescribed tools. Although not stressed during delivery, divergent and convergent processes were used within each phase. For example, we tended to use a form of brainstorming as an idea generator (divergence) and clustering and dot voting to filter ideas (convergence). Where possible, progress was summarised and the adopted design thinking methods reviewed at the end of each day using various participatory and reflective tools. Prototyping was based on various materials including paper, cardboard, Lego and the ability to wireframe. The following provides more details.

#### **3.1 International workshop for academics**

The international workshop for academics was held in Dresden over five days in April 2018. Attended by representatives of all DT:Uni partners, each day covered a different phase of design thinking: defining the challenge; explore; create; prototype and evaluate. Participants worked in groups of five to six and were introduced to various tools and techniques as summarised in Figure 1. During the prototyping stage all groups developed, unprompted, a video of their solution. The authors of this paper all attended this workshop.

Prior to the workshop, all participants completed a questionnaire that asked about their level of design thinking knowledge as well as for three challenges in their daily work. The latter were used as the basis for defining the challenge on the first day. These mainly covered motivating students and finding time to do research.

#### **3.2 International workshop for HE managers**

This workshop for university managers was held in Birmingham, UK in November 2018. It followed the same format as the Dresden workshop, using the tools and techniques as given in Figure 1.

Again, all participants completed a questionnaire that asked about their level of design thinking knowledge as well as for typical challenges in their daily work. Here concerns included attracting overseas students and developing lifelong learning.

#### **3.3 Local workshop**

Through discussions with the local project team, including the authors, the multiplier workshop condensed the five day process into a single day. To accommodate the reduced time span the participants were provided with a predefined challenge: 'how can you motivate students to engage within the teaching & learning experience?'. This was supplemented with four identified student personas drawing on those developed during the Dresden workshop. The tools used for each stage are also shown in Figure 1.



	Form and define	Explore	Create	Prototype	Evaluate
<b>DRESDEN - academics</b>	<ul style="list-style-type: none"> <li>Icebreaker</li> <li>Brainstorm challenges</li> <li>Storyboard – who, what, how, why</li> </ul>	<ul style="list-style-type: none"> <li>Warm up</li> <li>Topic vote</li> <li>Interviews</li> <li>Persona</li> <li>How might we?</li> <li>Evaluation</li> </ul>	<ul style="list-style-type: none"> <li>Warm up</li> <li>Brainstorm (evil, nice, quick, realistic ideas)</li> <li>Brainwriting</li> <li>Write a postcard to explain the solution – goal, who, how</li> <li>Evaluation</li> </ul>	<ul style="list-style-type: none"> <li>Warm up</li> <li>Build a prototype solution</li> <li>Evaluation</li> </ul>	<ul style="list-style-type: none"> <li>Robot warm up</li> <li>Evaluation of the week individually, teams, whole group</li> </ul>
<b>BIRMINGHAM - managers</b>	<ul style="list-style-type: none"> <li>Icebreaker</li> <li>Present challenges</li> <li>Select your preferred challenge</li> </ul>	<ul style="list-style-type: none"> <li>Team forming</li> <li>Explain to a stranger (museum)</li> <li>Mindreading</li> <li>Persona</li> <li>Analogies – perspectives</li> <li>Stakeholder mapping</li> <li>How might we?</li> </ul>	<ul style="list-style-type: none"> <li>Lean Café</li> <li>Design brief</li> <li>Brainstorm</li> <li>Brainwriting</li> <li>Idea communication sheet</li> </ul>	<ul style="list-style-type: none"> <li>Introduction to prototyping (included make a phone holder)</li> <li>Rapid prototyping sheet</li> <li>Build a prototype</li> <li>Pitch the solution (videoed)</li> </ul>	<ul style="list-style-type: none"> <li>‘Show and tell’ of prototypes (peer review)</li> <li>Evaluation of the week individually, teams, whole group</li> <li>Next steps</li> </ul>
<b>BIRMINGHAM – one day multiplier for academics</b>	<ul style="list-style-type: none"> <li>Challenge and groups predefined</li> </ul>	<ul style="list-style-type: none"> <li>Persona (based on examples)</li> <li>Customer journey</li> </ul>	<ul style="list-style-type: none"> <li>Brainstorm</li> <li>Brainwriting</li> </ul>	<ul style="list-style-type: none"> <li>Introduction to prototyping</li> <li>Build a prototype</li> <li>Peer review</li> </ul>	<ul style="list-style-type: none"> <li>Post workshop evaluation by email</li> </ul>

Figure 1. Phases and tools used during the workshops

### 3.4 Other activities

As well as attending and facilitating workshops all authors have used design thinking methods in other areas since the Dresden workshop. These include teaching, work with external organisations and research. These have been captured in individual questionnaires that the two lead authors put together to stimulate reflection and capturing experiences and which were completed by all four authors.

## **4 Results and discussion**

The following presents the major findings from the pre and post questionnaires for the workshops. These are supplemented by reflections of the four academics arising from observations during planning, participating in and facilitating DT:Uni workshops, or teaching experiences in a design thinking context.

Feedback from the wider participants of the workshops has been very positive. The vast majority of participants have enjoyed the design thinking process and felt enthused as a result.

The findings have been grouped to cover opportunities, challenges and benefits of the design thinking process as experienced during the DT:Uni project, as these seemed to be the dominant categories within the individual and group-based reflection tasks.

### **4.1 Opportunities**

#### **4.1.1 Group working**

A major part of the design thinking process as used in the DT:Uni project has been the formation of interdisciplinary cross-institutional groups to find solutions. Due to the range and type of tools used various positive effects have been observed. These include:

- Many design thinking methods, such as, brainstorming and brainwriting, encourage interdisciplinary working and allow all group members to present their ideas.
- In a similar vein, groups have not been hierarchical and trust has formed in groups relatively quickly.
- The process also promotes peer review as part of working groups, so that ideas are discussed and assumptions challenged and/or tested in a relatively safe environment.
- In developing solutions, group members felt that they would not have arrived at such effective solutions individually.

As reported by one facilitator at the academic one day workshop: “all groups seemed to develop quite good interdisciplinary communication and collaborative group dynamics”, even though one group initially had some character frictions but this issue seems to have disappeared by the start of the prototyping phase.

However, the positive aspects of group working may result from the people involved not working together on a daily basis and where new working relationships are temporarily formed and no ‘history’ (good or bad) dominating group dynamics. If the group includes participants with persisting relational tensions, the challenging nature of the design thinking may block ideas and stifle creativity. We also encountered situations where the attempt to use design thinking internally was resisted and seemed to be seen as a threat to decision-making power and ‘preferred’ ideas or trajectories.

#### **4.1.2 Prototypes of solutions – testing ideas**

All workshops have included building a prototype as a means of hands-on shaping and testing of ideas. The longer workshops have also resulted in the production of videos or pitches where the prototype is used as the basis of an explanation to help sell the idea through the institution, particularly levels of senior management. In all instances the prototyping activity seemed to flow very smoothly and was easily delivered within the allocated time; and this efficiency and ease impressed several participants.

Prototyping also allowed thinking time for participants to consider how to use design thinking methods and create innovative solutions in their own area of work. A physical artefact, constructed from Lego, paper, cardboard and other materials, allowed peer review of proposed solutions and an opportunity to discuss, share and get useful and relevant feedback from colleagues and/or potential users.

Furthermore, the model also provided an opportunity for storyboarding the user experience of the solution. This provided opportunities to visualise the results and record videos or similar to promote the benefits of the proposal in a time efficient and resource effective manner. While the artefacts were dismantled at the end of the prototyping session, the videos produced are still accessible.

#### 4.1.3 Different methods and tools provide versatility

Reflection on using design thinking with students has highlighted that the different tools and techniques clearly map on to different types of learners and learning styles. Also, the design thinking techniques such as personas, empathy map, test grid and customer/user journey maps can be combined with more traditional management tools to develop new materials for small business management students.

## 4.2 Challenges

### 4.2.1 Choosing the right tools

As evidenced in a number of design thinking toolkits (eg, Fraser, 2012; Lewrick et al., 2018) there is a plethora of tools and techniques available. Also, underlying the DT:Uni toolkit, there seems to be an assumption that the sequence of 'define the challenge, explore, create, prototype and evaluate solution(s)' is the best way of applying the design thinking process. This leads to a number of issues including:

- In defining the initial challenge and workshop format, we had a number of debates on how prescriptive versus how flexible the process should be. How much should this stage be guided by existing design thinking templates or own preferences?
- When facilitating workshops, we found that sometimes the overall process or a particular tool were not well explained. Instructions need to be clear and easy to understand and ideally appeal to different learning styles, eg, oral and visual.
- In moving onwards, it is easy to forget to check back on how well a proposed solution addresses the initial challenge and meets user needs.
- Through the experiences, it became clear that reflection on the effectiveness of methods as well as own and shared learning needs to be built into the process at regular intervals.

### 4.2.2 Group dynamics and facilitation

At times in our journey, groups did not work together effectively. Tensions arose from outspoken and dominant members, people not listening and confusion and mini-conflicts regarding instructions. The design thinking process is intense, with strictly time-bound tasks, and some people did not respond well to the pressure. In our experience, these disruptions could mostly be smoothed over with good facilitation, but group dynamics do need to be monitored to ensure effective delivery.

Related to this is the level and style of facilitation. Some groups (eg, undergraduate students and participants not previously exposed to such a creative working environment) may prefer a degree of direct facilitation and a sounding board to check that they are on the right path.

In workshops, we found that groups tend to focus on finding a solution rather than the process of design thinking. In future we will focus on encouraging participants to better understand the various techniques and how to adapt and implement them for own use.

#### 4.2.3 Design thinking expert versus a design thinking novice

We observed, on occasions, friction arising when design thinking experts and novices are trying to work together. Here the expert tends to want to control the process and define how it should be done rather than embracing the benefits of organic development. This can be compounded with language issues – different words are used to describe the same thing, eg, the phases of the process, or a different amount of emphasis was given to a task, or the keeping or killing of specific ideas. This is not always simple to resolve and can result in a direct (more linear rather than creative), task-focused approach to find the shortest route which may not provide the best solution.

### 4.3 Benefits

Our work to date has identified four major benefits of design thinking:

- A solution developed jointly is better than one developed individually, in all instances the sum (developed prototype) seemed more than its parts. The group nature and focus of design thinking supports buy-in of the solution and can almost be evangelical.
- The process is output-directed – developing a prototype takes the focus from the problem and allows consideration of how the solution is going to be used and the context of its application.
- Using design thinking tools changes mindsets and ways of working. It encourages learning to be negative/positive (kill/keep ideas) as well as helping people to leave their comfort zone.
- Finally, by fostering the notion that the result does not need to be perfect, it promotes faster working.

### 4.4 Discussion

In this paper we are exploring the value of design thinking in a higher education context. Throughout, as academics, we have been part of a learning process, as well as trying to teach other academics and students about the process. Importantly, the academics and students involved are engaged in non-design courses.

We have embraced the design thinking tools experientially in a ‘learning by doing’ context with very little theoretical background being provided to help ground the principles. While the importance of the user has been highlighted and tools introduced and employed to build empathy, there has been little explanation or emphasis on the notion of divergent and convergent thinking. Further, the concept of designerly thinking, has not been part of the experience at all and only emerged as a focus of discussion through working on this paper and deeper reflection on the design thinking approach and applications. In this sense, we did not engage with designing as an individual activity but our experience centred on working in groups, coming to joint solutions using design thinking tools and techniques.

This prompts a consideration of who might be a design thinking expert. In our work, we found that the more a person knows of the design thinking methods, the less flexible they seemed to become in their approach. This can shut off many of the benefits we have perceived on our design thinking journeys to date. We believe a major advantage of design

thinking is the generation of many ideas, with the user at the centre, which are then filtered in a rational manner leading to a solution that meets with the user's approval as well as the constraints of the environment. It requires a change of mindset that is not always easy and demands that participants go with the flow and not be too fixated on instructions. This can make it difficult to use with students where there is a need for clear instructions and a definite outcome. This is as observed in previous work, for example Mosely et al. (2018).

With the DT:Uni project focus being on the design thinking approach and methods, the true value of designerly thinking has only become apparent through our recent reading of the pertinent literature. As described in Section 3, the underpinning theoretical grounding and complexity of designerly thinking was not covered in the workshops. However, through being part of a practical experience and undertaking the workshop in that way, the understanding of some of the values of design thinking have come to the fore. These include an appreciation of its divergent – convergent nature, moving out of one's comfort zone and feeling safe to challenge and question, particularly in relation to assumptions. In this way a solution arises from the consideration of an array of ideas and ways of combining ideas and experiences that is more than just one idea on its own, with the user (rather than the designer/idea creators) firmly at the centre of thinking throughout the process.

## **5 Conclusions and further work**

In the DT:Uni project we are being tasked with passing on design thinking techniques and principles. While there are many books listing the techniques (eg, Fraser, 2012; Lewrick et al., 2018), there are few examples of how to run the process and instil the process into other people, ie, how this knowledge may be transferred.

Also, the perception that design thinking can be taught in short workshops led by non-designers may result in its value being diluted. However, the feedback we have received contradicts this perception and our experience was that actually it worked amazingly well and was empowering with interest in the process and its 'grounding' rather than just as a business formula for innovation. We thus found that it spreads awareness and knowledge of the value of design to a much wider audience.

Undoubtedly the project has made a difference – participants gained confidence with the design thinking approach through a realistic experience of the techniques and using them in a practical way. Being part of a week-long workshop gave participants time to absorb the techniques and the impetus to consider implementation of design thinking methods in teaching and research.

So in response to the question posed by the IASDR2019 call "is it [design thinking] still a valuable proposition?", we conclude that design thinking is not dead. It is thriving and having an impact in many areas through facilitating interdisciplinary working and changing mindsets. But, as yet, it is not clear how much designerly thinking can be taught in a short time-frame and a non-design environment.

In future work we would like to test the change in people's experience, confidence, learning from doing and mindset change, as a result of being part of the workshops. We would also like to explore what else they have managed to achieve in trying to transfer their knowledge to other higher education groups.

## 6 References

- Aflatoony, L., Wakkary, R., & Neustaedter, C. (2018). Becoming a design thinker: Assessing the learning process of students in a secondary level design thinking course. *International Journal of Art & Design Education*, 37(3), 438-453. doi:10.1111/jade.12139
- Baaki, J., Tracey, M. W., & Hutchinson, A. (2017). Give us something to react to and make it rich: Designers reflecting-in-action with external representations. *International Journal of Technology and Design Education*, 27(4), 667-682. doi:10.1007/s10798-016-9371-2
- Bennett, S., Agostinho, S., & Lockyer, L. (2015). Technology tools to support learning design: Implications derived from an investigation of university teachers' design practices. *Computers & Education*, 81, 211-220. doi:10.1016/j.compedu.2014.10.016
- Blanco, T., López-Forniés, I., & Zarazaga-Soria, F. J. (2017). Deconstructing the tower of babel: A design method to improve empathy and teamwork competences of informatics students. *International Journal of Technology and Design Education*, 27(2), 307-328. doi:10.1007/s10798-015-9348-6
- Cahn, P. S., Bzowycyk, A., Collins, L., Dow, A., Goodell, K., Johnson, A. F., Zierler, B. K. (2016). A design thinking approach to evaluating interprofessional education. *Journal of Interprofessional Care*, 30(3), 378-380. doi:10.3109/13561820.2015.1122582
- Cook, K. L., & Bush, S. B. (2018). Design thinking in integrated STEAM learning: Surveying the landscape and exploring exemplars in elementary grades. *School Science and Mathematics*, 118(3-4), 93-103. doi:10.1111/ssm.12268
- Cropley, A. (2016). The myths of heaven-sent creativity: Toward a perhaps less democratic but more down-to-Earth understanding. *Creativity Research Journal*, 28(3), 238-246.
- Cross, N. (2001). Designerly ways of knowing: Design discipline versus design science. *Design Issues*, 17(3), 49-55.
- Design Commission (2011). *Restarting Britain: Design education and growth*. London: Design Commission, Policy Connect. [https://www.policyconnect.org.uk/sites/site\\_pc/files/report/490/fieldreportdownload/designcommission-restartingbritain1.pdf](https://www.policyconnect.org.uk/sites/site_pc/files/report/490/fieldreportdownload/designcommission-restartingbritain1.pdf) [last accessed 14 April 2019].
- Doorley, S., Holcomb, S., Klebahn, P., Segovia, K. & Utl, J. (2018) *Design Thinking Bootleg*. D.school at Stanford University. <https://dschool.stanford.edu/resources/design-thinking-bootleg>
- Eckman, M., Gorski, I., & Mehta, K. (2016). Leveraging design thinking to build sustainable mobile health systems. *Journal of Medical Engineering & Technology*, 40(7-8), 422-430. doi:10.1080/03091902.2016.1218560
- Fraser, H. M. (2012). *Design works: How to tackle your toughest innovation challenges through business design*. University of Toronto Press.
- Henriksen, D., Richardson, C., & Mehta, R. (2017). Design thinking: A creative approach to educational problems of practice. *Thinking Skills and Creativity*, 26, 140-153. doi:10.1016/j.tsc.2017.10.001
- IDEO (2013). *Design Thinking for Educators' Toolkit*, version 2. <https://designthinkingforeducators.com/> [last accessed 14 April 2019].
- Lewrick, M., Link, P., & Leifer, L. (2018). *The design thinking playbook: Mindful digital transformation of teams, products, services, businesses and ecosystems*. John Wiley & Sons.
- McGann, M., Blomkamp, E., & Lewis, J. M. (2018). The rise of public sector innovation labs: Experiments in design thinking for policy. *Policy Sciences*, 51(3), 249-267. doi:10.1007/s11077-018-9315-7
- McLaughlan, R., & Lodge, J. M. (2019). Facilitating epistemic fluency through design thinking: A strategy for the broader application of studio pedagogy within higher education. *Teaching in Higher Education*, 24(1), 81-97. doi:10.1080/13562517.2018.1461621
- Mosely, G., Wright, N., & Wrigley, C. (2018). Facilitating design thinking: A comparison of design expertise. *Thinking Skills and Creativity*, 27, 177-189. doi:10.1016/j.tsc.2018.02.004
- Mummah, S. A., Robinson, T. N., King, A. C., Gardner, C. D., & Sutton, S. (2016). IDEAS (integrate, design, assess, and share): A framework and toolkit of strategies for the development of more effective digital interventions to change health behavior. *Journal of Medical Internet Research*, 18(12), e317. doi:10.2196/jmir.5927
- Norton, P., & Hathaway, D. (2015). In search of a teacher education curriculum: appropriating a design lens to solve problems of practice. *Educational Technology*, 55(6), 3-14.
- Pohl, C., Krütli, P., & Stauffacher, M. (2018). Teaching transdisciplinarity appropriately for students' education level. *GAIA - Ecological Perspectives for Science and Society*, 27(2), 250-252. doi:10.14512/gaia.27.2.14

- Shapira, H., Ketchie, A., Nehe, M. (2017). The integration of design thinking and strategic sustainable development. *Journal of Cleaner Production*, 140(Part 1), 277-287.  
doi:10.1016/j.jclepro.2015.10.092
- Stables, K. (2008). Designing matters, designing minds: The importance of nurturing the designerly in young people. *Design and Technology Education: An International Journal*, 13(3), 8-18.
- Stirling, A. (2008) "Opening Up" and "Closing Down": Power, participation, and pluralism in the social appraisal of technology, *Science, Technology & Human Values*, 33(2), 262-294.
- Tu, J., Liu, L., & Wu, K. (2018). Study on the learning effectiveness of Stanford design thinking in integrated design education. *Sustainability*, 10(8), 2649. doi:10.3390/su10082649
- Wrigley, C., & Straker, K. (2017). Design thinking pedagogy: The educational design ladder. *Innovations in Education and Teaching International*, 54(4), 374-385.  
doi:10.1080/14703297.2015.1108214.

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