

eDDea

Ψηφιακές υπηρεσίες για ιδεασμό, συνεργασία
& σύνθεση στη σχεδιαστική σκέψη

Deliverable 1

**Needs analysis and active, experiential
methodological learning framework for building
knowledge and skills for innovation**

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ΚΑΙ ΑΝΔΡΕΥΣΤΟΤΗΤΑΣ



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Introduction

In the future, all problems will be design problems (Brown and Katz, 2019). This includes both industry challenges and 21st century societal challenges such as fighting poverty and hunger, quality education, health for all, clean and affordable energy, sustainable cities, equality and equity, innovation and infrastructure, climate action, preserving life on land and in the sea and much more (United Nations Sustainability Goals, 2023).

Effectively addressing these issues can best be achieved through user-centered design applied to software engineering and other practices (Sommerville, 2011). User-centered design aims to effectively understand needs and wants, enabling the introduction of solutions with a positive impact. Often, this is achieved through interviews, questionnaires, or focus groups. Design thinking is a design methodology that offers a new approach to understanding user needs through empathy and observation (Brown and Katz, 2019). The process aims to support design teams to better understand real, as opposed to perceived, needs by opening new avenues for introducing effective solutions through processes of problem investigation, immersion in the user environment, observation, problem definition, ideation, creation of consumables prototyping, and evaluation of a proposed solution by the users themselves. Design thinking aims to synthesize innovative solutions to difficult entrepreneurship and social entrepreneurship problems even when they are not visible at first glance.

The eDea research project is an initiative that aims to create a learning digital intervention to support innovation processes in education and industry through design thinking combined with emerging active learning methodologies, such as experiential learning, problem-based learning, and gamification. The goal of the digital learning intervention for innovation is to push design teams to discover innovative solutions that combine the desired outcome with technological and economic possibilities.

The eDea research project applies a holistic approach to promoting innovation in both industry and higher education. The project aims to create digital services and innovation activities that support design teams in introducing solutions and experiences with a positive impact on society and the economy. The proposed digital collaboration services are aimed at students, designers, and educators in the context of formal and informal problem-centered learning processes that aim to prepare young people to participate in society as active citizens and have the skills needed to deal with urgent problems of the 21st century through innovation. In addition, they are aimed at design teams who want to improve innovation practices. The eDea project also aims at the adoption of the proposed digital learning and design

intervention by end-users, i.e. higher education students and lecturers as well as design teams through supporting content and dissemination.

This report summarizes research on user needs analysis and the methodological framework for encouraging innovation in design and learning processes. It describes the interested or involved user groups that will benefit from the results of the implementation as well as their needs, captured through literature and questionnaire-based research. In addition, it describes the current situation in innovation processes, analyzing current trends in design thinking. It also analyzes existing digital solutions that contribute to effective collaboration aimed at innovation. And finally it presents the proposed digital methodological learning intervention eDea which is based on design thinking and aims to introduce a holistic method that supports innovation through collaboration, active group participation, and collective idea-building in an inclusive way that leverages a wealth of skills and knowledge of interdisciplinary teams.

1. Brief description of design thinking

Design thinking has been defined in many ways by researchers and designers from different fields. One definition that seems to prevail is that which describes design thinking as a human-centered problem-solving process (Tschimmel, 2012). Other sources describe design thinking as a non-linear, iterative process that design teams use to understand users, challenge preconceived assumptions, redefine problems, and create innovative solutions that are prototyped and tested.

Design thinking is applied in different ways by design and research groups. However, its key processes are empathy to better understand user needs, problem identification, brainstorming to generate ideas, prototyping, and testing (Interaction Design Foundation, 2022). It is considered a useful method, mainly for dealing with problems that are vague, complex, or wicked (wicked problem). The term twisted problem was coined by (Rittel, H., & Webber, M., 1973) to describe a type of ill-defined, complex, systemic, and apparently unsolvable problem. Such problems are composed of seemingly different but interdependent elements each of which constitutes a separate problem and is based at a different level (Irwin, 2011). Because of these characteristics, solving complex problems requires a deeper understanding of those involved. Design thinking provides the necessary innovative approach to address such challenges. Complex issues such as health care, education, and the climate crisis are some examples of twisted problems. The iterative process of design thinking is extremely useful for tackling these kinds of problems by reframing the problem in human-centered ways, generating many ideas through brainstorming, and taking a hands-on approach to prototyping and testing them with users.

The basic processes of design thinking are analyzed below.

- **Empathy**, which aims to understand the users for whom a solution is designed. This first phase of design thinking is particularly important. Planners are asked to make decisions that will be representative and beneficial to the target group.
- **Identification**, which involves the analysis and clarification of data collected about users as well as the conclusions drawn from problem investigation through the process of empathy. This analysis leads to the identification of challenges and observations and creates opportunities for innovation.
- **Ideation**, which refers to the introduction of solutions and ideas that could potentially meet the needs of users either independently or after their synthesis into innovative interventions.
- **Prototyping**, which concerns the selection of ideas proposed by the design team in the previous steps and their transformation into quick and consumable

prototypes that can be used by users in a way that produces information about the suitability of a proposed solution.

- **Testing**, which refers to the evaluation of prototypes in order to obtain feedback from potential users. The interaction with the users is usually done through pre-selected steps while it is important to record the reactions in a way that allows them to analyze the data at a later time.

2. Investigation of user needs for innovation development

This section presents the methodology and tools used to identify users who directly or indirectly can benefit from the eDea digital learning intervention to promote innovative group thinking. It also presents the results of the user needs analysis on which the design of the proposed eDea digital learning intervention for innovation is based, presented at the end of the technical report. Data collection and analysis was supported through a small questionnaire-based survey, literature review, and use of popular needs description tools.

2.1 Tools for describing user needs

This section presents tools for describing users and their needs.

2.1.1 Stakeholder Map Tool Description

The stakeholder map is a tool that offers a visual representation of the ecosystem of groups of people, or in other words participants of parties involved in the experience of using a proposed solution. The term participant (stakeholder) refers to individuals, groups of people (target groups), or companies and organizations that influence or are directly or indirectly affected by the product.

The stakeholder map helps first capture and then understand the broader ecosystem in which the product, service, system, or process being designed provides value. In addition, the tool helps to identify relationships or partnerships that could be created so that the designed platform leverages and provides value to multiple parts of the ecosystem (stakeholders), thus providing added value and sustainability to the project.

2.1.2 Description of the behavioral archetype (persona) tool

A behavioral archetype (persona) of a user represents a group of people who are characterized by a common way of behaving, have similar motivations that guide their choices, and by extension common needs and problems. Persona as a tool is used to identify and capture different patterns and archetypes of behavior. Usually, some social and demographic information is added to make a persona more realistic. However, recording demographic information needs special care so that a persona does not end up being a reflection of some stereotypical perceptions of specific audiences. Recording the needs and interests of users through the persona can contribute to the design of products, services, systems, or processes that respond to their behavior, ensuring greater chances of success of a proposed solution as it answers their deepest needs (latent needs).

In contrast to the description of needs through user groups that categorize the target audience based on user type, such as student or teacher type, the description through

a behavioral archetype penetrates more deeply with the aim of recording and revealing people's behaviors and motivations. In this context, a certain category of users, such as learners for example, can be separated into more behavioral archetypes. Conversely, a behavioral archetype may be relevant to more than one audience category.

2.1.3 Point of view tool description

The point of view recording tool is part of recording and understanding the problem space of a project and therefore should not include the formulation of any idea or solution. The way of formulation should focus on recording the needs of the users that are directly related to a problem that they face or a specific way of behavior that they express and have adopted. The method provides a broad enough scope to allow design teams to begin analyzing multiple possible solutions that potentially address the need. The user perspective method is used to capture the requirements of a digital or other application or service from the users perspective, as opposed to the features or functional requirements captured from the system perspective. Each user perspective is a short sentence written in plain language avoiding the use of specific terminology from the field of technology and IT. It usually has the form: "Y/N ... [user type / behavioral archetype], needs / wants to ... [user need], because [important research finding e.g. problem faced or desired outcome / goal]".

..... **needs/wants to** **because**

user need important research finding

Figure 1. Formulation of the user's perspective (point of view).

2.2 Stakeholder analysis of eDea digital learning intervention for innovation

This section describes the user groups that can benefit from the eDea digital learning intervention for innovation.

2.2.1 Pupils and students

Students are the problem solvers of tomorrow. They are the ones who will be called upon to introduce sustainable solutions to both entrepreneurship and social entrepreneurship challenges of the 21st century, such as achieving sustainability goals. Students need to develop innovation skills such as analytical and critical thinking, creativity, the ability to work in groups, the ability to investigate and evaluate sources, design and evaluate prototypes.

Students can benefit from core values of human-centered design to be able to put into practice principles such as adaptability, resilience, and flexibility. Additionally, students need to develop knowledge, experience, and skill to apply design and innovation practices in practice, from problem analysis to solution implementation and testing.

Pupils and students can benefit from the eDea innovation digital learning intervention, which provides the opportunity to develop innovation skills needed to solve problems through problem-based processes.

2.2.2 Trainers and training organizations

Educators and educational organizations have an important role in developing the coordination skills of design thinking processes in their students. They need support in building and following design activities in the classroom, promoting problem solving through collaborative collaboration and the search for innovative solutions. In addition, educational organizations can create opportunities to connect learning with industry through partnerships that introduce real-life problems into learning processes. In this way, pupils and students can develop skills and knowledge that will help them in their professional careers in the future.

In addition, educators need continuous and lifelong renewal of their skills that will allow them to adapt learning objectives, activities, and content according to the evolution of technology and society in a way that develops students' knowledge and skills needed to develop themselves and be active scientists and professionals in industry and society.

On the other hand, educational organizations need to renew programs, processes, and learning methodologies so as to offer the desired knowledge and develop the skills that are in demand in industry and society. At the same time, the continuous renewal of learning programs contributes to the attraction of new students and the competitiveness of educational organizations.

The eDea digital learning intervention for innovation provides the possibility to develop content or training programs that focus on problem-based learning contributing to the improvement of teaching practices.

2.2.3 Designers and design teams

As design and product development professionals, designers and people involved in design teams must be familiar with the latest product design and development processes. This entails understanding fundamental design principles such as analyzing customer and user needs, communicating with customers and users to create effective solutions, and understanding technologies and their capabilities to create innovative products.

They also need to develop organizational and project management skills in order to manage their time and resources effectively. These skills will support them in the timely completion of the projects they undertake, introducing high quality solutions. In addition, they must apply design principles to create products that are ergonomically, functionally, and aesthetically enhanced.

The eDea digital learning intervention for innovation supports the collaborative processes of design teams in a way that promotes the collective synthesis of new solutions that more effectively address the needs of end users.

2.2.4 Companies

For companies, working with executives who possess high critical thinking, business thinking, and problem solving skills can provide many benefits. Professionals with high critical thinking and problem solving skills can contribute to the creation of innovative ideas and solutions for the company. Their ability to recognize challenges, analyze problems, and propose creative solutions can contribute to the company's growth and competitiveness.

Business-minded professionals can identify potential growth opportunities for the company. Their ability to analyze the market, identify customer needs, and anticipate industry trends can help the company evolve to meet ongoing changes.

The eDea digital learning intervention for innovation supports leveraging the knowledge and skills of a company's executives in collaborative design processes to connect solutions that address the needs of industry and society.

2.3 Investigation of user needs through a questionnaire

In order to capture user needs through real-world data, a quantitative survey was conducted using a questionnaire. The purpose of the research was to study the perspectives of stakeholders regarding the concept of creativity, design, and emerging related methodologies, such as design thinking. In addition, the research aimed to analyze the desired function and activities that should be covered by the eDea innovation digital learning intervention.

2.3.1 Questionnaire design

This section presents the design of the questionnaire which forms the basis of recording the needs and wishes of the users. The questionnaire initially focuses on gathering demographic data for statistical analysis. It then seeks to capture stakeholders' thoughts on creativity, design, and the skills necessary to promote and encourage innovation.

The questionnaire questions distributed to potential users are shown in the table below.

Stakeholder perspective capture questionnaire
Age.
Sex.
Highest completed level of education.
Current professional status.
In case you are a design professional, what is your main expertise?
<p>In your opinion, what does creativity mean?</p> <ul style="list-style-type: none"> • Ingenuity. • Ability to propose something new, such as a new solution to a problem, a new method, or an object of art. • Using imagination to suggest something new. • Identifying connections between ideas, objects, or situations to bring something new into the world. • Turning ideas, imagination, and dreams into something real.
<p>In your opinion, what does design mean?</p> <ul style="list-style-type: none"> • The planning behind an action, an event, or an object. • A sketch showing the appearance and functionality of an object. • Creating something decorative. • Conceptualizing new ideas, objects, user interfaces, products, spaces, services, and more. • The art of the possible. • A visualization of the programming process for creating new objects. • The intention to create something new.
<p>Are you involved in design activities?</p> <ul style="list-style-type: none"> • If you answered "yes", briefly describe the activities.
<p>What do you consider the most essential group design skills?</p> <ul style="list-style-type: none"> • Analytical thinking.

- Entrepreneurial or innovative thinking.
- Critical Thinking.
- Deductive thinking.
- Creativity.
- Generalization and abstraction.
- Collaboration in groups.
- Open thinking.
- Communication, written and verbal.
- Time management.

How important is design to progress and improve the quality of life?

What do you consider the most important activities for effective design team collaboration?

- Face-to-face collaboration.
- Creating a sense of team, team bonding.
- Remote collaboration.
- Exchange of ideas.
- Brainstorming and ideation.
- Analyzing different aspects of a problem.
- Analysis of user needs.
- Understanding the needs of a typical user.
- Identify connections between different situations and solutions with common characteristics.
- Practical training.
- Evaluation of ideas and solutions.
- Prototyping.
- Scheduling.
- Human resource planning.
- Transparency and honesty.
- Cooperation with the target group.

<ul style="list-style-type: none"> • Collaboration with experts outside the design team. • Collaboration with other designers. • Encouraging participation.
Do you think technology can contribute to group design?
Do you know what design thinking is?
Have you applied design thinking?

Table 1. Stakeholder perspective recording questionnaire.

2.3.2 Analysis of questionnaire-based research results

The survey was conducted from September 2022 to January 2023. The questionnaire was available online. The research sample includes 161 people.

2.3.2.1 Demographics

92.6%, i.e. the majority of respondents who answered the questionnaire, belong to the age group 18 - 25. 4.9% belong to the age group 26 - 35, 1.9% belong to the age group 46 - 55, and only 0.6% belong in the 36 - 45 age group.

Ηλικία

162 responses

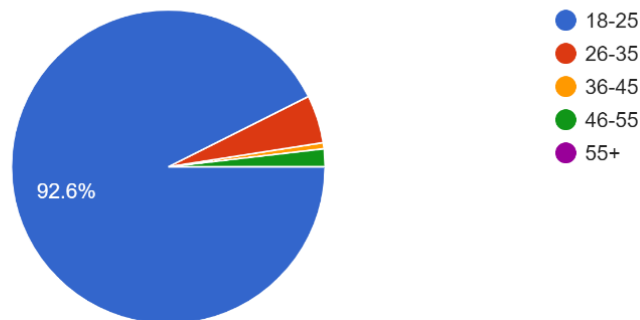


Figure 2. Age of respondents.

42.2% of participants self-identified as female and 56.5% as male.

Φύλο

162 responses

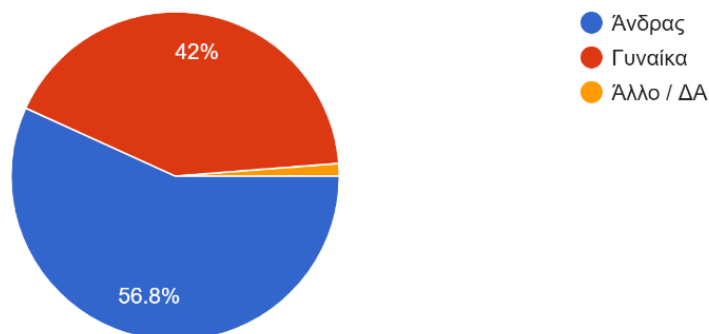


Figure 3. Gender of respondents.

The majority of respondents (82.1%) have completed secondary education, 15.4% have completed tertiary education, while only 1.2% have completed postgraduate and doctoral studies.

Υψηλότερη ολοκληρωμένη βαθμίδα εκπαίδευσης

162 responses



Figure 4, Highest completed level of education of the respondents.

Regarding the current professional status of the respondents, 92% are students, 6.8% are employed, and only 1.2% are self-employed.

Τρέχουσα επαγγελματική κατάσταση

162 responses

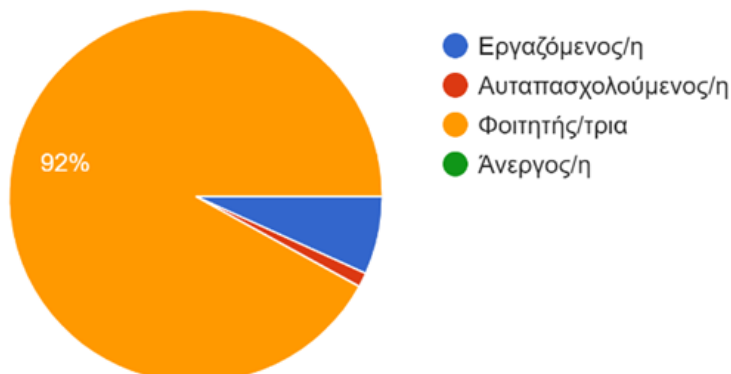


Figure 5. Current occupational status of respondents.

88.3% of the participants answered that they are not professionals in the field of design, 3.7% answered that they specialize in product design, and 3.7% that they specialize in service design. Additionally, 1.9% specialize in user interface (UI) design and 1.9% in experience (UX) design. Only 1 person (0.6%) answered that she is a student who mainly deals with UI/UX and interaction design.

Σε περίπτωση που είστε επαγγελματίας στο χώρο της σχεδίασης, ποια είναι η κύρια ειδίκευσή σας;

162 responses

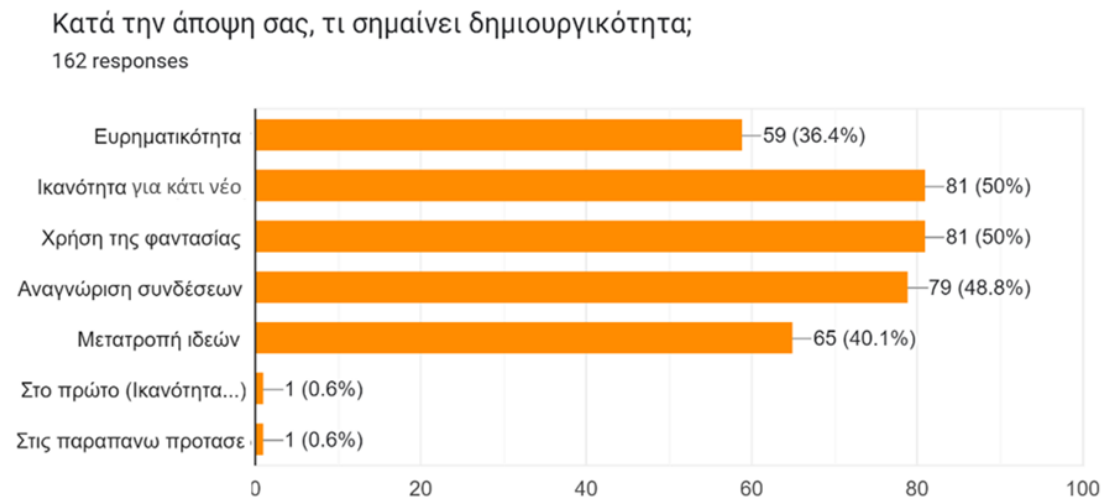


Figure 6. Main specialization of respondents who are design professionals.

2.3.2.2 Views on key concepts

A total of 81 respondents answered that in their view creativity means the ability to propose something new (a new solution to a problem, a new method, or an object of art). Additionally, 81 respondents answered that creativity is the use of imagination to propose something new while 79 answered that creativity is the recognition of connections between ideas, objects, or situations to introduce something new into the

world. In addition, 65 people answered that creativity means turning ideas, imagination, and dreams into something real, while for 59 respondents, creativity means ingenuity.



7. The concept of creativity according to the respondents

Regarding the concept of design, 77 respondents answered that in their opinion design means the conception of new ideas, objects, user interface, products, spaces, services, etc. and another 74 that design is the planning behind an action, an event, or an object. An additional 55 people answered that design is a visualization of the planning process for creating new objects, and 43 characterized design, as defining the specifications of an object under implementation or construction. In addition, 35 people answered that a design is the intention to create something new and 27 that a design is a sketch that shows the appearance and functionality of an object. Finally, for 24 respondents design is the art of the possible and 6 that design is the creation of something decorative.

Κατά την άποψη σας, τι σημαίνει σχεδίαση;

160 responses

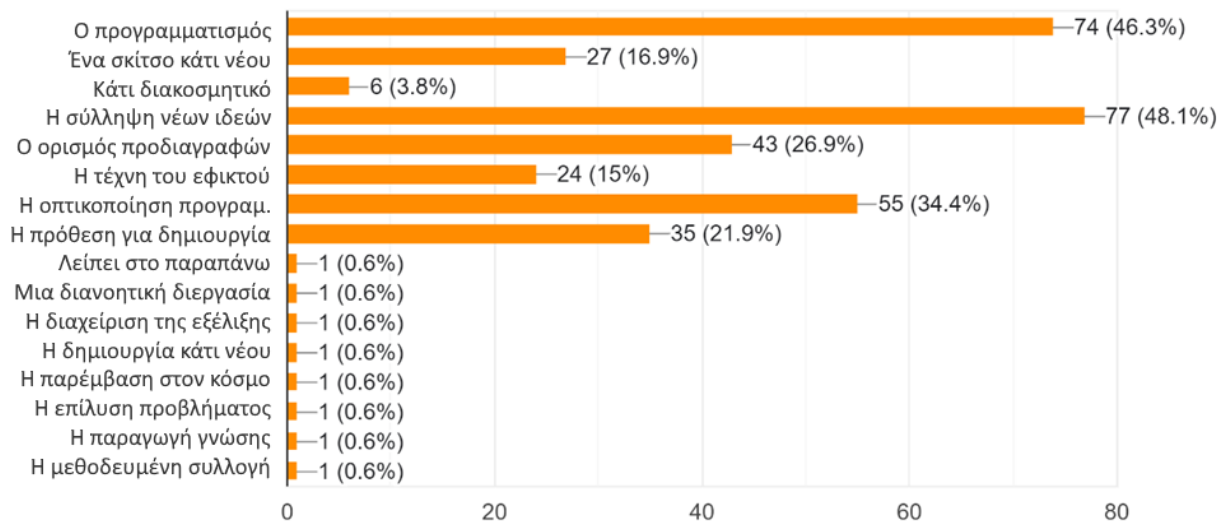


Figure 8. The concept of design according to respondents

60.5% of respondents have not participated in design activities, while 39.5% have.

The majority of respondents who answered that they have participated in design activities noted that these activities took place in the context of university courses, where they were asked to design new products, objects, or services. They have also participated in the "programming" of an action, an event, or an object in a way that enables and facilitates the conception of new ideas, objects, user interfaces, products, spaces, services, etc. by groups of many. These activities were carried out with the participation of various stakeholders in real time, simultaneously, either face-to-face in a physical space or remotely in a digital collaboration space.

Συμμετέχετε σε δραστηριότητες σχεδίασης;

162 responses

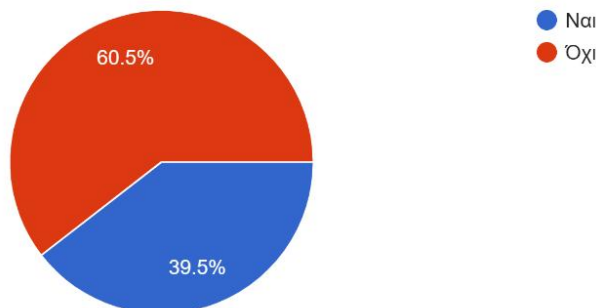


Figure 9. Respondents' participation in design activities.

Several respondents have also been involved in designing and building frontend and backend websites and applications, designing digital services, objects, applications,

and art, as well as various organizational-level tasks. There were additional respondents who had dealt with the design of electrical installations through the Autocad® tool, with graphic design, but also in all phases of design. Some of the respondents mentioned that they are members of the Centaur team of the University of Thessaly, where they design electronic circuits for various uses.

One of the respondents mentioned that he has participated in design activities as part of his training in group problem-solving activities where participants were asked to study the conditions and people associated with a situation through investigations and propose corresponding ideas for solving the problem. Then, after deciding which of the ideas was the most suitable, they were asked to build a rough prototype and present the purpose and functionality of the product they designed. Modern ways of learning, Photoshop®, and free drawing were also mentioned.

2.3.2.3 Views on design skills

A total of 125 respondents answered that, in their opinion, creativity is one of the most essential skills in group design, and 92 voted for critical thinking. Additionally, 87 respondents believe that one of the most essential skills is teamwork itself, and 85 respondents answered that it is communication, both written and verbal. In addition, 74 of the respondents answered that gathering information and data is one of the most basic skills in team design, 64 chose open thinking, 62 time management, and 59 analytical thinking.

Finally, 57 respondents answered that in their view entrepreneurial or innovative thinking is one of the most essential team design skills, 50 chose deductive thinking, and 21 respondents said that generalization and abstraction is one of the most essential team design skills.

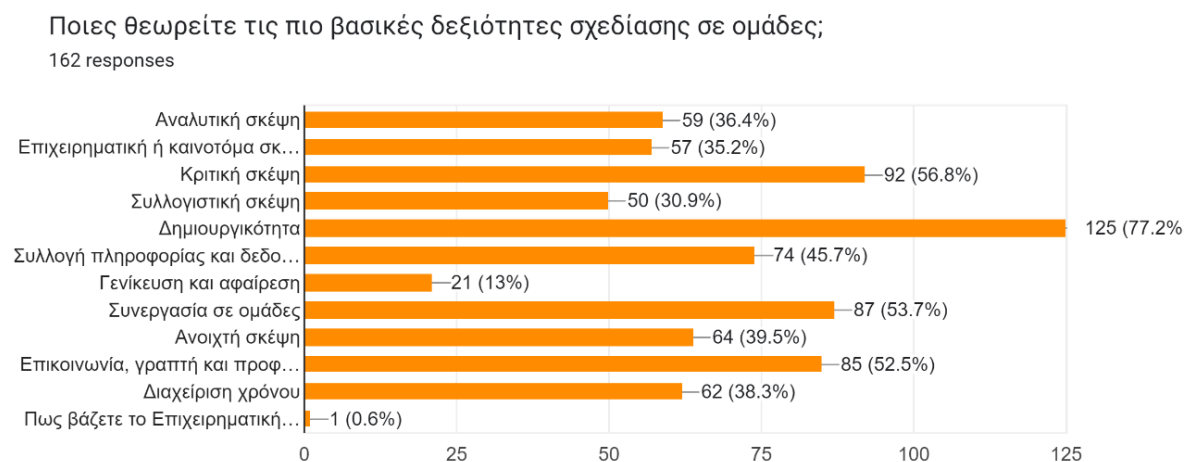


Figure 10. The most basic group design skills.

50% of respondents answered that design is very important to progress and improve the quality of life, and 42.6% answered that it is very important. 6.8% of respondents answered the question neutrally and only 0.6% consider design to be somewhat important for progress and improving the quality of life.

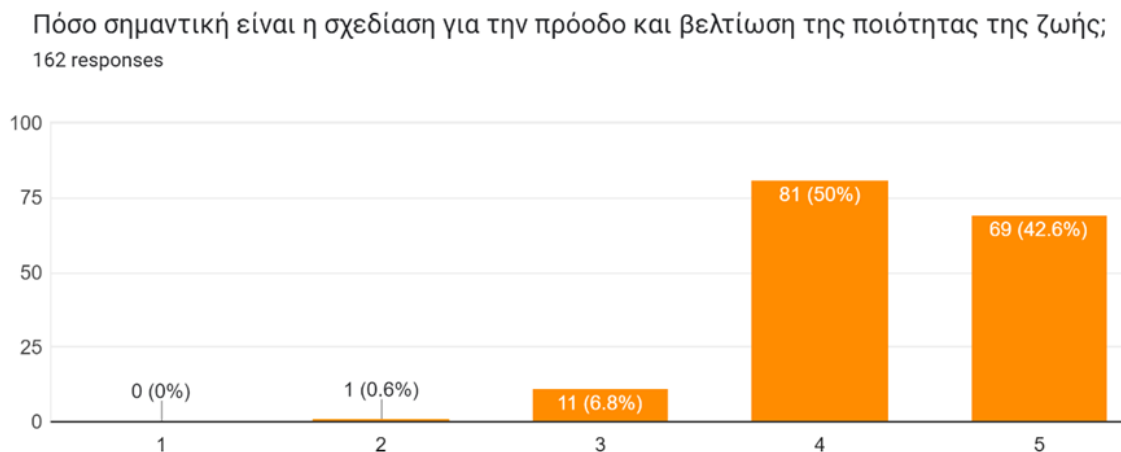


Figure 11. The importance of design to progress and improve the quality of life

This was followed by an open-ended question where respondents were asked to give examples of where design contributes to progress and improving the quality of life. The majority of respondents mentioned health services and more generally technology in the field of medicine. They noted that the design of new laboratory tools has contributed to the optimization of the scientific process and more specifically to the advancement of medical research. They further noted that the design of medical devices has also facilitated the medical staff and patients by making difficult operations much easier and in general the different medical devices used in modern medicine have been created after analytical design.

An equally large portion of the respondents mentioned as an example of the contribution of design to the improvement of the quality of life the development of new products for daily use and in general the design of the daily program, which could contribute to the better coordination and planning of everyday life, to the facilitation of the lives of people, and saving time. Some specific examples cited of improving people's quality of life were the design of technological devices such as mobile phones and computers. Also, some participants noted that the proper and detailed design of all modern means of transportation has contributed greatly to the safety of drivers, passengers, and pedestrians outside of these means. It generally contributes to the safety of public transport and electric vehicles.

2.3.2.4 Views on design activities

A total of 105 respondents answered that the most important activity for effective design team collaboration is sharing ideas, 82 mentioned analyzing different aspects of a problem, and 78 mentioned creating a sense of team. Additionally, 65 respondents believe that one of the most important activities is analyzing ideas and solutions, 51 chose face-to-face collaboration, 47 answered that the most important activity is analyzing user needs, 40 chose brainstorming and ideation as one of the most important activities for effective design team collaboration, 39 voted for scheduling, 33 for transparency and honesty, 31 for identifying connections between different situations and solutions with common features, and 29 for working with the target group.

In addition, 27 respondents answered that in their view understanding the needs of a user characteristic is an important activity for effective design team collaboration, 27 respondents chose hands-on practice, 26 collaborating with experts outside the design team, 24 encouraging participation, and 22 prototyping. Finally, 19 respondents answered that the most important activity for effective design team collaboration is collaboration with other designers, 15 voted for human resource planning, and 8 voted for remote collaboration.

Ποιες θεωρείτε τις πιο σημαντικές δραστηριότητες για την αποτελεσματική συνεργασία σχεδιαστικών ομάδων;

162 responses

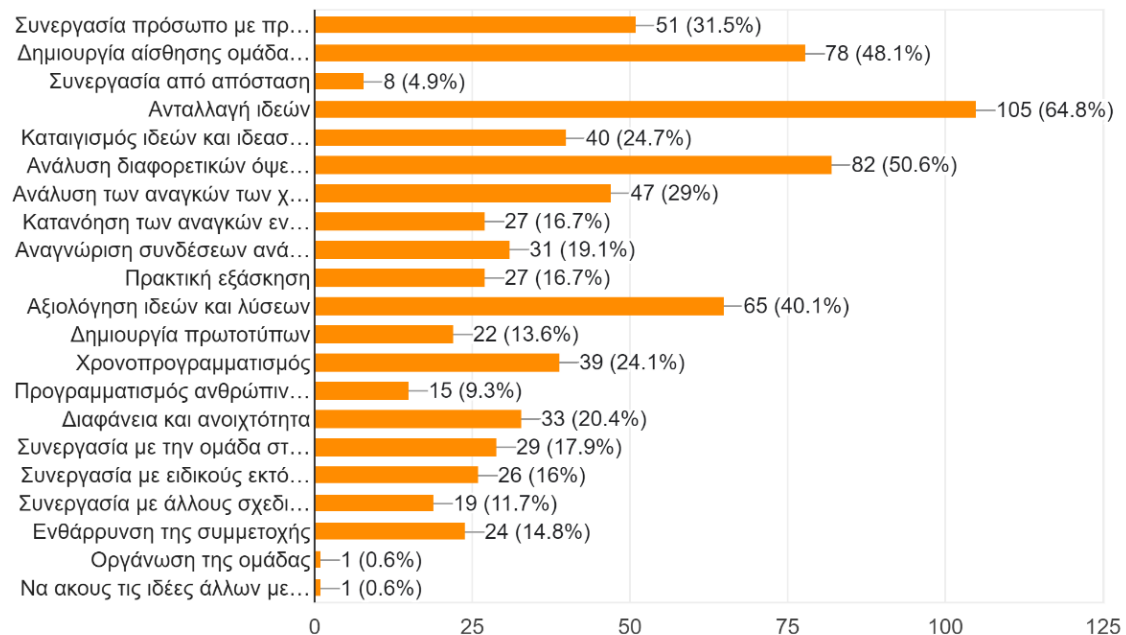


Figure 12. The most important activities for effective design team collaboration

53.1% of respondents think technology can contribute a lot to team design, 36.4% think it can contribute a lot, and 9.9% think technology's contribution to design is neutral. Just 0.6% believe that technology contributes little to group design.

Θεωρείτε πως η τεχνολογία μπορεί να συμβάλλει στη σχεδίαση σε ομάδες;
162 responses

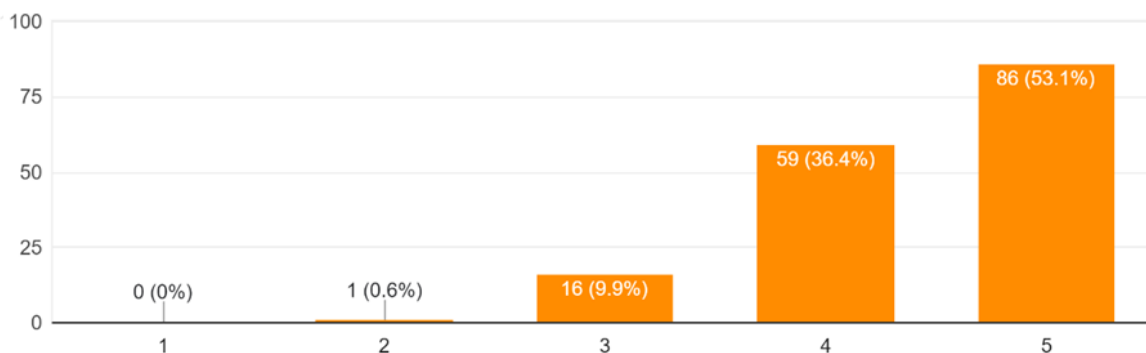


Figure 13. The contribution of technology to group design

This was followed by an open-ended question asking respondents to give examples of where technology can contribute to group design.

The majority of respondents reported that technology has helped remote communication between team members, using platforms such as Skype®, Zoom® and MTeams®. With these applications, team collaboration can be done from anywhere in the world, without physical limitations. Especially during the pandemic and quarantine, these kinds of applications have enabled universities as well as businesses to continue remote collaboration, since online meetings filled the void of physical distance. Digital technology also provides the ability to schedule and assign tasks and project planning through task management. Through digital technology, team members can simultaneously design and participate in the same design program and create shared notes with their files and projects available at any time. In addition, there is the possibility for members to be able to ask for help from the rest of the group in case of a problem and to discuss any queries.

It was also mentioned the recording of the results of each stage of the design process on a digital whiteboard for transparency, the visualization of information, the modern and asynchronous collaboration of the lady as well as the extended work group, the creation of digital material to support ideas and easier communication of these to a wider audience, as well as the use of digital tools for better, faster, and clearer application and presentation of research results and use of design tools.

Finally, task scheduling services during the design and implementation of software, sensors that can be used in measurements to build a vehicle, and the design of robots for medicine were mentioned.

2.3.2.5 Familiarity with design thinking

The majority of respondents corresponding to 49.4% answered that they have heard the term design thinking but do not know what it means while 35.8% answered that they have some basic knowledge. 8% of the respondents answered that they know nothing about design thinking, while only 6.8% know the concept of design thinking well.

Γνωρίζετε τι είναι η σχεδιαστική σκέψη (design thinking);

162 responses

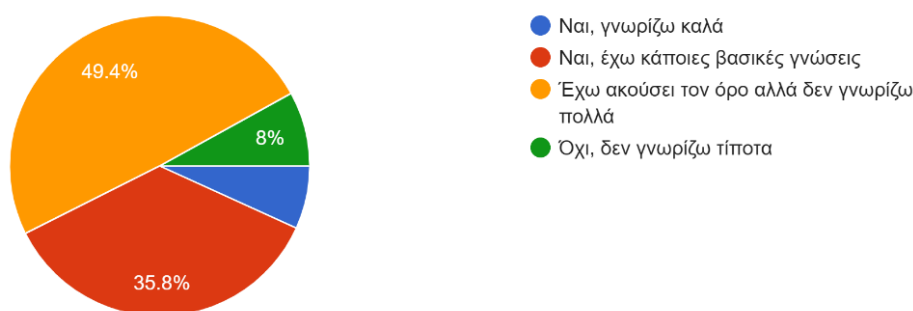


Figure 14. Respondents' familiarity with design thinking.

42.6% of the respondents answered that they do not know if they have used design thinking, 35.2% have not applied it, while only 22.2% have applied design thinking.

Έχετε εφαρμόσει τη σχεδιαστική σκέψη (design thinking);

162 responses

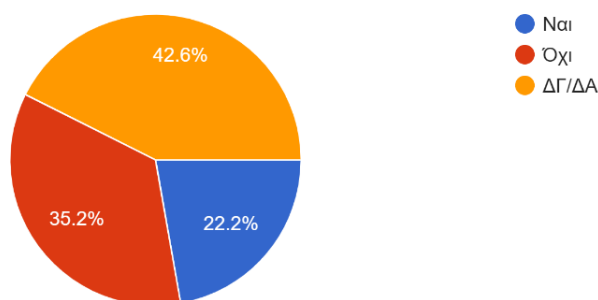


Figure 15. The application of design thinking by respondents.

Of the respondents who answered that they had applied design thinking, some reported that they had used it at university in group work in various subjects, such as entrepreneurship and game development.

Most also agreed that design thinking refers to a set of processes used by designers in the design process. Design thinking begins with the understanding of a problem space or the conception of an innovative idea, which is researched, analyzed, and prototyped without having the image of the solution in the mind of the designer from the beginning of the process. Familiarity with design thinking processes before applying them to design activities helps to achieve a more satisfying result. Design thinking is applicable to a wide range of design processes, as through its various tools and steps it achieves the breakdown of the design activity into smaller stages that can be repeated until the needs of the users are successfully addressed by a product or service.

In addition, some reported that they have applied design thinking to digital service design, travel organization, as well as to innovative product design activities at a theoretical level. One of the interviewees mentioned that he has applied design thinking as a methodology as a technique and tool in service design projects. Another reported having applied design thinking in the context of his work to improve a certain situation that directly affects a group of people.

2.3.2.6 Conclusions of the analysis of the questionnaire responses

The majority of survey participants, namely 46%, recognized the importance of organizing creative work. 48% emphasized conceptualizing a new design framework regardless of format. In addition, 35% of participants emphasized the visualization aspects of the design process, while 27% emphasized the importance of writing the design specifications of the design object.

Regarding design as a group activity, 77% of participants highlighted the importance of creativity, 56% of critical thinking, 53.5% of team collaboration, 52% of good oral and written communication, and 38.5% of time management.

In relation to the functions of collaborative work in design contexts, 65% of participants highlighted the importance of exchanging ideas, 50% of analyzing different sides of a problem, and 48% of creating a sense of team.

Only 8% of the participants had not heard the term design thinking but 85% reported that they do not have much knowledge about it. This finding highlights the need for training students in design thinking.

2.4 Capturing user needs

Based on the objectives of the project and the results of the quantitative research through a questionnaire, 2 different behavioral archetypes of users with regard to the trainees and correspondingly 2 different behavioral archetypes of users with regard to the trainers emerged.

The information captured in each behavioral archetype was selected to be able to guide the subsequent design stages of the eDea digital learning intervention for innovation. Each behavioral archetype represents different attitudes, values, and preferences both in relation to the way it perceives learning and in relation to the design methodology itself.

2.4.1 Learner or designer behavioral archetypes

Each learner or designer behavioral archetype consists of the following information modules.

- **Demographics:** Name, age.
- **Striking quote:** A phrase that the behavioral archetype has said, or could have said, that captures its main characteristic.
- **Description:** Brief description of the daily life of the behavioral archetype including information that will then influence the design of the eDea digital learning intervention for innovation.
- **Behavior and familiarity with respect to design and innovation key features:** Capturing how close or far the behavioral archetype mindset is in relation to specific features of the design process and emerging related methodologies, such as design thinking. These are elements that will potentially make it difficult to familiarize the behavioral archetype with the way of thinking proposed by the emerging methodologies. The eDea digital learning intervention for innovation can provide specific ways of managing them to facilitate learners and designers to understand the relevant concepts and then put them into practice. Examples of new elements introduced into emerging design methodologies such as design thinking follow.
 - **The management of ambiguity**, especially in the early stages of design.
 - **Divergent thinking**, which calls for designers using design thinking to broaden the scope of the original question or project in order to explore different aspects of the problem before choosing which features to focus on to introduce a solution.
 - **The development of empathy with the user**, which then guides the design decisions and operations of each product, service, system, or process as it contradicts strongly held beliefs that business needs drive design.
 - **The transformation of ideas into something tangible**, which allows the description and communication of the exact way the user interacts with the product, service, system, or process proposed as a solution.

- **The basic needs of the user (makers)**, such as features that it is desirable to integrate a solution under design or behaviors of the behavioral archetype that the solution is called to support in order for the user to choose it.
- **The elements that the user would not like to see in a solution (breakers)**, because they will discourage him from choosing and using the proposed solution.

2.4.1.1 Behavioral archetype of an experienced business planner

Users who correspond to the behavioral archetype of an experienced business designer (business designer) usually work for several years in the market and have a good relationship with technology. Practical, pragmatic, and always result-oriented, they look for quick solutions to improve their skills in order to develop professionally as well as to improve their daily work life and the productivity of their team.

Flexibility is one of the key features of the solutions they choose, as it allows them to better respond to their busy schedule that requires them to divide time between work and family.

A general representation of the business planner behavioral archetype is shown in the figure below. The image shows the name of the behavioral archetype that is Peter, demographic characteristics, a brief description, and behavioral elements.

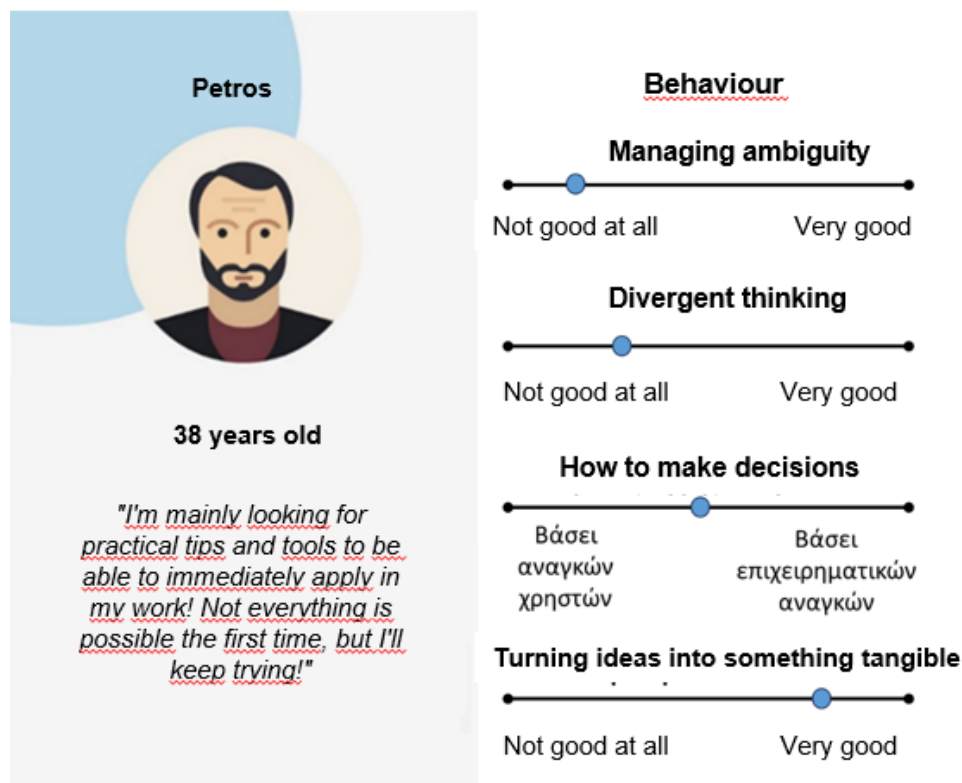


Figure 16. Behavioral archetype of business planner.

To understand the behavior of the behavioral archetype, its journey to date is described. Petros has been working for 3 years in a computer company as a product owner. He lives with his partner and their 4-year-old daughter. He loves his job very much and often works an extra 1-2 hours in the evening from home after spending time in the afternoon with his daughter. For some time now he has identified some problems regarding the formulation of project specifications (project requirements) and cooperation between teams. Trying to find solutions he started reading about design thinking and it seemed to him that it would be easy to apply it as there are plenty of tools on the internet. Although he tried to use some tools in his team, the venture was not very successful.

The table below describes the needs of the behavioral archetype from the user's perspective.

The user... [Behavioral Archetype]	... needs (wants) to ... [Need]	... because (in order to) ... [Significant research finding, problem faced, goal, or desired outcome he wants to achieve]
Petros ...	... he wants educational or learning options that will give him more flexibility in how and when he attends ...	... because he has a busy daily schedule.
Petros, as a professional who manages teams, ...	... wants to improve his skills related to cooperation and teamwork ...	... because he wants to help the teams he works with communicate better at work.
Petros, as a professional who manages teams, ...	... he wants to propose to his superiors, but also to his team members, procedures and ways of working that will improve cooperation and communication between colleagues and teams ...	... because he wants to increase the productivity of the teams and the quality of the end result of their work.
Petros, as a professional, ...	... wants to improve his soft skills ...	... because he knows that they are very important for success

		in his work and will help him develop further.
Petros, as a professional, ...	... he wants to get practical advice that emerges through experience on how to immediately and successfully apply the tools and methods of design thinking ...	... because he has made previous attempts but failed to successfully apply them to his team.
Petros, as a mid-level manager, ...	... he needs practical advice and tools to help him convince both his superiors and his team to invest in emerging design methods such as design thinking as a way of working ...	... because he knows from his experience that if people do not believe in this change it will not be able to materialize.
Petros ...	... wants to know how well he is doing in the program ...	... because he will be able to put more emphasis there and really improve.
	... he wants to know where he has weaknesses ...	
Petros, as a professional who manages issues of a technical nature,...	... needs more help and time to get used to and manage ambiguity in the early stages of design thinking ...	... because it is used to relatively clearly manage certain design and implementation specifications of products, services, and systems.
Petros ...	... needs to become more familiar with the ambiguity that characterizes the early phases of design thinking ...	... because it will be able to contribute more effectively to shaping the direction of the project's implementation throughout the process.

<p>Petros, as a professional, ...</p>	<p>... wants training processes in new design methodologies to emphasize practical application and practice on concepts and tools and not so much on theory ...</p>	<p>... because in this way he will be able to immediately apply the knowledge he receives in his work.</p>
<p>Petros ...</p>	<p>... wants to be able to connect and exchange knowledge and opinions with people who have common interests and concerns about the subject ...</p>	<p>... because in this way he will receive added value that contributes to his development over time even after the end of a training program.</p>
<p>Petros ...</p>	<p>... wants to clearly communicate the value of a design thinking training program ...</p> <p>... he wants to clearly communicate the benefits that a design thinking training program will provide him in his work ...</p>	<p>... so that he can convince his superiors to pay the tuition.</p>

Table 2. Experienced business designer behavioral archetype user view.

Finally, the description of the behavioral archetype is complemented by the description of the basic needs (makers) and characteristics that would not like to be included in a possible solution (breakers).

The basic needs (makers) are analyzed below.

- Ability to network and share knowledge and experiences.
- Emphasis on strengthening soft skills related to design thinking, such as collaboration, communication, teamwork, and empathy.
- Digital education experience.

Deliverable 1: Needs analysis and active, experiential methodological learning framework for building knowledge and skills for innovation

- Access to tools to improve productivity and utilize design thinking.
- Clear indicators to measure progress.
- Opportunities to reflect on new knowledge.
- Learning by doing.
- Positive feedback from other users about educational programs.

The elements that the behavioral archetype would not want included in a potential solution (breakers) are discussed below.

- Structure of a training program that cannot be adapted to the needs of team collaboration.
- Lack of flexibility in the way of training.
- Vaguely presenting the value of a training program and not linking it to benefits at work.
- Lots of theory.

2.4.1.2 Behavioral archetype of emerging or nascent designer

Users who fit the emerging designer behavioral archetype are typically students in full- or part-time undergraduate or graduate programs. They are ready to absorb knowledge. Having grown up in a world of many stimuli, they are looking for highly interactive educational experiences that will make them feel like they are having a fun and creative time while developing new knowledge and skills. They approach the educational experience in a more alternative way to the predominantly traditional model of education based mainly on lectures, exercises, and case studies. They are always looking for clear instructions on how to perform an exercise or how to move from one stage of a methodology to the next and therefore have more difficulty managing ambiguity, a key feature of emerging design methodologies such as design thinking. Although technology is an integral part of their daily lives, they nevertheless prefer educational experiences that combine digital and real-life lessons.

A general representation of the emerging or nascent designer behavioral archetype is shown in the figure below. The image shows the name of the behavioral archetype that is Peace, demographic characteristics, a brief description, and behavioral data.

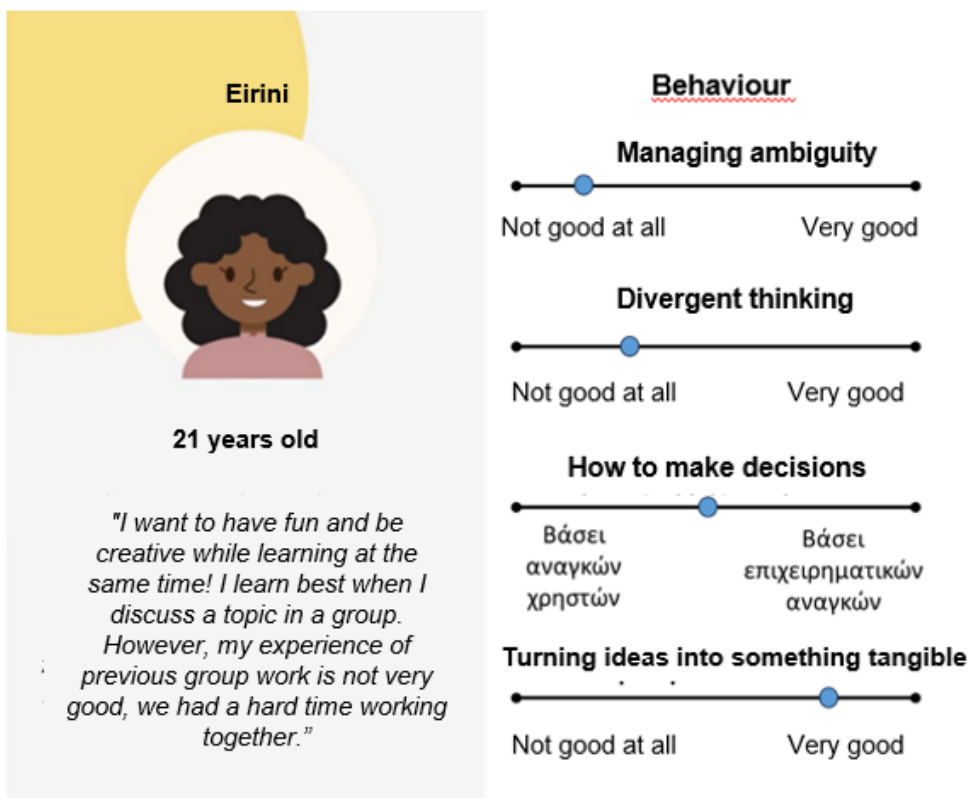


Figure 17. Behavioral archetype of emerging or nascent designer.

To understand the behavior of the behavioral archetype, its journey to date is described. Irini is in her final year of business administration studies. She really likes the hotel industry and the organization of the experience and the organization of the customer experience. Every summer she does an internship at a hotel while in the winter she helps in her free time at her mother's hair salon, in customer service. Her dream is to one day create her own business in the hotel industry. For now she is focusing on getting her degree with good grades. As part of the school's activities, he had attended a design thinking seminar. He had found it very interesting as a subject, however he struggled to understand that design thinking is a continuous circular process.

The table below describes the needs of the behavioral archetype from the user's perspective.

The user...	... needs (wants) to ...	... because (in order to) ...
[Behavioral Archetype]	[Need]	[Significant research finding, problem faced, goal, or desired outcome he wants to achieve]

Eirini ...	... needs very clear instructions on how to use design thinking tools ...	... because she gets confused when the instructions are not clear and fails to complete the assigned exercise.
	... needs to first study some examples of how design thinking tools are used ...	
Eirini ...	... wants to work better with her fellow students in group work ...	<p>... because usually only certain people end up doing all the work.</p> <p>... because some people dominate the discussions and strongly guide the whole group and the final solution so that not all opinions are heard.</p>
Eirini ...	... wants to see theory in practice ...	... to better understand the methodological framework.
Eirini ...	... needs proper guidance ...	... in order to understand what she is interested in doing in the future and how she will achieve it.
Eirini ...	... wants to take life lessons ...	... because interacting with her fellow students and professors helps her share more information making the learning process easier.
Eirini ...	... needs support when working with fellow students in group work ...	... because he finds it difficult to cooperate
Eirini ...	... needs to follow certain rules within the lesson ...	... to be able to respond more effectively to the requirements of the program.

Eirini ...	... there needs to be a clear structure of the program which has been communicated from the beginning ...	... to make it clear to her what the context is and what expectations to have for the course.
Eirini ...	... wants to produce creative and innovative solutions in the context of course exercises and assignments ...	... because she is used to measuring her performance against the end result.
		... because in this way he gets more pleasure from the lesson.
Eirini ...	... wants to receive feedback, such as comments and observations, in a positive way so that she can improve her weaknesses ...	... because negative comments discourage her.
Eirini ...	... wants to access financial education programs ...	... because she is not yet financially independent.
Eirini ...	... she needs to develop her soft skills more ...	... because, especially in the context of group work, he is called upon to utilize soft skills such as collaboration, communication, and others.
Eirini ...	... wants to participate in tasks that are relevant to her interests ...	... because a lack of interest in the subject matter of the work may affect its adherence.

Table 3. User view of emerging or nascent designer behavioral archetype.

Finally, the description of the behavioral archetype is complemented by the description of the basic needs (makers) and characteristics that would not like to be included in a possible solution (breakers).

The basic needs (makers) are analyzed below.

- Direct application of theoretical knowledge to tasks inspired by the labor market.
- Blended learning, both in the classroom and online.
- Clear instructions for using tools and definitions of concepts (show me how to do it).
- Specific rules for implementing the tasks.
- Combining theory with practical application.
- Emphasis on the final solution (solution focused) with production of creative, innovative ideas and solutions within the context of the course.
- Guidance in terms of personal and professional development.
- Criticism based on feedback provided with encouragement and positivity aimed at improvement.

The elements that the behavioral archetype would not want included in a potential solution (breakers) are discussed below.

- Cost of training program.
- Unclear instructions in exercises and how to use methods and tools.
- Tasks with a topic that is not close to the user's interests.
- Lack of instructions on what is the next step in implementing the tasks.
- Use in tasks of soft skills before they are sufficiently developed.
- Uncertainty about the grading system and the structure of the training program.

2.4.2 Behavioral archetypes of instructors

The information captured in each instructor behavioral archetype presented in this section was selected to guide the subsequent design stages of the eDea digital learning intervention for innovation. Each behavioral archetype represents different behaviors, values, and preferences both in terms of how it structures, coordinates, and delivers the course and in terms of what aspects of the design process it leverages to shape the course.

Each trainer behavioral archetype consists of the following information modules.

- **Demographics:** Name, age.
- **Striking quote:** A phrase that the behavioral archetype has said, or could have said, that captures its main characteristic.

- **Description:** Brief description of the daily life of the behavioral archetype including information that will then influence the design of the eDea digital learning intervention for innovation.
- **Behavior and familiarity with respect to key design and innovation features:** Capturing how close or far the behavioral archetype's thinking is in relation to focusing on which aspects of design thinking it leverages to design the students' educational experience:
 - **Behavior in terms of the educational style** adopted, which affects the educational experience students will receive.
 - **Method of teaching**, which can be based either on traditional learning methods that consider the instructor responsible for producing and passing on knowledge to students using tools such as lectures, presentations, theory study, literature study, exercises, and case studies or alternative methods that support that knowledge can be produced equally by both the trainer and the trainees using tools such as role play, simulation of real situations, and others. Of course, many individual educational models can be distinguished in between, however, for the needs of capturing the behavioral model, it was chosen to record the two extremes.
 - **Variety of educational methods**, which contribute to meeting the educational needs of more pupils or students. Lourenco F. and Jones O. (2006) listed 30 different pedagogical methods that can be used to teach design, innovation, and entrepreneurship.
 - **Use of technology in education**, and more specifically degree of familiarity, adoption, and integration of technological tools in learning processes.
 - **Academic approach**, which concerns the adoption of a research or theoretical approach as opposed to an approach focused more on market needs.
 - **The basic needs of the user (makers)**, such as features that it is desirable to integrate a solution under design or behaviors of the behavioral archetype that the solution is called to support in order for the user to choose it.
 - **The elements that the user would not like to see in a solution (breakers)**, because they will discourage him from choosing and using the proposed solution.

2.4.2.1 Behavioral archetype of collaborative design instructor

Users who correspond to the behavioral archetype of a collaborative design educator (collaborative design educator) have a strong connection to the labor market and this characteristic significantly affects the way they shape the course. They are usually full-time professionals who simultaneously teach undergraduates, graduate students, or other professionals in continuing education and lifelong learning programs. They may also be university professors who coordinate or participate in the implementation of research and development projects. They experiment and want to constantly evolve. It gives them particular pleasure to collaborate with others, such as market professionals, colleagues from the university, and with the students themselves, or to create conditions that promote collaboration, inside and outside the classroom.

Learning for them is a highly interactive experience aimed at sparking students' interest, imparting know-how that will be immediately usable when they enter the job market, and motivating them to challenge the status quo of things and how they learn.

Regarding the principles of design thinking, they make the most of the experimentation part by testing different educational methods to evaluate which ones fit their educational approach but also which ones are more effective in achieving the learning goals.

A general representation of the collaborative design instructor behavioral archetype is shown in the figure below. The image shows the name of the behavioral archetype that is Betty, demographic characteristics, a brief description, and behavioral data.

To understand the behavior of the behavioral archetype, its journey to date is described. Betty is a university professor and mother of 2 children. She is in charge of 4 courses. Of these, 2 are in the direction of entrepreneurship. As a working mother and wife, her week is full, especially at this time when she is participating in a project to redesign the identity and strategic communication of the Municipality of Athens. She is excited that some of the project partners are from abroad, as she is learning a lot and feels that she is developing as a professional. Being in direct contact with the market, she wants to transfer this pulse to her courses. In fact, in one of her courses, she has managed to establish a solid partnership with a company with whom, for the last 2 years, she has been shaping the students' work based on real processes that run in the company.

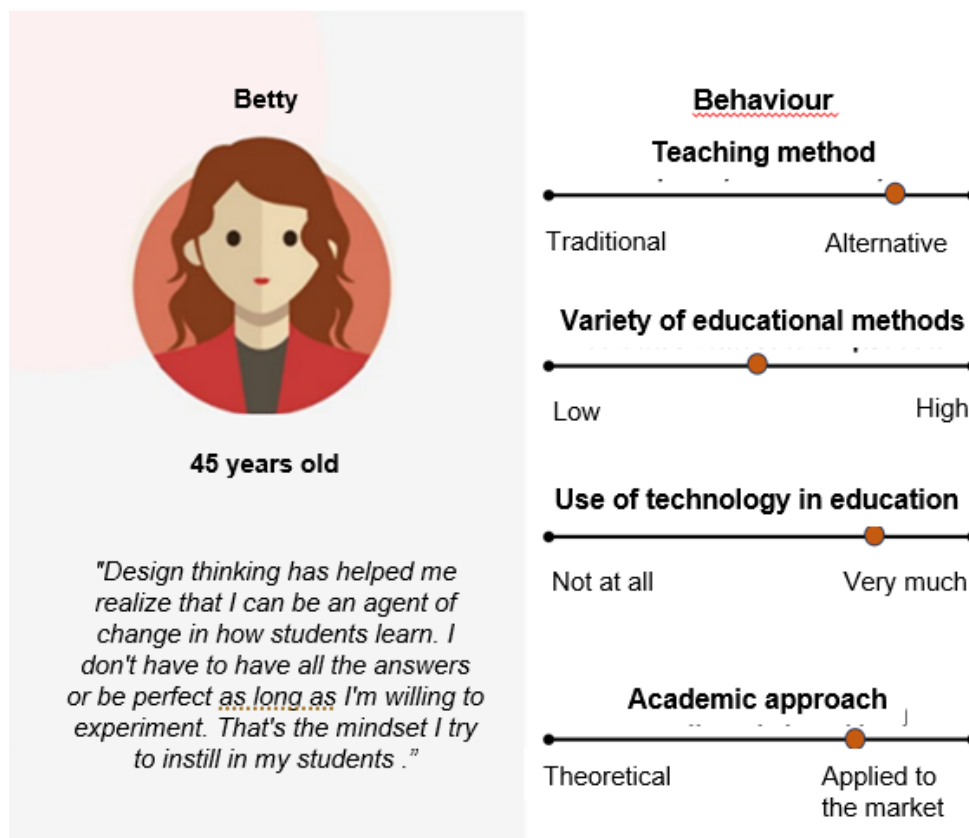


Figure 18. User view of collaborative design instructor behavioral archetype.

The table below describes the needs of the behavioral archetype from the user's perspective.

The user...	... needs (wants) to ...	... because (in order to) ...
[Behavioral Archetype]	[Need]	[Significant research finding, problem faced, goal, or desired outcome he wants to achieve]
Betty ...	... she wants to help her students further develop their soft skills and especially collaboration skills ...	... because he knows they are important skills that companies are looking for.
Betty ...	... wants to find creative ways to connect the course with the job market ...	... to help its students understand how businesses and organizations work in real-world settings.

Betty ...	... he wants to do a fairly practical lesson ...	... to help students understand theory by putting it into practice.
Betty ...	... wants each lesson to be a separate interactive experience ...	... to enhance the active participation of students.
Betty ...	... likes to get feedback from her students and colleagues ...	... to constantly improve her lesson.
Betty ...	... needs support to adopt and integrate good practices regarding the educational process ...	... to continuously improve the educational process it provides to students.
Betty ...	... wants to be informed about new trends and good practices in the field of education ...	
Betty ...	... needs proper support to build relationships with companies from the market ...	... to shape a training program very close to the labor market trends.
Betty ...	... needs appropriate support to effectively utilize a variety of educational methods ...	... because he wants to help students through various means and ways to understand the basic principles of design thinking.
Betty ...	... needs support regarding the time to spend on each phase of design thinking	... because the ~14 week time span of an average semester is not enough time for students to see all phases of design thinking in detail.

Betty he wants to have flexibility in the way he structures and shapes the lesson to be able to bring it closer to her personal teaching style.
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Table 4. Behavioral archetype of collaborative design instructor.

Finally, the description of the behavioral archetype is complemented by the description of the basic needs (makers) and characteristics that would not like to be included in a possible solution (breakers).

The basic needs (makers) are analyzed below.

- Supporting students in the development of soft skills, especially in the part of collaboration.
- Direct connection of the course with the labor market.
- Support for active learning processes (learn by doing).
- Designing each course as a unique interactive experience for students.
- Access to ideas and tools for the continuous development of the course.
- Exchange views and ideas with other academics about the structure and content of a course.
- Lesson planning based on personality and preferred teaching style.
- Possibility of information about the latest trends in the field of education.

The elements that the behavioral archetype would not want included in a potential solution (breakers) are discussed below.

- Time required to find partners from the market to co-design student work.
- Difficulty in creating interdisciplinary teams for students' work.
- Time and difficulty required to define assignments so that they are neither too broad nor too specific to provide opportunities for students to innovate through design thinking.

2.4.2.2 Behavioral archetype of an empathetic design instructor

Users belonging to the empathetic design educator behavioral archetype have typically jumped into the fields of design thinking, innovation, and entrepreneurship from more traditional fields such as management. They are practical in the way they plan the course with the main aim of achieving the learning objectives as set out by the program's study guide. At the same time, they are also quite emotional with their

students and try to help them as much as they can to understand the concepts and successfully meet the course requirements. This sometimes leads them to adapt the course content or exercises to make it easier for students. They make sure to give students plenty of case studies to study in order to help them better understand the concepts covered in the course. They will often complain that students are not intrinsically motivated to actively participate in class.

A general representation of the collaborative design instructor behavioral archetype is shown in the image below, showing the name of the behavioral archetype that is Nick, demographic characteristics, brief description, and behavioral elements.

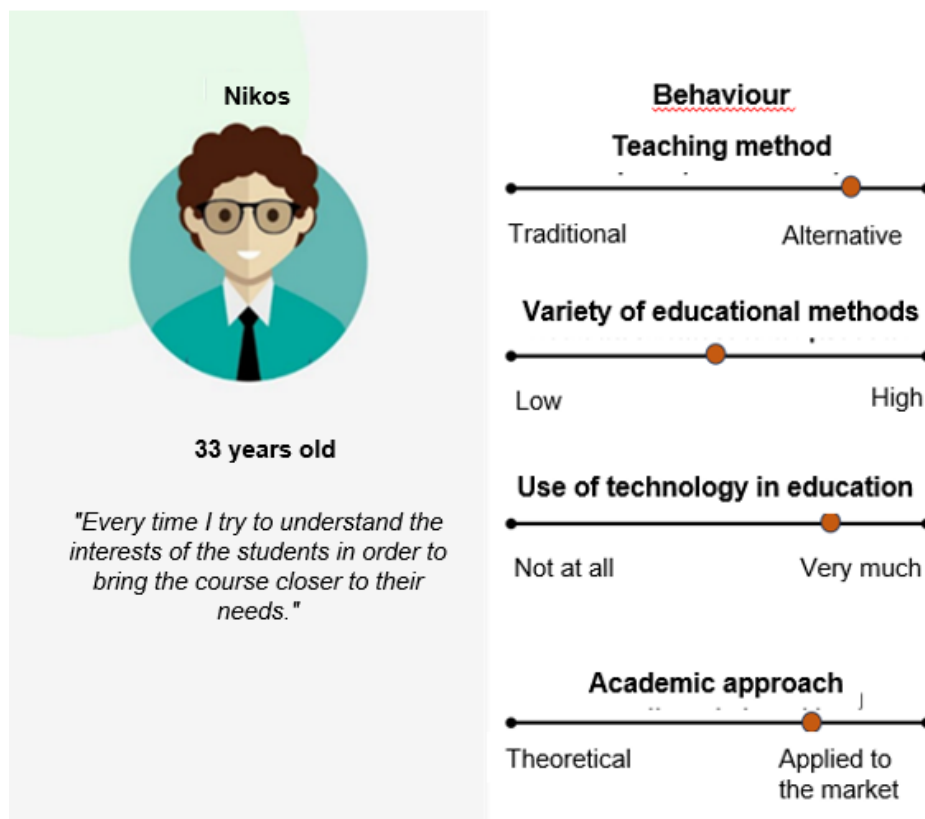


Figure 19. Behavioral archetype of an empathetic design instructor.

To understand the behavior of the behavioral archetype, its journey to date is described. Nikos started teaching while doing his PhD in Business Administration. As part of his research, he came into contact with design thinking for the first time and understood the importance of empathy with users. For this reason he now makes sure to get feedback from his students about the course and adjust it accordingly. However, he finds it difficult to manage the ambiguity involved in the first phases of design thinking and tries to ensure that both the course and the exercises he gives the students have a clear structure, as he himself has noticed that many times the students resent exercises where the question has high degree of ambiguity.

The table below describes the needs of the behavioral archetype from the user's perspective.

The user...	... needs (wants) to ...	... because (in order to) ...
[Behavioral Archetype]	[Need]	[Significant research finding, problem faced, goal, or desired outcome he wants to achieve]
Nikos ...	... wants to collect information about the interests of the students he teaches ...	... because he wants to tailor the course to fit their needs.
Nikos ...	... wants to customize the lesson and the exercises ...	... to help students overcome difficulties and successfully apply what they have learned.
Nikos ...	... wants to provide students with many practical examples ...	... because he wants to help them understand the theory better.
Nikos ...	... wants to follow a well-structured process and plan the lesson based on the educational objectives that have been set ...	... to ensure a coherent and comprehensive learning experience.
Nikos ...	... wants to consult other academic colleagues ...	... because he wants to get advice and new ideas to improve his teaching.
Nikos ...	... wants to adapt the lesson and exercises to the needs and level of understanding of the students ...	... because he wishes to provide an educational experience that will be applicable and useful to them in the future.
Nikos ...	... needs support and proper tools to create	... to facilitate students while reading.

	properly designed presentations ...	
Nikos ...	... needs support to make his lesson more interactive ...	... because it wishes to provide an active and mutually participatory teaching experience
Nikos ...	... wants to motivate students for active participation in the educational process ...	

5. Behavioral archetype of collaborative design instructor.

Finally, the description of the behavioral archetype is complemented by the description of the basic needs (makers) and characteristics that would not like to be included in a possible solution (breakers).

The basic needs (makers) are analyzed below.

- Collection of information about the interests of the students, which allows the appropriate configuration of the course.
- Customization of the course and exercises, in a way that helps students overcome difficulties and successfully apply what they have learned.
- Providing students with practical examples (case studies) to understand the theory.
- Well-structured course design process based on educational objectives.
- Collaborate with other academics to improve content and teaching methods.
- Discussion with other academics about the problems that may be faced in the classroom.

The elements that the behavioral archetype would not want included in a potential solution (breakers) are discussed below.

- Lack of interactivity in the lesson.
- Lack of functionality for the flexible presentation of educational content.
- Lack of functionality that encourages the active participation of students in the educational process.

3. Analysis of the existing situation: existing design thinking frameworks

Design thinking is a set of cognitive processes that aim to draw up a design plan which, if implemented, will bring about a desired and original change in the world. This change can take the form of physical or digital artifacts, processes, and more. Design thinking, as a term, has a history that dates back to the 1950s and 1960s. It is rooted in the study of the cognitive science of design and design methods. According to Cross (2011) an alternative term for design thinking is design ways of knowing, thinking, and acting (Cross 2001). Many of the key concepts and aspects of design thinking have been identified through studies, in different areas of design in both laboratory and natural environments.

This section captures the current situation regarding processes for developing design thinking skills in the context of formal or informal learning processes. In the first part of the unit, a historical review of design thinking as a field of research and action is carried out. The presentation of the historical framework is followed by the presentation of contemporary methodologies and design thinking frameworks. The design thinking methodology of IDEO®, the design thinking methodology of Stanford University (Stanford d.School, 2022), the double diamond methodology of the British Design Council, design thinking, and finally the Collective Action Toolkit (CAT) are analyzed. by frog design®.

3.1 Historical review of design thinking

Drawing on psychological studies of creativity since the 1940s, such as Max Wertheimer's generative thinking (Wertheimer, M., Wertheimer, M. , 1959), new creativity techniques in the 1950s, and design methods in the 1960s led to the idea of design thinking as a particular approach to creative problem solving. Among the first authors to write about design thinking were John E. Arnold in Creative Engineering (Arnold, 2016) and Bruce Archer in Systematic Method for Designers (Archer, Systematic Method for Designers, 1965).

In his book Creative Engineering (1959) Arnold distinguishes four areas of design thinking:

- New functionality, i.e. solutions that satisfy a new need or solutions that satisfy an old need in a completely new way.
- Higher performance levels of a solution.
- Lower production costs.

- Increased marketability.

Arnold recommended a balanced approach. According to Arnold, product designers should look for opportunities in all four areas of design thinking. Arnold believed that it is interesting to look at the development history of any product or product family and make attempts to classify the changes into one of the four areas listed above.

Herbert Simon (1969) aiming to demonstrate that it is possible to have an empirical science of artificial phenomena apart from that of natural phenomena, advocates the distinction between the artificial and the natural. It is based on the fact that artificial things are synthetic and characterized by their functions, goals and adaptation. Simon characterizes an artificial system as an interface that connects two environments - internal and external. Therefore, artificial systems are susceptible to change because they depend on their environment, i.e. the conditions in which they find themselves. Furthermore, these environments exist in the realm of natural science, while the interface exists in the realm of artificial science. For Simon, artificial science is the science of design, while artificial sciences relate to all fields that create designs to perform tasks or fulfill goals and functions. Therefore for Simon from an anthropological point of view, design thinking is universal and is the one that, historically, is the cornerstone for the transition from the natural world to the artificial through the design of tools and the emergence of homo faber.

Bruce Archer's Systematic Method for Designers (1965) is primarily concerned with defining a systematic design process, yet expresses the need to broaden the scope of design. According to Archer, ways must be found to incorporate knowledge from ergonomics, cybernetics, marketing science, and management into design thinking. Archer also developed the relationship of design thinking to management and strategy, arguing that the time is fast approaching where planning and management decision-making techniques will have so much in common that one will become no more than an extension of the other. This expansion highlights the interdisciplinary nature of design as a common ground that facilitates collaboration between different fields of knowledge around a common goal.

Bryan Lawson's book *How Designers Think* (1980), mainly concerned with how we observe the design process in architecture, started a process of generalizing the concept of design thinking. In his *Designerly Ways of Knowing* article Cross (1982) established some of the inherent qualities and capabilities of design thinking that also made it relevant to general education and therefore to the wider public. Peter Rowe's book *Design Thinking* (1987) describes methods and approaches used by architects and urban planners. The reference to design thinking is an important early use of the term in the wider design research literature. An international series of research symposia in design thinking was started at the Delft University of Technology (TUI

Delft) in 1991. Richard Buchanan's article *Wicked Problems in Design Thinking* (1992) expresses a broader view of design thinking as a method for dealing with wicked problems through of design.

John E. Arnold started a long tradition of design thinking at Stanford University, continued by many others, including Robert McKim and Rolfe Faste. The latter taught design thinking as a method of creative action and contributed to the shift of design thinking to the field of innovation management in the 2000s. Design thinking was adapted for business purposes by Faste's colleague at Stanford, David M. Kelley, who founded the design and consulting firm IDEO in 1991.

IDEO® is often credited with coining the term design thinking and establishing its application. In fact, design thinking has emerged from a global dialogue and research that has been going on for decades. What IDEO® has achieved is to create an approach that can now be put into practice by promoting the adoption of design thinking by partners and organizations to a level that places it at the center of their decision-making process.

As a mindset and methodology, design thinking is relatively new. By comparison, the scientific method is amenable to centuries of rigorous use and research. Modern management practices such as Six Sigma have benefited from decades of implementation and evaluation experience. Design thinking is only 15 years or so into widespread adoption. It is a set of methods for guiding cooperation. All of this is based on the existence and operation of a design team.

Today, design thinking is used as a common language of communication in many industries. The approach is fresh and efficient and beginners can easily learn it and engage productively with it. The term design thinking can be used as a communication tool without a real commitment to understanding and applying the practice.

In his article *Design Thinking, A Useful Myth*, Don Norman (2010) argues that the term has simply become a public relations tool and is not sufficiently differentiated from the creative thinking of artists, scientists and engineers. Norman argues that the design community perpetuates this myth because it serves design consultants well. Hire us, they say, and we'll bring you the magic of design. In a subsequent article in 2013 Norman revises his position and states that he has changed his mind believing that design thinking is truly distinct. According to Norman, unfortunately it is not properly adopted by all designers but where it exists it is a powerful tool. Again according to Norman maybe design thinking is something all designers should be doing. Norman adopts Bill Moggridge's view that the term design thinking is not a myth. It is a description of the application of a well-tested design process to new challenges and opportunities used by people with and without design backgrounds. The use of the

term will continue to expand and the theory and process of design thinking will become more universally understood, so that eventually every person in a decision-making position will know how to use design and design thinking for innovation and better results. (Moggridge, 2010)

3.1.1 Historical timeline

This section presents a historical timeline of the development of design thinking.

3.1.1.1 Before 1960

Design thinking has its roots in the development of psychology studies of creativity in the 1940s and the development of creativity techniques in the 1950s.

3.1.1.2 1960s

The first notable books on creativity methods were published by William J. J. Gordon *Synectics, the Development of Creative Capacity* (1961) and Alex Faickney Osborn's *Applied Imagination: Principles and Procedures of Creative Thinking* (1963).

The 1962 conference on Systematic and Intuitive Methods in Engineering, Industrial Design, Architecture, and Communications in London catalyzes interest in the study of design processes and the development of new design methods.

Books on design methods and theories in various fields are published by Morris Asimow *Introduction to Design* (1962) for engineering, Christopher Alexander *Notes on the Synthesis of Form* (1964) for architecture, L. Bruce Archer *Systematic Method for Designers* (1965) on industrial design, and John Chris Jones *Design Methods* (1970) on product and system design.

3.1.1.3 1970s

Don Koberg and Jim Bagnall lead the way by proposing a process of designing soft systems (soft systems) for dealing with the problems of everyday life, in their book *The Universal Traveler: A Soft Systems Guide to Creativity, Problem-Solving, and the Process of Design* (1972).

Horst Rittel and Melvin Webber publish the book *Dilemmas in a General Theory of Planning* (1973), in which they show that planning and strategizing problems are wicked problems, as opposed to "tame", single-issue problems of science.

L. Bruce Archer extends the exploration of design ways of knowing in his article *Whatever Became of Design Methodology?* (1979), where he claims that there is a design way of thinking and communicating that is different from scientific and academic ways of thinking and communicating, but at the same time just as powerful as scientific and academic research methods when applied to its own kinds of problems.

3.1.1.4 1980s

The 1980s bring the rise of human-centered design and design-centered business management.

Donald Schön publishes his book *The Reflective Practitioner: How Professionals Think in Action* (1983), in which he aims to establish an epistemology of practice that is embedded in the artistic, intuitive processes that [designers and other] professionals bring to situations of uncertainty, instability, uniqueness and value conflict.

3.1.1.5 1990s

The first symposium on design thinking research is held at the University of Delft, the Netherlands, in 1991.

The company IDEO is created by the merger of three industrial design companies. They are one of the first design companies to present their design process, which is based on design methods and design thinking.

3.1.1.6 2000s

The beginning of the 21st century brings a significant increase in interest in design thinking as the term becomes popular in the business press. Books are being written about the business sector on how to create a design-focused workplace where innovation can thrive. Some of them are Richard Florida's books *The Rise of the Creative Class: and How It's Transforming Work, Leisure, Community and Everyday Life* (2002), Daniel Pink *A Whole New Mind: Why Right-brainers Will Rule the Future* (2006), Roger Martin *The Opposable Mind: How Successful Leaders Win through Integrative Thinking* (2007), Tim Brown *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation* (2009), Thomas Lockwood *Design Thinking: Integrating Innovation, Customer Experience and Brand Value* (2010), and Vijay Kumar *Design Methods: A Structured Approach for Driving Innovation in Your Organization* (2012).

The design approach is also extended and adapted for use in service design, marking the beginning of the service design movement.

In 2005, Stanford University's d.School began teaching design thinking as a generalizable approach to technical and social innovation.

3.1.1.7 2010s

In 2018 in Harvard Business Review Jeanne Liedtka claims that design thinking works for business.

At the same time, the development of design thinking in the field of service design continues, with the landmark book by M. Stickdorn, ME Hormess, A. Lawrence, J.

Schneider This is Service Design Doing: Applying Service Design Thinking in the Real World” (Stickdorn , M., Hormess, M.E., Lawrence, A., & Schneider, J., 2018).

3.1.1.8 2020s

Research into the design process continues apace. The method finds application in more and more areas.

Design thinking and its teaching has begun and is systematized in volumes such as the book by F. Uebernickel et al. Design Thinking: The Handbook (2020).

The use of design thinking to deal with the effects of the Covid-19 pandemic is noteworthy (P. Cankurtaran, M.B. Beverland Using Design Thinking to Respond to Crises: B2B Lessons from the 2020 COVID-19 Pandemic” (2020).

At the same time, voices are being raised calling for a review of design thinking and its harmonization with the modern era and its needs. For example, GK VanPatter's book Rethinking Design Thinking: Making Sense of the Future That has Already Arrived (2020).

3.2 IDEO®'s Design Thinking Approach

According to Tim Brown, CEO of IDEO®, design thinking is a human-centered approach to innovation, drawing on the designer's toolbox to integrate the needs of people, the capabilities of technology, and the requirements for business success.

IDEO® is a design and consulting company with a strong presence around the world. She is known for her human-centered, interdisciplinary approach. Her work has greatly contributed to the development of the principles and practice of design thinking and human-centered design. Having managed to build a diverse team of experts, IDEO® applies design thinking to the projects it undertakes, contributing to the innovation of its clients. The IDEO® design process modus operandi is detailed in the book The Art of Innovation (Kelley, T., Littman, J., 2001), which is considered a landmark in the presentation of design thinking methodology, although the term design thinking is not expressly refers to it.

IDEO® has established a specific internal value system that shows how it operates. These values are mentioned below, not to evaluate IDEO®'s corporate identity and culture, but because they have served as a foundation for the development of IDEO®'s design thinking both as a theory and as specific practices and methodologies. Specifically, therefore:

- **Optimism (be optimistic):** Constraints are seen as opportunities. There is faith in a world full of possibilities. No problem is insurmountable.

- **Collaborate:** Group collaboration has a central role. The challenges are too great to be solved individually.
- **Contribution to the success of others (make others successful):** Dedication to mutual support and to the success of partners in their projects.
- **Embrace ambiguity:** Faced with big, hard-to-solve challenges, we recognize that we don't have all the answers, but we are confident that we can discover them.
- **Take ownership:** Ownership of projects means commitment and responsibility.
- **Learning from failure (learn from failure):** Every solution has to start somewhere. The initial mistakes are given, they are taken seriously, but they do not prevent the continuation of the effort.
- **Talk less, do more:** New solutions emerge from practical friction in the field using appropriate tools and practices.

IDEO® emphasizes the need to focus on the people we design for. The first question in any case of new design and innovation, according to IDEO®, should be what human need it is trying to satisfy. Based on this, i.e. what is desired by people, two other factors should also come into play, composing a triptych of design thinking goals concerning what is technologically feasible and what is economically viable in the sense of realistic feasibility as opposed to environmental sustainability. At this level, the right questions should be asked that lead to an understanding of the problem before any attempt to design solutions.

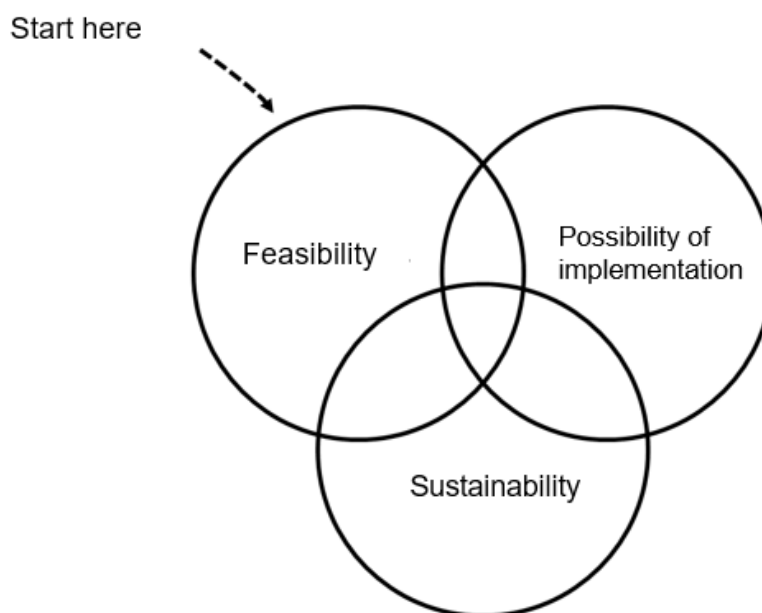


Figure 20. The triptych of design thinking according to IDEO®. Schematic based on original source: <http://ideou.com>.

An important distinction in design thinking is divergent and convergent thinking. In the divergent way of thinking, the goal is to expand the field of research and study, in order to give space and fertile ground for new, original, and innovative ideas to be born so that there are multiple options and possible design outcomes. In convergent thinking the central goal is to make decisions from available options and to process existing ideas to synthesize information.

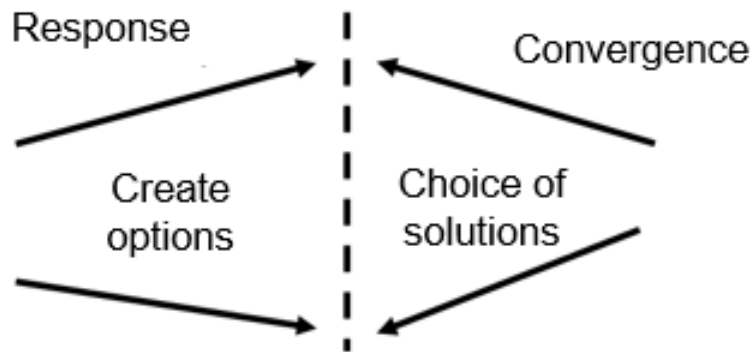


Figure 21. Divergent and convergent thinking. Diagram adapted from original source: <https://www.ideo.com/pages/design-thinking-resources>.

In practice, the design process that follows the principles of IDEO® design thinking is divided into 6 phases:

- **Query Definition:** Designers inspire and inspire the rest of the design team to think about the customers they are designing a solution for and what they really need. They identify a question that inspires the search for creative solutions.
- **Gather inspiration:** Designers are encouraged to get out of the office and explore the world by talking, observing, and discovering what people really need.
- **Idea generation:** Designers use the inspiration they've built to move beyond obvious solutions to new revolutionary ideas.
- **Turning ideas into tangibles:** Designers build rough prototypes to learn how to make ideas better and quickly discover what works and what doesn't.
- **Testing for learning:** Designers test their prototypes and collect feedback and feedback. They adapt ideas iteratively, moving forward.
- **Communicate the story:** Once a good solution is arrived at, designers shape and share with colleagues and clients. They create a narrative to inspire others to action.

These phases should not be seen as a linear process that is strictly followed. They may be carried out in a different order, while it is possible and useful that some steps are carried out iteratively, going back for additional processing and redesign having received new information from other phases.

These phases can in practice be carried out in various ways. The main tool is IDEO.org's *The Field Guide to Human-centered Design* (2015). A rich toolbox of methodologies is provided to assist a human-centered design process. These methodologies are drawn from the rich repertoire of design practice methodologies found more widely in the field of design and have been adapted by IDEO® to offer a framework capable of helping to apply the principles of design thinking. Some of them are presented epigrammatically below.

Methodology	Ho2	Why	Category
Empathy tools	Designers use tools like fogged glasses or weighted gloves to experience experiences as if you had the skills and abilities of other users.	It's an easy way to build empathetic understanding of special needs or specific physical conditions.	Testing
Experience prototype	Designers create a rapid prototype of an idea, using whatever materials you have available, and use it to learn through a simulation of the product's user experience.	It is useful for discovering unexpected issues or needs as well as for evaluating ideas.	Testing
Informance	Designers act out an informational performance scenario as actors, acting out roles that highlight findings, knowledge, and behaviors they have seen or studied.	It contributes to the effective communication of a finding, building shared understanding of an idea and its implications.	Testing
Paper prototyping	Designers sketch an idea quickly and roughly on paper to test the structure of a potential solution and evaluate interaction elements for a basic usability.	It's a good method for organizing, implementing, and quickly visualizing interaction design ideas.	Testing

Predict next year's headlines	Designers ask their clients to think about what their company will be like in the future, recognizing how they want to develop and maintain relationships with their customers.	Based on customer research, these predictions help customers define which design issues to focus on in product development.	Testing
Quick and dirty prototyping	Using any available raw material, designers quickly design potential prototype solutions or interfaces for evaluation.	It is a good method of communicating ideas to the team in a way that quickly allows for a quick assessment of how the design can be improved.	Testing
Role-playing	Designers identify the people involved in a design problem (stakeholders), and assign these roles to team members.	By acting out the activities within a real or artificial environment, the team can build empathy for real users and discover additional relevant aspects of the problem.	Testing
Scale modelling	Designers use a general architectural model at scale to be able to design spaces in collaboration with clients, team, or even users.	It is a satisfactory way of uncovering issues and meeting the basic needs and wants of the various stakeholders.	Testing

Scenarios	Designers build a multi-character story or narrative that details the circumstances of using a product or service.	It contributes to the communication and testing of the design concept within a possible use environment offering benefits in service design cases.	Testing
Scenario testing	Designers show potential users cards depicting possible future scenarios and ask them to share their thoughts, while also observing their reactions.	It is a useful method for gathering impressions regarding specific usage scenarios and also for communicating the value of an idea to customers.	Testing
Try it yourself	Designers test a product, service, or prototype they design.	Testing the product under design gives the team an opportunity to appreciate and understand the experience a real user might have.	Testing
Behavior sampling	Designers give potential users a phone or similar notification device and ask them to rate the conditions and state they are in when the device rings or alerts.	It's a good way to discover how specific products and services fit into people's everyday lives, even in unexpected ways.	Testing

Be your customer	Designers ask their client to describe, document, or even represent their user experience.	It is a useful method of recording the needs of the client regarding its users, which gives the opportunity to compare with the actual experiences and opinions of the users.	Testing
Bodystorming	Designers prepare a scenario and take on specific roles, with or without the use of equipment, focusing on the intuitive responses and reactions evoked by the representation.	It helps generate and quickly test many ideas related to the user environment and user behaviors.	Testing
Fly on the wall	Designers observe and record behaviors in the natural environment where they occur without interfering at all with the participants' activities.	It is a good method of observing and investigating people's behavior in real situations and in everyday times, which can complement the information they provide through interviews or narratives.	Observation
Guided tours	Designers accompany potential users and give them the opportunity to tour relevant spaces and activities related to the current design.	It contributes to the exploration of objects and actions in their natural manifestation space and helps people to remember their intentions and values.	Observation

Personal inventory	Designers record the items that potential users find important, as a way of gathering information about their lifestyles.	It helps reveal people's activities, perceptions, and values as well as any patterns among them.	Observation
Rapid ethnography	Designers spend as much time as they can with design people, gaining their trust. In this way they can participate in the daily life of the users, so that they can observe some of their activities.	It is a good way to gain an in-depth understanding of customs, rituals, languages, and concepts related to specific actions, activities, and objects.	Observation
Shadowing	Designers accompany potential users in their daily lives to observe and understand their daily routines, their interactions, and the situations they face.	It is a valuable way to uncover opportunities for design intervention but also to assess how a product might influence user behavior.	Observation
Social network mapping	Designers observe the different social relationships that exist in a particular category of users, mapping this web of relationships and interactions.	It contributes to the understanding of the interpersonal and professional relational structures that exist in specific groups.	Observation

<p>Still photo survey</p>	<p>Designers organize and follow a photo shoot capturing specific actions, objects, and more.</p>	<p>It contributes to the use of photographic material to discover patterns of behavior and perceptions related to a particular product. Photographic material can also help inspire and structure new design ideas.</p>	<p>Observation</p>
<p>Timelapse video</p>	<p>Designers place a timelapse camera to record the movements and flows in a space over time.</p>	<p>It serves to gain an objective perspective on how a space is used and what activities take place there.</p>	<p>Observation</p>
<p>A day in the life</p>	<p>Designers record all the activities that users experience during an entire day and the spaces where they take place.</p>	<p>It is a good way to discover unexpected issues related to the routines and circumstances that people experience in their daily lives.</p>	<p>Observation</p>
<p>Behavioral archaeology</p>	<p>Designers consider evidence and information about the activities of potential users, the space in which they occur, signs of wear and tear on the space and objects, and the organization of spaces and objects.</p>	<p>It helps to reveal how potential users interact with objects and space in their daily lives and offers possibilities to highlight elements of their lifestyle, habits, priorities, and values.</p>	<p>Observation</p>

Behavioral mapping	Planners record the positions and movements of people in space over time.	It is a useful method of recording the routes and movement patterns of users that helps to highlight and define zones and areas where different spatial behaviors are observed.	Observation
Error analysis	Designers make a list of all possible undesirable outcomes when using a product by determining the possible causes.	It is a good way to understand the characteristics of the objects being designed to help deal with inevitable human errors or other failures.	Contemplation
Flow analysis	Designers depict the flow of information or activity through all phases of the system or process.	It helps to identify problem points and opportunities for alternative use of a solution.	Contemplation
Historical analysis	Planners compare the characteristics of an industry, organization, group, market segment, or practice at various stages of their evolution and development over time.	It is a useful method of identifying trends, patterns, and recurring cycles in product usage and user behavior.	Contemplation

Long-range forecasts	Designers record narrative scenarios that describe how social or technological trends might affect user behavior and use of a product, service, or environment.	Anticipating changes in behavior, industry, or technology can help understand the implications of design decisions.	Contemplation
Activity analysis	Designers list or detail all the actions, tasks, objects, users, and interactions of a process.	It is a useful way of identifying different groups of stakeholders by allowing the creation of a list of priorities between groups and needs that are the subject of research.	Contemplation
Affinity diagrams	Designers group elements of a proposed solution according to criteria such as similarity, interdependence, proximity, and more.	It helps identify correlations and connections between topics, thereby revealing new opportunities for innovation.	Contemplation
Anthropometric analysis	Designers use physical measurement data to confirm the appropriateness and percentage population coverage that their design proposal achieves with respect to the user group of interest.	It is a useful method of identifying a portion of the population in which some design prototypes should be tested and also of evaluating the usability of product details.	Contemplation

Character profiles	Based on observations of real people, designers draft and develop profiles of fictional characters that represent specific user archetypes including details about their behavior and lifestyle.	It contributes to the creation of the profile of a typical user with the aim of communicating the value that different types of users give to specific ideas and propositions.	Contemplation
Cognitive task analysis	Designers capture and annotate all the information users receive through their senses, decision points, and actions they take.	It is a useful method of understanding user needs, perceptions, and information channels as well as identifying friction points where failures and problems may occur.	Contemplation
Competitive product survey	Designers collect, compare, and evaluate the existing competition of the product being designed.	It is a useful way of defining functional requirements, quality and performance prerequisites, and other metrics and benchmarks.	Contemplation
Cross-cultural comparisons	Designers use personal or public information to discover differences in the behaviors and objects used by different cultural population groups.	It contributes to the understanding of social factors and their impact on a possible solution regarding unknown or international markets and societies.	Contemplation

Extreme user interview	Designers look for people who are very familiar or have no experience or knowledge of the product and conduct interviews to assess the user experience.	It helps to highlight key issues of the object under design by producing useful comments and opinions to improve a design.	Investigation
Five whys?	Designers design explanatory questions that begin with "why" into five consecutive answers.	It encourages people to study and express the root reasons for their behavior and attitudes.	Investigation
Foreign correspondents	Designers solicit feedback from colleagues and acquaintances from other countries by conducting a cross-cultural survey to derive key design principles with an international reach.	It is a good way to highlight cultural and physical characteristics of the environments in which a solution will be used.	Investigation
Narration	Designers ask research participants to describe their thoughts as they carry out a process or take a specific action.	It helps to draw conclusions about users' motivations, their concerns, how they understand the problem, and where they think.	Investigation
Surveys and questionnaires	Designers ask targeted questions with the goal of eliciting information about specific user characteristics and perceptions.	It is a quick way to get answers and information from a large number of people.	Investigation

Unfocus groups	Designers create a diverse group of people to carry out a workshop. They use a variety of thought-provoking materials, and generate ideas and solutions about a goal.	It gives potential users the opportunity to contribute in an imaginative, rich, and diverse way without inhibitions opening the way to fresh ideas.	Investigation
Word - concept association	Designers ask potential users to associate descriptive words with different design ideas, concepts, and features to observe how users perceive and value them.	Contributes to the evaluation and prioritization of design features and ideas.	Investigation
Camera journal	Designers ask potential users to keep a visual and written diary of their impressions, situations, and activities related to the product.	It is a rich technique carried out by the users themselves giving them the opportunity to reveal their opinions, views, and patterns of behavior.	Investigation
Card sort	Designers write on separate cards possible functions, features, or design qualities and ask potential users to arrange the cards in the space in any way that makes sense to them.	It contributes to revealing mental models formed regarding a solution, the organization and classification of which can reveal user expectations and priorities in relation to expected functions.	Investigation

Cognitive maps	Designers ask potential users to produce a layout of their physical or digital spaces and show how they move through them.	It contributes to the discovery of important features, trajectories, and other spatial behavioral data related to a real or digital space or system.	Investigation
Collage	Designers ask potential users to make a collage using photos and materials they provide encouraging them to explain the meaning and significance of these images and the layout they chose.	It reveals users' understanding and perceptions of specific issues and helps them express complex or unexpected issues, themes, and thoughts.	Investigation
Conceptual landscape	Designers produce diagrams of various aspects of abstract social or behavioral structures and phenomena.	It contributes to the understanding of mental models in relation to the solution under design.	Investigation
Cultural probe	Designers provide potential users who are members of one or more cultural groups with recording tools such as a camera, notebook, instructions and ask them to describe their thoughts.	It is a useful method of collecting and evaluating the perceptions of users belonging to different cultures with minimal intervention.	Investigation

<p>Draw the experience</p>	<p>Designers encourage potential users to visualize an experience through drawings, sketches, and diagrams.</p>	<p>It contributes to demystifying prejudices and stereotypes and highlighting how users really perceive and classify their experiences and activities.</p>	<p>Investigation</p>
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Table 6. Problem investigation activities by IDEO (IDEO, 2003).

3.3 Stanford d.School's Design Thinking Approach

The Hasso Plattner Institute of Design (Hasso Plattner Institute of Design), previously and more commonly known as the Stanford Design School (d.School) is one of the main contributors to research and development of the methodology and theory of design thinking in academic level.

In a first phase, the institute based the teaching of design thinking on a simple but powerful three-step process:

- Understanding.
- Improvement.
- Application.

Based on these steps and the experience of teaching and developing the framework, d.School formulated and communicated the famous 5-step process, which is widely used around the world.

d.School has chosen to represent this 5-step process using a hexagon layout, which has become a symbol of design thinking widely. The choice of diagram symbolizes that the stages are seen more as factors or ways of thinking, than as specific linear steps

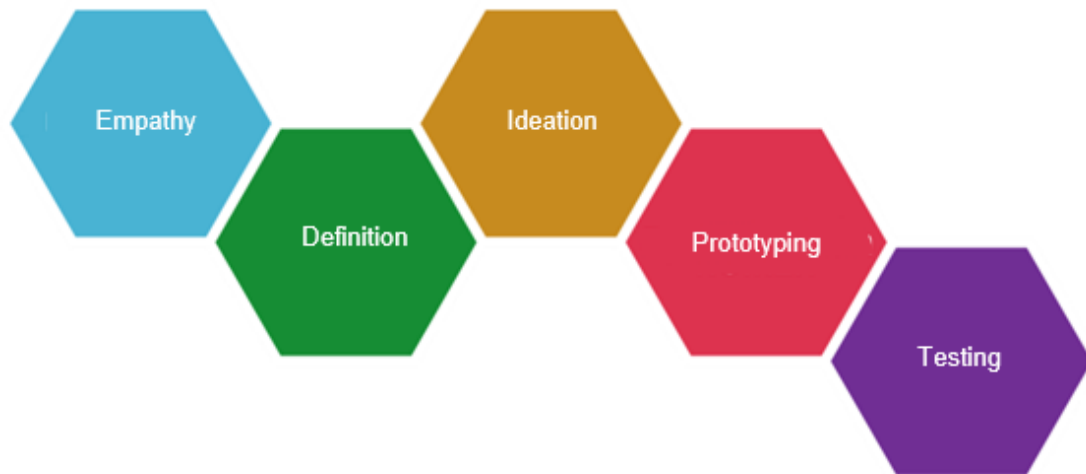


Figure 22. The diagram with the hexagons of d.school. Diagram adapted from original source: Stanford d.School web, Public License, <https://dschool.stanford.edu>.

The 5 stages of the design thinking process, as described by the d.School, are as follows (2010):

- **Empathy**, which is the focus of the human-centered design process. The empathy stage includes the activities that need to be done to understand the people in the design work. It is the effort to understand how and why users act the way they do, their physical and emotional needs, how they interpret the world, and what is meaningful to them. To build empathy, designers must observe users and their behaviors, interact with them to understand them more, and listen and see with an open mind, without biases and preconceptions.
- **Definition**, which is about clarity and focus of design. It is both the designer's opportunity and responsibility to define what to focus on based on the information they have about the users and the context of use. The goal of this stage is to build a meaningful, grounded, and workable definition of the problem. It should act as a guiding statement of intent based on the ideas and needs of a specific group or class of users. Building a specific view and picture of the problem results from a process of synthesizing information to reveal connections and patterns. The definition stage is the stage of building understanding.
- **Ideation**, where attention is focused on generating ideas. In this stage designers expand the definitions of the problem in search of new ideas and results. Ideation is the source for prototyping and creating innovative solutions

that can be quickly tested by users. The aim is to explore beyond the obvious solutions in a way that increases the possibility for real innovation in design proposals. There are several methodologies that facilitate the generation of ideas through brainstorming using up-to-date understanding of the problem, stakeholders, and environment.

- **Prototyping**, which involves the iterative production of objects and artifacts that help test ideas, find, and solve problems, bringing the design process closer to a final solution. In the early stages of a project, low-resolution prototypes are created quickly and cheaply to build, which can bring useful feedback and ideas from users and colleagues. In later stages the prototyping can become more specific and with greater fidelity and detail. A prototype can be anything that a user can interact with, whether it's a wall of notes, an object quickly assembled from available materials, a role-playing activity, or even a hypothetical scenario. The goal is for the user to try the designed artefact and to be able to experience it to some extent.
- **Testing**, where feedback and feedback are sought on the prototypes created. Feedback can come from users being researched and tested. The testing stage provides another opportunity to build deep understanding and empathy for the wants, needs, and values of the users we are designing for. Important at this stage is for designers not to settle for superficial "like/dislike" comments, but to make a serious effort to elicit information about users' motivations and perceptions, often asking "why", and focusing on what more can be learned about users and their life circumstances. Testing can be done by asking potential users to try the prototype or product in their everyday life. This can be achieved in specific cases and with specific usage scenarios in specific locations, especially in service and experience design cases. The testing stage is important for finding problems and issues for improvement in the design. It should be done with the sincere aim of uncovering these issues, and not simply positive feedback.

For each of these stages there are various methodologies and tools that can be used. Some of those suggested by the d.School educational material are presented below.

Name	Description	Empathy	Definition	Ideation	Prototyping	Testing
Assume a beginner's mindset	Designers have experiences, understanding, and expertise that include assumptions and personal beliefs. Designers' biases may, in fact, be wrong or stereotyped and limit their empathy towards users. Adopting a beginner's mindset helps to move beyond preconceived notions and approach the problem as a design challenge from a new perspective.	X				
What? How? Why?	The tool helps to extract deeper information, allowing designers to take a step beyond specific observations of a situation to more abstract emotions and motivations that play a role in the background. Designers start from specific observations and try to build further understanding that will contribute to the design process.	X				
Interview preparation	Interviews offer opportunities to gain a deeper understanding of users' needs, desires, and motivations. User interaction time is valuable. Designers should make the most of it. To achieve this they should prepare the interview process in advance. It may not be possible for planners to ask all of the questions they have prepared, but they should have a specific plan for how the interview will flow. In addition, interviews should leave room for spontaneous, unstructured discussions initiated by users.	X				

<p>Interview for empathy</p>	<p>Interviews also help gain empathy. Through the interview process designers better understand the behaviors, choices, and needs of each user personally. The interview process is most efficient when conducted by two interviewers at the same time, so that one person can talk while the other records.</p>	<p>X</p>			
<p>Extreme users</p>	<p>Designers communicate with users to understand their needs and gather information about their lives. By talking to and observing extreme users, they discover their unique needs and the solutions they may have come up with on their own to achieve their goals. This helps uncover essential needs that may not emerge when designers survey users who are in the average target group.</p>	<p>X</p>			
<p>Story share -and capture</p>	<p>When the interview process is complete, designers can share the stories they heard with their team. Sharing stories serves several purposes. It allows team members to be informed about the information collected by others in the field. Even if everyone was present in the field research, comparing how each member of the group experienced and understood it is valuable. In addition, by listening and exploring more information through discussion, group members tend to elicit meanings and details that were not initially perceived. Thus begins the composition process.</p>	<p>X</p>	<p>X</p>		
<p>Journey map</p>	<p>A user journey map is a tool for breaking down a process into its individual parts and segments with the aim of deriving possible conclusions and insights. At this stage it is important to focus on details gathered in the empathize stage that contribute to understanding a user as well as their experience. The road map can be used to build empathy or share findings with others.</p>	<p>X</p>	<p>X</p>		

Powers of ten	<p>The Powers of Ten is a reframing tool that contributes to synthesis or ideation. It helps the team understand the problem at different degrees of scale. When implementing the tool, designers can reduce or increase the order of magnitude of the scale of the environment to discover connections.</p>		X	X		
2x2 matrix	<p>The 2x2 matrix helps spatialize information about both the users and the design space on two axes, enabling the discovery of relationships and associations. The aim is to highlight ideas or areas that need to be explored more deeply. The tool is also a great way to visually communicate a relationship.</p>		X			
Why - how laddering	<p>The tool helps to specify the needs of the users to introduce a workable solution. The "why" question leads to abstract statements while the "how" question leads to concrete ones. Often, abstract statements are more meaningful, yet not as actionable. The opposite is true for more specific statements. Starting from specific user needs, designers can construct a ladder diagram by asking such questions.</p>		X			
Point of view	<p>The user perspective helps describe the design problem through an understandable problem statement that facilitates brainstorming to synthesize solutions. In practice, designers analyze the perspective of a particular user that they have detailed as a persona and try to understand that user's points of friction and interest.</p>		X			

Design guidelines	Design guidelines are written statements that articulate a strategy for how to approach and solve the design problem regardless of any particular solution. They translate designers' conclusions about user needs and knowledge into tangible and actionable instructions that contribute to the implementation of the design.		X			
How might we	“How could we ...” questions are short brainstorming questions. They are broad enough to allow for the introduction of a rich range of solutions, yet clear and targeted enough to set useful boundaries.	X	X			
Stoke	Stimulation activities relax and energize groups, both mentally and physically. They can be used to fire up the design team at the start of the day, start a meeting, or start a brainstorming session. They should be short and very active.			X		
Brainstorming	Brainstorming is used to generate a large volume of ideas. This is a timed session. Designers operate with the creative part of their brain as opposed to the evaluative part. The purpose is to utilize the collective thinking of the group. Brainstorming can be used throughout the design process, such as planning activities in the empathy stage, evaluating products and services, and synthesizing design solutions.			X		
Facilitate brainstorm	a Good coordination is a key factor in a creative and productive brainstorming process, where broad and sometimes seemingly unhelpful ideas are generated. An effective facilitator in such processes sets boundaries and spaces the discussion leaving room for open, active, and fruitful interaction.			X		

<p>Brainstorm selection</p>	<p>Brainstorming produces a wealth of ideas. The next step is choosing the ideas that will be used. Choosing design solutions can in some cases be simple and straightforward while in others it may require more complex thinking. It is desirable that designers do not choose only one idea and also do not settle for safe and obvious options. It is recommended that designers select a range of ideas to be prototyped with the aim of maintaining the variety of solutions produced by the team.</p>			X	
<p>Impose constraints</p>	<p>It may seem counterintuitive, but imposing constraints, with specific intent and targeting, can actually increase the creative potential of idea generation. As an example of an application of this tool, designers are asked to name as many metal objects as they can within ten seconds. In a second step, to name metal objects in their kitchen and compare in which of the two cases they introduced more options.</p>		X	X	
<p>Prototype for empathy</p>	<p>When implementing a prototype it is recommended that designers think about the people who will interact with that object, service, or experience. Prototype or experience design should be done in such a way that it helps to gain empathy. It is not necessary to search for solutions during user testing of prototypes. In the same way that a solution-oriented prototype reveals new information about the concept being tested, an empathy-building prototype contributes to understanding about users and the design space.</p>	X			X
<p>Improvise to life</p>	<p>Design teams sometimes over-analyze when prototyping for user testing, slowing down work progress. Representing the solution by assigning roles to team members can facilitate experimentation as well as rapid prototyping.</p>				X

Scenes, props, roles	The Scenes, Objects, and Roles tool helps prepare designers to test a prototype in the field with real users. The tool applies techniques inspired by theater improvisation to help understand where and how the prototype will be tested, as well as the roles of each team member involved in the field testing process.				X	
Δοκιμή με χρήστες (testing with users)	User testing is a fundamental and pivotal part of human-centered design. Designers conduct tests not only to improve a solution but also to better understand the people they are designing for. During testing, designers seek to learn more about both the proposed solution and the users.				X	X
Pprototype to decide	During the design process, the direction of implementation progress may not be clear, especially when team members have different opinions. The best way to resolve team disagreements about individual design elements is to build prototypes and have users evaluate them.				X	X
Identify a variable	The process of testing a prototype can be more productive if it is not focused on a complete solution but on a specific variable of the problem. Specifying a variable not only saves time and money by not having to implement all aspects of a complex solution, but it gives the opportunity to test multiple prototypes that differ in a single property. This encourages users to make more targeted comparisons between prototypes, giving clearer feedback.				X	X

User-driven prototyping	<p>These prototypes are created by users, not by the design team. When users create specific aspects of the design themselves, they reveal assumptions and desires that would otherwise remain unknown. The goal is not to incorporate users' ideas and suggestions into the final design, but to improve understanding of their thinking and uncover user needs, perceptions, and ideas.</p>	X			X	
Wizard of Oz prototyping	<p>Prototyping in this technique aims to mimic the desired functionality to be tested with users, without implementation. This saves time and money over actually building and implementing these functions. Wizard of Oz prototypes often involve digital systems. During testing, users have the impression that the system is responding to their interactions, when in reality a person is manually controlling the system's reactions and responses.</p>				X	X
Feedback capture matrix	<p>The school collection board makes it easy to capture real-time feedback from users or even design team members during prototype testing. It helps classify thoughts and ideas into four categories for easy evaluation, namely likeable and noteworthy features, constructive criticism, questions and concerns, and new ideas.</p>					X
Storytelling	<p>A well-told story full of rich detail, meaning, and emotion affects both the brain and the heart. Stories are a great way to communicate ideas on a human level. Telling a story that directly concerns users can impress an audience, whether it's colleagues, customers, or investors.</p>	X	X	X	X	X

<p>I like, I wish, what if</p>	<p>Designers rely on personal communication and, in particular, feedback and receiving constructive feedback during the design process. The tool is a simple way to encourage open discussion and feedback. Designers ask potential users to form statements that begin with these three phrases.</p>	X	X	X	X	X
<p>Empathetic data</p>	<p>The introduction of many new ideas makes it difficult to prove them empirically, especially when there is no basis for comparing or evaluating them. But designers can create data through simple prototyping. If the decision-making process is not progressing due to a lack of data, designers can create a data set with empathy, derived from prototype testing with real users.</p>	X			X	X
<p>Review your portfolio</p>	<p>Ideas introduced during brainstorming can range from small improvements to radical innovations they compose. Reviewing and categorizing them contributes to their understanding and the desired focus of the design team's energy and attention. to focus your energy and attention. Categorization can be achieved by plotting the ideas on a two-axis graph, where one axis corresponds to the depth of information and insight about an idea and the other to the radicalness or novelty of the idea.</p>	X	X	X	X	X
<p>Empathy probe</p>	<p>Sparking an emotional conversation with users, especially since they are usually strangers, can be difficult. Facilitating the first empathy-building interviews can also be difficult. Empathy tests help reduce friction by giving users something to do and creating space to speak their minds. It also gives plenty of opportunity to observe users before selecting which features of a solution the design team will engage with in more depth.</p>	X				

Describe your concept	Many brainstorming sessions end with the design team realizing they don't fully understand the idea they chose to implement. This tool helps to clarify what resonated with team members from the initial idea and to understand what needs to be created in the prototyping stage.		X			
Analogous empathy	The difficulty of design teams, especially firm ones, to innovate is often because they neglect to look outside their usual environment for inspiration. Unlike competitive research, analogies push teams to look at radically different industries and offerings so they can apply a new perspective to a problem that seems solved in classic ways.	X				
Shooting video	Video is a powerful medium for sharing ideas, knowledge, and stories. The video frame can be a means of communication in an energetic and specific way. If something isn't in the video frame, it doesn't exist.	X	X	X	X	X
Editing video	At its core, video editing is a storytelling tool. It is the medium that brings the narrative to life. Meticulous editing is of great importance to achieve the best and clearest possible narrative.	X	X	X	X	X

Table 7. Problem investigation activities from d.School (Doorley, S. et al, 2018).

3.4 Design Council's Double Diamond Methodology

The UK Design Council (Design Council, 2019) is an independent not-for-profit organisation. It was established in 1944 with the aim of post-war economic recovery. Its original mission was to promote by all practical means the improvement of the design of the products of British industry. Now the Planning Council has taken on the role of national strategic adviser on design, demonstrating an alternative model of design consultancy which is independent and promotes specific national goals and interests.

The council works with government, the public sector, business, and communities to deliver skills and learning that integrates design into a range of activities. The Design

Council promotes design, focusing on its potential to address the biggest challenges of our time and make real, positive changes in people's lives.

The principles and values of the Design Council reveal the understanding and role it gives to design. The primary goal of design is to improve life with processes that help people, communities, businesses, the economy and, most importantly, the planet to achieve this. The Design Council has a vision for a world where design acts as a force that restores, renews, and revitalizes. It recognizes that sustainability is no longer enough if we are to restore balance and live in harmony with the Earth's finite, limited resources, and that design is at the heart of this necessary change. It also places great importance on the value of collaboration, participation, diversity, and the perceptive spirit of inquiry, questioning, and broadening of knowledge.

The Design Council has designed the Double Diamond methodology, one of the most widely used and useful design and design thinking tools. The double diamond is an abstract model of the ideal design process, and how it combines two stages of convergent and divergent thinking. This tool has been used and commented on a lot, both by theoretical academics and in practice.

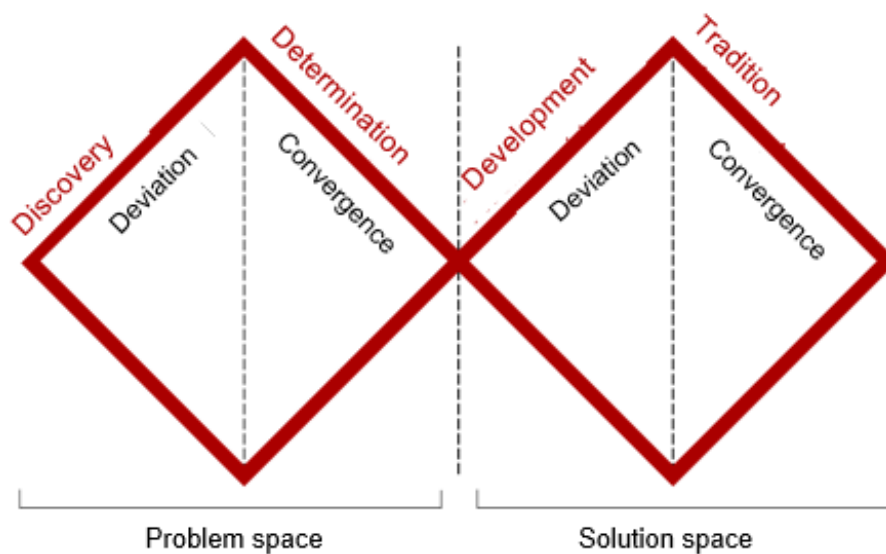


Figure 23: The Design Council's double diamond. Adapted from original source: Design Council (2019).

In summary, the double diamond describes the design process in 4 stages: discover, define, develop, and deliver. From this description comes the alternative name 4 D's. Here is a description of the stages of the double diamond.

- **Discovery**, where the design challenge is explored and research is conducted to understand user needs.

- **Definition**, where an effort is made to understand the results of the research, highlighting correlations between the needs of the users and the problem. The stage culminates in the creation of the design reference that specifically defines these needs and information.
- **Development**, where it is sought to develop alternative possible solutions, test them, and improve them.
- **Delivery**, where one of the solutions is selected that according to the above research works in the desired way and is implemented as a deliverable for release.

The double diamond was proposed in 2004. It has since evolved into a complex design thinking framework and understanding of how design should be done. This framework is defined by the Design Council as the Systemic Design Framework (2021) recognizing the value of systems theory and science as a catalyst in dealing with the complex problems of modern life. The System Design Framework is based on six principles:


- **Focus on people and the planet**, as well as the common benefits of all living things.
- **Centering both the tree and the forest**, from the micro- to the macro-level, from the root cause to the hopeful vision, from the present to the future, and from the personal to the larger system.
- **Testing and developing things**, through prototyping that contributes to understanding how they work and further creating more.
- **Not excluding**, instead, embracing diversity by creating safe, shared spaces and languages to incorporate multiple and possibly marginalized perspectives.
- **Collaboration and connection**, treating the project as one component of a wider movement for change.
- **Circularity and regenerative design**, with a focus on existing goods, both physical and social, and their reuse and development.

In this context, an expanded model and layout of the double diamond has been proposed, now also referred to as a framework for innovation (2019).



Figure 24: The framework diagram for innovation. Adapted from original source: Design Council (2019).

Moving on this mental map of the design process, the Design Council suggests specific modes of operation and thinking within the context of a design activity. The Planning Board's proposals are shown in the table below, which presents the key concepts of the proposed planning process.

Elements of the double diamond process	
	<p>Divergent and convergent thinking</p> <p>The design process as suggested by the double diamond methodology is a key element of the systems design framework. It is based on a more traditional design process that alternately uses divergent and convergent thinking, where time is spent understanding the context and context of the design challenge before starting the solution-finding process.</p>

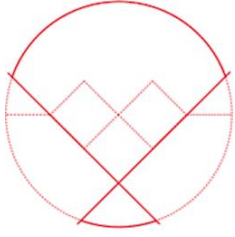
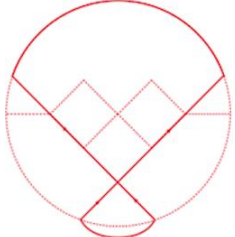





	<p>Zooming in and out</p> <p>Zooming in and out is a key practice, along with divergent and convergent thinking. It is about being able to shift focus between the micro and the macro, from the specific design project to the larger context in which it fits, from the personal level to the larger system, seeing the wider consequences, positive and negative, that the outcome of design. The design process is seen as one component among a variety of activities, from design to policy and culture change efforts, that collectively promote a more regenerative and sustainable future.</p>
	<p>Disrupting and remaking</p> <p>An important part of the design process is looking for the root of a problem. This can be anything within the complex web of governance, regulations, deeply held assumptions, or beliefs. With this knowledge and perspective, it is considered what can be designed and implemented, such as a product, service, space, or other design intervention that could disrupt the problem and create the necessary change.</p>
	<p>Resourcing invisible activity</p> <p>The connections, associations, guidance, and narrative that surround a project are just as important as the design project itself. Through the projects they undertake, designers can direct their work toward their larger vision while recognizing that problems are never definitively solved. The design process is an evolutionary process that must be linked to complementary initiatives in order to achieve the desired change.</p>

Table 1. Fundamentals of the Double Diamond Methodology (Design Council, 2021).

On this expanded double diamond, 4 elements are proposed that can be seen as actions and approaches peripheral to the design process itself.

Details of the process	Description	Methods of achievement
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<p>Vision Orientation and Targeting</p> 	<p>Complex environmental and social challenges are not static. They can't just be fixed. Instead of seeing the design outcome as a problem and a solution, designers should start with a vision of what they want to achieve. It is important that they start their work positively and based on values. These values should be shared and shared by all involved.</p>	<p>Designers must consider the personal motivations of everyone involved in the project through questions of the form "why are we here?"</p> <p>These questions contribute to understanding the larger system within which they are designing.</p> <p>To achieve their goals, design teams must set a specific vision that all members can identify with.</p> <p>They must also develop specific values and design principles that will guide joint action.</p> <p>Designers can consider nature and the environment as an involved part in the design process.</p>
<p>Leadership and storytelling</p> 	<p>Anyone can become a leader. This is achieved through personal actions and the example they set, but also through position within the organization and system. Leaders offer a specific vision based on their values. This carries over at all levels, from their personal actions and choices to the level of the team and the wider system that can be influenced by the stories and narrative of the leaders.</p>	<p>Designers need to look after yourself to be the best possible version of yourself.</p> <p>They have to review and learn from the entire design process.</p> <p>They must promote the agreed principles and values to the wider team and organisation.</p> <p>They need to work openly and share their stories and approach.</p>



		They must cultivate a cohesive community that can cope with adversity.
<p>Connections and correlations</p> 	<p>System design is hard work. It never ends and requires persistence and hope. Relationship building takes place throughout the design process, and is just as important as the design itself. It is about developing empathy and taking into account all the different perspectives of those involved in the project. Acting as mediators, designers connect people to a project in a way that may not be immediately measurable, but is undoubtedly very important and provides value far beyond the project itself.</p>	<p>Designers must spend time with communities, listen, and allow space and power to contribute to the evolution of the design process.</p> <p>They must identify all stakeholders, human and non-human, and understand how their plan affects them.</p> <p>They must create inclusive spaces where there is equality and a common language of communication.</p> <p>They need to build new partnerships and create platforms where people and nature can come together and shape ideas together.</p> <p>They must use inclusive methods, such as codesign, coproduction, and others.</p>
<p>The trip goes on</p> 	<p>Conditions are constantly changing and the work never stops. At the end of a design project, conscious learning and learning should be sought, especially from any mistakes or failures. Conclusions should be open-ended, with an emphasis on creating and sharing knowledge in future work.</p>	<p>Designers should rejoice in success and learn from mistakes.</p> <p>They need to understand the impact their design intervention has on individuals as well as on the wider system.</p> <p>They must share the knowledge they gain with others so that the vision and</p>

		<p>goals can continue to advance.</p> <p>They must use the relationships and alliances they formed in future design projects.</p>
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Table 9. Double diamond actions and approaches (Design Council, 2021).

The basic stages of the double diamond remain, although in the expanded context of systemic design they are renamed to cover a wider range of design conditions. These steps can be carried out linearly, but in practice design processes usually evolve both forward and by repeating previous steps, generating more knowledge and improving design solutions and interventions.

Details of the process	Description	Methods of achievement
<p>Exploration</p> 	<p>In all phases of the design process, designers must dig deep into what's going on, discover the root cause, look for existing ideas and resources that can be reused in a solution, and build a clear and bold vision for the future.</p>	<p>Designers must continuously evolve the existing system and state, as well as their individual components</p> <p>They need to gather different knowledge and perspectives from people with different views and experiences.</p> <p>They must explore the connections between things using techniques such as system mapping and circular flows.</p> <p>They must identify opportunities, new technologies, and existing practices and materials that can be reused.</p>
<p>Redefining</p>	<p>The transition to a world of more equality and regeneration requires the</p>	<p>Designers need to include different people and</p>

	<p>evolution of the current collective way of thinking. Designers must create things that reflect new values and that guide and change the collective behavior of society. Adequate space, time, and permission must be given to redefine the problem from different angles in order to find new ideas.</p>	<p>different perspectives and ideas in the design process.</p> <p>They must evaluate opportunities through different perspectives, such as sustainability goals or values.</p> <p>They must identify specific opportunities and challenges. This may require specifying and modifying the design objective so that it focuses on a specific domain, or alternatively broadening it to reveal the connections of the various systems.</p>
<p>Creation</p> 	<p>Creating a variety of actions and ideas that link to other interventions and that help with the broader goal is essential. It can range from simple small steps to radical proposals for change that may never materialize but allow designers to imagine what is possible.</p>	<p>Designers should create catalogs of their ideas and proposed interventions, as well as those of third parties, to examine the system at various levels.</p> <p>They must adopt a circular way of thinking and working. They must reuse ideas and materials and explore possible new ideas that may emerge from the design process.</p> <p>They must analyze which actions and interventions have the greatest value in the broader transition to a more regenerative world.</p>
<p>Catalysis</p>	<p>After all, design also includes making things. Systems thinking alone can seem to</p>	<p>Designers should use prototyping to test and refine their ideas, but also to</p>


	<p>lead nowhere or to be too complex and abstract. Therefore, creating objects and prototyping helps to communicate the vision in a tangible way. In this way the various functions can be tested and the interconnection of ideas with other interventions can be explored.</p>	<p>analyze what new ideas can come from them.</p> <p>They must check the consequences of their plan on the wider system, especially as it relates to minorities and nature.</p> <p>They must adopt specific metrics that will be able to reveal the environmental and social impact of the proposed solution.</p> <p>They must consider sustainability.</p> <p>They must compose narratives in a way that leaves room for others to insert their opinions and ideas.</p>
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Table 10. Double diamond design processes (Design Council, 2021).

3.5 The frog design® collective action toolkit

The Collective Action Toolkit (CAT) is a tool developed by frog design®.

frog (formerly esslinger design) has been active in the field of design and consulting since 1969, having made iconic collaborations with companies such as Sony, Apple, Microsoft, Disney, and others. The company summarizes its work and general value framework in the following text/manifesto:

- The talent of the members is both art and science. It is both business and social.
- They are fanatics about improving the world.
- Their passion is the transformation of ideas into realities.
- They are curious, ever-vigilant, experienced, cost-driven and aware of the need to save the scarce and finite environment.
- They direct and choreograph cultural and social change through design.

- Their customers are the key to their success. Nevertheless, they do not accept irrational behavior, either internally or externally.
- It is not just a business. With 50 years of presence, it is part of the social fabric.
- Their work is more permanent than ephemeral movements and fads.
- They live honestly, with an open mind, and without fear.
- They fight to change minds, move markets, and touch hearts.
- Quality is their uncompromising obligation.
- Entertainment, fun, and humor are what frog is all about.

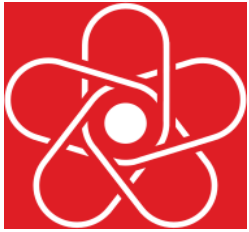
The collective action toolkit has been developed for the purpose of building groups with a common goal (2013). It acts as a framework that offers guidance during the creative process with the goal of achieving innovation and generating ideas and solutions. It consists of an action map (CAT Action Map), which divides the design activities into 6 sections. Using the map, a course of action can be drawn up for the design process individually or as a group. The sections are described below.


- Clarification (clarify).
- Build.
- Search (seek).
- Fantasy (imagine).
- Implementation (make).
- Planning (plan).





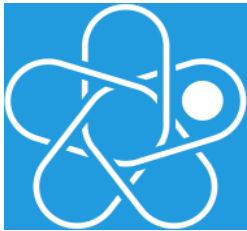
Figure 25. The action map. Adapted from original source: frog design (2021).

Below are presented schematically these 6 sections as well as the proposed activities and actions related to each of them. The detailed description of the activities and the way of carrying them out and supporting material for their organization can be found in the basic presentation document of the toolkit (2013).

Unity	Description	Recommended Activities
<p>Clarification</p> 	<p>The activity is about clarifying the design goal. The team must agree on the problem it is trying to address and the goals it is seeking to achieve. This module is critical to the team's success, and should be given the appropriate space and opportunity to refocus based on the outcomes and lessons learned from that module.</p>	<p>Chain reaction, where the team explores the impact they want their work to have, from improving people's lives to changing the world.</p> <p>Problem definition, where designers clearly define the problem the design team will try to solve. They pose key questions to be</p>

		<p>answered during the design process.</p> <p>Search for direction, where design team members agree on their common goals and way of working.</p> <p>Targeting control, where planners analyze potential changes in the team's goals See if anything has changed in the team's goals and adjust accordingly.</p>
<p>Construction</p> 	<p>The activity is about building the design team by bringing together people from the community, identifying each person's unique strengths, as well as their commitment to the common goal. It contributes to strengthening the relationships of team members, building mutual understanding, and defining and achieving common goals.</p>	<p>Knowledge sharing, where design team members are encouraged to share their knowledge, talents, and skills while identifying what knowledge or skills the team lacks to achieve goals.</p> <p>Knowledge hunting, where team members identify existing knowledge about the challenge at hand as well as additional desired knowledge needed to solve the problem.</p> <p>Identifying people who inspire from the team's community or wider communities, who mobilize, or who can help work and meet the challenges faced by the team.</p>
<p>Search</p>	<p>The activity is about seeking new understanding through contact with third parties and analyzing their perspective in</p>	<p>Search for issues and uncover ideas, where team members learn about the problems facing people in</p>

	<p>relation to issues concerning the group. Designers need to ask the right questions and explore users' lifestyles. They identify unmet user needs to be able to provide appropriate information and inspiration to team members so that they can collectively succeed in solving the challenge.</p>	<p>their community and analyze the possibilities that the team collectively has to contribute and help.</p> <p>Basic interview practices, where team members plan an interview from start to finish. They use the plan they prepared to get in touch and talk with users about the issues that concern them and concern them.</p> <p>We saw and heard where each team member shares the information they discovered through the team member interviews. Members jointly discover and identify important common themes that have emerged.</p> <p>Pattern search, where designers dig deeper into the information they've discovered to identify the root causes of the problem to be solved.</p>
<p>Imagination</p> 	<p>The activity is about using imagination to introduce additional ideas.</p> <p>Designers create new solutions for the problems they want to solve. The activity helps the team imagine more ideas and decide which ones are more</p>	<p>Brainstorming, where team members use brainstorming techniques to collectively input as many ideas as possible by exploring different possible solutions and building and augmenting each other's</p>

	<p>achievable and sustainable than others.</p>	<p>ideas in a supportive and productive context.</p> <p>New combinations of ideas, where team members use existing ideas, whether they think they are good or not, trying to combine them together in different ways to form new ideas.</p> <p>Idea cultivation, where team members combine the strengths of multiple ideas from different individuals to produce new, better ideas.</p> <p>Targeting, where team members analyze all existing ideas and decide which ones to try and why.</p>
<p>Implementation</p> 	<p>Activity is about creating something real.</p> <p>Designers are not in a position to know if an idea works before they try to implement it. They test their ideas in an entertaining way, such as telling stories or creating prototypes for evaluation.</p>	<p>Camera, and... go, where designers use characters, settings, and dialogue to tell an audience a meaningful story related to their idea.</p> <p>Quadrilateral, where designers illustrate their story in a quadrilateral, like a comic book, describing how the concept affects people in a specific time sequence.</p> <p>Like, not like, where team members share their ideas in a way that relates them to other existing examples.</p> <p>Prototyping, where designers create a version of their idea with available materials. They test the</p>


		prototype with people in their community.
<p>Programming</p> 	<p>Activity is about planning for action.</p> <p>Planners organize themselves around each team member's role in achieving common goals. They decide on implementation actions and analyze how they contribute to the promotion and eventual achievement of common goals.</p>	<p>Agenda setting, where team members identify the immediate challenges they need to address and agree on next steps.</p> <p>It divides and conquers, where the team is divided into subgroups that undertake and implement specific actions and actions.</p> <p>Schedule setting, where team members prepare a work plan and monitor its implementation.</p> <p>Keeping the momentum going, where designers motivate their team to keep moving forward. They clearly communicate who does what.</p> <p>Value map, where designers clearly document how to implement the proposed solution by assessing the resources and supplies necessary to produce something of added value that meets the team's goals.</p>

Table 11. Collective action toolkit activities (frog design, 2013).

3.6 Analysis of design thinking methodologies

The study of the above established design thinking methodologies leads to the identification of certain common points, which can be considered as fundamental characteristics of such design processes.

The first characteristic of any design thinking methodology is the successive phases of convergent and divergent thinking (convergence - divergence). During the design process, there should be room for periods of open thinking that correspond to divergent thinking, where the scope is openly and freely explored and new ideas are discovered. At the same time, the process should also be followed by phases of concentration and focus, which correspond to the convergent way of thinking, where clearer goals are set, decisions are made, and a result is approached. This is the fundamental *modus operandi* of the Design Council's double diamond methodology, but it has been largely adopted by IDEO and other design thinking methodologies.

At a first attempt at a simple explanation, the double diamond of the Design Council and the 5 hexagons of the d.School might seem like linear processes with a specific beginning and end. However, all methodologies argue that the design process should be circular and iterative. Designers can jump from one stage to another depending on the need of the project and the available data. There should not be strict linearity in the sequence of steps, but the ability to adapt design thinking to the fluid needs of each individual design process should be allowed.

Beyond the generalized definition of the way of thinking and the path followed by a design process, each of the above design thinking methodologies has a very rich toolbox of research and design methods, in which a great deal of overlap appears. These should not be considered necessary steps in a design process. It is not necessary to carry out all the proposed research activities. What needs to be done, however, is to make an appropriate selection of the tools to be used depending on the needs of the design problem. The above methodologies offer the necessary flexibility of adaptability, so that they can be used in very wide design cases, bringing satisfactory results.

An important element of design thinking, perhaps not often brought up in discussions about methods and tools, is its anthropocentrism. Design thinking calls for designers to show strong empathy for the people they design for. Many of the toolkit methods aim to build this empathy with the goal of deeply understanding users to better serve their needs and values. This step should not be second-guessed as utopian wishful thinking, but should be the focal point of any design process that adopts the principles of design thinking. This point is subtle, and one could say it is the defining difference between an engineer and a designer. The engineer works with the aim of achieving a specific tangible technical goal while the designer fulfills the needs and/or desires of the users. In design, anthropocentrism is a cornerstone and empathy for the needs and desires of others is a key tool. Design thinking obviously takes this position. All methodologies place great emphasis on focusing on people's needs.

In order to be able to design successfully, as presented by design thinking methodologies, the design team must follow a way of thinking that is radically different from the way of analysis of other fields, such as engineering and the positive sciences. Design thinking defines that the design starts from the analysis of the problem on a white canvas. This means that designers do not know in advance what form the possible solutions to the problem might take. They should not attempt to synthesize such solutions before analyzing the problem. Otherwise, by pre-existing specific design outcome expectations, the most radical, invisible, and innovative solutions are de facto excluded.

Ultimately, design thinking through all these steps and focuses has the ultimate goal of achieving true innovation, that is, finding new innovative solutions that have not been proposed before. These ideas understandably do not usually arise automatically and are not based on some kind of deep creativity of individual designers. Instead, they can be produced or emerge through a deep understanding of the problem domain, the space where the design takes place, and the people to whom it is addressed. Design thinking is a structured method that enables design teams to sort through the chaotic and complex information they have to arrive at real innovation.

4. Using technology to support learning and collaboration through design thinking

In terms of the tools used to apply design thinking, a wealth of resources have been created that show a fair amount of overlap, with the majority of them working extremely well at many of the stages of the process. Technology can facilitate collaboration, visualizing ideas, sharing ideas, collaboratively designing a solution by team members, organizing and categorizing ideas, managing the implementation of a project, and more.

4.1 Review of digital design tools

This section analyzes digital tools that can be used to support the various tasks at each step of design thinking. Tools useful in the empathy stage offer the ability to organize and visualize user needs as well as other information derived from field research. Tools useful in the problem definition stage include the ability to organize and visualize user needs, and any other information that has emerged from the research carried out during the first stage. Tools useful in the ideation stage enable brainstorming in real-time or in asynchronous sessions, helping design team members visualize, contribute, comment, and vote. Tools useful in the prototyping stage provide the ability to design prototypes through collaboration, contribution, and annotation. Finally, tools that are useful in the testing stage provide logging so that designers can analyze the data afterwards.

The presentation of the digital tools includes a general description of them as well as basic features. In addition, it mentions the design thinking steps where the tool is applicable. Because of the importance of team collaboration in design thinking, the analysis describes the tool's user community support. Finally, reference is made to the cost of the tool.

4.1.1 Typeform

4.1.1.1 Description

The Typeform® tool (Typeform 2023) is a platform for collecting and recording data used to achieve design goals. It differs from a simple questionnaire because it is designed human-centered, with each question following a conversation-like flow. This structure yields a high degree of completion of the questions by the users and therefore more complete and accurate results of the design research in the processes of empathy and definition of the problem.

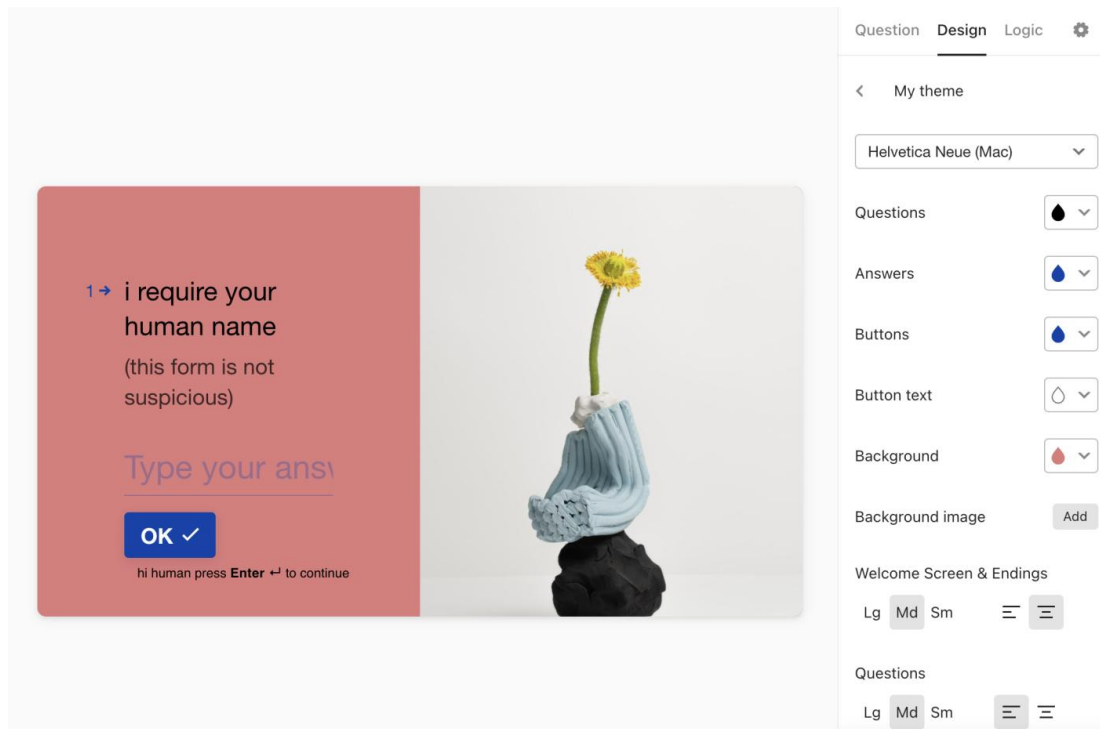


Figure 26. The Typeform® tool. Source <https://zapier.com/blog/typeform-features/>.

4.1.1.2 Characteristics

In its free version, Typeform® provides the following features.

- Unlimited forms.
- Ten questions per type.
- Ten responses per month.
- Branching questions.
- Multiple end screens.
- Hidden fields.
- Calculator.
- Standards.
- Integration of the form into a web page.
- Possibility of saving the data on the user's computer (download).
- Integration with platforms like Zapier®, Automate.io®, Slack®, Mailchimp®, HubSpot®, and more.

4.1.1.3 Application to design thinking

The tool can be used in the processes of empathy and problem identification.

4.1.1.4 Community

The tool provides access to a collaborative community. The Typeform® community platform offers the ability to ask questions to the developer team and users of the application. The information is active and organized. Participants are incentivized to participate with a points system. Announcements about new features, case studies, and articles from company members are provided.

4.1.1.5 Cost

The tool has a free plan, which supports 10 responses per month for one user.

4.1.2 Google Forms®

4.1.2.1 Description

The Google Forms® tool (Google Forms, 2023) is a popular online questionnaire creation application that can be used to understand user needs, habits, and preferences during the design process.

4.2.2.2 Characteristics

The tool offers a variety of data collection functions, described below.

- Create questionnaires easily and simply, following the logic of creating a document.
- Ability to choose between multiple question types, color customization, and custom logic through which it displays different questions based on the respondent's previous answers.
- Analyze responses with automatic summaries in graph form, with the ability to view raw data in Google Sheets® for deeper analysis or automation.
- Create the questionnaire, and answer it, from any mobile device, tablet or computer.

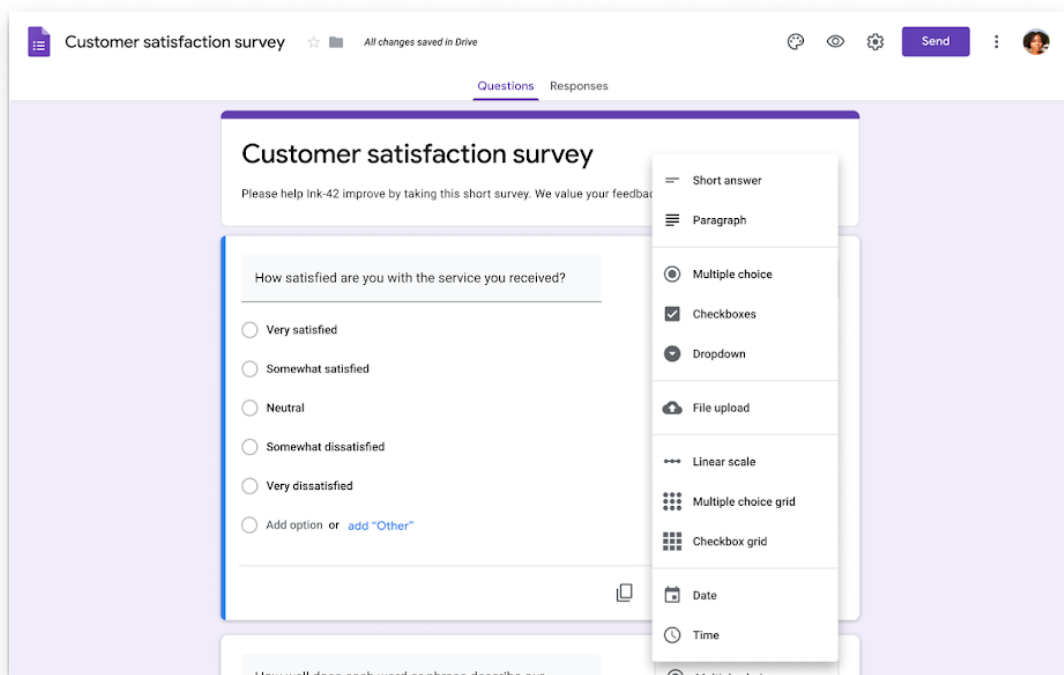


Figure 27. The Google Forms® tool. Source: <https://workspace.google.com/products/forms/>.

4.1.2.3 Application to design thinking

The tool can be used in empathy and problem identification processes to gather information about user needs. It can also be used in the testing process to collect and analyze user feedback on the effectiveness of a proposed solution.

4.1.2.4 Community

The tool does not offer a specific brainstorming and support page for the Google Forms® community. However, due to its popularity, the tool's support team has enough material online to answer questions.

4.1.2.5 Cost

The tool offers free creation of unlimited questionnaires and receiving of unlimited answers with a Google® account.

4.1.3 Hotjar

4.1.3.1 Description

The HotJar® tool (HotJar 2023) offers an intuitive, visual way to discover, collect, and communicate user needs. It works by capturing the data from users' navigation on an already designed web page, whether it is consciously captured by users through feedback windows or questionnaires, or unconsciously through their behavior such as navigation, scrolling, clicking, and more.

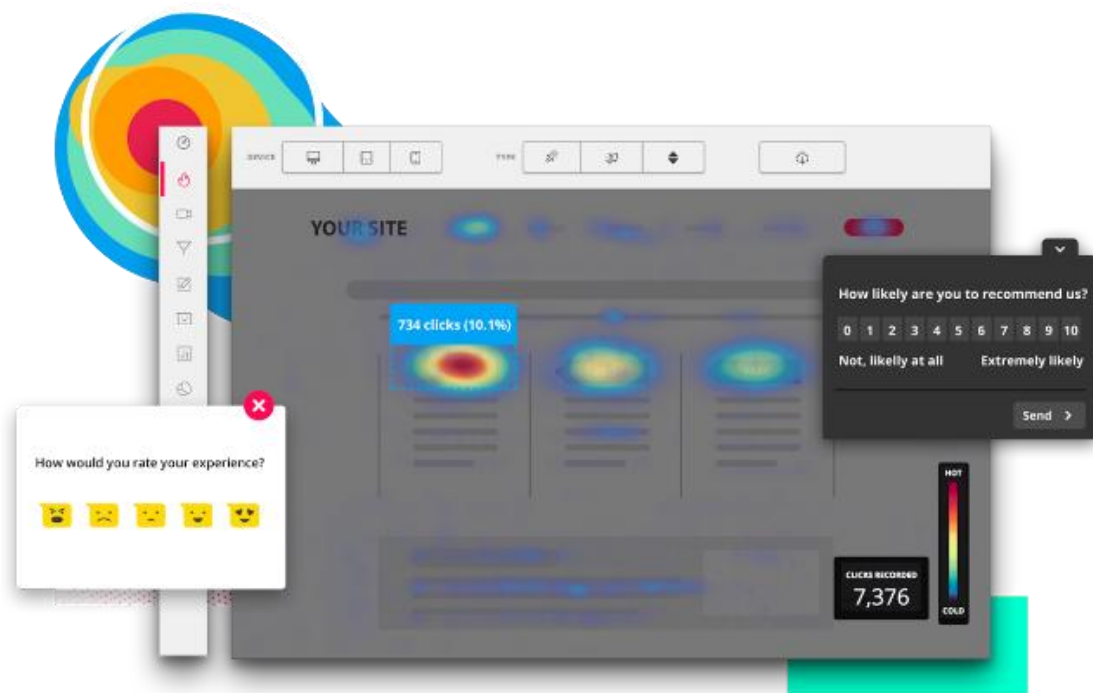


Figure 28. Image source: <https://www.hotjar.com/competitor-comparison/>.

4.1.3.2 Characteristics

Some of the featured features of the tool are as follows.

- Visualize user behavior with heatmaps, which visually represent where users click, move, and scroll on a web page.
- View users' screen through recordings where users' movements on a website are reproduced.
- Access to the entire log of every visit, including clicks, mouse movements, hesitations, and user tension points.
- Real-time feedback on content usability through an interactive box added to the web page that allows users to express their frustration or pleasure about individual parts of the web page, such as the page, form, or image they are viewing.
- Ability to target research on new features to understand user needs.

4.1.3.3 Application to design thinking

The tool can be used in empathy and problem identification processes to gather information about user needs. It can also be used in the testing process to collect and analyze user feedback on the effectiveness of a proposed solution.

4.1.3.4 Community

There is no dedicated website for the tool's user community. There is material created by the company to resolve questions related to the use of the platform.

4.1.3.5 Cost

The tool has a free plan to use heatmaps and their logs with support for 35 sessions per day. However, the free version of the tool does not offer many options for filtering the data. For questionnaires and feedback, the free plan supports 20 responses and a total of only 3 questionnaires per month, with minimal form customization and no platform auto-enhancement of the questionnaire.

4.1.4 Figma

4.1.4.1 Description

The Figma® tool (Figma 2023) is an online platform that combines the design of digital products and systems with the creation of interactive templates. It is designed with optimization of design workflow in mind.

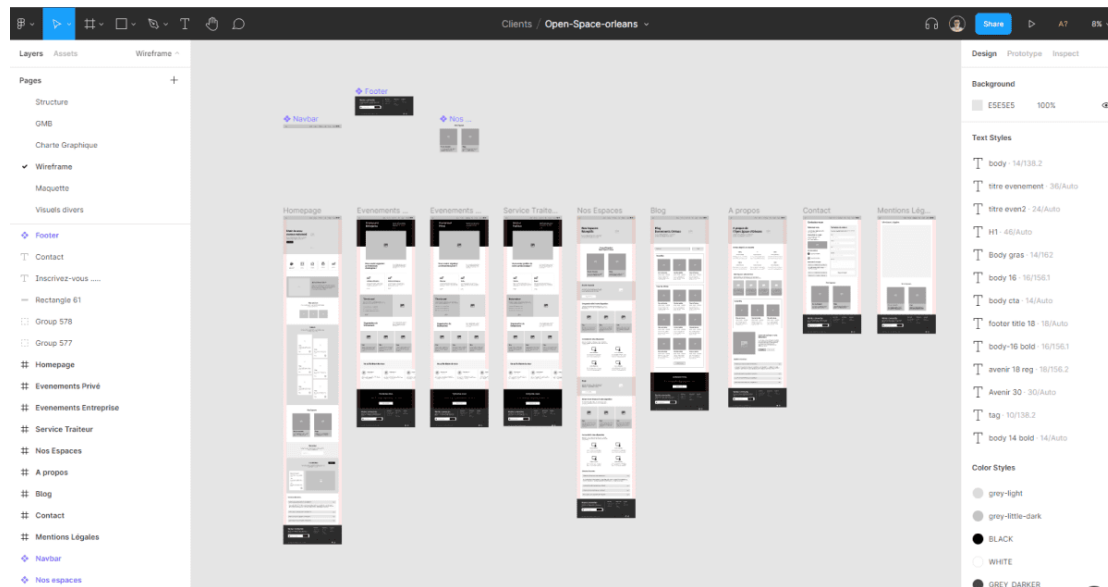


Figure 29. The Figma® tool. Source <https://www.digidop.fr/en/tools/figma>.

4.1.4.2 Characteristics

The main features of the tool are described below.

- Access files anywhere through internet access.
- Automatic file saving.
- Share the file via a link.

- Version history for easy sharing and collaboration.
- Easy design for the web: design in any direction with a modern pen tool, easy and smart curve design with the arc tool, and advanced text functionality with the open type tool.
- Design digital products that respond to different contexts with the auto layout tool. Using this functionality ensures less manual changes by automatically formatting the size of buttons and lists, which adapt to the movement of the rest of the objects.
- Better communication with team developers, with all useful features of designed objects visible, such as distances, direction, and more.
- Unlimited single-file viewers, with access to generated code snippets generated for CSS, iOS®, and Android® and the ability to export the necessary elements in the format needed.

4.1.4.3 Application to design thinking

The tool can be used in prototyping and testing processes to produce a visual representation of a product or user experience. Visual representation can be used to communicate the design to team members and users to generate feedback.

4.1.4.4 Community

The tool, combined with the Figjam® add-on software, has a very active community. Users share templates, tips, design systems, and other resources. In addition, it has a specially designed forum with organized categories and dynamic content search.

4.1.4.5 Cost

The free plan of the tool supports the creation of 3 Figma® and 3 FigJam® files, creation of unlimited personal files, unlimited number of collaborators, use of plugins, widgets, and templates, and use of the mobile app. The professional plan, which is free for students and teachers, supports the creation of unlimited Figma® files, unlimited version history, sharing rights, shared and private projects, group libraries, and audio chats.

4.1.5 FigJam

4.1.5.1 Description

The FigJam® tool (FigJam 2023) is an online whiteboard that allows teams to develop ideas and engage in collaborative brainstorming.

4.1.5.2 Characteristics

The main features of the tool are described below.

- Easy diagram creation with automatic connection of shapes.
- Timer for carrying out design workshops.
- Stickers and notes for sharing and grouping ideas.
- Freehand tool for drawing, annotating, and quick notes.
- Support votes and reactions for quick feedback on questions and choosing between ideas.
- Integrate existing screens or elements from the Figma® tool design libraries.
- Share files via link.

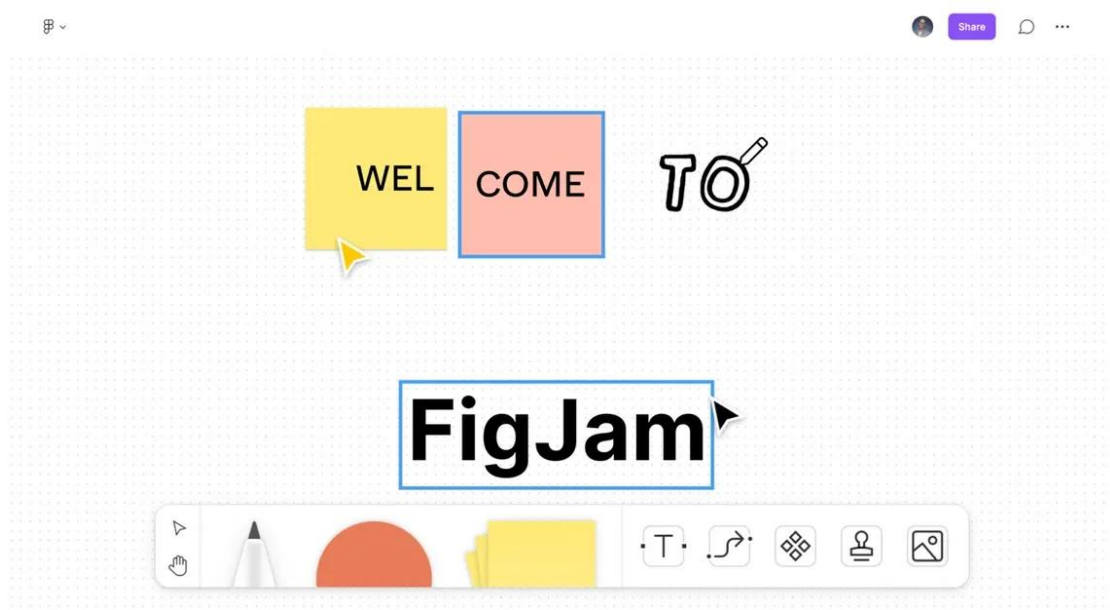


Figure 30. The FigJam® tool. Image source: <https://www.figma.com/figjam/>.

4.1.5.3 Application to design thinking

The tool can be used in empathy and problem identification processes to gather information about user needs. It is also useful in the ideation and brainstorming process to support the seamless collaboration of team members. Finally, it can be used in the testing process to collect and analyze user feedback on the effectiveness of a proposed solution.

4.1.5.4 Community

The tool, along with the complementary FigJam®, have a very active community, which shares templates, tips, design systems, and other resources. The tools offer a website dedicated to community feedback and sharing of ideas.

4.1.5.5 Cost

The free plan of the tool supports the creation of 3 Figma® and 3 FigJam® files, creation of unlimited personal files, unlimited number of collaborators, use of plugins, widgets, and templates, and use of the mobile app. The professional plan, which is free for students and teachers, supports unlimited files, sharing permissions, group libraries, audio chats, open sessions, and voting.

4.1.6 Google Jamboard

4.1.6.1 Description

Google Jamboard® (Jamboard 2023) is a digital whiteboard that enables real-time collaboration using either the Jamboard® device, a 55in digital whiteboard, a web browser, or a mobile app.



Figure 31. The Google Jamboard® tool. Source <https://workspace.google.com/products/jamboard/>.

4.1.6.2 Characteristics

The main functions of the tool are described below.

- Creative design tools, clipping content from the web using Google® search, and adding images and content from Google Drive® or mobile.
- View Jamboard® in a Google Hangouts® meeting, engage team or stakeholders from tablet or mobile, and work with multiple Jamboards within or outside of the design team.
- Save work directly to Google Drive® with Jams retaining their interactivity so the team can pick up where they left off without deleting their ideas.

4.1.6.3 Application to design thinking

The tool can be used in empathy and problem identification processes to gather information about user needs. It is also useful in the ideation and brainstorming process to support the seamless collaboration of team members. Finally, it can be used in the testing process to collect and analyze user feedback on the effectiveness of a proposed solution.

4.1.6.4 Community

The tool has a page where users can ask questions, learn about new developments in the ecosystem, and talk to experts. This community is still not very active.

4.1.6.5 Cost

The tool is free to use. However, for Google Workspace for Education® customers to use the Google Jamboard® tactile board, the cost starts at \$4,999 and includes 1 Jamboard® screen, 2 styluses, 1 eraser, and 1 wall mount for a one-time fee management and support of \$600 with no recurring annual fee.

4.1.7 InVision

4.1.7.1 Description

The InVision Freehand® tool is an online platform for designing digital products. It brings together tools that are useful at all stages of the design process and enables the creation of projects, prototypes, and design canvases.

4.1.7.2 Characteristics

The main functions of the tool are presented below.

- Ability to create and share design presentations.
- Ability to design prototypes.
- Project management tools.
- Tools to conduct real-time remote meetings with InVision Freehand®.

- Tools for user research and prototype testing.
- Inspect module, which allows designers to optimize and automate workflows and prototyping.
- Design tools. Specifically, InVision Studio®, which offers vector, layer, and animated sketch editing. Additionally, shared design libraries facilitate collaboration with instant feedback, mobile information sharing, and schedule editing.
- Management of design systems and processes. Specifically, the design system manager tool offers the ability to make changes, identity design, user experience design (UX), and rollback.
- Integration with Adobe®, Asana®, Atlassian®, Dropbox®, Basecamp®, JIRA®, Teamwork®, Trello®, Slack®, Confluence®, and Microsoft Teams® tools, among others.

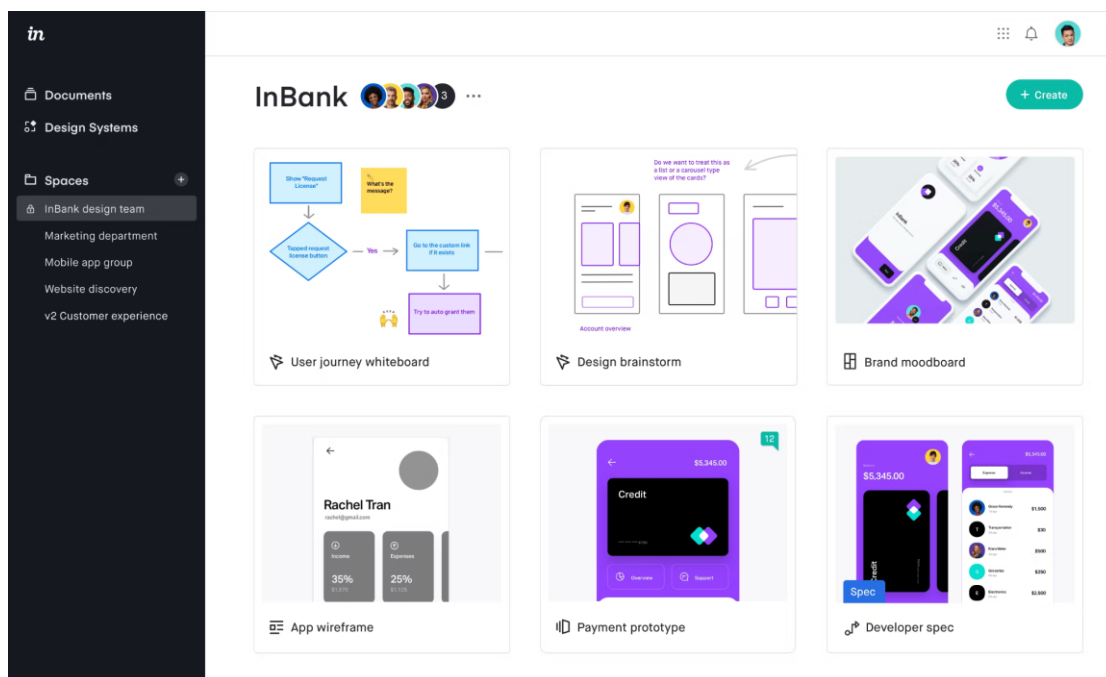


Figure 32. The InVision® tool. Source <https://www.capterra.fr/software/145720/invision>.

4.1.7.3 Application to design thinking

The tool can be used in empathy and problem identification processes to gather information about user needs. It is also useful in the ideation and brainstorming process to support the seamless collaboration of team members. Finally, it can be used in the testing process to collect and analyze user feedback on the effectiveness of a proposed solution.

4.1.7.4 Community

The InVision® ecosystem of programs has a user feedback and question page. Although well organized, it is not very active for more InVision® products than Freehand®, which seems to be used more by design teams.

4.1.7.5 Cost

The tool's free plan allows up to 30 active users, 3 Freehand® files, and unlimited public and private work folders. Additionally it provides templates and the ability to edit them, polls, file export, history, and guest permissions.

4.1.8 Miro

4.1.8.1 Description

Miro® (Miro 2023) is an online collaboration tool aimed at small and medium-sized design teams. It features a board that can be used for research, ideation, describing user needs through stories and experience journeys, as well as project management and planning at a high organizational level.

4.1.8.2 Characteristics

The basic functions of the tool are presented below.

- Participatory design tools such as notes, shapes, stickers, smart design tools, timer, polls, screen sharing, and more.
- Organization and planning tools such as tables, mind map, estimation app for planning future activities, charts, comments, and more.
- Chat via messaging and video calling.
- Patterns of design thinking and agile design exercises.
- Decision making standards.
- Upload files, images, and texts with Google Drive® integration.
- Integration with Jira®, Asana®, Trello®, and other project management applications.
- Integration with Figma® tools, Adobe Creative Cloud®, InVision®, and other design applications.
- Integration with Zoom®, Microsoft Teams®, Webex®, and other video chat applications.

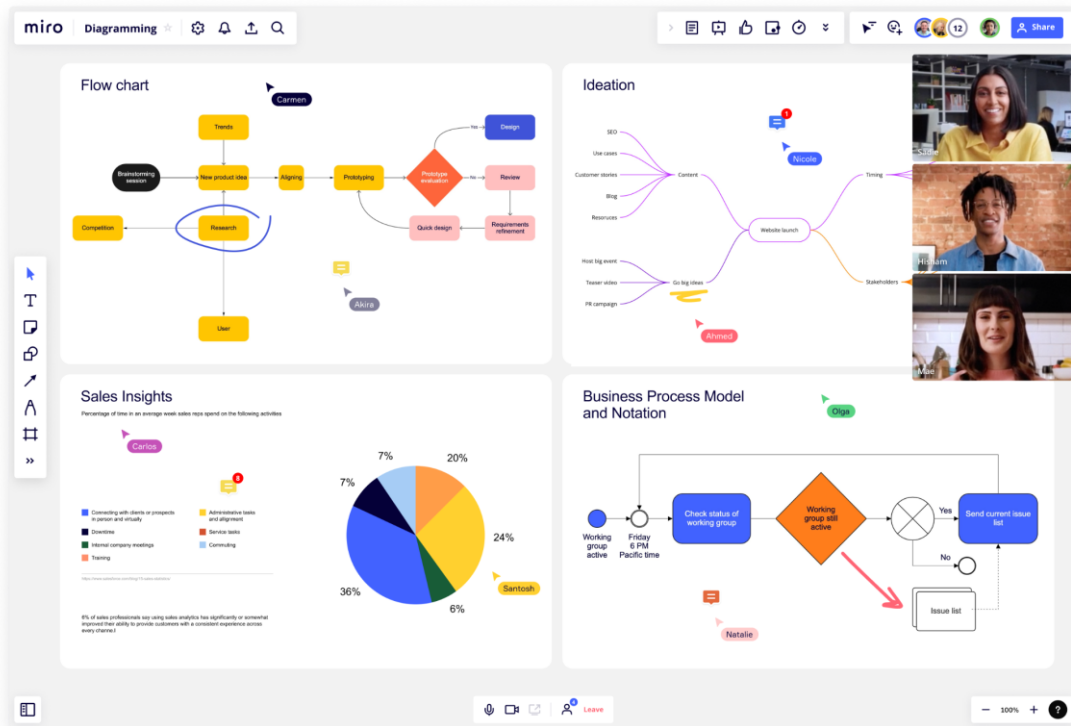


Figure 33. The Miro® tool. Source <https://www.softwareadvice.com/product-roadmap/miro-profile/>.

4.1.8.3 Application to design thinking

The tool can be used in empathy and problem identification processes to gather information about user needs. It is also useful in the ideation and brainstorming process to support the seamless collaboration of team members. Finally, it can be used in the testing process to collect and analyze user feedback on the effectiveness of a proposed solution.

4.1.8.4 Community

The tool has an active website where users can get support from others or give advice themselves, add suggestions for new features, find announcements and other content from the Miro® team, read stories or inspiring discussions, and develop creatively.

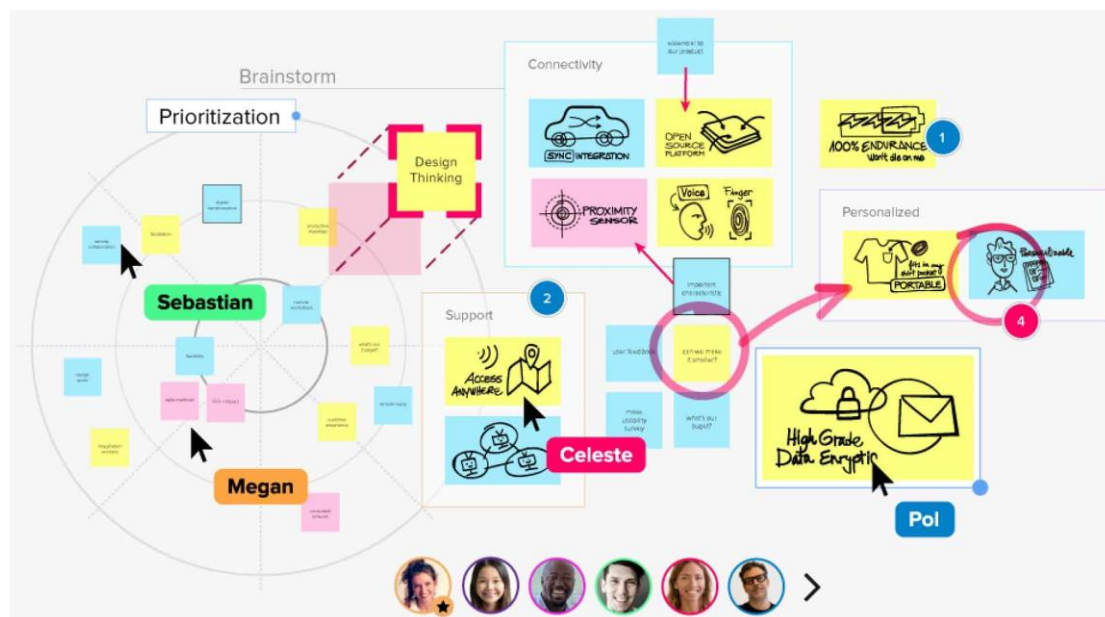
4.1.8.5 Cost

The tool's free plan includes unlimited members, 3 editable canvases, pre-made templates, basic integrations, and basic attention management.

4.1.9 Mural

4.1.9.1 Description

Mural® is an online tool that enables design teams and their partners to visually co-create and propose solutions to problems or challenges. It supports the creation of simple but comprehensive diagrams and the emergence of ideas in a virtual, collaborative space.



Εικόνα 1. Το εργαλείο Mural®. Πηγή Figure 34. The Mural® tool. Source <https://www.innovationtraining.org/what-is-mural-and-how-to-use-mural-for-design-thinking/>.

4.1.9.2 Characteristics

The main functions of the tool are described below.

- Ability to embed images and symbols.
- Notes and text support for entering ideas and suggested actions for grouping and observing emerging patterns.
- Flexible access rights with support for observer, editor, or organizer roles.
- Diagrams and sense mapping to easily create flows, processes, and user journeys.
- Create and publish templates, tailored to the needs of the design team.
- Ability to resize the design canvas.

4.1.9.3 Application to design thinking

The tool can be used in empathy and problem identification processes to gather information about user needs. It is also useful in the ideation and brainstorming process to support the seamless collaboration of team members. Finally, it can be used in the testing process to collect and analyze user feedback on the effectiveness of a proposed solution.

4.1.9.4 Community

The tool has a website where all the resources that design teams can find useful are grouped into templates, announcements, ideas for adding new features, best practices for collaborative design, new product releases in the Mural® ecosystem, social groups, and resources for educators using the platform. The community is relatively active.

4.1.9.5 Cost

The tool's free plan includes 3 canvases, unlimited members, all features that help with visual collaboration, a full library of templates, and custom templates built by members while allowing access to guests with one-click viewing rights.

4.1.10 Maze

4.1.10.1 Description

Maze® tool (Maze 2023) supports research into a team's design decisions by collecting and analyzing user information. This process becomes a way that leads to feedback and corrections in the testing stage and redirects the design process to the empathizing stage.

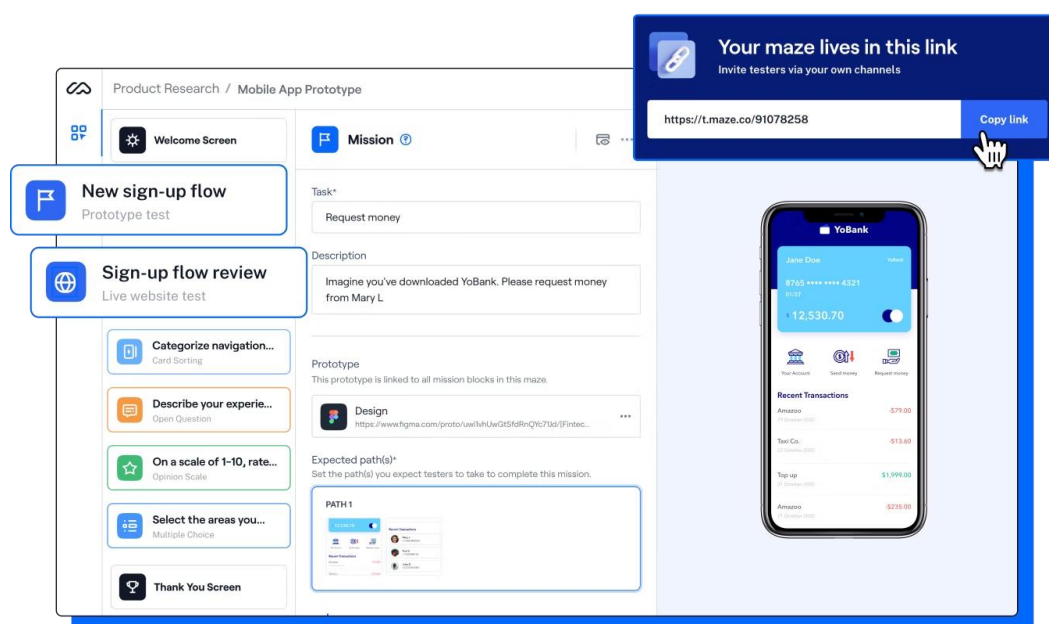


Figure 35. The Maze® tool. Source [https://maze.co/..](https://maze.co/)

4.1.10.2 Characteristics

The main functions of the tool are described below.

- Prototyping with file integration of Figma®, InVision®, Adobe XD®, and Sketch® tools.
- Visualize test results through heatmaps, usability scores, design metrics such as error clicks and time spent on a web page.
- Customize the display of search results with filters.
- Testing the information architecture (tree testing), the navigation capabilities, and the names of the features (card sorting) of a web page or application.
- Video and screen recording during usability tasks to conduct asynchronous research sessions.

4.1.10.3 Application to design thinking

The tool can be used in the empathizing and testing processes to gather and record information about users' needs and their experience using a proposed solution.

4.1.10.4 Community

The tool has a small but active and organized community where users can find announcements and resources as well as attend events, networking events or training sessions.

4.1.10.5 Cost

The tool's free plan includes 25 viewable responses per month, 1 active project, and up to 10 canvases in predefined

4.1.11 Webflow

4.1.11.1 Description

The Webflow® tool (Webflow 2023) is a Software as a Service (SaaS) application that allows designers to create dynamic web pages with browser-based visual processing software. Automatically generates HTML, CSS, and JavaScript code. Websites built with Webflow® are powered by Amazon Cloudfront® and hosted on Fastly®.

4.1.11.2 Characteristics

The main functions of the tool are described below.

- Create a functional website through creative control and adaptability without the need to write code.
- Ability to create a content management system.

- Ability to create an online store.
- Coordination of interactive immersion experiences on the website under design, using animation.
- Smart website editing system for functional collaboration between the design team and stakeholders.
- Optimization of the website for search engines, without the help of programming engineers.
- Website security settings with state-of-the-art practices.
- Fast and reliable website hosting.

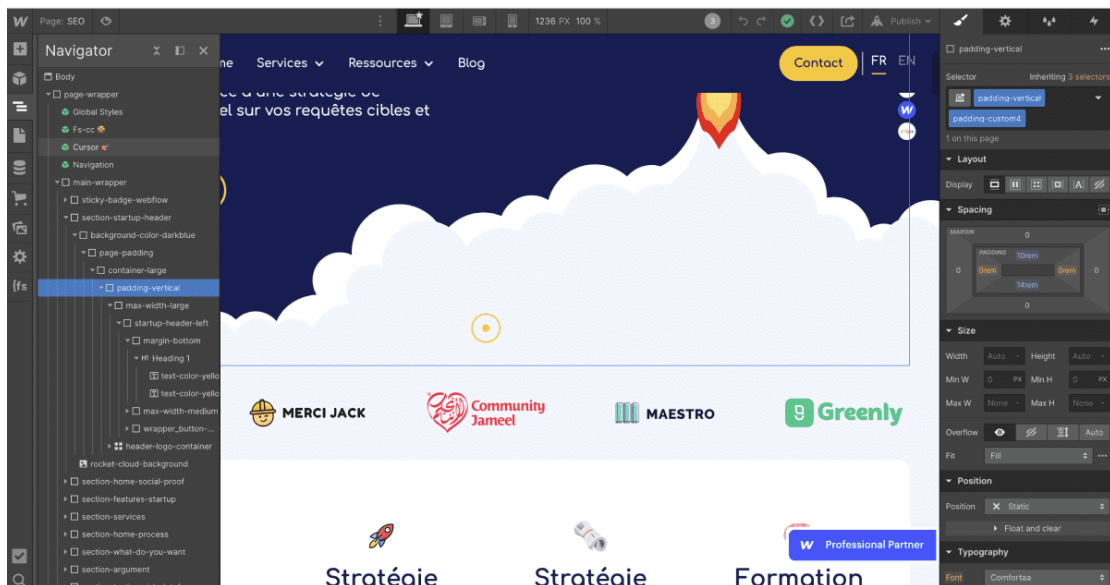


Figure 36. The Webflow® tool. Source <https://www.digidop.fr/en/tools/webflow>.

4.1.11.3 Application to design thinking

The tool can be used in the processes of prototyping digital tools and user experiences.

4.1.11.4 Community

The tool features an organized website where users can share good practices, expand their knowledge, interact with other members by having meaningful discussions, receive announcements about platform news, create a website for their business, promote their portfolio, and meet the Webflow® team. An account is required to access these features.

4.1.11.5 Cost

The free package of the tool is intended for designers who first want to learn how to use it. Includes a webflow.io domain, 50 CMS elements, 50 forms for unlimited use, and up to 1GB of bandwidth.

4.1.12 Google Optimize

4.1.12.1 Description

The Google Optimize® tool (Google Optimize, 2023) allows the design team to test variations of web pages they have created by analyzing their performance against a predetermined goal.

4.1.12.2 Characteristics

The main functions of the tool are described below.

- Different types of experience to suit the needs of testing and personalizing a website, such as multivariate testing, splitting a website into two, and more.
- Visual web page editor, allowing a new variant to be created without the team having to rewrite code. This is achieved with easy editing, useful diagnostics, customizable graphics editor, and sophisticated code editing.
- Customize the website for each audience segment, with advanced user feedback, custom user properties, and more.
- Use of Bayesian statistical methods to model the performance of group experiments and more accurate results. Examples are the summary of the experiment, the overview of the proposed improvement, the details of the goal set, and the optimization of reports through the Google Analytics® tool.
- Built-in functions that facilitate the management of all experiments performed by the team as part of the design process. Examples are the activity log, experiment preview, user permissions, and experiment scheduling.
- Providing several types of goals for creating experiments, such as system goals, Google Analytics® goals, and other goals tailored to the needs of the design team.
- Integrations with other Google® products, enabling all available information about users to be leveraged so that the team can deliver the right experience to the right user.

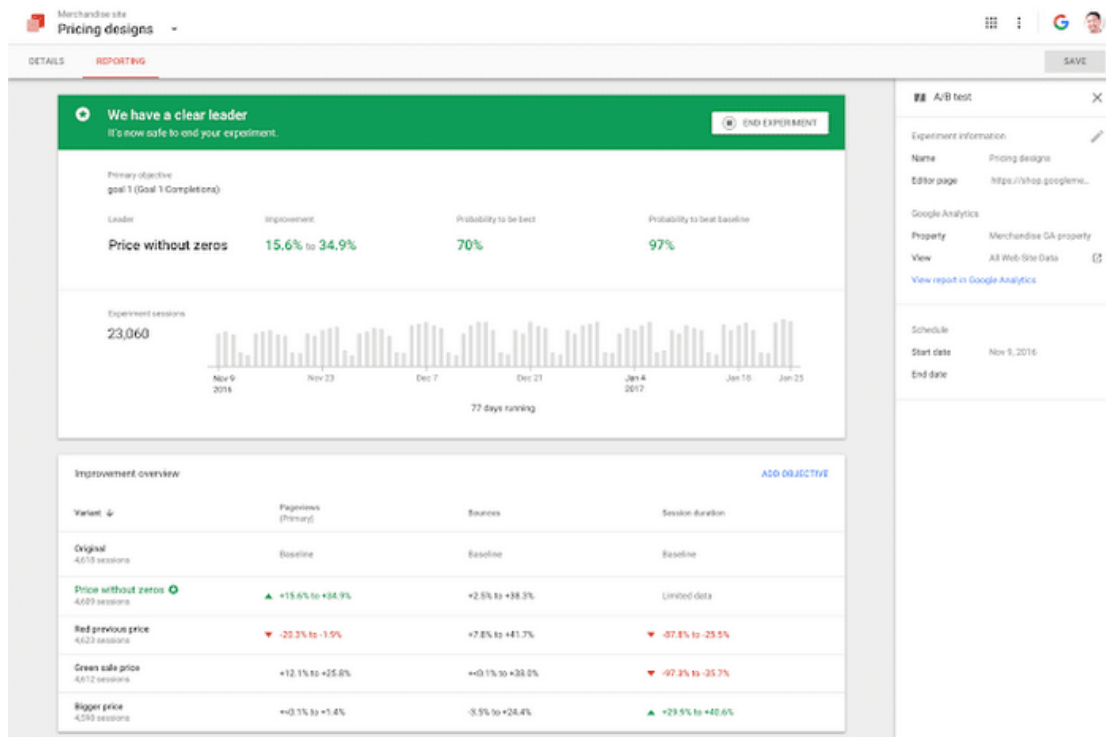


Figure 37. The Google Optimize® tool. Source <https://blog.google/products/marketingplatform/analytics/this-is-not-a-test-google-optimize-now-free-for-everyone/>.

4.1.12.3 Application to design thinking

The tool can be used in the empathizing and testing processes to gather and record information about users' needs and their experience using a proposed solution.

4.1.12.4 Community

The tool has a user questions and requests page where the community can access and contribute their knowledge. The content is organized and users have special badges so that the validity of their answers can be checked. It also has statistics to overview community activity over specific time periods.

4.1.12.5 Cost

The free version of the tool does not differ greatly from its paid version, especially in relation to the needs of a small or medium-sized business that is starting to conduct design experiments. It includes all the features described above but lacks audience customization in the Google Analytics® tool, has limitations on multivariate testing, has default experiment targets, and finally provides basic concurrent experiment capabilities.

4.2 Comparison of digital design tools

The table below summarizes the main functions of digital tools that can support design thinking activities. The table helps to compare the characteristics of the tools and analyze their usability in the different steps of design thinking.

Tool	Functionality					
	Data collection	Needs analysis	Generating ideas	Prototyping	Testing	Community
Typeform®	Dynamic questionnaires	Analysis, organization, visualization of data				Active, organized
Google Forms®	Questionnaires	Analysis, organization, visualization of data				
Hotjar®	Observing and recording behavior	Real-time data analysis, organization, visualization			Observing and recording behavior	
Figma®	-	-	-	Design tools, version history, asset reuse, audio chat	Distribution of prototypes	Very active, organized

Figjam®	Design workshops for data collection	Stickers, votes, reactions, layouts, notes	Drawing tools, text, timer, add content from the web, audio chat, share by link	Templates for quick low-fidelity prototyping, shapes, text, adding content to the web		Providing templates and support from the Figma® community
Google Jamboard®	Conduct design workshops for data collection	Stickers and notes	Add content from the web, design tools, text, link communication	Low fidelity - prototyping shapes, text, add content from the web		Not very active
Invision®	Conduct design workshops for data collection	Stickers, votes, reactions, and notes	Templates for quick design, shapes, drawing tools, text, add content from the web, share by link	User interface design tools at a medium or high level of detail		Not very active but quite organized
Miro®	Conduct design workshops for data collection	Stickers, votes, reactions, layouts, and notes	Templates for quick design, notes, shapes, smart design tools, text, timer, votes, screen sharing, add content from the web, share by link, video call	Templates for fast low-fidelity prototyping, shapes, text, adding content from the web		Active and organized
Mural®	Design workshops for data collection	Stickers, votes, reactions, notes, layouts	Sketches, templates for quick design, notes, symbols, text, share by link	Templates for fast low-fidelity prototyping, shapes, text, adding content from the web		Active and organized

Maze®	Data collection of user preferences, behaviors and interactions	Stickers, votes, reactions, notes, layouts			Analysis of user interaction data	Small but active and organized
Webflow®				Εργαλεία δημιουργίας διαδραστικών ιστοσελίδων		Active and organized
Google Optimize®	Data collection of user behaviors on a website	Diagrammatic data analysis	-	-	Data analysis from the use of prototypes	Relatively active and organized

Table 2. Overview of the basic functions of digital tools that can support the design thinking process.

Through the description of the tools and the functionality available to each, it is clear that there is no platform that fully satisfies the needs of all five stages of design thinking. In addition, some tools offer specific functions that are not precisely replaced by others. For example, data on the empathy stage can be collected either through applications that support questionnaire research, such as Typeform®, Google Forms®, and Maze®, or by conducting design workshops through applications such as Mural®, Miro®, Figjam®, InVision®, and Jamboard®. Accordingly, for the determination stage, the data visualized through the platform's questionnaire response analysis algorithms could, alternatively, be collected and organized with the help of applications such as Mural®, Miro®, Figjam®, InVision®, or Jamboard®. In these first two stages, it is important to consider the time required for each process. Through platforms that largely automate the collection and visualization of data, the design team saves time and energy, which can be channeled into analysis and further research. In conclusion, for the first two stages, it is useful to use ready-made solutions where this is useful, combined with the design functions offered by most modern software.

In terms of ideation, the three platforms that have relevant functionality are Mural®, Miro®, Figjam®, and Invision® as Google Jamboard® provides significantly less functionality. Looking at the design process holistically, however, tools that are part of the Figma® or Invision® ecosystem can handle most stages of the process by ensuring a smooth transition to other tools for the empathize, define, and most importantly test stages. Another feature that is important in this phase is the integration capabilities of video sharing applications, offered by tools such as Google Meet®, Microsoft Teams®,

Zoom[®], and others, for better collaboration of participants. Analysis of the tools' capabilities revealed that they all have the ability to integrate with some of the most popular video calling applications. In conclusion, depending on the workflow of each design team, one integration may be valued over another.

For the prototyping stage Figma[®] and Invision[®] fully meet the needs of low and high fidelity prototyping while Webflow[®] is intended for high fidelity design deliverables that are ready to market. FigJam[®], Jamboard[®], Miro[®], and Mural[®] tools can also be used in cases where the design team wants to create low-fidelity prototypes.

As for the last stage of the design process, i.e. the testing stage, most tools use the produced prototype to analyze user behavior in asynchronous sessions. Examples of tools that offer this functionality are Maze[®], Google Optimize[®], and Hotjar[®], while others can help extract information about usability and experience by implementing questionnaires. Examples of tools that offer this functionality are Typeform[®], Google Forms[®], and Maze[®]. The direct use of the prototype on the test platform is critical for extracting accurate data in relation to user behavior, without negating the importance of more detailed questionnaires in the final design phase.

5. Methodological framework for building knowledge and innovation skills eDea

5.1 Design thinking as a basis for building innovation knowledge and skills in the eDea intervention

Design thinking aims to introduce human-centered solutions to difficult problems through an empathetic process that enables design teams to more accurately understand the real, as opposed to perceived, needs of users, both functional and emotional, leading to solutions even to difficult problems even when they are not obvious at first glance. This is achieved through a process of inquiry, empathy, ideation, collaboration, and prototyping.

Human-centered design is not a new concept. It is a basic design principle of digital and non-digital systems and processes that aims at solutions that more closely address the needs and desires of the users of a product or service. Human-centered design can lead to a more efficient manufacturing process, shorter implementation time, fewer errors such as specification conflicts and poor communication between the design team and users, more competitive products and services, and greater return on investment. Human-centered design is characterized by processes of understanding the context of a problem and users, defining user requirements as well as business requirements, formulating solutions, and evaluating designs. The advantages of the method are more usable and understandable products and services, improved user experience, and increased satisfaction with the product or service, increased efficiency due to the adaptation of the design to the needs of the users, wider adoption of the results, improved accessibility, and improved business Results. Human-centered design is often based on the use of questionnaires aimed at understanding user needs through carefully designed questions. User responses lead to the design of specifications and then the transformation of specifications into products or services.

Design thinking is a deeply human-centered process that goes several steps beyond classic user experience-based design. Design thinking focuses on the experience as well as the feelings of the user from being exposed to a proposed solution. This is achieved in two ways. In the first, the design team members try to put themselves in the shoes of the users by experiencing the challenges they face. For example, if the goal is to design solutions and processes to improve the quality of life of residents in a remote village, designers may choose to spend a few days in the village to experience the challenges the residents face. In the second, team members observe users in their daily lives trying to perceive through simple and often unconscious actions how they could improve the user experience.

More than anything, design thinking is about innovation. Designers as thinkers strive to discover solutions that are desirable, feasible, and sustainable (Brown, T., Katz B., 2019). Solutions that address the real needs of users are desired. Feasible are solutions whose functionality can be implemented in the near future. Sustainable are the solutions that correspond to a sustainable business model.

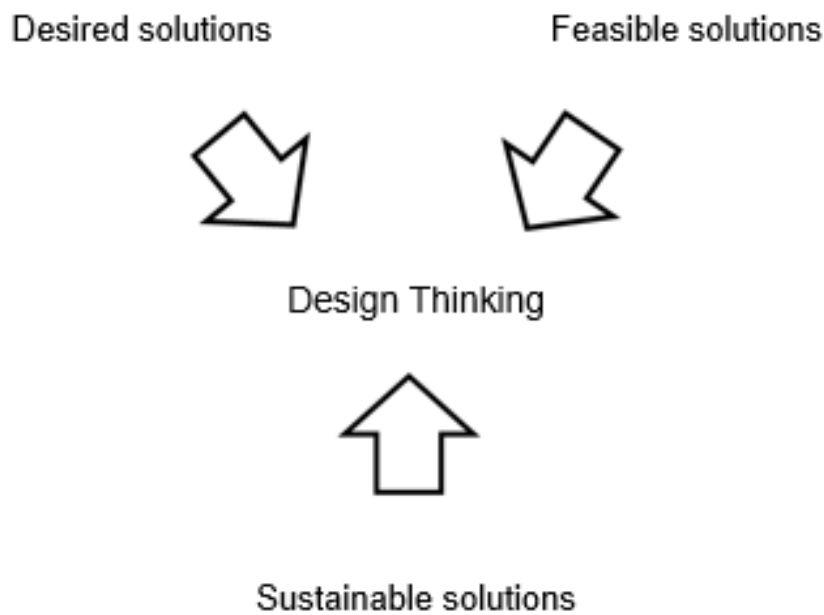


Figure 38. Design thinking is about desirable, feasible, and sustainable solutions, adapted from (Brown and Katz, 2019).

Design thinking manifests itself at the intersection of the processes of design, entrepreneurship, and technology. The combination of factors from these fields can lead to the introduction of innovative solutions to difficult challenges. Entrepreneurship is about innovative thinking, applied to solve problems of industry and society. Technology is often an integral component of proposed solutions, contributing to the implementation of products, services, processes, or systems that emphasize people, more effectively meet user needs, improve quality of life, and contribute to the creation of positive experiences.

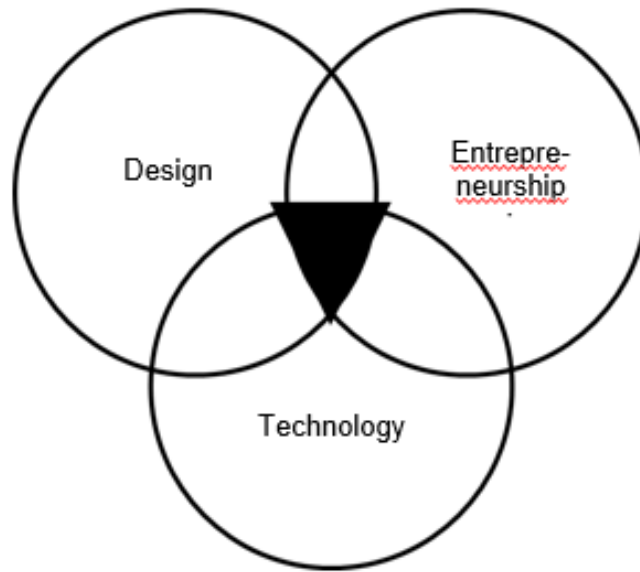


Figure 39. Design thinking is the intersection of design, business, and technology, adapted from (Brown & Katz, 2019).

5.2 Where does the eDea methodology apply?

Design thinking offers opportunities to introduce human-centered solutions in the context of both entrepreneurship and social entrepreneurship (Chou, 2018), that is, the development of innovation for the greater good. More specifically, design thinking can provide value (United Nations sustainability goals, 2021):

- In designing business models to introduce effective products to the market.
- In social entrepreneurship to address complex social challenges.
- Empowering communities by addressing complex social issues and improving quality of life by bringing together different stakeholders and co-creating solutions.
- In redefining value to increase the value of a product or service.
- To improve the quality of life through human-centered planning.
- In product design to promote evolving markets to better understand customer and user needs.
- In education to design learning experiences that best meet the needs of students and help achieve educational goals.
- In medicine to design innovative treatments that best meet the needs of patients.

5.2.1 Design thinking in entrepreneurship

Design thinking is used in entrepreneurship to design innovative products and services that improve the user experience. It helps identify the problem to be solved, collect and analyze data, and understand user expectations about possible solutions.

A well-known example of using design thinking in entrepreneurship to improve user experience concerns AirBnB (First Round Review, 2015). The company was struggling in 2009 with stagnant revenue. To understand the cause of the problem, service planners looked at 40 listings of homes for rent on the platform and noticed that their common feature was poorly defined photos. The team hypothesized that customers were not renting the properties because they did not have a clear picture of the premises based on the available photos. As a next step, the designers conducted an experiment. They replaced the photos of the properties in the listings with new high definition ones. After this simple intervention property rentals increased and the company is now extremely successful. This example shows that a focus on user experience can play an important role in increasing customer value.

Another example of the application of design thinking in entrepreneurship concerns the company Bank of America®. Bank of America® used the method in 2004 to achieve an increase in the number of new customer savings accounts. The bank turned to IDEO (IDEO, 2022), a pioneering design firm, which used design thinking to discover why it was so difficult for customers to save successfully. The bank was particularly interested in attracting mothers. IDEO interviewed and followed the mothers while they shopped. What the designers found is that women manage their families' money. An extreme case involved mothers in single-parent families with a very limited budget who managed it with particular care. The team noticed that the women kept lists of income and expenses. However, they were rounding the bills up. Instead of entering, say, \$24.50 for groceries, they entered \$25. This simplified the accounts but also had a positive side effect: at the end of the month, they had a few dollars left over. A second observation the team made was that women had difficulty saving money by making impulse purchases. Designers realized that women needed an incentive to save. They created the Save the Change program in which the computer system automatically rounded expenses up, automatically saving the balance that accrued at the end of the month. This program proved to be highly successful (von Schmieden, 2018).

5.2.2 Design thinking in social entrepreneurship

In social entrepreneurship design thinking can help develop solutions to social issues through innovative and effective approaches that have a positive impact on communities and address pressing challenges.

A well-known example of design thinking in social entrepreneurship contexts is related to an initiative undertaken by the Vietnamese government to reduce child malnutrition in rural areas. At the time, 65% of children under the age of 5 suffered from malnutrition. The project was conducted by Jerry Sternin of the Positive Deviance Initiative and his wife Monique. The researchers used an approach called positive deviance that uses existing, sustainable practices followed by families without malnourished children despite being just as poor as the rest. They observed patterns in food collection and preparation. The basis of the diet is rice which the families collected from paddy fields. The researchers observed that families that did not face a problem of malnutrition collected together with the rice tiny shrimps, crabs, and snails that were an adequate source of protein. Most families did not use this food source because they considered it unsafe. Based on these findings, the researchers trained rural residents to adapt their food preparation practices. The result was that 80% of the 1,000 children enrolled in the program were adequately nourished (Brown, T., Wyatt, J., 2010).

Another example of the application of design thinking in social entrepreneurship concerns the design of facilities for housing the homeless (Davis, 2004). Davis describes considerations and ideas for good design of spaces that serve diverse communities. The analysis examines challenges related to the design and organization of spaces, building organization, interior layout, and cost optimization. In addition, it examines what is desirable and feasible, whether spaces should be elegant or austere, and what is a proper balance between function, build quality, and architectural design.

5.2.3 Design thinking in learning

Innovation skills are desirable for everyone, but especially for young people who will be the problem solvers of tomorrow, enabling the transformation of ideas into action. For this reason, polytechnics and other schools of higher education include design courses in the curriculum. Design thinking can help develop the knowledge and skills to turn innovative ideas into action. It offers a thinking model that helps participants break down a problem into smaller ones making it easier to introduce solutions. Design thinking can be applied to a wide range of courses to implement team work, such as Software Design, Educational Technologies, Machine Learning, Application Design, and more. It can also be taught as part of independent design courses. Design thinking can be applied practically to help understand goals and implement a task in a way that meets the needs of end users.

Additionally, design thinking can be applied to improve the learning process itself by creating engaging, effective, and meaningful learning experiences for learners. Through empathy, design thinking can contribute to understanding the needs, goals, and motivations of learners. It can also assist teachers in designing learning activities

that more effectively lead to the achievement of learning objectives. Through feedback from learners it can contribute to the improvement of learning practices.

5.2.4 Design thinking for the 21st century

In the 21st century, the global community has been faced with a series of significant challenges. The UN's sustainability goals include eradicating poverty and hunger, promoting good health and well-being, ensuring access to quality education, affordable and clean energy, innovation, responsible consumption and production, sustainable cities and communities, equality gender equality, climate action, conservation of life on land and sea, and much more ("United Nations sustainability goals", 2021). These problems are fundamentally design problems that need creative solutions (Brown & Katz, 2019). Addressing the challenges of the 21st century requires a design mindset, a disposition to solve challenges, and optimism about society's potential to address them effectively. Design thinking can contribute significantly to addressing these challenges by introducing solutions that improve the quality of life while being sustainable.

5.2.5 The importance of teamwork in design

Design thinking can provide significant benefits to interdisciplinary teams that collectively synthesize solutions to current challenges. While large groups are common during project implementation, small and focused groups are preferred in the planning process (Brown & Katz, 2019). Each team member has a role. Each person brings different skills and knowledge to a team. For example, a person may be a good facilitator, idea finder, resource seeker, source and resource evaluator, implementer, finisher, or team player. Usually, most people have one of the above skills highly developed and a second one to a lesser extent. However, a team requires all of these roles to function properly, which highlights the need for collaboration to complete a project.

Moreover, the complex challenges of the 21st century require interdisciplinary knowledge that is not available to a single individual. For this reason, important problems are solved by teams that collectively possess the required specialized skills.

The benefits of working in teams to introduce innovative solutions are significant. Through collaboration, the design team can discover new ideas and solutions that team members may not have thought of individually. In addition, collaboration in groups is more efficient, as it allows the distribution of tasks and their simultaneous implementation, making group work more effective than individual work. Collaboration contributes to the quality of results, as designers can review and evaluate each other's work as part of quality control activities. Teamwork can also enhance creativity, as different team members can bring different experiences and

perspectives to the table, leading to more innovative solutions. Finally, teamwork can also help solve problems more effectively, as different team members can contribute different ideas and approaches.

In conclusion, teamwork is essential to successful design projects as it allows designers to leverage the strengths and expertise of their colleagues and create a more cohesive and effective final product.

5.2.6 Combining design thinking with relevant agile design methodologies

Another methodology for designing and implementing solutions is agile design (Sommerville, 2011). Agile design is primarily applied to software design, however it can be useful in solution design in general. It is used when the implementation specifications of a solution are not known from the beginning or when they are volatile. In agile design, specifications are described in “stories” that are broken down into smaller goals that are marked independently in a common workspace. Implementation takes place in cycles. At the end of each cycle the implementation team delivers to the customer an increment, i.e. a working software version that offers part of the final functionality. The implementation team in collaboration with the client decides which goals will be included in each increment.

The advantage of agile design is that it allows the implementation of a project to move forward even if the desired functionality is not fully understood from the start. Additionally, it gives a sense of progress as at regular intervals the implementation team delivers increments with new functionality.

Agile design does not have the same purpose as design thinking. Its purpose is to contribute to the organization of the implementation of a project and less to the encouragement of innovation. However, agile design has some common elements with design thinking. The most basic is describing the desired functionality with stories and goals noted as different ideas on a common canvas.

In agile design the implementation team often uses work organization tools. Maintains a list of all implementation goals or ideas, a list of goals implemented in the current increment, and a list of goals already completed. These lists allow the monitoring of the project implementation progress. This functionality could be added to design thinking processes to make the method more attractive in engineering and polytechnic education by offering an additional functionality and making design thinking applicable to broad problem-solving practices.

5.3 Basic design concepts of eDea digital learning intervention for innovation

5.3.1 Observing the user to understand functional, emotional, or latent needs

One of the ways to understand the needs of users is to observe their activity in their natural environment. This method offers us the possibility to collect information about the functional needs of the users that are satisfied by the offered functionality of a proposed solution as well as the emotional needs that are equally important in a holistic treatment of a problem or a challenge. In addition, design thinking aims to capture latent needs, i.e. needs that users do not realize they have, as well as needs that users cannot describe. This may be because users do not know the exact terminology or the alternatives available.

It is important for designers to be insightful in identifying and addressing latent needs, even if users are unable to articulate them explicitly. This can be achieved through research, observation, testing, and the development of flexibility and adaptation options in products, services, and systems. An example of observing user activity is given by Sommerville (Sommerville, 2011), who describes investigating the needs of air traffic controllers through ethnographic observation which showed that, since controllers work in the same room, they often ask colleagues to inform them of the number of aircraft they are sending to their area of responsibility to prepare, bypassing the digital system. This observation provides information on how controllers work in their professional environment and with real working conditions, which is useful for designing effective air traffic safety procedures.

In addition, designers can draw information from seemingly different situations that nevertheless have commonalities with respect to the introduction of efficient solutions. For example, to design emergency procedures and spaces in a hospital, which require the efficient, cool, and rapid collaboration of a team of specialized doctors and nurses for the benefit of patients, designers could draw ideas from the seemingly disparate but nevertheless with some analogies process of changing tires of a car in speed races, where again a team of specialized technicians with different specialties must work together for a quick response (Brown & Katz, 2019).

Finally, designers can gain insight by observing atypical users. For example, to design cooking tools aimed at families, designers can observe children, who need great usability, or chefs, who need easy cleaning (Brown & Katz, 2019). The observations of these groups can provide inspiration for improving the user experience of the recommended products.

As a general principle, it is important that designers enter the process of investigating a problem with an open mind, not thinking they already know the solution, seeking answers from users. In this way, they are more likely to recognize innovative solutions and not leave opportunities untapped (Stanford d.School, 2022).

5.3.2 Approaching a problem from different angles

Approaching a problem from different angles can provide additional information for designing solutions. Different perspectives help design solutions for different user groups. For example, the design of a library user management service must take into account the needs of both the public borrowing a book and the library staff managing the collection. Different perspectives offer more opportunities to analyze users' functional and emotional needs. For example, by taking a walk around his neighborhood a designer may notice possibilities for improving the quality of life. Repeating the walk accompanied by a maintenance technician will notice different problems, such as poor workmanship on the roads, traffic signals that are not sufficiently visible, and others. Repeating the walk accompanied by a gardener will observe issues related to the gardens or the balconies of the houses. This exercise contributes to understanding the contribution of different perspectives in broadening the understanding of a problem (Stein Greenberg, 2021).

5.3.3 Divergence before convergence

The basic process of design thinking is to create a rich collection of ideas that can be combined to design a solution. The richer this collection, the greater the opportunities to introduce a solution that meets the needs of users. Entering multiple possible solutions is referred to in design thinking as ideation or brainstorming (MIT Media Lab, 2022). To be successful, a design team must be willing to diverge, introducing many possible solutions, before converging on a solution that will become a prototype. The goal of the divergence process is to create several alternative implementation paths. The goal of the convergence process is to select an idea to implement.

Design thinking follows a circular process of divergence and convergence that gradually leads to the desired solution. At the end of each cycle of the process the design team evaluates the ideas that have been proposed by its members and chooses which ones will remain in the collection of possible solutions in the next cycle of ideation.

5.3.4 The importance of experimentation

Experimentation is a basic method of investigating our environment. From an early age, children experiment to understand the world around them. For example, they dip their hands in paints and paint or build brick towers (MIT Media Lab, 2022) (Lifelong

Kindergarten, 2022). Exploring the world through experimentation is a key idea of constructionism, in which knowledge is not transmitted but synthesized (Papert, 2022). In the process of designing new processes and products, each company or team has a different tolerance for experimentation. Tolerance for experimentation can be paralleled with a company's or group's tolerance for risk. However, experimentation is indicative of a company's culture and helps usher in new ideas. The people in a team who are in the best position to introduce new ideas are those who have direct contact with the outside world, such as users, and perceive opportunities and threats. At the same time, a group's optimism that the solution to a problem lies within its capabilities contributes to innovative design (Brown & Katz, 2019).

5.3.5 Steps of design thinking in the eDea methodology

The steps of design thinking are not strictly defined. Design teams apply the method in different ways. Here, the steps of design thinking are defined as problem investigation, empathy, problem definition, ideation, prototyping, and evaluation. These steps may be repeated in cycles until the design team arrives at a desirable, feasible, and sustainable solution. The team can go back to a previous step and repeat the process if it realizes that the desired convergence with user needs has not been achieved. The following is a description of the steps of design thinking as applied to the eDea project.

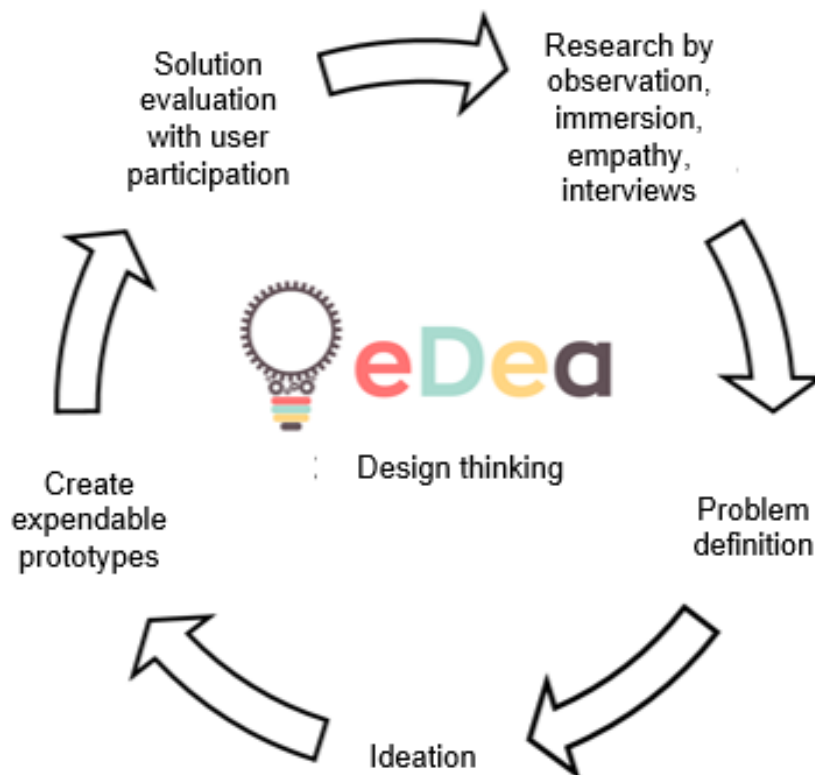


Figure 40. The stages of design thinking, adapted from (Stanford d.School, 2022; IDEO, 2022).

5.3.5.1 Investigation of the problem

Investigating the problem is about understanding its real parameters and the real needs of the users. It can be achieved in different ways or a combination of them.

In **field research**, the design team looks for sources to describe a problem. These sources may be found in the literature, the internet, the mass media, and elsewhere. The design team may use text, images, video, links, diagrams, or other media to describe the space and context of the problem.

The next step is to understand the real needs of the users. In design thinking it is pursued through empathy. **Empathy** is about making the design team aware of the real, rather than the perceived, needs of the users.

Empathy can be achieved by **observing** users in their natural environment with the goal of discovering through functional, emotional, or latent needs.

Another way is to **immerse** yourself in the users' environment. The design team chooses to follow the steps of a process they want to improve. For example, if the goal is to design a more user-friendly application service for admission to a master's program, the design team follows the steps provided in existing practices to identify areas of potential improvement.

Finally, user needs can be analyzed and recorded by **conducting interviews**. The design team can prepare interviews. This preparation includes the selection of the place of the interviews as well as the interviewees who should be selected based on the richness and range of information they can contribute. In addition, preparation includes designing questions that should initially create a climate of trust with the interviewees and gradually encourage the interviewees to delve into topics of interest, broaden the scope of the discussion, and cultivate reflection in a way that it can potentially help interviewees become aware of additional facts about themselves and the world that they had not previously considered.

On the other hand, the design team seeks to discover connections between analogous situations that could contribute to understanding the problem. For example, if the problem is effective waste management, the team can look for connections between waste management and people, places, feelings, or solutions to similar or even different challenges that can provide inspiration for introducing innovation.

The result of the investigation process is a broad collection of notes describing the different aspects of the problem.

5.3.5.2 Definition of the problem

Problem definition is important in design thinking as it forms the basis for introducing solutions allowing the design team to focus on real user needs. Problem definition is based on the problem analysis performed in the investigation step. It also includes the design team's perspective, i.e. the team members' understanding of the problem and their views. Accurate problem definition can enable the design team to tackle even difficult problems by helping to simplify the parameters of the problem and making it possible to formulate a solution. An example of the importance of defining a problem correctly concerns the story that Ford, who designed one of the first automobiles, when asked about his design experience, said that his customers thought they needed a faster horse, but in fact, they needed a new means of transportation, namely the car (Brown & Katz, 2019). While it is debatable whether Ford actually told this story, the idea that the right problem definition can lead to solutions is an interesting one. Another example of the importance of precisely defining a problem is reported on graduate student work on design thinking at Stanford University. Students were asked to design a solution to address the shortage of incubators in India (Stanford d.School, 2022). After analysis, the students defined the problem as the need to maintain an infant's body temperature at 37 degrees Celsius. Based on this definition, the students proposed as a solution the design of an economic bag that the mother could take with her. This example shows how precisely defining the parameters of a problem can lead to designing a solution to difficult problems, even when it is not obvious at first glance.

At this stage the design team can additionally describe a user characteristic through tools such as the behavioral archetypes (persona) described above, contributing to the understanding and mapping of the needs, desires, and emotions of the users by the design team. The featured user is not an actual person. Instead he is a fictional person who has the characteristics of most who will use a possible solution. User description can be done with different tools. The **empathy map** is a description of the challenges faced by the user. It records what the user sees, what he hears, what he thinks, what he feels, what he says, what problems he faces, and what the desired benefits of a potential solution are. The **user journey** describes the user's experiences at different stages of his life that determine his current way of thinking. The user's **holistic description** describes not only his experiences but also how all aspects of his life, such as career, family, friends, education, or health, and others, shape him as a person. The design team selects the tool that can provide the richest information relative to the problem under investigation.

5.3.5.3 Ideation

Brainstorming is the process of brainstorming ideas. Ideation is the divergence stage of design thinking, where the design team introduces as many possible solutions as

possible. Creating a rich collection of ideas allows the team to evaluate the data and select one more for implementation based on specific parameters. Solutions can be categorized as passable, innovative but implementable, or not yet implementable due to a lack of, for example, the appropriate technology. Ideally, the design team chooses a solution that is innovative but can be implemented with existing resources. The solution chosen for implementation must be convertible to a prototype that will allow the implementation team to test its ideas with users, who will be able to interact with a product, service, or process in practice and to provide feedback.

The ideation process can include exercises that help the design team input ideas. For example, the team can think of ideas that need significant or, conversely, limited financial resources for implementation. Other exercises encourage group members to jot down their ideas and then build on other members' ideas in a circular fashion (Lewrick, M., Link, P., Leifer, L., 2020). The method is most effective in groups with a moderate number of people, such as for example 6, and allows the introduction of many alternatives in a short time.

5.3.5.4 Designing prototypes

Prototyping refers to the creation of a consumable prototype of the idea chosen for implementation. The prototype does not have to be complete or high fidelity. It just needs to allow users to experiment with it. An original can be digital. It can also be made from simple and inexpensive materials such as cardboard. Finally, a prototype can take the form of a poster describing the solution or even a storyboard that describes the user's expected experience when interacting with the proposed solution. The latter option applies to the description of experiences or other intangible solutions for which a physical prototype cannot be manufactured.

The purpose of the prototype is to be developed, generate user feedback in a way that contributes to the design of the final solution, and be discarded. A good prototype creates user reactions during their experience of using a solution by offering information about the functionality of the solution as well as the emotions that may arise.

5.3.5.5 Evaluation

The last stage of design thinking is the evaluation of the prototype and the final solution. The design team observes users as they interact with the proposed solution and records reactions, comments, suggestions, and emotions that may provide information to enrich a possible solution, bringing the final result closer to their needs.

5.4 Key concepts of eDea digital learning intervention for innovation

The eDea digital learning intervention aims to encourage innovative thinking in both business and learning contexts. The design concepts described above are useful in both contexts. Regarding learning, the eDea digital learning intervention also aims to achieve learning objectives related to the development of innovation skills in a way that enables the transfer of new knowledge from the academic to the professional environment after the completion of higher education studies. Thus, students will be able to act as tomorrow's problem solvers, both in terms of entrepreneurship and social entrepreneurship.

The additional goals, beyond the design ones analyzed above, of the eDea digital learning intervention are described below.

5.4.1 Developing innovation skills

Innovative thinking and capacity for innovation are based on soft skills, which combined with basic knowledge, such as mathematics, science, and languages, synthesized through educational processes enable students to turn ideas into action and become active citizens. Here is a breakdown of the desired soft skills that drive innovation.

- **Independent research:** Searching and analyzing information and data and combining them to identify correlations and synthesize new ideas and solutions. Research can be conducted either through sources such as the internet, scientific articles, books, mass media, and others or through the application of tools such as questionnaires, interviews, observation, and immersion.
- **Evaluation of sources:** Analysis of their reliability, especially important in the age of the internet that provides access to a wealth of information, both authoritative and non-authoritative.
- **Collaboration in teams:** The knowledge and skills required to introduce solutions are not concentrated in a single person. Instead, innovation processes are based on the collaboration of interdisciplinary and cross-cultural teams that collectively offer knowledge, skills, and different perspectives. The ability to collaborate is important for collective success.
- **Open minded:** Designers should approach a problem with room to design different solutions, without assuming they know the optimal solution from the start. Otherwise, they risk overlooking potential solutions.

- **Imagination:** Designers are forward-thinking individuals who use their imagination to introduce creative ways to achieve a goal. Imagination offers the possibility of predicting the results and impact of implementing a new idea. Imagination additionally contributes to ideation and brainstorming. It can inspire team members to contribute to new solutions and progress in a scientific field.
- **Problem Solving:** People with innovation ability see problems and challenges as opportunities to introduce new products, services, systems, or processes. The ability to solve problems in a systematic way helps to tackle difficult challenges.
- **Critical Thinking:** Innovative designers apply analytical and critical thinking to discover opportunities for improvement. They also use it to identify connections between challenges, situations, and possible solutions. In this way they come closer to achieving a goal.
- **Flexibility and alternative thinking:** Innovative designers are flexible and apply alternative thinking to introduce innovative solutions by adapting to available resources that can be combined to design solutions.
- **Persuasion:** Innovation requires collaboration. Persuasion is important to get members of a group to try or experiment with new ideas and solutions.
- **Entrepreneurial thinking:** Entrepreneurial thinking is synonymous with innovation. It is about designing solutions to industry and societal challenges in a way that addresses the needs and wants of users.

5.4.2 Active learning with action and experience

Active learning is a knowledge building methodology where pupils and students build knowledge by doing, as opposed to watching, i.e. seeing and listening (Bonwell and Eisen, 2019). The method owes its name to the active participation of pupils and students in the procedures. In active learning, students role-play, explore, collaborate, solve problems, visit places of interest, and more. Through analysis, synthesis, and evaluation they build knowledge, skills, and positive attitudes. Active learning offers many advantages that contribute to the achievement of learning goals.

- Enhances understanding of abstract concepts.
- Develops basic knowledge and soft skills.
- Provides frequent and immediate feedback, which contributes to understanding the connection between cause and effect of choices.

- Contributes to the recognition of connections between educational material and real life, increasing students' intrinsic motivation to learn.
- Promotes cooperation and teamwork and builds a sense of community.
- Develops self-esteem through discussions between students or students as well as between students or students and teachers.

Active learning contributes to the development of higher order thinking skills as defined by Bloom's taxonomy of knowledge acquisition (Armstrong 2010, Armstrong 2016). More specifically, Bloom's taxonomy recognizes six levels of progressively increasing acquisition of knowledge, memorizing, understanding, applying, analyzing, evaluating, and synthesizing new knowledge. Traditional learning, where the teacher is at the center of the learning process by imparting knowledge, focuses on the lower layers of the classification, i.e. seeks memorization and understanding, while in rarer cases the application of knowledge. On the contrary, active learning, where the student or student is at the center of the learning process, is also effective at the higher levels of the classification of knowledge acquisition, that is, it encourages analysis and evaluation as well as the synthesis of new knowledge.

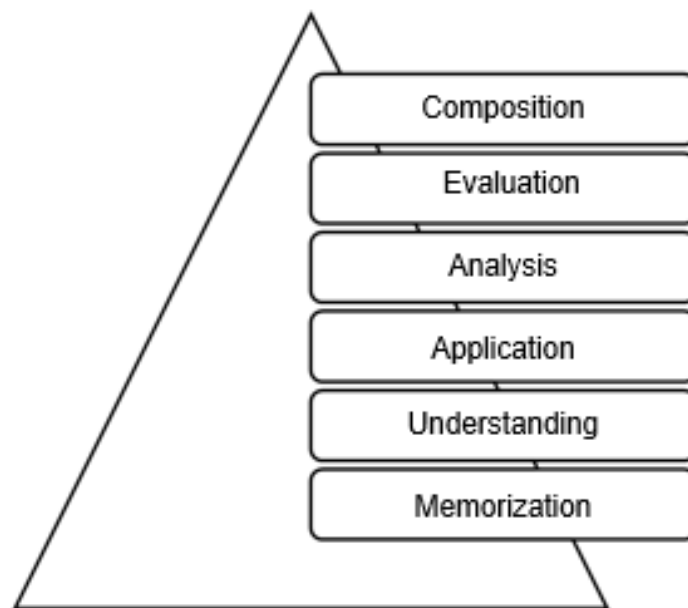


Figure 41. Bloom's taxonomy of knowledge acquisition. Available via a Creative Commons license.

Given the learner-centered nature of active learning, the teacher's role in it is no longer to convey information, but instead to guide, encourage, build students' and students' confidence, coordinate the learning process, and broaden understanding of the learning object by answering questions.

A popular approach to active learning is also problem-based. In **problem-based learning** students build knowledge by solving a problem, which is usually inspired by real life and is open-ended, encouraging the introduction of multiple solutions. Problem-based learning is directly related to design thinking, which also focuses on introducing innovative solutions to difficult challenges.

Problem-based learning emerged in the 1960s in higher medical education. In the 1960s, educators at McMaster University located in Hamilton, USA observed that the content in the first three years of the curriculum was not relevant to clinical medicine (McMaster, 2023). Therefore, they sought to promote the practical application of new knowledge by applying it to processes that simulated future roles. With the new problem-based learning approach, the training included real patient case studies. 80% of medical schools in the US now use this method. Problem-based learning is now widely applied in secondary and higher education in a wide range of fields beyond medicine, such as law, entrepreneurship, engineering, the social sciences, and elsewhere through case study processes.

Problem-based learning is applied in various ways. However, some common steps are found in most practical applications of the methods. Typical problem-based learning activities follow.

- Identification of the problem, i.e. the learning objective.
- Determination of the known parameters and data of the problem.
- Import cases.
- Brainstorm.
- Evaluation of ideas.
- Break down a problem into smaller tasks.
- Synthesis of solutions through collaboration and integration of knowledge from different fields [43].

Finally, **experiential learning** is another active learning approach. In experiential learning the building of knowledge starts from an event that leads to the revision of students' perceptions of the world around them (Kolb 2009, Kolb 2010, Kolb 2011, Kolb 2014). Kolb defined a learning cycle that includes concrete experience, reflective observation, abstract reflection, and active experimentation. According to Kolb, students can enter the cycle at any of these steps and continue through the rest to build knowledge and develop. Based on this observation, Kolb argued that not everyone learns in the same way and identified the following learning styles.

- **Convergent learning**, where students build knowledge through conceptualization and active experimentation. Students learn by feeling and observing.
- **Divergent learning**, where students build knowledge through concrete experience, reflection, and observation. Students learn by thinking and observing.
- **Assimilative learning**, where students learn through abstract conceptualization and reflective observation. Students learn by thinking and doing.
- **Adaptive learning**, where students combine experience with active experimentation. Pupils and students learn by feeling and doing.

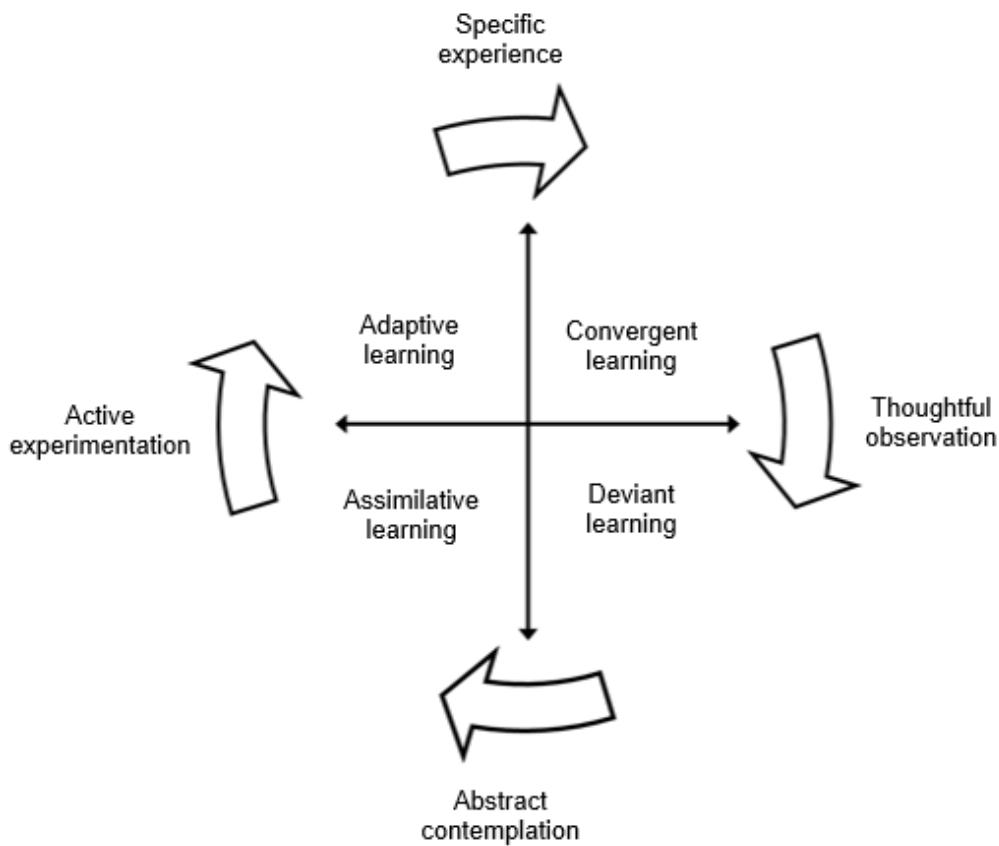


Figure 42. Kolb's learning styles. Adapted from (Kolb, 1984).

The eDea learning intervention combines the above emerging learning methodologies with design thinking to more effectively develop innovation skills through active methods that contribute to knowledge retention and real-life application beyond the academic environment. Specifically, the eDea learning intervention combines the following methodologies.

- **Design thinking**, to promote innovation.
- **Problem-based learning**, through open-ended challenges that encourage the introduction of multiple solutions.
- **Experiential learning**, through missions inspired by real problems of the 21st century.
- **Gamification**, to cultivate internal learning motivations.

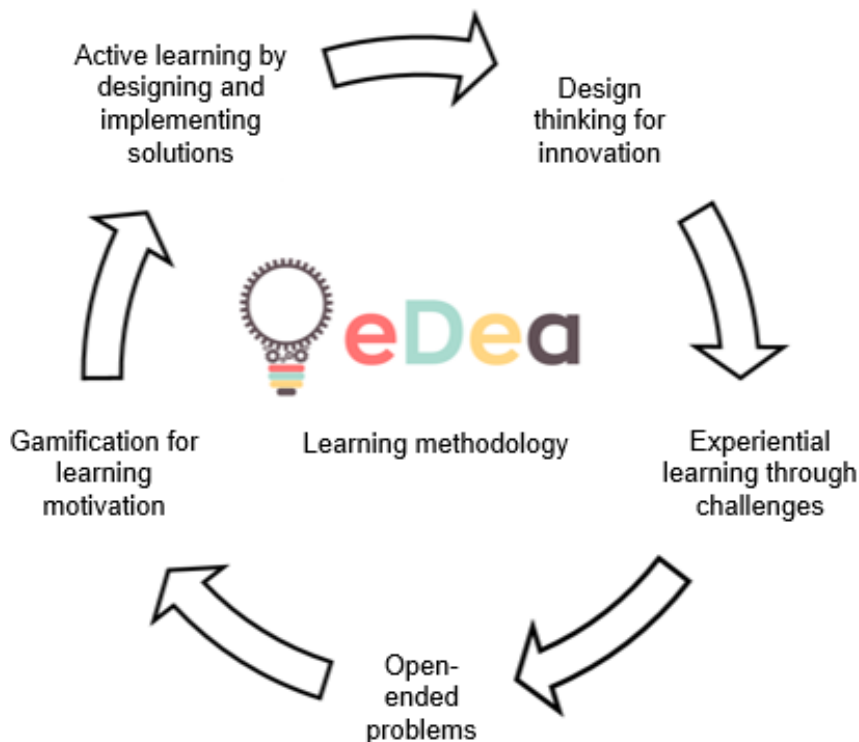


Figure 43. eDea learning methodology.

5.4.3 Gamification of learning to encourage participation and gradual knowledge building

One of the main goals of the eDea digital learning intervention for innovation is to encourage the long-term involvement of designers and students in knowledge and skill building processes. This is pursued through the gamification of the design process.

The term gamification refers to the integration of game elements into contexts beyond entertainment, such as entertainment, marketing, digital games, digital and non-digital communities, eLearning platforms, massive open online courses (Massively Open On-line Systems – MOOCs), business processes, and elsewhere.

Examples of gamification elements that can be incorporated into these processes include (Sailer, 2017) meaningful and clear missions, structure and rules, reward,

sanctions, sense of progress and success, activities that are difficult but achievable, collaboration, immersion in a digital world, socialization, social recognition, instant feedback, and more. It is worth noting that it is not necessary to incorporate all possible gamification techniques into an environment. On the contrary, in the design of a product, a service, an experience, or a process, a combination of some gamification techniques is chosen that as a whole serve these goals.

The learning digital learning intervention eDea incorporates gamification elements that contribute to the active participation of designers and students in the design process through the cultivation of intrinsic motivation, such as the following.

- **Meaningful quests**, expressed in choosing to solve real-life challenges.
- **Reward and social recognition**, expressed through positive voting (likes) of others on the contribution of designers and students.
- **Socialization and cooperation** expressed through group work.
- **Feedback**, expressed through comments and suggestions of the teacher or other designers and students regarding the contribution of each participant to the design process.
- **A sense of progress and success**, expressed through the gradual completion of the design thinking steps.

5.4.4 Flexibility in structuring design activities

The eDea digital learning intervention for innovation aims for flexibility in terms of structuring design or learning activities based on design thinking in a way that makes it possible to use it in a wide range of cases and situations.

This goal is achieved through the modular structuring of activities in steps chosen by the teacher or coordinator of the design process. Specifically, the proposed solution supports the following structure.

- **Individual activities**, which are self-contained exercises that, like atoms in physics, are not further divided and can be combined and used in different steps of design thinking. For example, an individual activity might be to conduct interviews to understand user needs at the problem investigation stage. Alternatively, the interview tool could be used at the stage of testing a proposed solution using a relevant prototype from users providing feedback. It becomes clear, that the specific tool can be applied in different steps of the process. Another example of individual activity is investigating the problem by searching the internet. Another example is creating a quick and consumable prototype of a tangible solution with available materials or alternatively

describing an intangible experience through a story, which are two different ways of prototyping with the aim of conducting tests and generating feedback.

- A **selection of design process steps**, which gives flexibility to the teacher or facilitator to apply different approaches to design thinking, such as those described above, as well as specific steps that are appropriate in different contexts. For example, one teacher may choose to structure an activity with the steps of problem exploration, problem definition, ideation, prototyping, and evaluation while another may choose the steps of problem definition, ideation, and prototyping.
- **Creation of a pipeline of activities**, which synthesizes the above into an integrated design and innovation process.

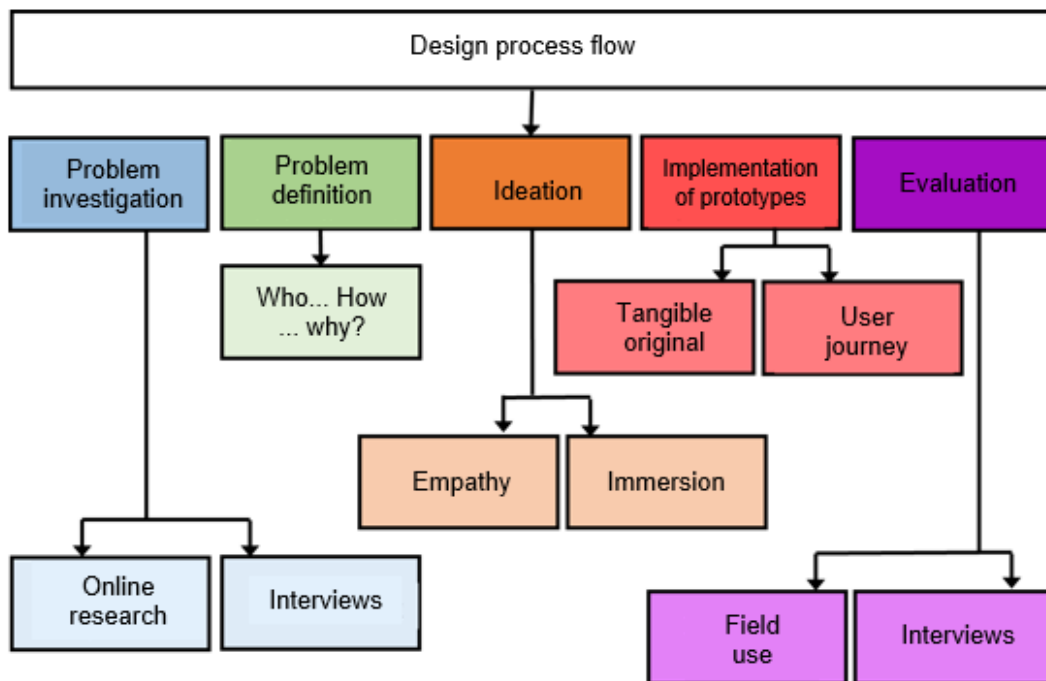


Figure 44. Example of a modular eDea design thinking process structure.

5.4.5 Reuse and foster a community of good practices

An additional advantage of the modular structuring of eDea design activities is the opportunities it offers for reusing activities, both individual activities, steps, and entire design thinking flows. The modular structure allows teachers and facilitators to mix and match activities from a library of available templates prepared either by the eDea project implementation research team or other teachers, facilitators, or stakeholders.

Users of the digital learning intervention eDea have the possibility to create individual or even broader activities in a personal workplace. They also have the ability to publish their activities for sharing by other teachers or moderators. This feature encourages

the sharing and reuse of content and activities. It also cultivates a community of good practice where participants learn and inspire each other with the aim of collectively improving innovation skills.

5.5 Expected results of the eDea digital learning intervention for innovation

The eDea research project adopts a holistic approach to the implementation of the proposed digital learning intervention for innovation with the aim of designing and implementing collaboration solutions but also supporting the use of the proposed solution in planning and learning processes. This is achieved through the completion of the following deliverables.

- Needs analysis and development of a learning framework promoting innovation skills, described in this report.
- Design and implementation of a digital collaboration platform in the context of design thinking.
- User manual of the digital collaboration platform.
- Planning design thinking activities inspired by real life, which can be directly used in design or learning activities or provide a point of reference and inspiration for planning further related actions.
- Supporting content for lecturers and design team coordinators that contributes to the adoption of the eDea digital learning intervention after the end of the research project implementation.
- Evaluation of the digital learning intervention eDea in the context of learning experiments (learning experiments) with the participation of external users and integration of their feedback in the implementation of deliverables.
- Dissemination of information about the objectives, activities, and results of the research project through differentiated actions, such as project website, informational content (leaflet), scientific articles, publications in the mass media, articles on the websites of the research project partners, presence in social networks, presentations, and others.

5.6 Initial design of eDea digital learning platform to promote innovation through collaboration

The discussion above reveals that while there are digital tools that contribute to individual design activities, there is still a gap in the market for a comprehensive, holistic intervention to encourage innovative thinking at all stages of the design process in both industry and higher education. education. The digital learning

intervention eDea to promote innovation aims to support the application of design thinking both by design teams and in learning through the design and implementation of a digital service that supports creativity in all steps of design thinking in a modern way, that is, in real-time, as well as asynchronously, offering the ability to share ideas with all team members as they arise, often outside of a formal schedule or working hours. The final product will be able to be used to introduce innovative solutions both in design processes in industry and in learning.

The functionality described in this section is designed with teams working together more effectively to bring innovative solutions to difficult challenges face-to-face. Their members can share ideas and build on the ideas of others. This is true in all collaborative contexts but is especially important in design thinking that relies on intense interaction and different perspectives to understand real user needs and build solutions. However, in today's digital world collaboration takes place not only face-to-face but also online. Members of a group may be in different rooms, buildings, or countries. What motivates remote teams is the ability to brainstorm and build consensus (Brown & Katz, 2019). Classic digital tools such as e-mail, video conferencing, and data sharing can only support remote teamwork to a certain extent by facilitating access to shared information. Social media is also sometimes used for group collaboration as it allows people to network and share ideas. However, they are not designed as collaboration tools. What geographically or even temporally dispersed design teams need, and which is rarely available through digital tools, is the ability to collaborate on joint projects by capturing ideas, identifying connections between ideas, and categorizing ideas into thematic units in real time in a way that makes them accessible to all members. Additionally, design teams need services that facilitate ideation and easy sharing of ideas by allowing members to build on each other's ideas in a way that simulates face-to-face collaboration.

The eDea digital service includes functionality for design coordinators and design team members.

5.6.1 Functionality that supports collaboration

The functionality facilitates the collaboration of teams whose members are located in the same or remote locations.

Functionality Code	eDea 1.1
Title	Shared work canvas of distributed teams
Description	The shared canvas is a digital space shared by all members of the design team
Purpose	Designers can use the space to share ideas that are commonly visible to all team members

Functionality Code	eDea 1.2
Title	Avatar
Description	Each team member has an avatar, i.e. a recognizable digital presence within the digital platform. The avatar shows its owner's location by tracking mouse movement. The avatar may have a simple form, for example a circle with the initials of the owner's name, because even this representation satisfies the purpose of communicating presence
Purpose	Notification of presence and activity of each member of a group to the rest

Functionality code	eDea 1.3
Title	Real-time activity notification
Description	Each intervention of a team member on the shared work canvas is visible in real time by all team members. This may involve publishing or converting notes. The implementation of this functionality requires a server that keeps a record of all group members' actions and allows only group members to have access to them at the time they are carried out
Purpose	Ability to share ideas from anywhere at any time in a way that makes them instantly visible

Functionality code	eDea 1.4
Title	Access from the internet and mobile devices
Description	Team members can access the shared work canvas over the internet with minimal technical requirements. They can also be accessed online and from mobile devices. This requires an implementation that will make the canvas content easily distinguishable and manageable on small screen sizes
Purpose	Facilitating collaboration from anywhere at any time

5.6.2 Functionality that supports the exploration, ideation, and evaluation of solutions

Functionality helps to explore a problem, ideate or brainstorm, and evaluate ideas to select the most dominant one to prototype.

Functionality code	eDea 2.1
Title	Post idea
Description	Each designer can post ideas via notes placed on their team's shared canvas. The post may include text, images, or a link to

	a video
Purpose	Sharing ideas in problem-solving and ideation processes

Functionality Code	eDea 2.2
Title	Instant visibility of posts from all members of a group
Description	All members of a group have direct access to other members' posts
Purpose	Access to ideas posted by team members in problem-solving and ideation processes

Functionality Code	eDea 2.3
Title	Change the color of a note
Description	The color of a note can be changed. The platform supports a number of predefined colors
Purpose	Categorize ideas into thematic sections that are easily distinguishable based on the color of the corresponding notes. Organizing ideas and identifying associations that may contribute to solution design

Functionality Code	eDea 2.4
Title	Correlations of notes with arrows
Description	Two ideas posted to a team's shared canvas can be linked by an arrow that starts from the note corresponding to one of them and ends at the note corresponding to the second
Purpose	Organizing ideas and identifying associations that may contribute to solution design

Functionality Code	eDea 2.5
Title	Create blueprints
Description	An idea can be represented by a simple layout published in note on the shared work canvas
Purpose	Describing ideas through simple blueprints

Functionality Code	eDea 2.6
Title	Note conversion
Description	Each team member can transform a note by adding text,

	photos, or links to videos. It can also change the color of the note
Purpose	Sharing ideas in problem-solving and ideation processes

Functionality code	eDea 2.6
Title	Delete note
Description	Any team member can delete a note
Purpose	Sharing ideas in problem-solving and ideation processes

Functionality code	eDea 2.7
Title	Request for feedback
Description	The working group can request feedback on its activity from its coordinator
Purpose	Processes of problem-solving, ideation, and evaluation

5.6.3 Functionality that supports implementation coordination

Functionality helps define the goals of a task, organize the steps of design thinking, and monitor the progress of a project by the team coordinator.

Functionality code	eDea 3.1
Title	Create a design thinking activity
Description	The design team facilitator can create an activity and define the design thinking steps to be used by the team during design. Each step is a different canvas of work. The coordinator can add through notes on the corresponding canvas instructions to the design team regarding each step of the design thinking
Purpose	Setting goals of an activity. Structuring the work in steps of design thinking. Communicate instructions from a group's moderator to members

Functionality code	eDea 3.2
Title	Activity statistics of members of a group
Description	Members of a group can access their activity statistics, such as number of notes created, changes, and more
Purpose	Work organization and monitoring of implementation progress

Functionality Code	eDea 3.3
Title	Implementation progress monitoring
Description	The task force can create a list of all implementation goals or ideas, and a list of goals implemented in the current increment, and a list of goals that have already been completed
Purpose	Work organization and monitoring of implementation progress

Functionality Code	eDea 3.4
Title	Provide feedback
Description	The moderator of a group can give feedback to members if they ask for it
Σκοπός	Processes of problem-solving, ideation, and evaluation

5.6.4 Scenario of using the eDea platform for innovation

Each member of a design team, including the coordinator, creates an account in the eDea service.

The group facilitator structures an activity into design thinking steps. At each step, he has the option to add instructions to the design team in the form of notes.

Team members connect to the platform synchronously or asynchronously. This can be achieved both when team members are in the same space and in different spaces.

Each member can create notes with ideas described with text, images, or links to videos. Can convert or delete notes. It can group notes into thematic sections that are identifiable by color. Can associate pictures with arrows. And it can create diagrams that describe ideas.

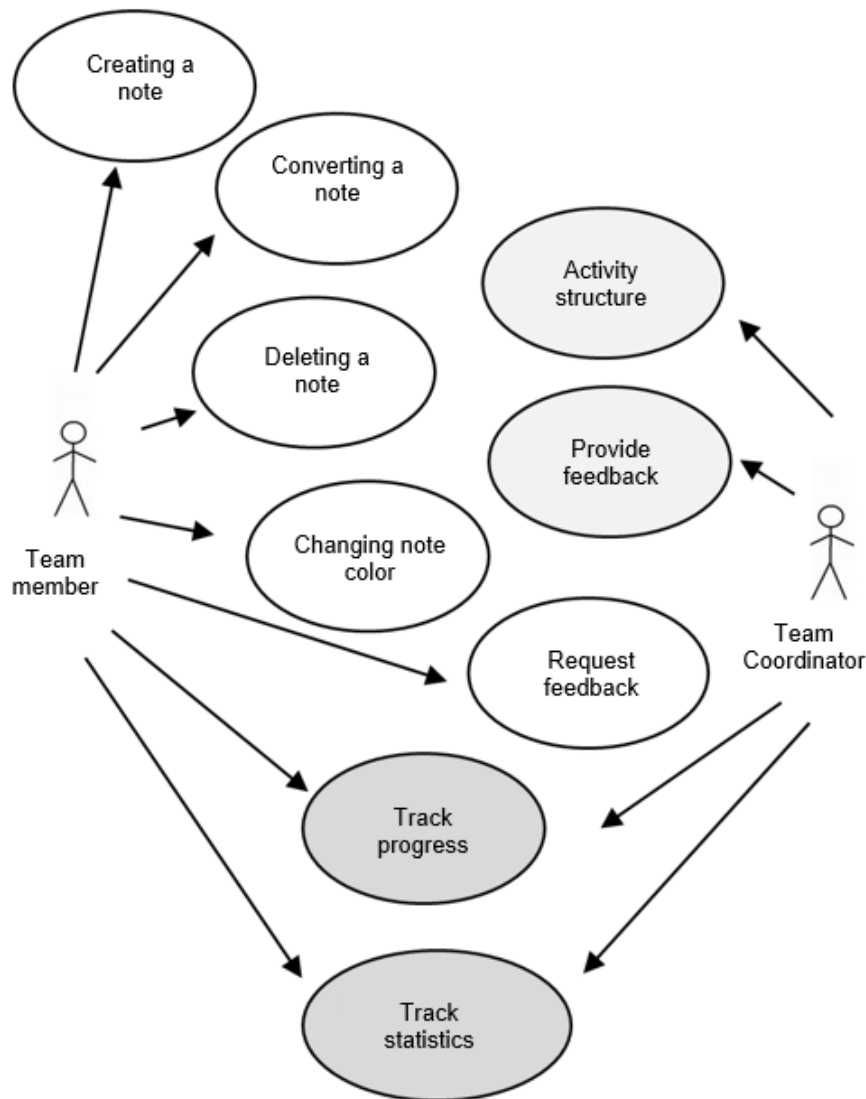


Figure 45. Diagram of the use of the eDea service.

When members of a group feel that work on one step of design thinking is complete they can move on to the next step or ask for feedback from the facilitator. Once they ask for feedback, the facilitator provides it and the team continues the implementation to the next step of design thinking.

Design team members can use the dashboard to plan the implementation of actions by categorizing them into a list of all implementation goals or ideas, and a list of goals implemented in the current increment, and a list of goals that have already been completed.

Design team members can view activity statistics.

Conclusion

The technical report presented the methodological theoretical framework that forms the basis for the design and implementation of the eDea digital learning intervention for innovation. The theoretical framework was based on a needs analysis of the directly interested users of the intervention, i.e. the designers or students and the teachers or coordinators for their effective collaboration in the context of innovation activities, such as the management of ambiguity, divergent thinking, the practice of empathy, and the ability to turn ideas into something tangible. To meet these needs, the digital learning intervention eDea was developed taking into account and expanding existing design thinking approaches, such as those of IDEO®, d.School®, the Design Council, and frog design. The eDea learning intervention combines design thinking, experiential learning, problem-based learning, and gamification methodologies to encourage innovative thinking through effective collaboration. The eDea methodological framework will be put into practice towards the realization of a digital collaboration platform that facilitates the members of a design team to collectively synthesize interesting solutions to today's entrepreneurship and social entrepreneurship challenges through the sharing of ideas, the evolution of other members' ideas, collaboration, and constructive communication.

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