The Process Models of Design Thinking

A Literature Review and Consideration from the Perspective of Craft, Design and Technology Education

Satu Grönman and Eila Lindfors

Design thinking (DT) has gained attention over the last few decades in a wide range of contexts beyond the traditional preoccupations of designers. It has changed from the activity of designers to an all-round approach to the innovation process. DT is seen as a human-centred and systematised approach to problem identification and problem solving. It is a way to create innovation, using the designer's toolkit to integrate the needs of people, the possibilities of technology and the requirements for business success. DT has also become a pedagogical phenomenon in education due to its relevance in cross-curricular learning and the development of twenty-first-century skills. The aim of this article is to search for common ground between the design thinking process (DTP) and the learning process in craft, design and technology (CDT) education. Learning in CDT education relies on the concept of the holistic craft process (HCP), in which the person, or a group, ideates, designs, implements and evaluates the production process of an artefact. The HCP aims to develop individuals' ability structure widely by enhancing problem solving, creativity, self-expression and knowledge building. Through a narrative literature review and a qualitative analysis of three well-known DTP models, this article aims to identify the elements and phases of the DTP and determine the possibilities for nurturing the development of HCP as a teaching method for innovation and future skills.

Keywords: design thinking; education; design thinking process; craft, design and technology education; holistic craft process

Introduction

The concept of design thinking (DT) has been under academic discussion for over 30 years (Baker & Moukhliss, 2020; Brown & Katz, 2011; Retna, 2016). A shift from studying DT as a cognitive process of designers to a way for non-designers to make use of design methods is a shift from design as a science to design as a mindset. The difference between these two distinct discourses can be described by the terms 'designerly thinking' and 'design thinking'. Designerly thinking refers to the theoretical framework and academic construction around professional designers, while design thinking refers to the discourse of design practice used among people without a scholarly background in design. In this way, DT is understood as a simplified version of designerly thinking – a way to integrate designers' methods into other fields beyond professional designing (Johansson-Sköldberg et al., 2013; Wrigley et al., 2018).

DT is a versatile approach to orchestrating conflicting ideas, identifying singular needs and common goals, making productive use of diverse backgrounds, enhancing empathy, and developing a shared vision (Elsbach & Stigliani, 2018; Panke, 2019; Viilo, 2018). The search for a strategy to teach twenty-first-century skills, work habits and character traits has aroused widespread interest in DT in the field of education (Retna, 2016; Razzouk & Shute, 2012; Hero et al., 2017). The possibilities of DT as an innovation method have led to an increase in education programs that teach DT as part of their curricula (Matthews & Wrigley, 2017; Tu et al., 2018).

The theories selected in this study represent a varied field of DT research, including Carlgren et al.'s (2016) review of the DT research as a science and a discipline, combined with an interview study of

design professionals in the business world, as well as Beckman and Barry's (2007) research on DT as a learning theory and Liedtka's (2015) research on DT as a practice for improving innovation outcomes through individual cognition and decision-making. Carlgren et al. (2016) frame the concept of DT in five common themes, based on an extensive literature review and interview study of 72 professionals applying DT in organizations of product, service and software marketing. The five themes are User Focus, Problem Framing, Visualization, Experimentation and Diversity. Beckman and Barry (2007) propose understanding DT through experiential learning theory and outline four core capabilities in the DTP: Observe and Notice, Frame and Reframe, Imagine and Design, and Make and Experiment. Liedtka (2015) describes the DTP as practice in three phases: an initial exploratory phase with data gathering, user-needs identifying and problem defining, a second phase of idea generation, and a final phase of prototyping and testing. The four main phase-categories (Table 1) for analysing the selected DTP models in this study are formed as a theory-driven integration of the themes, core capabilities and phases of these three researches of Carlgren et al. (2016), Beckman and Barry (2007) and Liedtka (2015).

Unlike in many countries, in Finland, CDT is taught as an independent school subject and as an academic discipline in universities. The basic elements of the subject are material and processing techniques, design and technology. The focus is on developing students' exploratory, creative, active and entrepreneurial future-oriented work. (FNBE, 2014; Lepistö & Lindfors, 2015; Lindfors & Hilmola, 2016.) The aim of the subject has changed substantially over the decades, from the practical need to learn to prepare daily life artefacts, to learning the skills of success in the future world (Marjanen et al., 2018). The Finnish Basic Education's Craft Curriculum (2014) is built on the concept of the HCP, which refers to a designing and manufacturing process in which the same person or group conducts all phases of the process: ideating, designing, implementing and evaluating the production process of an artefact. (Kojonkoski-Rännäli, 1995; Pöllänen, 2009; Rönkkö et al., 2016.) According to previous studies, the need for future development in HCP involves the lack of user-centeredness and collaborative design (Lindfors, 2010; Kohtamäki & Lindfors, 2020), the decline of basic education pupils' learning outcomes in design tasks (Lindfors & Hilmola, 2016; Lindfors et al., 2018), and the teachers' experience of difficulties in teaching design (Rönkkö et al., 2016; Pöllänen & Urdziņa-Deruma, 2017).

The aim of this paper is to compare and consider the commonly used DTP models and, on this basis, to nurture the development of the concept of HCP. The research questions that this study strives to answer are as follows: (1) What are the main elements and phases of the DTP models? (2) What are the main differences and similarities between the three selected DTP models? The results are considered in relation to the concept of the HCP to gain a more detailed understanding of the elements, phases and nature of the DTP that could be used to advance teachers' didactic view of DT in teaching practice.

Methodology

A narrative literature review was chosen for this study to suit the goal of identifying and describing the approaches of DT in previous studies, rather than providing a critical appraisal of the previous works (Grant & Booth, 2009; Snyder, 2019). Gathering the text corpus of the review involved keyword searches that included peer-reviewed articles, case studies and literature reviews. The articles were conducted via Volter, the electronic library database of the University of Turku. Preliminary searches, using the keywords 'design thinking', 'education' and 'design thinking process' identified articles determined to be relevant to the topic. Through a snowball method, the most essential articles defining design thinking in education and the design thinking process were selected. The DTP models analysed in this study are the model of Human Centered Design by the design agency IDEO (IDEO, 2015), the Design Thinking Model of the Hasso Plattner Institute (HPI) (Hasso Plattner Institute, 2021) and the Double Diamond design process model, developed in 2005 by the British Design Council (Design Council, 2015; Design Council 2021).

By executing a qualitative content analysis (Krippendorff, 2019) and a more detailed document analysis (Bowen, 2009), the selected DTP models were systematically monitored, and the elements and phases of the models were identified. First, the analysis criteria for theming the elements and phases of the models were formed on theory-based integration of previous studies of Carlgren et al. (2016), Beckman and Barry (2007), and Liedtka (2015). Secondly, the elements of the models were analysed using the method of inductive categorization (Elo et al., 2014), and nine sub-categories were formed (Table 1).

Results

First, the three DTP models are described. Then the elements and the phases of the models are summarized in Table 1 to facilitate a detailed presentation of the results. Later, the differences and similarities of the models are considered and discussed.

Design thinking process models

The model of Human Centered Design by IDEO

The model of Human Centered Design was developed by IDEO, a global design consulting company in the context of social innovation. The model was created after IDEO had increasingly been asked to work on problems removed from traditional design, such as health care and learning environments. The first space of the model, ***Inspiration***, includes the identification of the design problem, the framework of the design brief and the observation of the target group in its daily environment. The second space, ***Ideation***, is where the design team goes through a synthesis, distilling what they have learned into insights leading to opportunities for change or new solutions. During this process, visual representations are encouraged to help others understand complex ideas. In the third space, ***Implementation***, the best ideas are turned into an action plan. Through prototyping, new ideas and solutions are tested, iterated and improved. After creating the final product or service, a strategy to communicate the solution inside and outside the organization is developed (Brown & Katz, 2011; IDEO, 2015).

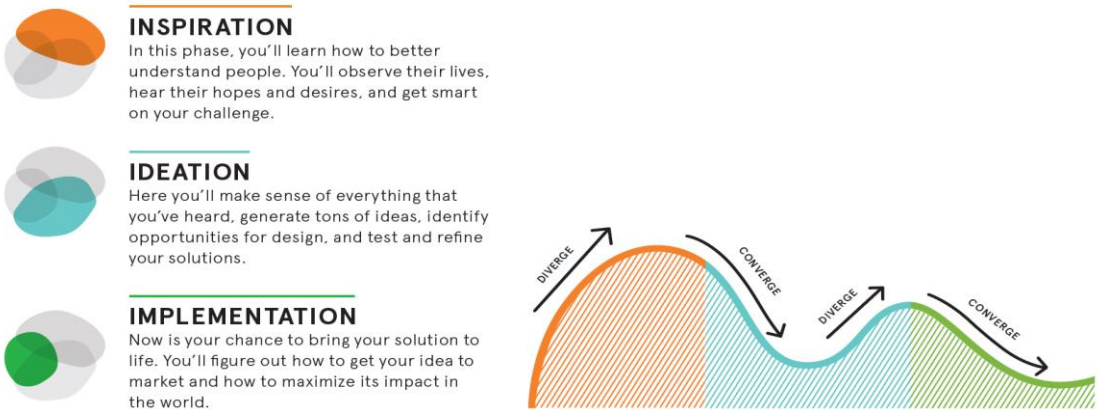

Figure 1. The model of Human Centered Design (IDEO, 2015, pp. 11, 13).

The Design Thinking Model of the Hasso Plattner Institute (HPI)

The DT Model of HPI, the Design School of Stanford University, was developed for an educational context. The steps are connected with curved lines, indicating the iteration of the process. The first step, ***Understand***, consists of gathering existing information about the topic through research. The second step, ***Observe***, consists of collecting insights about the users' needs by interviewing and observing. In the third step, ***Point of View***, the gathered insights are shared and synthesized into a visual framework of the user's perspective. In the ***Ideation*** step, the team generates numerous ideas using creative methods and summarizes and compares the ideas to find out what best meets the previously synthesized point of view. The fifth step, ***Prototype***, includes the physical forming of the ideas by drawing and prototyping

in order to communicate those ideas. In the last step, ***Test***, the core functions of the prototypes (forms, dimensions, feasibility and usability) are tested in iterative cycles in interactions between the team and potential users (HPI, 2021; Thoring & Müller, 2011; Carroll, et al., 2010).

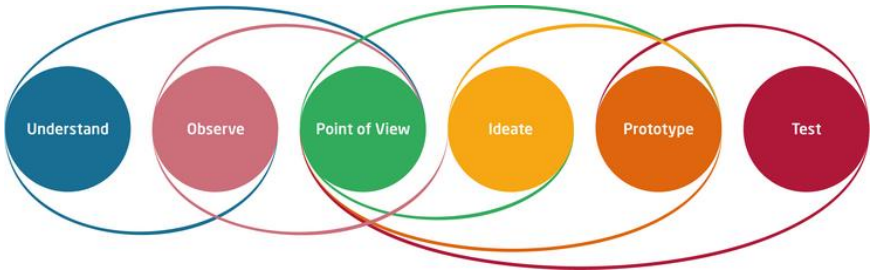

Figure 2. The Design Thinking Model of the Hasso Plattner Institute. Available in: https://hpi-academy.de/en/design-thinking/what-is-design-thinking.html

The Double Diamond design process model by the British Design Council

The Double Diamond (DD) design process model, developed by the British Design Council in 2005, graphically describes the divergent and convergent stages of the process. The first quarter represents the initial divergent part of the project, ***Discovery***, which contains searching for opportunities, information and insights. The second quarter, ***Define***, the first convergent part, works as a filter to review, select and discard the gathered insights. The mass of ideas are analysed and synthesised into a design brief, a clear definition of the challenge. The third quarter, ***Development***, is another divergent part in which the solutions are developed, iterated and tested within the multi-disciplinary teams, using creative tools as sketches, renderings and prototypes. In the last part, the convergent ***Deliver*** stage, the final concept is taken through final testing, finalized, produced and launched (Design Council, 2015; Tschimmel, 2012).

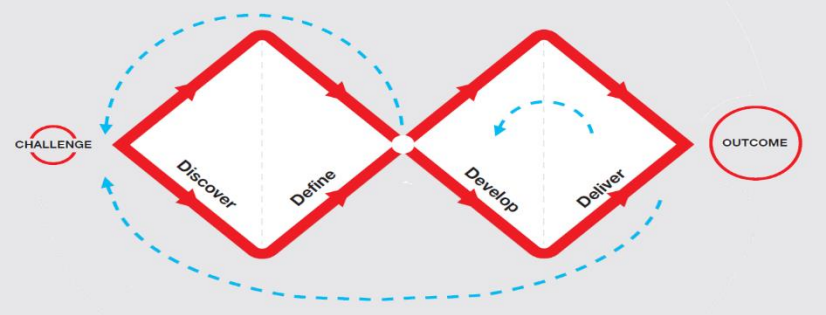

Figure 3. The Double Diamond model by the British Design Council (2019). Available in: https://www.designcouncil.org.uk/sites/default/files/asset/document/Double%20Diamond%20Model%202019.pdf

The elements and phases of the DTP models

The DTP is dominant in a holistic, non-linear way and described as an iterative process. However, to facilitate an understanding of the elements of planning and implementing, the DTP is often divided into phases. In this article, the phases were categorized into four theory-driven categories: A) Empathy and user focus, B) Defining and problem framing, C) Creating ideas and visualization, and D) Experimentation and iteration (Carlgren et al., 2016; Beckman & Barry, 2007; Liedtka, 2015). All models included divergent and convergent phases, and the order of the phases was the same in every model – divergent, convergent, divergent and convergent – except the partial overlapping of the divergent phase between the main phase-categories of A) and B) and between C) and D) (Table 1).

A) Empathy and user focus (divergent phase): This category was recognized in every model. It included elements of 'inspiration' and 'understand, observe and discover'. In the analysis, two sub-categories were identified in this main category: *A1) Primary research* and *A2) Secondary research*. The sub-category *A1)* contained elements like interviewing, observing and understanding the users in their own context and gathering insights directly from the users. The sub-category *A2)* included investigation of existing knowledge in documents, statistics and studies, as well as solutions that were already available.

B) Problem framing and defining (divergent and convergent phase): This category included elements such as sharing and reviewing gathered insights and framing the challenge. In the analysis, two sub-categories were identified in this main phase-category: *B1) Reviewing insights* and *B2) Framing and defining the design challenge*. The first sub-category, *B1),* contained elements of a divergent phase, such as sharing the insights founded in the previous phase. The second sub-category, *B2),* includes elements of a convergent phase, such as creating a framework of the ideas and defining the point of view. Both sub-categories were clearly identified in the models: in IDEO's model, Inspiration; in HPI's model, Point of View; and in the DD model, Define.

C) Creating ideas and visualization (divergent phase): This is the most similar phase across the models. It involves elements of sharing and developing ideas and making them visible. The category is divided into two sub-categories: *C1) Sharing and generating ideas* and *C2) Communicating with sketches and prototypes.* The elements of a divergent phase appear in all models with regard to creating numerous ideas and using different creative tools. In the second sub-category, *C2),* all three models place importance in sketching and prototyping to communicate with the team and potential users. In IDEO's model and the DD model, the category consists of one step (IDEO: 2: Ideation; DD: 3: Develop), but in HPI's model, two steps (4: Ideate and 5: Prototype).

D) Experimentation and iteration (divergent and convergent phase) This category is divided into three sub-categories: *D1) Usability testing, D2) Evaluating, developing and iterating* and *D3) Implementing and delivering*. The sub-categories *D1)* and *D2),* where the created solutions are tested, evaluated and developed, contain divergent elements, such as getting feedback and continuing to iterate. The third sub-category, *D3),* includes convergent elements, such as producing and launching the final concept, and it is clearly identified in IDEO's model (Step 3) and in the DD model (Step 4). In HPI's model, the elements of improving the prototype through iteration are mentioned in Step 6: Test, but the aspect of implementing and delivering is not as clear as in the IDEO and DD models.

Table 1. The elements and phases of the DTP models

PHASE -CATEGORIES		IDEO`s Human Centered Design process	HPI`s Design Thinking process	Design Council's Double Diamond design process
DIVERGENT	**A) EMPATHY AND USER FOCUS** *A1) Primary Research* *A2) Secondary Research*	**1. Inspiration** *A1) Primary Research:* - observing and understanding the challenge and the user context - interviewing users (needs, hopes and desires) *A2) Secondary research:* - researching the existing data	**1. Understand** *A2) Secondary Research* - understanding the existing information - conversation with experts **2. Observe** *A1) Primary research* - interviewing and observing - collecting insights about the user`s needs	**1. Discover** *A1) Primary Research and A2) Secondary Research* - searching for new opportunities, information, trends and insights - understanding instead of assuming - engaging a wider context of the identified opportunity
CONVERGENT	**B) PROBLEM FRAMING AND DEFINING** *B1) Reviewing Insights*	- open up for creative possibilities	**3. Point of View** - share the gathered insights	**2. Define** - "filter" to review, select and discard the first insights
	B2) Framing and Defining the design challenge	- frame the design challenge - create a project plan	- framework of the most promising insights - define a person to be the base of the ideation	- project development - project management
DIVERGENT	**C) CREATING IDEAS AND VISUALIZATION** *C1) Sharing and Generating ideas*	**2. Ideation** - sharing and making sense of collected data - identifying opportunities - generating lots of ideas	**4. Ideate** - generating numerous ideas - applying creative tools like brainstorm and role-play - silent individual work and energizing teamwork	**3. Develop** - developing solutions by using creative tools like brainstorming and scenarios
	C2) Communicating with sketches and prototypes	- getting visual and tangible by sketching and prototyping	**5. Prototype** - making tangible proposals: drawing up ideas and developing prototypes - reaching a consensus of the function of the ideas - presenting the ideas to potential users	- developing solutions by using DT tools like sketches, renderings and prototypes
CONVERGENT	**D) EXPERIMEN-TATION & ITERATION** *D1) Usability Testing*	- getting feedback	**6. Test** - testing every prototype with potential users - testing the form, function, dimension, feasibility and usability of the prototypes	- Ideas being tested and iterated in multi-disciplinary teams
	D2) Evaluating, Developing and Iterating	- keep iterating, refining and building until you are ready with your solution	- iterative cycles, collecting new feedback every time	
	D3) Implementing and Delivering	**3. Implementation** - bringing the solution to life and to market - building partnerships - refining business models - piloting the solution	- improving the prototype to be more realistic, detailed and functional	**4. Deliver** - taking the final concept through final testing, producing and launching

Conclusions and Discussion

The aim of this study was to compare and consider the commonly used DTP models and, on this basis, to widen and nurture the development of the HCP model. The analysis of the DTP models shows that the DTP, with its divergent steps, is iterative in nature, thus proceeding with convergent phases in aiming to construct a solution to a user-focused problem. The phases of the DTP models were analysed and fitted into four theory-based main phase-categories (Carlgren et al., 2016; Beckman & Barry, 2007; Liedtka, 2015). Despite the differences in the structure, shape and number of steps between the models, the common nature and elements of the models enabled a fluent fitting. The nine sub-categories were formed inductively, and a discussion between two researchers was needed to guarantee a logical and credible categorization that enabled the consideration of the various models' steps in a coherent way.

As an answer to the first research question, the key elements and phases of the DTP models can be recognized with four main phase-categories and nine sub-categories (Table 2). The sub-categories represent a new way to analyse DTP models and might be used and developed further in future research.

Table 2. The main phase-categories and sub-categories of the elements and phases of the DTP models

A) Empathy and User focus	***B) Problem framing and Defining***	***C) Creating ideas and Visualization***	***D) Experimentation and Iteration***
A1) Primary research	*B1) Reviewing insights*	*C1) Sharing and Generating ideas*	*D1) Usability testing*
A2) Secondary research	*B2) Framing and Defining the design challenge.*	*C2) Communicating with sketches and prototypes*	*D2) Evaluating, developing and iterating*
			D3) Implementing and delivering

As an answer to the second research question, the main differences between the selected process models are the number of process steps and the timing of the activities in the phases. For example, IDEO's model starts with primary research, HPI's model starts with secondary research, and the DD model starts by combining primary and secondary research. However, despite the different number of steps, all the models essentially contain the same elements and activities, although they are timed differentially in the process. From the perspective of nurturing the development of the HCP model, the similarities between the DTP models were more interesting than the differences. The joint elements in the DTP models are respect for human centeredness and collaboration, the importance of divergent and convergent stages, the use of creative tools, the equality of each step, the importance of iteration, and the appreciation of an open, experimental and playful atmosphere. All of these elements can be applied to the HCP model to increase the students' twenty-first-century skills alongside their craft substance skills.

Emphasizing user-centeredness through primary research (interviewing and observing) and secondary research (investigating existing knowledge) can widen up the ideating and designing phase of the HCP model and, as Lindfors (2010) and Lindfors & Kohtamäki (2020) state, make the learning task more meaningful when creating solutions for real-life challenges. Collaboration and an open, experimental atmosphere in learning, highly promoted in the DTP, can enhance learning motivation, which, according to Lindfors and Hilmola (2016), together with pupils' goal orientation, might have meaning for managing the HCP model. Designing as a part of HCP has proven to be difficult to concretize (Rönkkö et al., 2016; Pöllänen & Urdziņa-Deruma, 2017). Using creative tools and understanding the iterative nature of the DTP can provide concrete help and new didactical aspects for teaching design as a part of HCP. Considering the nature and definition of the HCP model, the aim of nurturing the development of the HCP model needs a paper of its own to discuss the matter in further detail. In light of the results of this study, however, it can be stated that supplementing HCP with an iterative, collaborative and open-minded nature and expanding the knowledge of the DTP through the sub-categories illuminated this analysis might grant teachers a detailed understanding of the DTP.

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