DT4VET

ERASMUS KA-202 Strategic Partnerships for vocational education and training

DT4VET: Educating Designerly Thinkers for Vocational Education and Training: Design Thinking Tool for Educators

PROJECT REPORT

O1 – Re-thinking Design Thinking

TÜRKİYE CUMHURİYETİ AVRUPA BİRLİĞİ BAKANLIĞI
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1 INTRODUCTION

Designing entails the planning and execution of a process to produce an object or system. The design action defines this elaboration process. An efficient design process involves planning from the beginning, determining advantageous and restrictive situations, as well as functional, aesthetic, and economic features, and communicating with the user and the environment.

The design process can be quick, such as just sketching an idea, or it can be long-term, such as research and development, user research, material and manufacturing modelling, prototyping and re-design. The design process is also framed by ambiguity, requires iteration and evolution, is circular in nature and formed by social, cultural, historical, technological, and other variables. In general, a tangible product or activity will emerge at the end of this development process.

Research methodologies and production systems have evolved significantly over the twentieth century, leading academics, and practitioners to develop the design process progressively. Governments and international organizations increasingly recognize design to drive innovation and growth in all sectors (OECD 2012).

The design process has always been user-oriented, but with the development of research and assessment techniques, an interdisciplinary and integrative approach has become more crucial. Thus, the product-oriented design process evolved into an experience-oriented, creative problem-solving process. A holistic design process was achieved by involving the user in the process and evaluating the outputs with the help of experts from different disciplines.

As design disciplines explore new ways of collecting data from the process, the interest in these methods is increasing. It is becoming more common for design principles and tools to be applied to areas outside of the traditional design domain. The design process is no longer limited to material objects but also pertains to immaterial things, like systems and organizations. This gave “design” a more global and strategic role.

So, how does this evolving approach affect design education? There has been a general acceptance of design disciplines in higher education as the main source of design knowledge. The

fast-paced and impatient nature of higher education focuses on an attitude that provides specific outputs during education and, ontologically, the experiences that can make the student part of a professional group in this limited time. It aims to create and develop students' professional skills through education and tries to maintain the structure of conventional education. However, design education, like design, is not static. With its focus on providing students with a progressive experience, it supports lifelong learning. Although the basic principles have not changed, the acceleration of the development of technology, the transformation in the definitions of creativity and innovation, the diversity of content, and access to information have changed the patterns of design education. The importance of human-centered approaches and reflective practices has brought educators out of their comfort zones and evolved them to be closer to an interdisciplinary culture, open to experience, to apply theory and practice in the same learning experience, and to prepare appropriate knowledge and skill sets.

Design is often directly associated with creativity. It has been stated in many studies that design education develops a creative and innovative thinking system prone to problem-solving. In design education, we teach the tools, skills, methods, processes, etc. that we believe a student should know to enter the design profession competently. In addition to theoretical knowledge, we provide students with the experience of 'need analysis, idea generation, design of solutions, the production process, and finally, reflective evaluation of the work and the whole process, that is, the completion of the design process. This, in turn, affects the mindsets of the designer candidates, feeds them with lasting knowledge, and enables them to acquire the design culture.

But what if design culture, design thinking, or designerly way of thinking were taught to students before they started higher education, while they were still studying at high schools? Would this affect their choice of profession or their way of practicing? Can design increase students' problem-solving and creativity competencies and improve their collaborative skills? And do these experiences positively affect their professional performance even if they do not choose a profession associated with design?

The DT4VET project focuses on these questions. DT4VET intended to introduce the concept of design or the perception of a "designerly way of thinking", which is also accepted in the literature, specifically for vocational and technical high school students to generate this way of thinking before starting their professional lives. It is supposed that students can make their future choices efficiently with this design-oriented perspective. To fulfil this long-term goal, primarily vocational and technical high school teachers should be trained in a "designerly way of thinking." Teachers who learn and adopt this design-oriented perspective methodologically are expected to integrate it into their educational system and, finally, transfer it to their students. This perception would provide students with the habit of problem-solving and multidisciplinary thinking.

DT4VET aims to inspire the DT method for initial vocational education and training (IVET) and to educate designerly thinkers who can define the problem creatively, are human-oriented, and have transversal skills. The transitions in the global economy, the use of digital technologies in the realm of work, and the development of new types of entrepreneurship are changing the profile of professions as well as devising new potential outcomes for solutions to social and economic issues in the form of innovation. These changes pose a major challenge to the systems of IVET. Having regard to the issues in the IVET system (slowness in updating curricula, governance models, and sector-specific characteristics), DT4VET aims to pursue a strategy apt to make the IVET system reflective and active in addressing the ever-changing skills demands of the labour market.

DT4VET sees benefit in changing the praxis of vocational education—the mindset, values, and practices of people who are educating the future qualified and entrepreneurial workforce of Europe. We believe that the most effective tool we can offer to educators in vocational schools is the ability to "think creatively like a designer." Designers work with "wicked, open-ended, and ill-defined problems," (Rittel and Webber 1973) as are the problems of our times. Their designerly way of knowing and analyzing these problems, their experiments with new perspectives, and their experiences in designing are considered a method and a process called Design Thinking. The thinking process is mainly human-centered, experimental, multidisciplinary, and collaborative. The "Design Thinking" method provides a method that has the potential to simultaneously address

most of the transversal skills, such as the ability to think creatively and critically, take initiative, work collaboratively for common goals, and have entrepreneurship competences, in a systemic/holistic approach. The field requires reflective educators who are open to taking initiatives responsively, skilled to determine problems and produce solutions, and skilled to critically revise/improve their teaching methods/contents based on their context and exigencies, even beyond the expectations of the market.

To this end, another goal of DT4VET is to enhance the transversal skills and entrepreneurial competences of educators teaching at vocational technical high schools by devising strategic actions/objectives that implement "design thinking" into the trainers' training. This strategy is detached from any governance model; it directly targets the people who implement the curricula, who, if equipped with designerly problem solving and creative thinking skills, have the potential to reflect on the exigencies of their field and update their teaching content in a sustainable way. DT4VET project activities are mediums of collaboration, co-learning, and teaching among its partners that pursue six strategic objectives:

1. Compile problem solving methods in the training of IVET educators across Europe; review existing courses and trainings, identifying deficiencies/mistakes, evaluate this information and make a mapping;
2. Make the method of design thinking an accessible, understandable, and sustainable tool through a shared and inclusive approach.
3. Teach educators in vocational technical high schools and future educators a PROCESS of solving complex tasks through the method of design thinking;
4. Make mutual collaboration between countries thru the groups of dynamic players to enable learning by doing, targeting augmented VET system awareness of global trends;
5. Promote the DT tool as a motivation for VET educators/trainers who want to rethink their current teaching/learning methodologies.
6. Support the DT toolkit as a transversal learning tool for an innovative, continuing online professional development course for VET educators.

DT4VET requires collective and transnational collaboration among the partners from the effective players and intending countries. Each country has place sensitive qualities (professional and educational practices) that influence and enhance certain countries. The DT4VET trilateral partnership model, by creating an interaction field among researchers in the design field (VAMK, METU, TOBB ETU) and VET providers (SNS), including trainers of VET educators (ITB Uni Bremen, MoNE), and VET Educators (MoNE, ASO), has the potential to foster innovation in multi-layered educational practices.

Within the context of the above-mentioned objective, DT4VET is expected to:

(1) diversify education, problem-solving creativity, and the positive impact of this method on the entrepreneurial personalities of the business world and the potential businesspeople who have vocational education. The idea of development, implementation, and prototyping of the DT4VET project, which is very important for vocational education, will be acquired as a method.

(2) create a new vocational training mechanism that considers mostly the needs of the market.

(3) build this problem-solving mechanism into a lifelong learning system.

(4) ensure conditions for this mechanism to be embedded in the vocational education system and transform into tacit knowledge for educators over time.

(5) become an exemplary model and practice in the multiplication of this successful application.

(6) develop a culture of creative thinking process by this tool among vocational educators.

(7) motivate VET educators for a new mindset of content and methods regarding technical vocational education.

(8) expand the formal, informal, and intellectual resources (literature, examples, and experiences) of their students.

The most important goal of this project is to make sure that the design-thinking method is sustainable, available, easy to understand, and common in the education ecosystem, and that teachers learn how to teach this method to their students. Within the context of the above-mentioned objectives, the expected results in the DT4VET project based on the project outputs are as follows;

The output 1: Re-Thinking Design Thinking

(1) reviews the design education and design thinking literature in general;
(2) categorizes design thinking tools appropriate for use in education;
(3) explores the potentials of existing design thinking methods.

The output 2: "What do IVET need?"

(1) identifies methods and tools currently applied in vocational training and creates a mapping.
(2) analyzes the needs of vocational educators for the preparation of future educational development.
(3) puts forth the skills and actions of vocational educators that are needed for new infrastructure to be built in the future.

The output 3: "DT4VET Toolkit"

(1) creates a user-friendly toolkit so that the user can naturally adapt creative problem-solving skills.

The output 4: "DT4VET Online Training Module" shared on online platforms:

(1) creates a social sharing and training platform that will make communication and exchange of information sustainable among stakeholders.

2 RE-THINKING DESIGN THINKING

2.1 DESIGN THINKING: A REFLECTIVE PRACTICE

As a methodology, the origin of "Design Thinking" (DT) is often credited to Herbert Simon's "The Science of the Artificial," (1996) first published in 1969, though it was Rowe (1987) in 1987 who introduced the term 'Design Thinking' to the terminology. DT was developed as a strategy or

method for problem solving, learning, and synthesis from a design perspective in the late 1960s for non-designers. Design Thinking is an approach developed to increase creative thinking and add value to the process, bringing multidisciplinary people together and conducting collaboration. It can also be defined as the use of design practice and design skills beyond the context of designing, for people who are not technically or academically trained designers. However, it is known from both literature and personal experience that there are many questions to be asked about this approach. What comprises design and the design process? Does "design thinking" and "designing" mean the same thing? If anyone embraces design thinking in his life, can he be designated as a designer? What is the role of creativity in design and technology practice? Are technological developments affected by the features defined in the design? How does designerly way of thinking affect education? Does our current technology curriculum support the concept of design thinking? Is thinking like a designer in education sustainable for a changing world? Since human development depends on discovery, invention, creativity, and design, providing learning opportunities about design and creativity and incorporating them into technology education will provide an important foundation for innovative technological development.

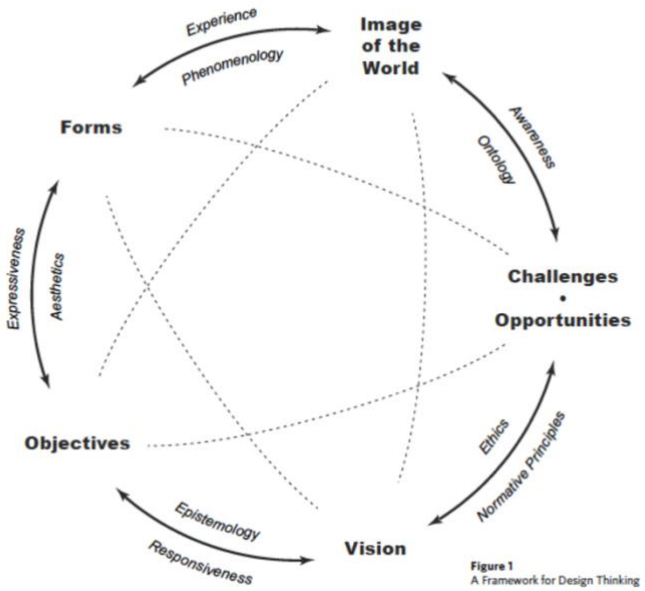


Figure 1: A Design Thinking Framework by Shearer (2015)

Johansson-Sköldberg et al. (2013) mention two different contexts while making an in-depth criticism of the design thinking experience. The first is the "design thinking" approach, which is usually used by business/management, and the other is the "designerly way of thinking,", which is basically a creative mindset. These are not different definitions; it is the nature of DT to set its framework according to different needs and practitioners. It is related to the fact that DT concerns process rather than result, and the process changes with the creativity, innovation, or systems thinking in the process.

The DT process is not an algorithmic process; different practitioners and teams will achieve different results even if they attempt to solve the same problem with the same tools. Design thinking is a collection of tools designed to support creative thinking and encourage people to explore and find human-centered design solutions. Again, it is certain that the principles of DT are basically the same, albeit with different models, methods of application, and communities. Friedman believes this should shift the emphasis in education from the "design of things" to the "understanding of things." This is a mentality that values meaning over theoretical or traditional skills. Wigley and Straker also theorized DT as a definitive method for non-designers to evaluate and use design methods to solve real-life problems (Wrigley and Straker 2017).

DT is a human-centered process that empathizes with the user/consumer and has holistic, collaborative, creative, and inspiring goals for innovation of products, services, processes, and businesses. This is not design thinking if the process is not human-centered. DT transforms observations into insights and insights into innovations through an exploratory, iterative, and non-linear process. The key principles that support this mindset are empathy, curiosity, collaboration, experimentation, visualization, flexibility, and continuous learning. Working collaboratively in multidisciplinary teams is central to the design thinking process. Collaboration between engineers, social scientists, and artists is important to define problems and generate solutions. Technological developments are inseparably influenced by creativity and design, and as a result, they are aimed at creating a human-centered, multi-disciplinary, and innovative relationship. Additionally, Jornet and Roth (2018) reframed design as essentially social, and Krippendorff (2006) emphasized the

communicative nature of design, both helping to frame the way professionals are involved in the design process to solve problems with/for users.

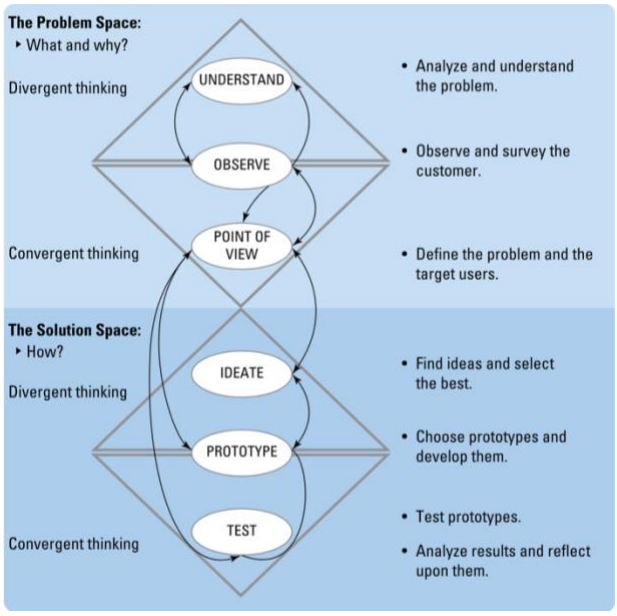


Figure 2: Process of Design Thinking supplemented with the Double-Diamond model. Source: (Plattner, Meinel, and Weinberg 2009; Lindberg et al. 2010; Design Council UK 2005)

Design thinking is a concept that has been often occurred in the fields of education, engineering, and business in recent years. The method transforms problem solving and project development processes into “thinking like a designer” or “design thinking”. The starting point of this method is to convey how designers see problems and think about their solutions from a multidisciplinary perspective. DT is a creative strategy for generating creative results and/or creative solutions to problems for the future, and it is an iterative and interactive process where designers visualize problem-solving methods and relationships between ideas.

2.2 INTELLECTUAL BACKGROUND OF DESIGN THINKING

This section presents the academic discourse and practice that have grown over more than fifty years. It also shows how the design-driven process is driven by DT's principles.

In the extensive literature on design thinking, it is noticed that this method has been used as a term long before it was conceptualized, and its meaning, content, and methodology have developed with/in the terminology of the design concept since the 1960s. The concept, first accepted by academics and practitioners, provides a background for the interdisciplinary model used today. DT can also be defined as a cognitive process based on design science that determines the pertinent questions, methods, and practices for problem solving. Although science's primary concern is the physical world, it can be applied to a wide range of disciplines as a method. For example, psychology borrowed methods from science at the beginning of the 19th century and was gradually accepted by academia as a novel science of behavior. Today, it proved its maturity among scientific disciplines. This method has been theoretically considered and contextualized by prominent researchers from design, cognitive sciences, and engineering disciplines such as Simon (1996), Lawson (2005), Schön (1983), Buchanan (1992), Cross (1982; 2001), and Krippendorff (2006). A discussion of the comparative history or evolution of DT is not one of the main topics of this research, but to give a general idea of how the concept succeeded to gain acceptance in academia, it is necessary to mention some important researchers who contributed to this progress beginning in the 1900s.

Before the realm of "design thinking" in terms of its closest epistemological and semantic meaning, John Dewey is another (1859–1952) educational theorist who should be mentioned since his thoughts triggered many discussions about reforms in education and social life. Dewey argues that for effective education, content must allow the student to relate to prior experiences and provide balance among their interests. Dewey’s thoughts influenced many other experiential models at schools, such as problem-based learning, i.e., a method used currently in many educational settings that requires active inquiry and doing.

Some of the earliest scientific design suggestions also came from one of the founders of gestalt psychology, Max Wertheimer. Although his works generally deal with perception, he collects his views on thinking in his seminal book titled "Productive Thinking." Wertheimer separates reproductive thinking from productive thinking. He defines productive thinking as involving

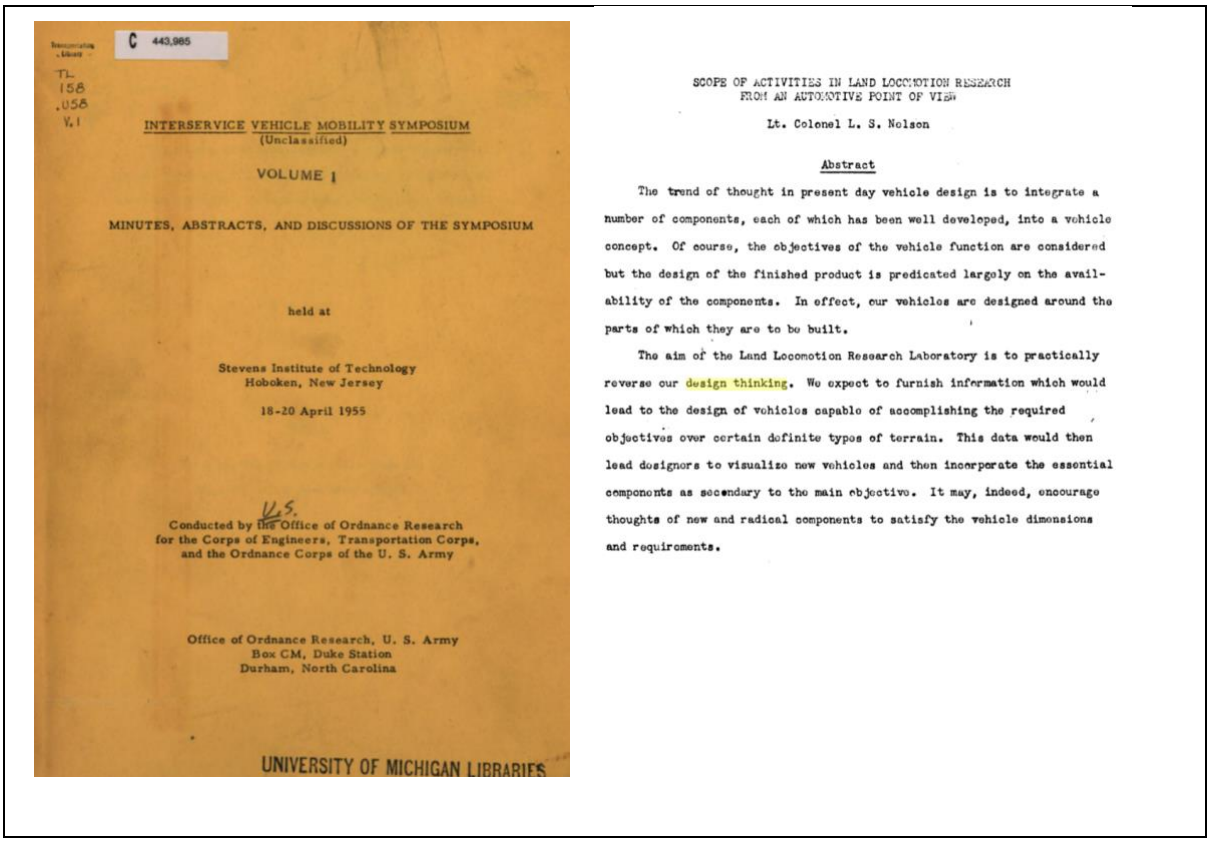
repetition, training, habits, or familiar intellectual territories. Productive thinking, however, is about new ideas and breakthroughs. He believed that logic and creativity were two inseparable parts of productive thinking. He suggested that accepting the given without suspicion can prevent a person from uncovering the solution. His ideas of productive thinking are still assumed to be relevant in modern ideas of schemas, plans, and knowledge structures today.

Before the 1950s, there were some erratic appearances of the "design thinking" term in books or magazines about engineering, naval or employee selection. Figure 3 shows one of these uses of the term "design thinking." Although the use of "design thinking" here refers to a product rather than the process of problem solving, this addition may still be accepted as the distant footsteps of the approaching design thinking storm.

Figure 3: "design thinking" on Motor Boating Magazine, 1944 Vol 74:5

When compared to the previous decade, the prevalence of "design thinking" was higher in the 1950s, but the context in which the term was used was still not very close to its current meaning. Design thinking refers generally to "the way of thinking about design or how they are handling design stages differently from before." DT is not used, nor is it a brand-new methodology for problem solving or a method that requires interdisciplinary teams. The excerpt in Figure 4 is an

example of how DT is used in documents from the 1950s. The abstract of "scope of activities in land locomotion research from an automotive point of view" suggests reversing the order of thinking about design by taking function as a starting point for vehicles that are operable on certain terrains and forming the components of vehicles accordingly.



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INTERSERVICE VEHICLE MOBILITY SYMPOSIUM
(Unclassified)

VOLUME I

MINUTES, ABSTRACTS, AND DISCUSSIONS OF THE SYMPOSIUM

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SCOPE OF ACTIVITIES IN LAND LOCOMOTION RESEARCH
FROM AN AUTOMOTIVE POINT OF VIEW

Lt. Colonel L. S. Nelson

Abstract

The trend of thought in present day vehicle design is to integrate a number of components, each of which has been well developed, into a vehicle concept. Of course, the objectives of the vehicle function are considered but the design of the finished product is predicated largely on the availability of the components. In effect, our vehicles are designed around the parts of which they are to be built.

The aim of the Land Locomotion Research Laboratory is to practically reverse our design thinking. We expect to furnish information which would lead to the design of vehicles capable of accomplishing the required objectives over certain definite types of terrain. This data would then lead designers to visualize new vehicles and then incorporate the essential components as secondary to the main objective. It may, indeed, encourage thoughts of new and radical components to satisfy the vehicle dimensions and requirements.

Figure 4: "design thinking" at Interservice Vehicle Mobility Symposium

In the 1950s, John E. Arnold (B.S. in psychology and M.S. in engineering) began researching the science of creativity to advance engineering and innovative business. He established the Design Division at Stanford University and developed a creative approach to product design together with humanistic psychologists and designers. Arnold's teachings aimed to develop creative designers by developing their thinking modes, attitudes, and attributes. He emphasized that design solutions have to serve people's needs and figured out many different creative techniques and approaches to identify needs related to a specific activity and product. Meanwhile elsewhere, Buckminster Fuller, a designer, inventor, philosopher, and futurist, began teaching Comprehensive Anticipatory Design Science (CADS) at MIT's Creative Engineering Laboratory. Fuller's laboratory studied

systematic methods for generating designs. His methodology was built on experienced teams of innovative engineers, industrial designers, and chemists who wanted to solve global problems like energy, urbanization, transportation, education, environmental damage, and poverty. Fuller's influence still has a lasting impact on generations of designers, architects, scientists, and artists working for sustainability.

The "concept of design thinking" as a methodology is attributed to Herbert A. Simon's book Artificial Sciences in 1969. Simon distinguished design thinking from scientific ways of thinking. According to him, communication is a powerful phenomenon as a scientific research method. Since then, scholars have underlined that communication is one of the main principles of designer thinking and is influential for collaboration. For example, Donald Schön's work on the reflective practitioner arose from his portrayal of design as a technical-rational process. One of the earliest scholars to examine the role of reflection in practice, Schön also pioneered the study of design thinking and stresses the value of integrating theory and experience in the educational process. Learning by doing and doing by experimenting are distinguishing features of design thinking. Designers intertwine doing and thinking in a learning cycle: a "reflective practice about the situation" (Schön 1983), where the positive and/or negative aspects of each solution plan reveal new information and provide an implicit understanding of the problem.

The current understanding of design thinking has some mottos that were not yet defined in the 1960s but will be defined in the coming years. Horst Rittel and Melvin Webber (1973) coined the term "wicked problems"[1] in 1973 to describe social policy, an area in which scientific or engineering methods are inapplicable due to a lack of a clear problem definition and divergent perspectives of social counterparts. Social problems can be solved in different ways depending on

[1] Richard Buchanan brings wicked problems into the mainstream with his influential 1992 paper, "Wicked Problems Thinking in Design."

how they are framed or how different people see them. The resources needed to solve these problems are also subject to change over time, which can make problems unsolvable for ever. One of the strategies to work on wicked problems developed by Kunz and Rittel (1970) facilitates the documentation of the rationale behind a group decision in an objective manner. They called their method an issue-based information system (IBIS) which is an argumentation-based approach to clarifying wicked, complex, and ill-defined problems involving multiple stakeholders. Diagrammatic visualization using IBIS notation is often called mapping. Problem mapping will gain popularity in the coming years, and it will become one of the design thinking mottos: "Think visually or go visually." The conceptualization of thinking in visual terms, i.e., using pictures or spatial relations rather than words, is an intriguing phenomenon in mentality. It is quite useful in terms of design for helping to communicate among group members more effectively than words and preventing miscommunication within the group. Using visual thinking tools as a medium to transfer information between group members promotes empathy, ideation, and prototyping. Moreover, the use of visual thinking is not limited to design; it is an inseparable part of education in general today. Early visual thinking researchers are Robert McKim (1972), a researcher from Stanford, and Rudolf Arnheim (1969) from Humboldt University of Berlin, both of whom made great contributions to the development of visual thinking and consequently design thinking. Robert McKim is also the mentor of David Kelley at the Stanford Design Division.

By the 1980s, the design thinking method had begun to take on its current form. In Kelley's own words, it started when he decided to quit in 1978.

> I got to Stanford, and it was like heaven… I met this guy Bob McKim, who was my mentor, and I studied under him, and all the other guys. The idea that engineering is a creative thing, that it's dreaming up possible futures, trying to understand what people want and give them that, and resonate with people-- that was so different from my electrical engineering training… Although the term used first social issues design problems are also wicked because their frequent ill-defined nature, different perspectives of stakeholder and not having an ideal solution and, then two things happened. I realized I didn't like reading or writing as much as I liked building, and that was a negative. The other thing was that Silicon Valley was booming, and these guys would call Stanford… So, I'd go down and see them, and it'd be fun, and you'd do some medical pipetting device, or it'd be a reading machine for blind people-- that was more exciting than writing a Ph.D. So, I said, "I'm going to quit and do this (Kelley 2000).

The 2000 interview with Kelley has numerous intriguing details regarding the origins of IDEO. Kelley mentions design thinking principles such as ill-defined problems and interdisciplinary teams. IDEO was established in 1991 by David Kelley Design, London-based Moggridge Associates, San Francisco's ID Two, and Matrix Product Design. Since then, IDEO's culture has demanded project teams, a flat hierarchy, individual autonomy, creativity, and collaboration during any product development. IDEO's design ideology is best depicted in "The Deep Dive: One Company's Secret Weapon for Innovation," a segment televised at the ABS Nightline show in 1999 ("IDEO Shopping Cart" 1999). In that episode, IDEO challenged the team to redesign a shopping cart in five days. Afterwards, demonstration of IDEO's innovation process led to the segment becoming part of numerous curricula.

IDEO's statement is an appropriate summary of the evolution of design thinking starting in the 1900s.

> IDEO is often credited with inventing the term "design thinking" and its practice. In fact, design thinking has deep roots in a global conversation that has been unfolding for decades. At IDEO, we've been practicing human-centered design since our beginning in 1978, and took up the phrase "design thinking" to describe the elements of the practice we found most learnable and teachable—empathy, optimism, iteration, creative confidence, experimentation, and an embrace of ambiguity and failure. We knew from experience that our clients valued these skills as much as they valued the designs, we created for them. That moved us to share the mindsets, approaches, and skills of design thinking. You've likely heard the proverb: Give someone a fish, and they'll have food for a day; teach someone to fish, and they'll have food for life. That applies to design thinking. We want to teach people how to use design thinking in their lives, communities, businesses, and organizations ("History" n.d.).

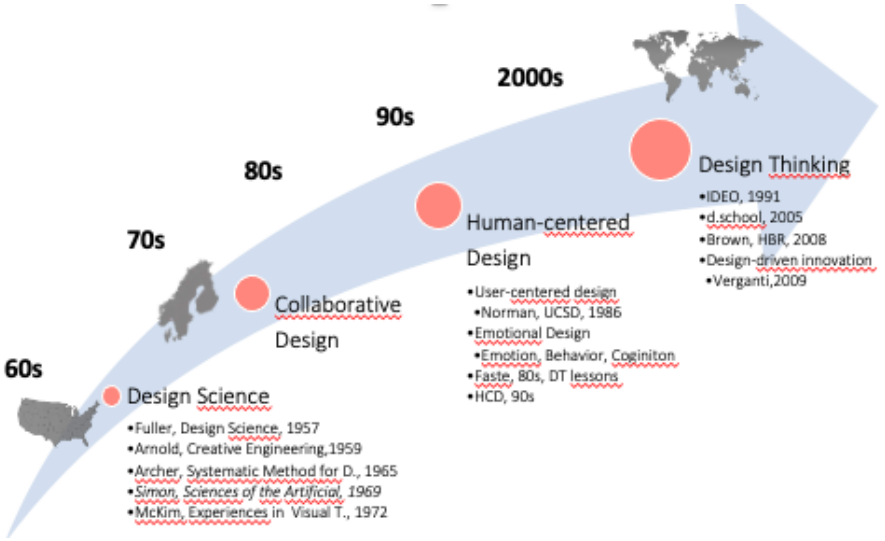

Figure 5: Progress of DT, (Akdemir, 2017).

Today, many educational institutions are fostering the use of design thinking in their research, curriculum, and social services as a medium. Apart from education, there are also other fields where practitioners are using design thinking and encouraging its use in other domains and applications, such as businesses, governmental institutions, or K–12 education. A list is given below to show the diffusion of design thinking into institutions.

- Stanford d.school (https://dschool.stanford.edu/)
- School of Design and Creative Technologies at the University of Texas at Austin (https://designcreativetech.utexas.edu/)
- MIT D-Lab (https://d-lab.mit.edu/)
- Design Factory Global Network (DFGN) (https://dfgn.org/)
- Berkeley Haas Innovation Lab (https://haas.berkeley.edu/ibi/)
- Designmatters at Art Center College of Design (https://www.artcenter.edu/)
- Northwestern's Segal Design Institute (https://design.northwestern.edu/)

Figure 6, a Google Ngram graph, shows how the popularity of design thinking has risen steeply since 2000. It has increased 25 times since 2000 and 50 times since 1980.

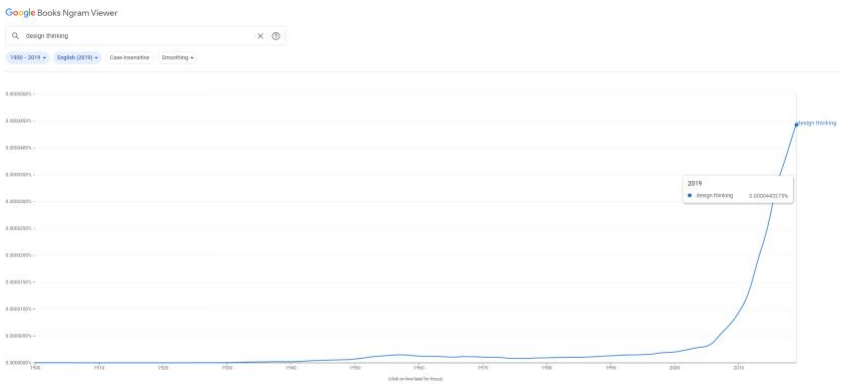

Figure 6: Google Ngram Viewer graph of "design thinking" between 1900 and 2019

A brief history of design thinking has been presented up to this point. In this project, the DT method was used as a new mind-setting tool. Specifically, this project is a quest to transform the learning approach applied in VET into a more collaborative, user-centered, problem-solving attitude and perception. The Design Thinking/Designerly Thinking (DT) paradigm is considered a mindset developed to add value to the VET education process. The goal of educating designerly thinkers by providing them with a design thinking tool and establishing a link between designerly thinking and design thinking may be a wise strategy for achieving this mentality.

2.3 GENERAL PRINCIPLES OF DESIGN THINKING

Digital technologies have greatly increased the number of design options and opened up a world of ways to share knowledge and information. In this setting, we can't ignore how technology and globalization affect design action and the people who take part in it. This influence continued to evolve from the development of desktop publishing in the 1980s, with the extension of the global network in the 1990s, to the opportunities of 3D printing in the 2000s. These transformations have also changed our way of thinking, perspective, and practice. Design has gone beyond its traditional role and evolved into a paradigm to address a wide range of issues, from strategy to social change. In the traditional design process, it can be said that the designers choose the appropriate method in the problem-solving process, and this is a set of creative and inventive solutions. According to Archer, in traditional design, the designer's expertise is the knowledge of configuration, meaning,

value, and purpose in man-made works (Archer 1979). According to Nigel Cross (1982), design is a cognitive function that anyone can perform. What distinguishes the designer, then, should be his perspective on the process. The designer's problem definition, user interaction, problem-solving methods, and creativity create the values of this perspective. Design is not a ready-made information package for problem solving, but rather a cognitive process that must be considered in conjunction with the problem and its ecosystem as a whole. Schön (1983) emphasizes that theory and practice must be combined to form design perception. Brown (2009) also claims that designers should be interested in designing "new processes, services, interactions, games and ways of collaboration" as design practices. Design practice requires different kinds of abilities and competencies, like empathy, problem-solving skills, and creativity.

After the 2000s, design thinking made creativity and innovation everyone's concern. But, at the same time, arguments like "it became a buzzword and its usefulness has been overrated" cannot be ignored. Design thinking can be used in a variety of contexts and by anyone. A recent paper by Laursen and Haase (2019) outlines the possible shortcomings of design thinking when compared to designerly thinking. They examined the literature about "designerly thinking" and "design thinking" and concluded their paper by suggesting that the current design thinking concept needs more methodological practices to guide the problem-solving process. They specified that current tools and techniques are common, not suitable for application, and sometimes not linked with design paradigms. More configured application and evaluation tools and techniques are needed for challenging. "Design thinking' differs from 'designerly thinking' with its systematic approach to building a new mindset from a design perspective. 'Designerly thinking' is about design practices in an academic context, which designers learn through various projects and/or experiences piecemeal during their training (such as user experience, empathy, visualization, and prototyping). DT, on the other hand, is a process-oriented problem-solving method in which these design practices develop a systematic method that is not mainly interested in the result/product/design. DT can act as a bridge between theoretical educational codes and real-world praxis. Thus, it is intended to transform knowledge and indicate the improvement of individual capabilities. Hence,

DT meets several criteria for 21st century skills such as collaboration, interaction, and integration in a holistic constructivist manner.

Cognitive features of design thinking include open-mindedness, non-judgment, and engagement. Diversity, collaboration, perspectives, and experiences are invaluable and often essential for creative problem solving. The DT paradigm is a circular approach for exploring ill-defined problems by acquiring information, analyzing experience, exploring new opinions, and visualizing and prototyping new ideas. Design thinking is principally human-centered, resilient, multidisciplinary, collaborative, flexible in terms of content, optimism and experimental. Together, the design thinking process and mindset offer professionals faced with complex decision-making a unique framework for problem-solving.

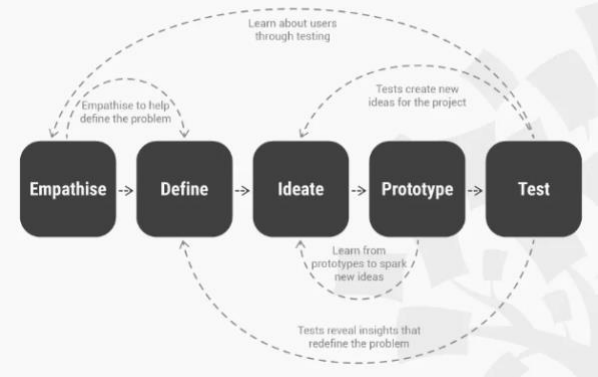

Figure 7: Design Thinking: A non-linear process, Interaction Design Foundation, 2018 (https://www.interaction-design.org/literature/article/stage-2-in-the-design-thinking-process-define-the-problem-and-interpret-the-results)

There are also different views, different approaches, and practices regarding the definition of DT. However, the basic characteristics are; user orientation and participation, sensitivity (understanding and expressing emotions), creativity and innovation, problem-solving, optimism, repetition (process has a circular rather than linear character), and experimentation and integrative thinking, collaboration, visualization ability, evasive reasoning (reaching the truth by reasoning), uncertainty (being comfortable in uncertain situations) and tolerance for failure (learning from mistakes), mixing analysis and intuition (using common sense when predicting the future).

Table 1: Characterizations of Design Thinking (DT) Across Fields, Authors, and Over Time (Svihla 2018)

Design research field characterizes DT (1992)	***IDEO president introduces DT to the business world, 2008***	***Stanford d.school (2012) & IDEO (2011) introduce DT resources for educators***	***Education researchers characterize DT for education research & practice, 2012***	***Design researchers continue to develop nuanced characterizations of DT in practice, 2013***
"how designers formulate problems, how they generate solutions, and the cognitive strategies they employ." These include framing the problem, oscillating between possible solutions and reframing the problem, imposing constraints to generate ideas, and reasoning abductively. (Cross, Dorst, & Roozenburg, 1992, p. 4)	"uses the designer's sensibility and methods [empathy, integrative thinking, optimism, experimentalism, collaboration] to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity." (Brown, 2008, p. 2)	"a mindset." It is human-centered, collaborative, optimistic, and experimental. The "structured" process of design includes discovery, interpretation, ideation, experimentation, and evolution (d.school, 2012; IDEO, 2011)	"analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign" (Razzouk & Shute, 2012, p. 330)	"a methodology to generate innovative ideas." These include switching between design tasks and working iteratively. (Rodgers, 2013, p. 434)

Though there is no consensus among prominent researchers of design thinking on its precise definition and how the process should be implemented, Jeanne Liedtka compares the role of design thinking to that of the scientific process and says, "The most fundamental difference between [design and science] is that design thinking is primarily concerned with what does not yet exist, while scientists struggle to explain what happened (2000)." Therefore, although both methods of thinking are hypothesis-based, the design hypothesis is different from the scientific hypothesis (Liedtka 2000). While describing the DT method, Brown (2008) expresses a designer sensibility. However, he says that it is not clear what this sensitivity consists of or whether a similar sensitivity will occur in non-designers. Norman (2000) defines design thinking as a provocative way of looking at designerly thinking. It emphasizes that knowledge is structured by experimenting and applying it; the process is human/user-centered; it develops learning-to-learn skills; and the concept of lifelong learning serves as a facilitator. There is no consensus among prominent proponents of design thinking on its precise definition or how the process should be implemented. So, what is special about design thinking? How is it different from other types of thinking? Answering these questions requires reconsidering and rethinking some of the accepted beliefs about thinking itself. How exactly does design thinking achieve this?

Contemporary design thinking was popularized by IDEO and the Stanford School of Design. According to Brown, Katz, and IDEO, DT consists of three main phases: inspiration, idea generation, and content implementation. However, although the operation logic is approximately the same, there are also different approaches to how the stages are named and grouped. These do not change the main principles and purpose of DT; they only reveal the differences in the application at the learning stage. It is quite possible to liken the DT approach to Wagner's (2008) seven survival skills that must be included in education to become "knowledge workers" in the 21st century. These are: critical thinking and problem solving; network collaboration and influence leadership; agility and adaptability; innovation and entrepreneurship; effective oral and written communication; accessing and analyzing information; and curiosity and imagination. Luchs et al. (2016), Stickdorn and Schneider (2011), and the British Design Council also highlight the importance of exploration.

The approach adopted by IDEO and institutionalized in Stanford's d.school has generally been reduced to five 'modes'. Empathize," "Define," "Think," "Prototype," and "Test"). Based on this framework, other organizations have also presented the design thinking method as an extended five-step process: (1) empathy or exploration, where the goal is to understand the target audience you are designing for; (2) define or interpret that includes identifying the individual's perspective and needs; (3) possible idea generation, which involves brainstorming to generate as many creative solutions as possible; (4) a prototype or experiment where a potential solution is generated; (5) testing or development involving sharing the prototype with target users for feedback.

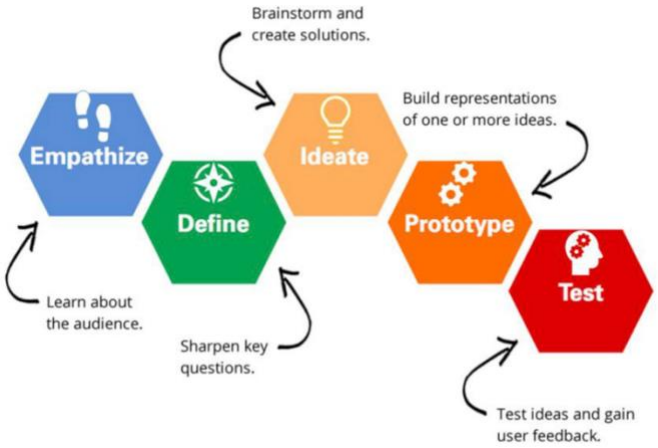

Figure 8: Design Thinking process derived from IDEO and d.school approach. Source: (Hoover 2018).

Believing that everyone has a creative capacity and will produce innovative results by directing it, the d.school defines four main working principles:

1. Unconditional Cooperation: It establishes collaborations by bringing together academics, students, and other stakeholders from different disciplines, and the different perspectives arising from these collaborations enable students to produce different designs.
2. Real project suggestions for real problems: problems that arise in the partnership of non-profit, corporate, and/or government institutions turn into solutions from the perspectives of students who want to make an impact on the world.
3. Unlimited problems: In real life, the solution to a problem is not always the only solution. Therefore, collaborating students can see many problems and different solutions through trial and error and taking risks.
4. Voluntary participation: Any student or academic can participate in this environment. Every individual who is a part of these studies is here if they want to. There is no obligation.

In a Harvard Business Review article, Tim Brown (2008) describes what is needed to make Design Thinking part of the innovation drill.

> "**Begin at the beginning.** Involve design thinkers at the very start of the innovation process, before any direction has been set. Design thinking will help you explore more ideas more quickly than you could otherwise.
> **Take a human-centred approach.** Along with business and technology considerations, innovation should factor in human behaviour, needs, and preferences. Human-centred design thinking – especially when it includes research based on direct observation – will capture unexpected in- sights and produce innovation that more precisely reflects what consumers want.

Try early and often. Create an expectation of rapid experimentation and prototyping. Encourage teams to create a prototype in the first week of a project. Measure progress with a metric such as average time to first prototype or number of consumers exposed to prototypes during the life of a program.
Seek outside help. Expand the innovation ecosystem by looking for opportunities to co-create with customers and consumers. Exploit Web 2.0 networks to enlarge the effective scale of your innovation team.
Blend big and small projects. Manage a portfolio of innovation that stretches from shorter-term incremental ideas to longer-term revolutionary ones. Expect business units to drive and fund incremental innovation, but be willing to initiate revolutionary innovation from the top.
Budget to the pace of innovation. Design thinking happens quickly, yet the route to market can be unpredictable. Don't constrain the pace at which you can innovate by relying on cumbersome budgeting cycles. Be prepared to rethink your funding approach as projects proceed and teams learn more about opportunities.
Find talent in any way you can. Look to hire from interdisciplinary programs like the new Institute of Design at Stanford and progressive business schools like Rotman, in Toronto. People with more-conventional design backgrounds can push solutions far beyond your expectations. You may even be able to train non-designers with the right attributes to excel in design-thinking roles.
Design for the cycle. In many businesses, people move every 12 to 18 months. But design projects may take longer than that to get from day one through implementation. Plan assignments so that design thinkers go from inspiration to ideation to implementation. Experiencing the full cycle builds better judgment and creates great long-term benefits for the organization."

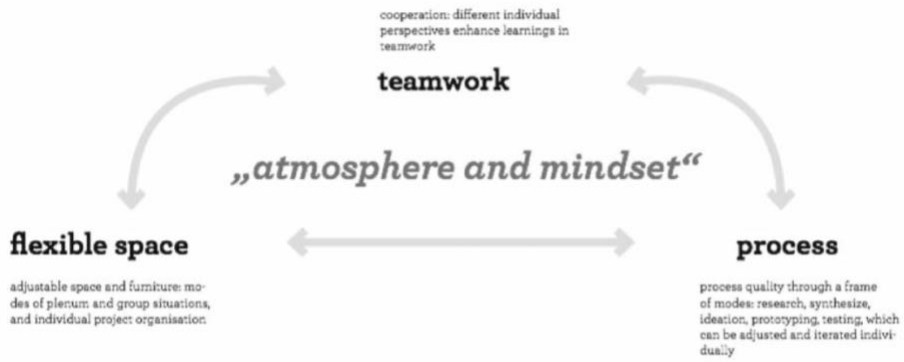

Figure 9: Core Elements of Design Thinking (Barrasch, 2012).

DT is by nature a reflective and creative process. The participant plays an active role in the problem-solving process. This practice is experimental (learning), team-working (collaborative), and realistic through analysis, synthesis, thinking, and doing (reflective), changing one's perspective to the most appropriate context (transformative). The facilitator helps participants move through the design thinking process by thought and action. He creates the design thinking

ecosystem (communicative), allows learners to be self-directed, is human-centered (humane), uses doing and learning to develop skills (practice-based), action and testing (cognitive), acknowledges interaction and empathy (social constructivism), and builds new experiences personally and through interaction (constructivist). As we consider DT as a process/method/mentality/mindset in DT4VET, we can summarize its basic elements;

Human and user-centred and co-creative: building of empathy to understand people's needs and motivations. It involves users and other stakeholders in the development process.

Multidisciplinary, collaborative and holistic: Collaboration with other sectors and organizations is normal and helps to reach a more holistic picture and a functional solution.

Solution-oriented and optimistic, reframing problems: The aim is to find the real underlying root problem and the most suitable solutions for that time. The focus is on the solution.

Sequential and iterative: The service design process forms of smaller consecutive phases, each with its purpose, that aim towards the solution. The process can iterate back to a previous phase or phases if needed.

Experimental: Ideas, concepts and prototypes are tested during the development phase. This helps save resources, eliminate faults and developing better solutions, and gives insight into how people use and approach services.

Visual and analytic: Design Thinking methods are often visual. This helps analyze information, see connections and the process, and concretize the work.

Divergent and convergent

Spontaneous: goal-oriented and working under pressure and within constraints.

Playful: It uses creativity, playfulness, risk-taking and dualistic reasoning

2.3.1 DESIGNERLY WAY OF THINKING

The DT approach is an ideal method to create a new mindset and mentality. It involves assigning learners to enable them to think and work like designers, be empathetic to people's needs, support multidimensional values, not be afraid of making mistakes, seek solutions to problems, and be

open to different ideas. The concept behind design thinking is the development of innovations, which is what the term "design" refers to; a methodical investigation of the practicality of real-life problems while applying designers' techniques and methodologies, which is what "thinking" refers to. It should be underlined that this project is not about design and design education directly. Design Thinking Uses and Process;

- Uses: products, services, company, and process development; tangible and intangible things.
- A product development process of usually 3-6 phases
    - Identifying the problem
    - Gaining insight into the problem
    - Ideation for the problem
    - Concepts and prototypes
    - Testing and evaluation
    - Finalization
- Each phase has a set of tools, e.g. Persona maps, and journey maps.
- Plenty of examples of existing pross models.

Design Thinking is a mindset that is constantly looking for solutions to user needs. It prioritizes being environmentally, socially, economically, inclusive, and effectively sustainable. The practitioner is capable of explaining his thoughts and ideas to partners both verbally and visually. He is always aware of the big picture and thinks outside the box while concentrating on its elements. He is ready for teamwork, dissimilar ideas, and interaction. He is used to teamwork, different ideas, and interaction. He is not afraid of unsuccessful solutions; he always perceives this as an opportunity and focuses on alternative solutions.

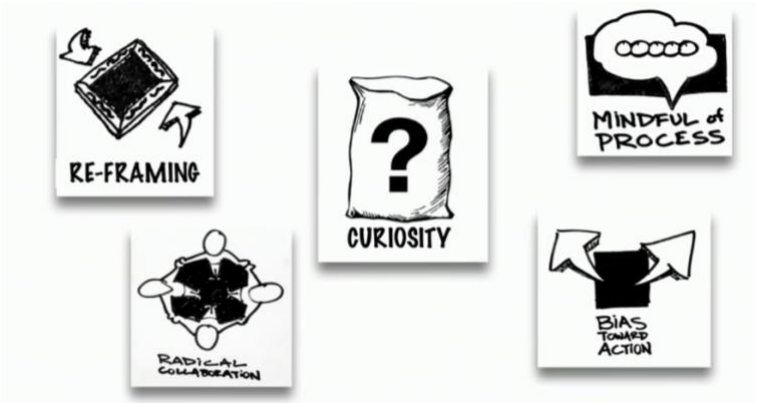

Figure 10: A culture of mindsets, Stanford d.school, 2018.

Design Thinking is a **method** and a **process** for…

- investigating and solving open and ill-defined problems,
- acquiring and analyzing information,
- identifying opportunities for innovation,
- deepening empathy,
- experimenting with new perspectives,
- visualizing and materializing new concepts.

…that can be applied to any sector.

Both method and process require a certain **mentality and mindset**, a designerly way of thinking and doing.

- Finding the root problem, clarity
- Increased usability and user-orientation
- Lowering costs and saving resources
- Finding new solutions. For example, a gap to find business ideas or for student development, learning, and discovering one's own skills and strengths.
- Design Thinking as a strategic tool
    - Increased competition
    - Increasingly complex, uncertain, and unpredictable world, no straight-line solutions
    - Innovation policies, Creativity and design

3 ANALYSIS OF DESIGN THINKING MODELS

This part aims to summarize the findings and analyze the existing Design Thinking tools and courses for the development of DT4VET training. Among these, five educational toolkits and five toolkits for innovation were examined. These were mainly analyzed based on their approach to DT methodology.

Design thinking is best for "thinking outside the box" of all design processes, accordingly helping teams' performance in idea development, UX research, and prototyping to explore a new way to meet user needs. Experts can also use Design Thinking to build a solution and gain a competitive advantage. As underlined in the previous sections, Design Thinking is often used to solve wicked or ill-defined problems, generate tangible, creative, and long-term solutions to real-world problems, and improve the end-user experience. In the 21st century, organizations from different businesses see design thinking as a valuable tool to solve users' problems with their services and products. Design thinking is a method and process that can be applied to any sector, like products and services, financial processes, enterprise and start-up development, education and studies, everyday life, etc. DT concerns a wide range of topics such as marketing, product development, health, etc. The DT methodology for various themed problems is the same, but the approaches may differ from each other. Apparently, different approaches can be implemented for different problems. It makes things more logical and easier to digest. Analogies can be used often, and the methodology requires multi-disciplinary collaboration, as mentioned above.

The process conceptualizes phases that allow participants to generate analysis, synthesis, and common sense from different issues through drawing, prototyping, and scenario building. The essence of design thinking is to put learners in contexts that enable them to think and work like expert designers, thereby promoting literacy, empathy, cultural awareness, and risk-taking (Sharples et al. 2016). In the design thinking process, the facilitator encourages students to see constraints as a source of inspiration (Brown and Wyatt 2010). The results are typically not a technological "quick fix" but new integrations of signs, objects, actions, and environments (Buchanan 1992).

There are various DT Toolkit models that have been applied by researchers, companies, and institutions, especially for innovation. In total, these provided over 1000 tools, some of which overlapped between different toolkits, and some of which were used differently in different phases of the DT process. DT Toolkits mostly have a common approach and process. In short, design thinking is based on a set of principles. These principles also form the basis of the design

thinking toolkits that we explore in depth in this chapter. Below are six of the most fundamental design thinking principles. Although the names of the phases and the organization vary, the toolkits were structured on the basic DT process, beginning with exploring the topic and gaining insight into ideation, prototyping, and testing. There are many DT models that have been published and applied by various academics, companies, and councils. These models were built up with numerous scenarios for different challenges. They have a product development process of usually 3-6 phases, which are: (1) identifying the problem, (2) gaining insight into the problem, (3) ideation for the problem, (4) concepts and prototypes, (5) testing and evaluation, and (6) finalization. These toolkits are typically used to create tangible and intangible things such as products, services, businesses, and processes. They have a set of tools for each phase.

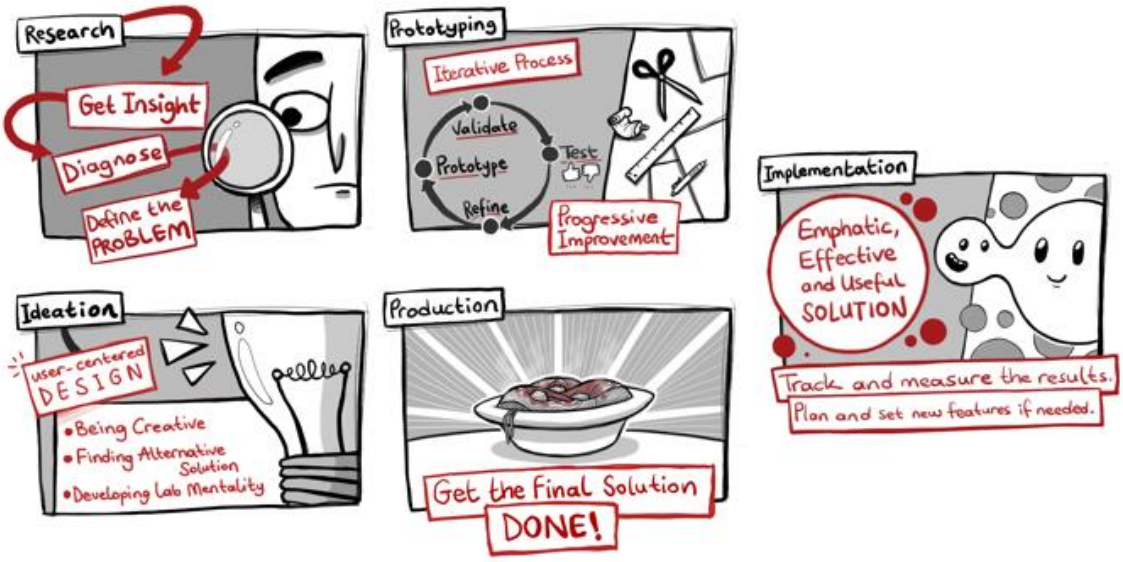

Figure 11: Design Thinking Phases, BFE Project, 2018

3.1 COMMON PHASES OF THE DESIGN THINKING PROCESS

Design thinking often focuses on a project, problem, or situation. Although models often overlap and it is simple to incorporate design thinking into project-based learning, frameworks have different purposes and frameworks. These stages may vary according to the purpose and usage

area of the toolkits. In this section, the research is based on the common stages of the toolkits that are generally known and used.

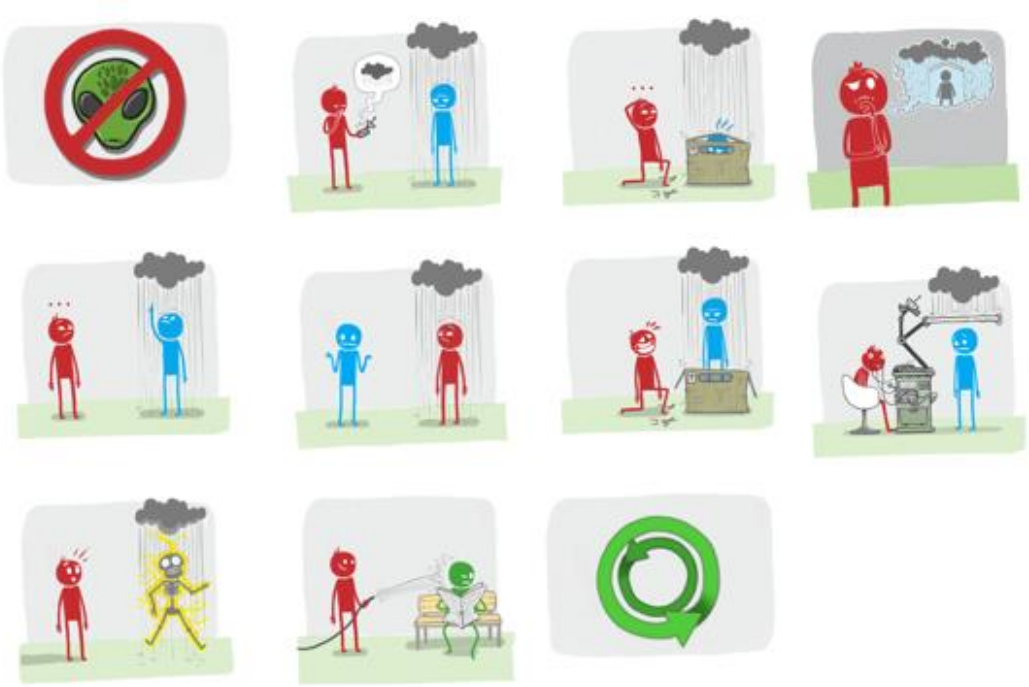

Figure 12: Design Thinking Process, BFE Project, 2018

Empathize: Developing an end-user experience for new users is one of the goals. Design Thinking is user-oriented, and this phase is a must for every Design Thinking Toolkit. In this phase, research is conducted to develop data about what users do, say, think, and feel about the problem. At this stage, interviews can be conducted with real users or/with user focus groups. The facilitators guide the participants to recognize the problem with observation and empathy techniques and monitor their motivation and experience. Such inquiries as what they do, how they think, and what they want are directly observed, and data about user motivation, experience, and usage patterns are obtained. The aim is to gather sufficient information about the user and his/her impression of the

problem/product/service/idea. Putting yourself in the shoes of your target audience and providing clarity for them is an important part of the process.

Define: At this phase, the data collected during the empathy phase are analyzed to define a problem framework. Common sense, form/function specifications, and usage scenarios begin to emerge. From a human-centered perspective, the relationship, connections, and interaction between various user experiences are interpreted into a problem definition.

Ideate: This phase is used to make scenarios, create personas, generate ideas, and find the best approach to solving the problem. Various techniques like brainstorming and creative thinking are encouraged in this phase. At this stage, a wide range of idea generation techniques can be employed. The facilitator guides the teams to develop ideas freely, away from definitions such as mistake, wicked, or imperfect. Team members work collaboratively on various ideas, visualize them, and share them with each other. As design thinking is a problem-solving framework, the goal is to generate as many ideas and potential solutions as possible. Ideation is a fundamental concept in design thinking as well as the process itself. The ideation phase is a designated judgment-free zone where participants are encouraged to prioritize quantity over quality of ideas.

Prototype: This phase is where ideas are represented and made tangible. The prototype can be tested by the design team or a small group of people outside the design team. Because design thinking is an iterative process, this is also the evaluation phase. The design team will iterate on or finalize the design process according to user input.

Test: The final step in the Design Thinking process is to redefine the problems. Corrections and modifications can be made here. Users can be revisited for feedback on whether their needs are met.

These five phases are the most commonly accepted and applied phases in a Design Thinking effort to solve any innovative problem. The simplest and most difficult part is the mindset, mentality and keeping the mind open.

- Going back to the roots
- Most of us apply design thinking or its elements and aspects in some activities
- Product (service, process, etc.) development method)
- Using common sense
- Simple questions
- Visualising
- Connecting the dots
- Being organized and creative

3.2 OCCASIONALLY USED DESIGN THINKING PHASES

Implementation: As Don Norman underlined, "we need more design doing." The success of design thinking lies in its ability to transform an aspect of the end user's life. Design thinking is influential for an organization if it leads to a real innovation, a product, or a service.

Flexibility: This phase provides scaffolding support for the Design Thinking process as needed. DT is iterative by nature; it is circular, meaning it is usual to go back to the define or ideate phases even after the initial prototype has been built. This phase is helpful to prioritize and make new decisions in the development process.

Interdisciplinary/Meta-Disciplinary Collaboration: The phase aims to bring together different areas of expertise and utilize concepts and toolsets from all fields to analyze, synthesize, and generate insights and new ideas (Melles, Howard, and Thompson-Whiteside 2012). In fact, collaboration can be an essential necessity for the Design Thinking process. Design thinking supports collaboration across diverse, multidisciplinary teams that might not normally collaborate.

Reducing Cognitive Bias: According to Liedtka (2015), people often project their own perspective on the team, creating limitations on these choices, and may ignore data that he/she does not approve. Design thinking practices reduce cognitive influence similar to these and provide the desired result.

Increasing Resilience: Design thinking supports participants' ability to perceive constraints as opportunities. For example, different team members will have different backgrounds and experiences, and discussions arising from interfering ideas will lead to reunion and eventually reconciliation.

Generating Surprising and Enjoyable Solutions: According to Elsbach and Stigliani (2018), the use of design thinking tools can result in surprising and pleasing emotional responses. In the design thinking approach, there is no right or wrong, better or worse solution.The process is open-ended, and the number of solutions can be many.

Improving Creative Confidence: DT also allows non-designers to be confidently involved in the creative process. Thus, participants perceive themselves as effective and ready to act as players in the problem-solving process.

Critical Thinking/Problem Solving: Design thinking reminds you that you are already a critical thinker and problem solver. It gives you a framework for how to solve complex problems. It encourages you to examine and test any propositions presented.

Adaptability: The Design Thinking approach trains for adaptation to change. Challenging circumstances, stimulating environments, and acceptance of new ideas are some of the key characteristics of design thinking. With its unpredictable nature, it is quite appropriate for innovation.

Skill Setting: Skills have often been the topic of discussions about education. The 21st century skills are discussed now. The importance of design-oriented thinking also emerges. DT's most affected and changed skills are critical thinking/problem solving, creativity, and collaboration.

Reflection: Reflection is the central aspect of the iterative working process in design thinking. Constructive questioning about the context, decisions, six whys, process, and progress allows you to gain feedback from yourself.

Learning to Learn: Learning to learn engages learners to build on prior learning and life experiences in order to use and apply knowledge and skills in a variety of contexts […]. This competence includes awareness of one's learning process and needs, the ability to identify available opportunities, and the ability to overcome obstacles to learn successfully (European Parliament 2006).

3.3 DESIGN THINKING MODELS

There are numerous Design Thinking methods. The models and tools used in this study were chosen based on their applicability to the context. Many different models and activities have been defined by research groups and firms since the spread of Design Thinking as a methodology to foster innovation and product development, with subtle discrepancies and overlaps. There are many factors that influence the steps of design thinking, for example, the formation of the team, the focus of the problem or consumer/user needs, the available time to develop a prototype, etc. The wide application area of design thinking in industry, business, or education diversifies the design thinking tools on the surface but makes them alike in the depths. The methodology and the tools of design thinking, which are not written in stone, can be modified according to the immediate needs of the situation by the experts in the area.

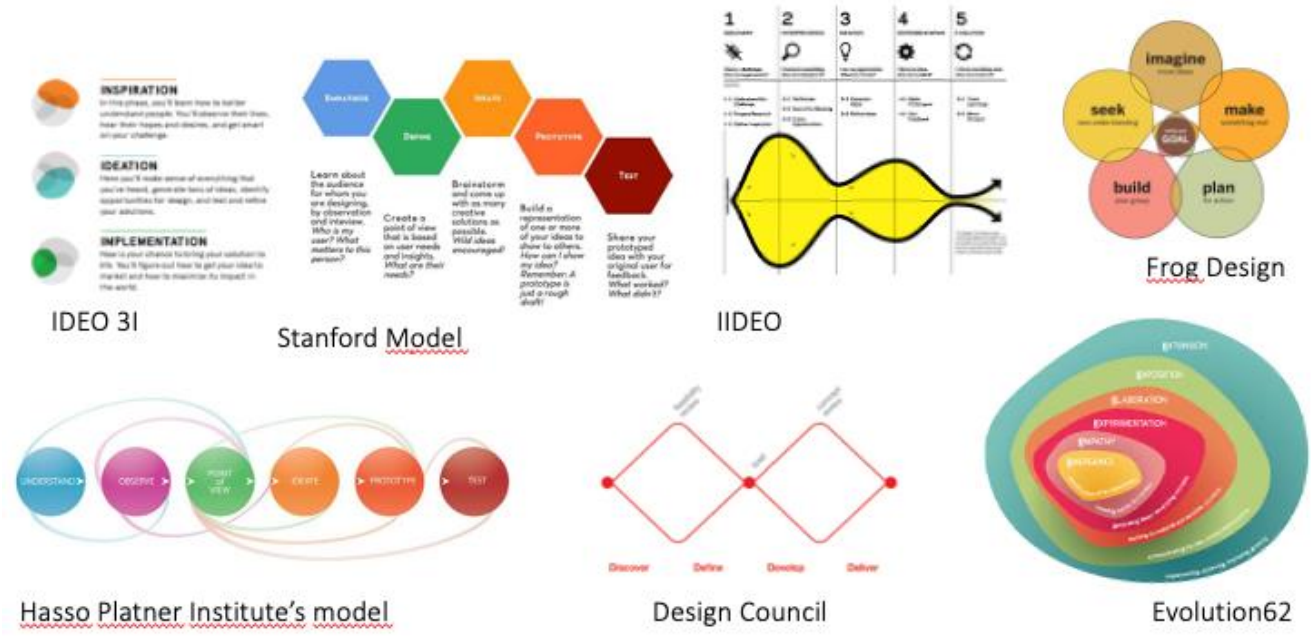

Figure 13: Most Common used Design Thinking ToolKits, DT4VET, 2022

The DT Toolkits that are utilized the most frequently all share some features in common. Briefly, these are changing the mind and mentality, being ready to explore, observing everyone's experiences, and transforming the obtained knowledge into practice.

Thom (2016) reviewed 15 well-known and most-used DT models according to five DT phases. Table 2 displays the overlapping characteristics of these models. The grouping of the processes from the 15 models in Table 1 reveals that the framing phase contains 26 processes, the ideation phase contains 16 processes, and Thom's research emphasizes that the number of processes in the framing stages is greater. When examined, it becomes clear that the models discussed are of primary importance to exploring and understanding the problem and context, which is the basic stage of DT. The processes are reduced at the framing to implementation stage because a synthesis has been made from the idea development stage to the solution.

Table 2: DT Models derived from Thom (2016)

MODEL	STEPS IN PROGRESS						
Human Centered Design Toolkit (IDEO, n.a.)	Hear	Create	Deliver				
Acumen HCD Workshop (Acumen Fund, n.d.)	Discover	Ideate	Prototype				
Design Thinking - Business Innovation (Vienna, Vienna, Adler, Lucena, & Russo. 2012)	Immersion	In-depth immersion	Analysis and synthesis	Ideation	Protoyping		
Design thinking (Cross, 2011)	Quantify problem	Generate concepts	Refine concepts	Select a concept	Design	Present	
Design thinking for Educators (IDEO, 2012)	Discover	Interpretation	Ideation	Experimentation	Evolution		
Basics Design 08 Design Thinking (Ambrose, 2010)	Define	Research	Ideate	Prototype	Select	Implement	Learn
Double Diamond (Design Council, 2015)	Discover	Define	Develop	Deliver			
IDEO (Myerson, 2001)	Observations	Brainstorming	Rapid prototyping	Refining	Implementation		
Leading Public Sector Innovation (Bason, 2010)	Knowing	Analysing	Synthesising	Creating			
Service Design (Stickdorn & Schneider, 2011)	Exploration	Creation	Reflection	Implementation			
Collective Action toolkit (Frog, 2013)	Seek	Imagine	Make	Plan	Build		
Bootleg Bootcamp, (dschool, n.d.)	Emphatize	Define	Ideate	Prototype	Test		
dSchool (dSchool, 2009)	Understand	Observe	Point of view	Ideate	Prototype	Test	
Designing for growth (Liedtka & Oglivie, 2011)	What is?	What if?	What wows?	What works?			
Business Model Generation (Osterwalder, Pigneur, & Clark, 2010)	Mobilise	Understand	Design	Implement	Manage		

Framing phase, investigates and develops an understanding of the context and the problem.

Idea generation phase, develops and documents ideas that can assist in providing a solution or lessens the impact of the context or problem.

Prototyping phase, creates an example or prototype of the solution to enable experimentation and further development of the solution.

Implementation phase, is about planning for and implementing the solution to enable testing and collecting of feedback by the users about the proposed solution.

The reframing phases, are used to check the validity of or changes in thinking, identify shifts or changes in focus, monitor changes in the context or problem and ascertain learning progress or needs.

3.4 REVIEW OF DESIGN THINKING MODELS

There are many toolkits available on the Internet today, whether they are protected by copyright laws or have creative commons licenses that allow them to be used freely with appropriate citation of the original sources and without commercialization. During the DT4VET project, an online review is conducted to identify available toolkits using open sources. The search results revealed a number of toolkits on the web, prepared as documents with proper explanations, including how-tos, and aiming to be an online hub serving trainers or trainees as valuable sources or design thinking tools. The purpose of reviewing those toolkits is to explore the variability of the toolkits, demystify overlaps, and name differences among the activities.

The toolkits, which (i) are available from open sources, (ii) have a design thinking approach, (iii) classify stages, and (iv) have activities explained properly, have been included in the data set. The visited sites and addresses are given below. But when copyright and ethical issues are taken into account, the results observed during visits (as of June 2022) are not presented; only general numbers are given.

Table 3: The list of DT toolkits reviewed by the DT4VET Project

Site Name	Site Address
Design Thinking Methods Catalogue by .MST	https://designthinking-methods.de/en/
18F Methods, An official website of US Government	https://methods.18f.gov/ (Human-centered design)
UX Planet One-stop resource for everything related to user experience	https://uxplanet.org/the-design-thinking-toolbox-100-tools-to-create-innovative-products-50ede1f5e3c1
This is service design doing	https://www.thisisservicedesigndoing.com/methods
DesignKit by IDEO	https://www.designkit.org/methods
Open Design Kit	http://opendesignkit.org/
IBM ToolKit	https://www.ibm.com/design/thinking/page/toolkit
Google Design Sprint	https://designsprintkit.withgoogle.com/methodology/overview
Product Discovery Methods	https://pdmethods.com
Design Thinking For Libraries	www.designthinkingforlibraries.com
SessionLab, facilitator guides	https://www.sessionlab.com/library/

The review showed that the design thinking methodology is well understood by almost the entire community. They have a good sense of design thinking's underlying assumptions, such as teamwork, empathy, prototyping, testing, defining, deciding, etc. And there are many tools—whether generic or unique—that fit well with each phase's aims. There are almost 500 different phase and activity names given at the sites mentioned above; excluding the session lab, they have more than 1500 activities in their own library.

When phases or stages are taken into account, excluding activities, there are more than 80 phases/stages. But a closer look shows that those 80 stages with different names can be grouped if generic names are preferred; these are (in alphabetical order) Define, Fundamentals, Ideation,

Prototype, Team, Test, and Understand. The table about generic stages, original stage names, and the number of activities in those stages is given below.

Table 4: The generic stages, original stage names and the number of activities in the DT tool strategies

Row labels	Count of ACTIVITY
Define	**142**
Confirm the problem	3
Decide	23
Define	26
Define the user problem you want to solve	14
Explore	3
Identify possible solutions	10
Implementation	15
Narrow the field	13
Plan your work	4
Research	22
Sketch	5
Synthesize research	4
Fundamentals	**3**
Fundamentals	3
Ideation	**107**
Brainstorm to generate solutions to your challenge	28
Generate new ideas	3
Ideate	8
Ideation	45
Inspiration	23
Prototype	**53**
Make	6
Prototype	16
Prototype and fail fast	17
Prototyping	14
Team	**26**
Align your team	2
Check-in activities	4
Facilitation	4
Icebreakers	16
Test	**48**
Create tests	3
Pivot on learnings	6

Test	1
Test your ideas	1
Test your prototypes and iterate	6
Validate	15
Validate with users	10
Testing	6
Understand	**100**
Discover	10
Empathize	7
Reflect	10
Understand	18
Understand customer needs (empathy)	27
Understand the opportunity	4
Understand the problem	10
Understand the user	14
Grand total	**479**

3.5 DESIGN THINKING TOOLKIT ANALYSES

The aim of this report is to provide information about and analyze existing Design Thinking tools used in education. The tools presented in this complementary report to the report of over 1000 design thinking tools listed aim to look into the educational structure of a set of educational practices applying design thinking. The tools analyzed in this report are:

1. CreaCIT/ CreativeMe Journal
2. Design Camp
3. InnoTAL: design thinking module
4. Edukata
5. DTHINK (Design Thinking Applied to Education and Training; Erasmus+ project number 2014-1-PT01-KA200-001075).

3.6 AN OVERVIEW OF THE SELECTED TOOLS

3.6.1 Target group

All five practices are addressed to non-designers from different sectors. Three of them, CreaCIT/ CreativeMe Journal, DesignCamp, and the design thinking module of the InnoTAL project, are addressed to higher education students, while Edukata is for all non-designers and teachers, and DTHINK is addressed to higher education teachers.

3.6.2 The main objective of these tools

1. CreaCIT/ CreativeMe Journal
   Multidisciplinary product development based on the design thinking process and using designerly thinking, though design thinking tools are not used directly.
2. Design Camp
   DesignCamp is a multidisciplinary, intensive course for higher education students that brings together businesses and students. Between June-August, a team of six multi-disciplinary students work on projects commissioned by six Ostrobothnian SMEs. The process is supervised by experienced designers.
3. InnoTAL: design thinking module
   The Design Thinking Introduction module helps students understand what Design Thinking is as a concept, as well as the process, methods, and tools that are used, and how we can use the design perspective to solve a problem. The goal of the module is to help students and the university as a whole be more creative.
4. Edukata
   Edukata is a way for teachers to show how to lead a collaborative design process with other teachers and students at school.
5. DTHINK
   Design Thinking (DT) tool to entrepreneurs and higher education teachers so that they can use DT to redesign their education.

3.6.3 The solution's methodology

3.6.3.1 CREACIT/ CREATIVEME JOURNAL

CreativeMe is a creative and cross-disciplinary e-learning environment for user-centered product development. It is based on constructive pedagogy and learning by doing. The training uses creativity, designerly thinking, narration, and visuality. The learning is organized around three different sector-agnostic fields that are organized around the design thinking process, but no specific tools are used. Learning is structured on three levels (a, b, and c), which gradually increase the level of difficulty and complexity while teachers' support reduces. Creativity is embedded in scenarios.

3.6.3.2 DESIGN CAMP

The planning and initial phases of the project:

- Meetings with rectors and study counselors, calling for students, and selecting and interviewing students, and the final selection of students.
- Call for SMEs and selecting-recruiting SMEs
- Beginning and running the DesignCamp during the summer
- Closing, final workshops and reporting.

The student-company cooperation includes several steps. Experts meet the participating companies in May to go through the process and discuss their needs, challenges, and wishes. Based on the meeting, the experts wrote a description of the commission for each company. These were revised by the participating companies. The written descriptions were used to combine the needs of the companies with the skills, know-how, and backgrounds of the students.

Background survey and education (June 2012): After giving company cases to students, students started the work with a background survey—an investigation on, e.g., the state-of-the-art and aims of the companies. A competitor survey and user interviews were also part of step two. The latter assisted in creating 'user personas'.

The results were presented to companies. Together, students and companies, with the help of the experts, agreed on the further focus of the process and the next steps.

The second step included most of the lectures and education. These focused on understanding users' and consumers' behavior, project work, design processes, product development, idea generation techniques, and service design.

Idea generation (July 2012): common idea-generating sessions for the cases. The experts assisted students in selecting appropriate idea generation methods for each company project. The ideas

developed into concepts were again presented to the companies. Companies and students together selected the ones for further development.

Conceptualizing (August 2012): Finalizing and visualizing the selected concepts.

Final presentation event (31.8.2012) where the final results were presented to companies and stakeholders. Participants: companies, students, experts, representative of the city of Vaasa and Vaasa University of Applied Sciences.

3.6.3.3 INNOTAL: DESIGN THINKING MODULE

The study module consists of basic information on design thinking, and participants work on a case using design thinking tools.

3.6.3.4 EDUKATA

Edukata is a model for educators to facilitate a participatory design process in collaboration with other educators and students at school. The design process starts with a scenario—an innovative and challenging idea of what learning and teaching could look like in the future. Scenarios are inspiring, but turning them into realistic classroom practices is often not easy. Through the design process, you will take the scenario and design new learning activities and detailed descriptions of how to perform learning and teaching in the classroom that incorporate new ideas, techniques, teaching methods, and tools into upcoming courses and lesson plans. This guide explains how to do that by presenting the Edukata model. It is primarily written for educators and certified Edukata facilitators, but everyone is warmly invited to use the guide and to practice participatory design based on the Edukata model.

3.6.3.5 DTHINK

D-THINK toolkit targets teachers of higher education institutions and entrepreneurships.

- Conduct research on Design Thinking in education and training to identify its role within these sectors, identify training trends, and, based on the research, identify new avenues and approaches to teaching, training, and learning using Design Thinking. The research results were summed up in a research report and harnessed for the development of the following main outputs and parts of the methodology.
- The development of a Design Thinking toolkit for education and training to function as a practical guide for teachers and trainers to redesign and plan their training/teaching, learning spaces, and evaluation.

- The D-THINK Digital Course provides Design Thinking training for higher education and entrepreneurship educators. The online course provides them with the tools and competences to use DT in education. It also provided space for reflection. It is based on information about design thinking and working on a case using the DTHINK toolkit.

D-THINK training material and toolkit for teachers to use in teaching in entrepreneurship and higher education follows the following steps:

a) setting the learning
   - Scenario 1 Setting the Pedagogical Framework
   - Scenario 2 Setting-up and Revising a Curriculum Context

b) Conceiving the Learning
   - Scenario 3 Developing Contents
   - Scenario 4 Setting the Assessment Context

c) Facilitating the Learning
   - Scenario 5 Designing the Learning Spaces
   - Scenario 6 The Role of Facilitator

These were created in the framework of the D-THINK project (Design Thinking Applied to Education and Training; Erasmus+ project number 2014-1-PT01-KA200-001075). The aim of the D-Think project was to "promote a wider use of Design Thinking as a transversal learning tool by developing and making available an innovative digital course supported by mobile learning for education professionals and professional trainers." (D-Think website) to prepare higher education and entrepreneurship teaching and training staff to better prepare education and students to respond to the future labor market and entrepreneurship.[2]

3.6.4 The active players of these tools (Partners, stakeholders, NGO's, educators, academics, researchers, policy makers, etc.)

1. CreaCIT/CreativeMe Journal:
   - TG: students and teachers of higher education and vocational secondary education
   - Stakeholders: companies, organizations, and the general public through learning cases.
2. Design Camp
   - TG: non-design students of higher education

[2] Website of the project: http://www.d-think.eu/
D-THINK toolkit online: http://www.d-think.eu/uploads/1/6/2/1/16214540/dthink_toolkit_en.pdf

- Stakeholders: SMEs providing cases

3. InnoTAL: design thinking module
   - TG: students and teachers of higher education
   - Stakeholders: companies, organizations, and the general public through learning cases.
4. Edukata
   - TG: students and teachers of higher education
   - Stakeholders: companies, organizations, and the general public through learning cases.
5. DTHINK
   - TG: students and teachers of higher education and trainers of entrepreneurship
   - Stakeholders: companies, organizations, and the general public through learning cases.

3.6.5 The field knowledge covered in the examples (skills, practice, mind-setting, user interaction, value building, empathy mapping, codesigning, etc)

1. CreaCIT/ CreativeMe Journal: creativity, product development using design process phases, not focusing on a specific toolkit but collecting tools for phases. Mindset and empathy. Case learning and learning by doing.
2. Design Camp: Case learning and learning by doing, mindset, empathy, design thinking, and service design theory and principles, including tools.
3. InnoTAL: design thinking process, models, and tools. Learning through a case.
4. Edukata: Case learning and learning by doing.
5. DTHINK: Design Thinking method, tools, skills, and mindset, including usability, creativity, and empathy

3.6.6 The DT methodology/approach (Hasso-Plattner, IDEO, etc.)

1. CreaCIT/ CreativeMe Journal: modification of IDEO's design process (exploring and gaining understanding, analyzing and gaining opportunity insight, generating solutions, and testing and defining) with generally selected tools for product development. Solutions orientation.
2. Design Camp: a general design thinking process and tools, service design, SME orientation. Cooperative and multi-disciplinary workshops, applied research, user and market-oriented design, Creative methods, learning by doing in project work
3. InnoTAL: a general design thinking module structure, mentality
4. Edukata: case-based learning and Edukata Participatory Design, which means "that the people who are likely to be affected by a design are invited to participate in the design."
5. DTHINK: Evolution 6^2 Design Thinking Model by Katja Tschimmel

3.6.7 *The type of assignments (Critical thinking, skill building, designerly thinking, etc.)*

1. CreaCIT/ CreativeMe Journal: qualitative grading based on learning performance
2. Design Camp: qualitative based on the outcomes of the project.
3. InnoTAL: for universities to set. Qualitative
4. Edukata: qualitative based on the outcomes of the project.
5. DTHINK: qualitative based on the outcomes of the project.

3.6.8 *The method/approach/tool (Education, capacity building, accreditation, etc.)*

1. CreaCIT/ CreativeMe Journal: education and real-life orientation
2. Design Camp: education and SME and real-life orientation
3. InnoTAL: education
4. Edukata: education
5. DTHINK: education and real-life orientation

3.6.9 *The materials (Toolkits, websites, MOOC, digital media, interactive media, interfaces, books, research)*

1. CreaCIT/ CreativeMe Journal: blended learning
2. Design Camp: Cooperative and multi-disciplinary workshops, Applied research
3. InnoTAL: design thinking module to be used as blended learning
4. Edukata: workshops
5. DTHINK: virtual and blended learning

4 DISCUSSION and CONCLUSION: Core findings based on the benchmarked practices

The following essential elements can be discovered from benchmarked design-thinking learning courses:

1. Educational solutions using design thinking are more than a toolkit or a model of the design thinking process. They have a specific pedagogical aim and purpose, target group orientation, curricular structure, and aim.
2. Educational solutions are either:

   a. In each case, they begin by explaining what Design Thinking is, what the process is, and what the tools are. These also include a workshop part where participants work on a case using the given Design Thinking process mode and its tools.
   b. Have a specific purpose that uses Design Thinking as a vehicle to achieve what needs to be done. These educational solutions also include workshops. DT is a vehicle designed to meet a specific need. These may not always use a specific DT process model but are more structured based on designerly thinking.
3. Educational solutions are highly practice-oriented and include workshops, using tools, and working on a case. The learning approach is participatory and based on learning by doing.
4. The existing educational solutions on Design Thinking focus little on purely the mentality of "designerly thinking," which those that apply it use more designerly thinking, although it is not taught separately. Overall, there is little teaching of and training of the mentality itself.
5. In one of the practices, called DesignCamp, people who aren't designers learn what "design thinking" is while being watched over by professional designers.
6. SME orientation is rather scarce in identified practices. Similarly, although D-THINK, apart from the higher education learning setting, also focuses on entrepreneurship learning, it is less present, and the tools and process, although highly adapted to education, could be used as such for any educational sector.
7. Using Design Thinking for setting, delivering, and evaluation learning is present only in D-THINK. However, CreaCIT also provides information for teachers in a creativity guide that focuses more on creativity and mentality, PPTs for teachers, and module guides that detail pedagogical aims, learning outcomes, and evaluation instructions for each module. Only these two provide information for teachers. In DesignCamp, SMEs participate in the evaluation of the outcomes.
8. Only CreaCIT provides detailed information on how to evaluate learning. Educational solutions that teach Design Thinking do not include any evaluation instructions for training delivery.
9. Based on these practices, it would be highly recommended that trainers and educators be provided with training instructions to train and evaluate Design Thinking. For this purpose, they also need to learn about id Design Thinking and designerly thinking. This is also useful for encouraging them to apply DT in education, as they are not experts in DT.
10. Based on the findings, it would be highly recommended to create such solutions use Design Thinking for a specific purpose, and educators are given guidance on how to use the methods and tools, as they must be able to connect with the context, learn how to

use the tools, and for using DT in education, they must also learn about it and its applications. Therefore, teaching about mentality is important.

11. The third recommendation is to develop training material for a specific purpose and target group to gradually guide trainers and educators to use design thinking.

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