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Synthesis of Current Knowledge and Research on the Design Thinking Methodology

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Abstract: Design thinking is an innovative way of thinking and solving problems in which the focus is on the user. This paper provides an overview of current research on the topic to gain insight into current practices and create a basis for further development of the area. Synthesis of knowledge is presented through historical development, methodology, and processes used in the field. The methodology used is a desk-research method through which a comparison of the literature was conducted. According to the results of the research, we can conclude that there is still no harmonized definition of design thinking. Therefore, due to the rapid development of this field, it is necessary to synthesize the latest research. Also, it is important to provide expert designers with specialized books and tools since the problems are becoming more complex, and designers with competencies required to solve such problems are needed.

Keywords: design methodology; design process; design thinking; problem-solving; user-centered design

1 INTRODUCTION

In today's age, designers are interdisciplinary experts who work in different fields depending on the problem they are solving, and their areas of expertise are no longer exclusively related to design. To address these problems, which are nowadays increasingly complex, they use design thinking methodology. Design thinking (DT) methodology has recently become more popular and the term itself has gained popularization. It is a way of thinking that puts the user at the center and within which innovative solutions are formed as a result of an iterative process. Design and business communities adopt and use DT [1] to improve innovation and gain competitive advantage. Some of today's largest corporations are using this methodology, such as Google, Apple, and Nike [2]. With the increasing development of technology, information, and modern techniques, the DT model is used more and more often in various sectors and industries. To provide insight into the observations related to DT, a cross-section of previous results and current practices will be presented in this paper.

2 RESEARCH AIM AND METHODOLOGY

Through literature analysis on this topic, this paper provides an overview of current research, conclusions, and existing theoretical assumptions to synthesize and compare knowledge about the DT process. Although DT stands out as a process that is for everyone (for non-designers), the focus of this paper is on the DT method used by expert designers. Also, although much of the research and literature is related to DT in the business context, in this paper we will focus on the process of a design thinker independently of the industry in question. Since the DT process itself differs from individual designers, teams, institutions, and companies, it is important that these kinds of reviews are done. In this way, findings are not dispersed, and we can summarize them to reach new conclusions. Although DT is closely related to the purpose and area of problem-solving, it is essential to approach the problem from a design perspective so that we can draw certain conclusions regarding processes and current reach. Thoring and Mueller [3] point out that if DT wants to achieve scientific field status, then the field must refer to the working mechanisms of the process to explain and improve the way designers think. In this paper we will present a synthesis of research within this area for the following subtopics: (a) historical development of the DT field, (b) approach and features of the DT methodology, and (c) existing DT processes. The aim of this paper is to summarize the knowledge related to DT, review and compare the process and review the current state of the field to gain insight into the possibilities of further development of the area.

In this paper we used a narrative literature review methodology [4] which is a secondary desk-research method based on a comparative analysis of the relevant literature. Books, scientific papers, and articles from the field of design thinking were compared with an emphasis on recent research and basic theoretical background (books relevant to the field). We searched the frequently used and popular databases Google Scholar and Web of Science using keywords design thinking, design education, problem-solving, visual thinking, design process, design methodology, and perception. We examined a total of 52 references spanning from year 1926 to 2021. Out of the mentioned 52 references, 24 (46%) were journal articles (1972-2020), 9 (17%) were conference proceedings articles (1987, 2011-2020), and 19 (37%) were books of prominent authors in the field of DT (1926-2021). We focused primarily on sources in English (47, 90%) and secondarily in Croatian (5, 10%). The examined journal articles are from state-of-the-art journals such as *Design Issues, Design Studies, Journal of Organization Design, Harvard Business Review, Journal of Innovation and Entrepreneurship, Thinking Skills and Creativity, International Journal of Art & Design Education*, etc. We analysed information available in each of the references on the beforementioned subtopics that we defined as the basis for our paper ((a), (b), (c)). When talking about individual tools used in DT, Liedtka [5] concluded that the richness of DT interactions does not lie in individual tools and steps observed in isolation, but in the form that the tools and the whole process form together. For this reason, in this paper we will not focus on individual tools whose detailed descriptions can be found in existing papers [6-8], but on the

overall processes defined in the literature and different ways of their implementation in practice and education.

3 HISTORY OF DESIGN THINKING

Design thinking methodology has long been practiced in different ways and is not something new but has been developed in different areas. Thus, its history dates long before its official beginnings, through the workshops of industrial designers, artists, and architects. These are workshops by art history pioneers such as William Morris, Frank Lloyd Wright, and Ray and Charles Eames whose efforts were to make the world more meaningful. Design thinking arose from a creative process in which different activities alternate and then lead to the final product. Also, it is interesting that design as a discipline did not develop linearly, but expansively [9]. The development of design and design thinking was a logical extension of the work of graphic, industrial, and interaction designers who until then were solving the problems of designing the environment and systems that shape the human experience [10]. Antoljak and Kosović [11] divide the history of DT into four phases of concept development: (1) 1960-1980. - design of intangible products (H. Simon, V. Papanek, H. Rittel), (2) 1980-1990. - research of creative individuals (N. Cross, D. Schon, P. Rowe), (3) 1990-2005. - focus shifts to man (R. Buchanan, D. Kelley, T. Kelley) and (4) 2002-present - use of processes in the business environment (T. Brown, H. Plattner). DT beginnings are found in the model of the Bauhaus school, which was praised and criticized precisely because of its approach to design education, which was radical and innovative and focused on the unity of art and technology [12]. Therefore, as phase zero, before the 1960s, we can single out the Bauhaus movement (1919-1933), Wallas [13] who represented four phases in the process of creative thinking (preparation, incubation, illumination, verification), and Dewey [14] who influenced later accomplishments related to DT. DT development began in the 1960s [6, 11], [15] which are also called the *Decade of Design Science* [16].

New research has focused on the way designers think [6] and the movement's desire was for the design process to be based on objectivity and rationality [16]. Herbert Simon is one of the pioneers of this way of thinking because he defined the parameters and classification of design in 1969 [11, 16]. In 1971 Papanek [17] pointed out that design must be an inventive tool that responds to people's needs, and McKim [18] defined visual thinking and provided a methodology that describes the process. One of the categories within DT are wicked problems related to solving extremely difficult problems. They are first mentioned in literature by Rittel and Webber [19, 20] and are defined as cultural problems that are complex and embedded in larger problems. Rowe [21] later divided problems into well-defined and poorly defined, and classified wicked problems as poorly defined.

Table 1 Significant design thinking literature through historical phases, 1919-2013

	Year	Author	Publication
Phase 0	1919-1933	Bauhaus school	
	1926	Graham Wallas	The Art of Thought
	1929	John Dewey	The Quest for Certainty: A Study of the Relation of Knowledge and Action
Phase 1	1969	Herbert Simon	The Sciences of the Artificial
	1971	Victor Papanek	Design for the Real World
	1972	Robert McKim	Experiences in Visual Thinking
	1972	Horst Rittel	On the Planning Crisis: Systems Analysis of the 'First and Second Generations'
	1973	Horst Rittel and Melvin Webber	Dilemmas in a General Theory of Planning
Phase 2	1980	Bryan Lawson	How Designers Think
	1982	Nigel Cross	Designerly Ways of Knowing
	1983	Donald Schon	The Reflective Practitioner: How Professionals Think in Action
	1987	Rolf Faste	Perceiving Needs
	1987	Peter Rowe	Design Thinking
Phase 3	1992	Richard Buchanan	Wicked Problems in Design Thinking
	1992	Elizabeth Sanders	Converging Perspectives: Product Development Research for the 1990s
	1996	Yu-Tung Liu	Is Designing One Search or Two? A Model of Design Thinking Involving Symbolism and Connectionism
	2001	Tom Kelley and Jonathan Littman	The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm
Phase 4	2008	Tim Brown	Design Thinking (Harvard Business Review)
	2009	Tim Brown	Change by Design
	2009	Roger Martin	The Design of Business: Why Design Thinking is the Next Competitive Advantage
	2011	Christoph Meinel, Larry Leifer, Hasso Plattner	Design Thinking: Understand – Improve – Apply
	2013	Tom Kelley and David Kelley	Creative Confidence: Unleashing the Creative Potential Within Us All

A significant development in the second phase is the emergence of new journals related to theory and methodology of design, such as *Design Studies* (1979), *Design Issues* (1984), *Research in Engineering Design* (1989), *Design Management Journal* (1989, former series, continues as *Design Management Review*) and many others [16]. During this period, the designer's way of thinking was studied, and researchers came to valuable conclusions related to the methodology itself. Cross [22] pointed out that methods such as modeling and shaping patterns are used in design, and Schon [23] emphasized that the concept of design has expanded in the last twenty years. Rowe used the term design thinking in the title of his book, and Faste [24] emphasized individual needs and the perception of needs. In the third phase, the DT process begins to be presented to people outside the design profession, and many universities

introduce design courses into their curriculum [11, 15]. The biggest turning point in the DT area came with the founding of the design consulting company IDEO in 1991 which led to the widespread acceptance of the methodology in the last ten years [11, 15]. IDEO founders are David and Tom Kelley who apply DT systematically in IDEO. Buchanan [25] at the time was returning to the idea of wicked problems, while Sanders [26] pointed out that all future products would have to meet customer needs. Liu [27] stated that design is one of the most sophisticated human behaviors. The last phase continues today in which the focus has shifted to creating new ways of thinking with collaborative design and teams [11]. Brown [9] showed a cross-section of the IDEO methodology and defined the DT process. Hasso Plattner founded the Hasso Plattner Institute at Stanford (d.school) in 2005, and d.school in Potsdam, Germany opened shortly afterward [28]. To summarize the most significant achievements according to the historical phases, Tab. 1 shows the significant literature through the stages of development of this field.

4 DESIGN THINKING APPROACH

There are various interpretations of the concept and ways of using design thinking depending on the meaning attributed to it in theoretical and practical situations. Although there is no harmonized definition of design thinking, common patterns in all definitions are user-centered approach, iterative exploration, prototyping, and teamwork [29]. For this reason, in the following chapters, an overview of different definitions and interpretations of the DT term will be made, as well as the definition of the characteristics, patterns, and mechanics of the procedures themselves.

Table 2 Design thinking definitions used in literature

SOURCE	DEFINITION
Herbert Simon, 1969	"Everyone designs who devises courses of action aimed at changing existing situations into preferred ones." [35]
Victor Papanek, 1971	"Planning and designing any action aimed at a desired and predictable goal is a design process." [17]
Nigel Cross, 1982	"Designerly ways of knowing rest on the manipulation of non-verbal codes in the material culture; these codes translate 'messages' either way between concrete objects and abstract requirements…." [22]
Richard Buchanan, 1992	"The new liberal art of design thinking … points toward the impossibility of relying on any one of the sciences for adequate solutions to what are the inherently wicked problems of design thinking." [25]
Tim Brown, 2008	"Design thinking is a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity." [32]
Hasso Plattner, 2011	"The method of Design Thinking melds an end-user focus with multidisciplinary collaboration and iterative improvement and is a powerful tool for achieving desirable, user-friendly, and economically viable design solutions and innovative products and services." [28]
Tom Kelley and David Kelley, 2013	"Design thinking is a way of finding human needs and creating new solutions using the tools and mindsets of design practitioners." [36]
Antoljak and Kosović, 2018	"Design thinking is a way of solving problems with the help of a structured process and a set of methods and techniques that originally originated from designers." [11]
Richard Buchanan, 2019	"Design is the transformation of surroundings into environments for human experience." [10]
Michael Lewrick, Patrick Link and Larry Leifer, 2020	"Design thinking makes it possible for us to realize solutions that meet the wishes of the customers, solve a genuine problem, and thus provide value for the customer." [38]
Jeanne Liedtka, Karen Hold and Jessica Eldridge, 2021	"DT's human-centered focus engages us by giving us experiences that matter, that impact us at a deep personal level." [39]

4.1 Definition

The development of the DT theory depends on the development of human thinking in the field of cognitive sciences, artificial intelligence, and neuroscience [27]. Therefore, DT is comprehensive, interdisciplinary, and difficult to define unambiguously and simply. That is why there is no final definition of design thinking. Thinking in DT is a way of thinking that is specific in solving challenges through multidisciplinarity. The term DT is often used as a unique approach to problem-solving in an innovative way [30] and is a link between process, product, and end-user [31]. This puts the focus on the user who is involved in all phases of the process. We can say that DT is a user-oriented approach to design in which innovation is achieved by direct observation of what people want and need [32]. Through research, testing, prototyping, and achieving empathy with users, they become the focus of every step and part of every decision. In this way, DT focuses on the solution, not the problem. In today's world, DT is a response to the complexity of modern technology [31] and can be viewed as a collaborative approach [33]. A comparison of different definitions that are prominent in literature is available in Tab. 2. Although it is evident from various examples from practice and scientific literature that DT is a complex field and a methodology that brings innovative results, it is important to emphasize that certain authors do not agree with this concept. Some authors consider DT to be a useless process, which they call a new myth and a failed experiment [11]. Also, some authors argue that DT research has not produced a definitive account of DT [34]. Most of the criticism is related to the fact that the DT methodology is fluid and ever-changing. Because of this some authors claim that DT does not follow a methodology and that it neglects constraints that designers need [44].

4.2 Characteristics and Thinking Patterns

Dorst [37] points out that different creative activities in popular literature are often classified as design thinking, and for this reason, many researchers in the design profession are opposed to the DT approach. For this reason, it is important

to look at DT from the perspective of defining the process because it has specific and intentional ways of thinking [37]. Cross [22] identifies five aspects of design modes of knowledge: designers deal with poorly defined problems, they are solution-oriented, think constructively, use codes that translate abstract requirements into concrete objects, and use codes to read and write object languages. The most important DT principle is human-centered design [2, 9, 15] used as an inventive tool that meets the real needs of people [17]. With understanding human behavior, what users want and need, a solution is reached that is appropriate for the user. In addition to empathy and focus on the user, DT is also characterized by the culture of prototyping. With constant and frequent prototyping, ideas materialize, and solutions are found faster through iteration. Users are also involved in this process because by testing the prototype with users, insights that are important for solving the problem are gained. Solution generation, synthesis, and evaluation are prominent DT features. It is important to know how to determine the level of compromise when choosing a solution since in design there is no single solution. Experimentation is imperative in research because ideas can be explored through conceptual development [26].

Innovation as a feature of design thinking is achieved with user focus, creativity, and teamwork. As a result of teamwork, different profiles of people of various professions and skills collaborate. Team interdisciplinarity is important because of interdisciplinary nature of the DT process itself, which solves problems from different spheres of life. Thus, Papanek points out that most discoveries are made on the border of different techniques or disciplines [17]. Through DT we observe the human, business, and technological aspects of a problem [31]. We can look at DT as a process of a series of steps taken to solve problems and as a way of thinking about problems [1]. Most cognitive design theories point out that the dominant design model is cyclical and iterative [40]. This means that the DT process is not straightforward, but the steps can be repeated and can be returned to multiple times. DT is a nonlinear process in which knowledge can be obtained during different phases that can influence certain decisions [9, 41]. DT deals with solving complex problems so it is essential to define the logical thinking that occurs in such a procedure. Problem-solving can be described as a search within a maze of possibilities in which the maze represents the environment [35]. Successful problem-solving involves selectively searching the maze and reducing the maze to manageable proportions [35]. Given the fact that DT differs from traditional ways of solving problems, it is not surprising that it also differs in the way of logical thinking. Central practice for design disciplines is the framework which is the general implication that we will create a certain value by applying a working principle [37]. We can define key patterns of conclusion in design with models of formal logic [37]. Thus, logical ways of reasoning used to solve a problem are deduction, induction, and abduction [37]. The most used are the deductive and inductive way of logical thinking, and the less used is the abductive way, which is what is used in the DT process [42]. Logical reasoning in productive thinking is an abduction process that can be carried out in two ways [37]. Abduction-1 is associated with conventional problem-solving and is a closed problem-solving process, while abduction-2 is associated with conceptual design and is an open problem-solving process, used in the DT process [37].

4.3 Procedure Mechanics

Three key strategic DT approaches are taking a broad systemic approach to problem-solving, distinctively framing the problem, and designing according to the first principles [43]. Thoring and Mueller [3] point out that three aspects of evolutionary creativity (generating, selecting, and retaining ideas) can explain most DT principles. The process begins with the identification and formulation of problems and constraints. Solving the set problem requires that the target space and the solution space overlap in such a way that they form an optimal solution between the two spaces [44]. The two main categories of productive thinking are convergence and divergence [45]. Divergent thinking is the ability to create different solutions and refers to the generation of ideas and the creation of choices, while convergent is the choice of one final solution from those previously defined [31], [46]. Design thinking encourages divergent thinking, which is then followed by convergent thinking [31]. Analysis and synthesis are complements to the divergent and convergent way of thinking [9]. It is these aspects that are the foundation of design thinking which is a continuous movement between divergent and convergent processes on the one hand, and analytical and synthetic on the other [9]. Stempfle and Badke-Schaub [44] propose generation, exploration, comparison, and selection as four basic cognitive operations for working with problem spaces. The first two expand the problem space, and the other two narrow it. Thoring and Mueller [3] present a typology of knowledge in which all patterns that enable decisions are defined as knowledge. Thus, they emphasize the typology of design knowledge with the following levels: physical (A), neural (B), symbolic (C), and model (D). The physical level refers to three-dimensional forms, the neural level to tacit knowledge, the symbolic level to explicit knowledge, and the model level to models and theories [3]. These four levels build on top of each other, and each level includes aspects of the previous level [3]. Buchanan [25] emphasizes the peculiar nature of design with the claim that design problems are wicked precisely because they do not have their subject of interest (one area), but the area of design interest is what the designer decides. Thus, the subject of interest is universal in scope because DT can be applied to any area of human experience [25].

5 DESIGN THINKING PROCESSES

The fluidity and flexibility of DT are interesting aspects of the process, but sometimes they can be a factor of misunderstanding. Given the use in various industries by different institutions and organizations, the process itself is not always the same. Various organizations have different DT approaches and the way they approach challenges. Because the process is not straightforward, it can often seem

chaotic and out of order, and it takes time to get used to this way of thinking [32]. However, to be able to methodologically define this technique as well as to conduct further research, it is necessary to set certain process definitions. Simon [35] points out that the design process can be seen as a process of generating different solutions and that it does not have to be just one test cycle but a multitude of cycles. In this chapter, we will compare some of the most used DT processes in education and the business world and show their similarities and differences. All processes differ in the way they are interpreted and in the number of stages, but they also have a lot in common. What they all have in common is a convergent and divergent way of thinking, analysis and synthesis, and the iterative nature of the process related to returning to certain phases or repeating them. Also, in all processes, the idea is to learn through failure. To explain and understand certain phases, processes are defined linearly, but they are never linear. All processes can be repeated several times and we can return to certain phases within the process. What is also common to all processes is prototyping and obtaining feedback from users through testing [1]. Trošić [2] presents different organizational models in higher education that provide an educational context for DT such as Darden School of Business, Royal College of Art, University of Technology Sydney, Delft University of Technology, School of Economics and Business (Ljubljana), Hasso Plattner Institute at Stanford (d.school), in Potsdam, Cape Town, Malaysia, and Paris. Brown [9] believes that the most important opportunity for long-term impact of DT lies in education and emphasizes the importance of shaping education in a way that encourages experimentation. Srhoj and Morić Milovanović [6] divide the design process into micro and macro processes. Thus, Darden School of Business, Rotman School of Management, d.school, and IDEO are classified as those that use micro processes, while the University of St. Gallen is classified as using a macro process [6]. In recent years, DT has been developed in various industrial workshops led by leaders who are often non-design professionals [47]. Some of the prominent DT processes are shown in Tab. 3.

Table 3 Overview of the most used design thinking processes

Process	Approach	Phases
Micro process	Double Diamond design model, British Design Council	discover, define, develop, deliver
	University of Virginia Darden School of Business, USA	What is?, What if?, What wows?, What works?
	Hasso Plattner Institute of Design (HPI) at Stanford, USA (d.school)	empathize, define, ideate, prototype, test
	Hasso Plattner Institute (HPI) in Potsdam, Germany	understand, observe, point of view, ideate, prototype, test
	IDEO (Tim Brown)	inspiration, ideation, implementation
	IDEO (Tom Kelley and Jonathan Littman)	understand, observe, visualize, evaluate, implement
	Rotman School of Management, Toronto, Canada	initiation, investigation, integration, implementation
Macro process	University of St. Gallen, Switzerland	diverging (design space exploration, critical function prototype, dark horse prototype, funky prototype), converging (functional prototype, X prototype, final prototype)

Antoljak and Kosović [11] state that most DT approaches have a common fundamental "double diamond" process. The basic phases of "double diamond" are discover, define, develop, and deliver [11]. Through this process, divergent (discover, develop) and convergent (define, deliver) processes alternate. In the first step the problem is identified, in the second a deep understanding of the problem is gained, in the third ideas are developed, and in the last step, a prototype and final solution are created. The process of the Darden School of Business is based on four steps: "What is?", "What if?", "What wows?", and "What works?" [11]. In the step "What is?" the problems that users have are defined, in the step "What if?" concepts are developed and opportunities are recognized, in step "What wows?" the most promising one is selected from the multitude of concepts, and in the last phase "What works?" prototypes are shaped and implementation is carried out [6, 11].

The Hasso Plattner Institute (HPI) at Stanford and in Potsdam are representative examples of a typical educational DT institution and their processes are also the most commonly used [12]. HPI at Stanford (d.school) divides the design process into five steps: empathize, define, ideate, prototype, and test [41]. With empathy, designers understand users and their actions [31]. In the definition phase, the collected information is processed, and the challenge is defined [11]. In the ideation phase, rough ideas are developed, and many ideas are devised, while in the prototyping phase, a functional model that helps to verify the design is created [11, 31]. The last step is testing in real conditions that can be carried out at all stages of the process and the purpose is to get feedback based on the prototype [11]. HPI d.school in Potsdam uses a similar six-step model: understand, observe, point of view, ideate, prototype, and test [3]. In phase understand the problem is defined, while insights into the user needs are gathered through observation [48]. By point of view, a micro theory of user needs is created [48]. During ideation, questions that address the defined problems and ideas for possible solutions are generated [48]. Through prototyping, a prototype is prepared, and through testing, feedback is collected from users and participants [48]. Tim Brown [32] points out that the DT process can best be described metaphorically as a system of spaces rather than as a predefined series of steps. Nevertheless, to define this process, Brown divides the DT process into three phases: inspiration, ideation, and implementation, and emphasizes that these steps overlap and are not sequential [9, 32]. The inspiration phase represents the problem that motivates the search for solutions and in which insights are gathered [9], [32]. Ideation is the process of generating, developing, and testing ideas, and the last stage is implementation, which is the path to the market [9, 32]. Through all three spaces, we can return to refine ideas and determine new directions [32].

Brown [9] also presents a model of constraints across three elements: feasibility, sustainability, and desirability. These are overlapping elements that the design thinker needs to balance [9]. Feasibility refers to what is functionally possible in the near future, sustainability to what is realistic to become part of a sustainable business model and desirability to what makes sense to people [9]. Kelley and Littman [49] presented the IDEO company methodology in five basic steps: understand, observe, visualize, evaluate, and implement. They pointed out that the interpretation of the method depends on the nature of the task to be solved. In the first step, the market, client, and technology are understood, in the observation step it is defined how users think, through visualization new concepts are visualized, in evaluation prototypes are evaluated through iterations, and in the last step, implementation is carried out [49]. Rotman School of Management divides the process into four phases: initiation, investigation, integration, and implementation.

As a macro process, we can highlight the University of St. Gallen which developed a process divided into two phases (divergent and convergent) within which micro processes related to prototypes are carried out [6]. The divergent phase consists of the design space exploration, critical function prototype, dark horse prototype, and funky prototype, while the convergent phase consists of a functional prototype, X prototype, and the final prototype [6]. Within the first step, the design challenge is explored, the first prototypes are developed in the critical function prototype, a prototype with neglected constraints is formed in the dark horse prototype, the best ideas are used in the funky prototype, functional prototype is shaped according to final requirements, and the X prototype defines key functionalities that meet customer needs [6]. Within each of the phases, a micro iteration process is performed [6]. As a result of the intersection of these processes of different organizations and institutions, we can see that all processes largely coincide with the already mentioned stages of the creative thinking process (preparation, incubation, illumination, verification) presented by Wallas [13] in 1926, which shows that DT evolved from this process and has been further expanded and changed since.

6 DESIGNER COMPETENCIES

Although DT often stands out as something that anyone can use, it is important to make a distinction between beginners and experts [50]. In this paper, we deal with the competencies of expert designers within this field. Creativity and artistic expression are only part of the competencies of designers whose work is often equated with the above-mentioned. The primary task of the designer is solving problems and the designer must have a sensibility in discovering existing problems [17]. DT skills enable readiness to face problems, thinking outside the box, and creating innovative solutions [50]. IDEO [8] singles out seven essential competencies of design thinkers: empathy, optimism, iteration, creative trust, creation, acceptance of ambiguity, and learning from failure. On the other hand, Brown [32] singles out empathy, integrative thinking, optimism, experimentation, and collaboration as essential characteristics of any design thinker. Razzouk and Shute [50] highlight focus on man and the environment, the ability to visualize, a predisposition to multifunctionality, a systematic vision, and an affinity for teamwork. Designers possess highly developed skills in graphic communication [45] and competencies of intuitiveness, pattern recognition, and expression in various media [9]. Some of the characteristics of designers are flexibility, quick thinking, and spontaneity because they often must quickly assess the conditions of a situation [26]. As a result of integrative thinking in which all factors are considered, designers look at all aspects of a particular problem and achieve innovative results [32].

While DT presents itself as a process for everyone, not just designers, that doesn't mean anyone can come up with innovative solutions with equal expertise. That is why it is important to practice interdisciplinarity at the level of the team itself. Through DT, designers emphasize their abilities, and it is interdisciplinarity that connects the various aspects that make up design thinkers. Therefore, designers should be T-shaped persons, which means that they are experts in one area (vertical bar on the letter T), but also that they have a broad knowledge of similar fields and strong communication skills (horizontal bar on the letter T) [46]. T-shaped persons can recombine their knowledge better than other professionals, which leads to the generation of many ideas and enables better transfer of knowledge [3]. Expert strategies most often involve a top-down approach [50]. Thus, DT uses integrated teams composed of members of different professions and fields [9]. In this way, everyone contributes to the process and the final solution. Teams play an important role in the organizational context because groups can solve problems that individuals cannot [44]. The ideal team consists of five to six people of different backgrounds [46]. In this way, teams consist of individuals from different professions and the team becomes multidisciplinary. For this reason, T-shaped persons are needed within the team because then the members overlap in certain areas, but diversity is still achieved.

7 SIGNIFICANT CONCLUSIONS OF EXISTING RESEARCH

In recent years, much research has been conducted [3-6, 12, 29, 44, 51, 52] on the topic of design thinking and the way designers think and come up with solutions. We singled out and reviewed the mentioned relevant empirical research results and compared them with the DT theoretical settings presented so far. For example, Liedtka [5] conducted research in 22 organizations to observe the use of DT elements in practice. The results showed that teams try to achieve a qualitative understanding of the user context, team heterogeneity is carried out, multiple solutions are created, and a structured process is used [5]. Also, research showed that teams first conduct user research and only then start preparing solutions [5], which coincides with the theories of processes of Brown, HPI schools, and others presented in previous chapters. It often happens that during research teams notice that the problem statement needs to be reformulated and they return to the beginning [5]. This is

consistent with the iterative nature of design thinking that is common to all theoretical models. Aflatoony et al. [51] conducted a study evaluating students' thinking skills and their experience during a DT class in two high schools. What the results showed in terms of students' thinking skills was that students showed different levels of understanding of the design process and that they all improved their DT skills by the end of the course [51]. From this, we can conclude that DT is a skill that can be learned and needs to be practiced. A problem with teamwork in this research was leadership, even division of tasks, and team size [51]. This is very significant because the team entity is very important for the DT process. Pap et al. [31] conducted workshops with twelve students of different fields who used the DT method during the workshop. They concluded that mixing disciplines works well, that placing students in a DT environment encourages their creativity regardless of prior knowledge, and that working in the right place can create new value [31]. These conclusions coincide with citations from literature that cite teamwork and interdisciplinarity as key characteristics of design thinking. Thoring et al. [12] compared Bauhaus and d.school education and observed many similarities between the two modes of education, although they are separated by almost a century [12]. Thus, the greatest similarities are in the way of thinking, culture, environment, and conditions for innovation [12]. Neither approach use evaluation, they encourage experimentation and creativity, strive for radical innovation, and want to improve the world [12]. Costa Valentim et al. [52] conducted an empirical study with postdoctoral students to examine their perception of DT. Results showed that students had difficulties in using DT and in team interaction [52]. We can conclude that there are still some difficulties that need to be addressed in the process. Goldschmidt and Rodgers [29] compared the DT process of different groups of designers. From the analysis of the results, they concluded that the respondents did not follow a linear process but iterated between activities [29]. This fact confirms all previous models that emphasize iteration as an important feature of design thinking.

8 CONCLUSIONS

According to the results of the research, we can conclude that there is still no harmonized DT definition or strictly defined processes and phases used in the methodology. In this paper we provided a detailed list of DT literature through historic phases in Tab. 1, overview of DT definitions in Tab. 2, and synthesis of DT processes in Tab. 3. As DT continues to develop expansively and expands into different areas, we assume that definitions and phases will be increasingly dispersed and broadened as more organizations and institutions begin to implement it in their business and education. Therefore, due to the rapid growth of the field, it is necessary to do syntheses of the latest research. The analysis shows that DT courses are taught at many universities around the world. For further research, we propose an overview of the implementation of DT courses at Croatian universities and schools, examining the level and manner of using this methodology in Croatian companies and comparison with foreign teams in which there is a DT education at the academic level. The first DT Croatian book focuses on the business side of solving problems and approaching the topic in a way that non-designers can understand it. Nevertheless, it is important to provide expert designers with structured processes and current research which was the goal and purpose of this review. In the latest edition of his book *Change by Design*, Tim Brown makes suggestions for further directions and development of design thinking. He cites redesign of outdated social systems, revival of participatory democracy, urban design, the humanization of artificial intelligence, biotechnology, and the circular economy. This instructs us that problems are becoming more wicked and therefore we need designers who have the necessary competencies and skills to solve such problems. The approach in which this is possible is design thinking. Therefore, we need to give designers a good background through education because they are the ones who know very well what the limitations are and where the boundaries lie. Even better than that they also know how, when, and how to move, expand, and break those boundaries. To be able to do so on an ever-increasing and complex level, they need to be supported in all aspects so that they can further develop this area.

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