Building Career Skills in Computer Science Students through Design Thinking Hackathons

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Astract: Career development is an important aspect of every young person's life as it helps them identify their skills, interests and goals and find the right career path for themselves. Career skills are a broad range of competencies and abilities that are necessary for success in the workplace. Developing them through education, training and experience can help students identify them and achieve their career goals. Design thinking is a powerful approach for this purpose. With its components-problem solving, innovation and creativity, collaboration and teamwork, iterative approaches, and empathy-design thinking can help students develop the skills they need to succeed in a wide range of professional fields. The specificity of the hackathon as a form of organization further contributes to building these essential skills that are directly related to students' career development. This paper explores the possibilities of forming career skills in students through design thinking hackathons.

Keywords: career skills, design thinking, hackathon, problem solving, empathy, innovation, collaboration and teamwork, iterative approach

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Introduction

Career skills are a broad range of competencies and abilities that are necessary for success in the workplace. Teamwork and collaboration skills, problem solving, effective communication, creative thinking and creativity, resilience, emotion regulation, self-awareness, work organisation and time management skills, initiative,

presentation and technical skills, among others, have been identified as leading career skills (LinkedIn 2023, Indeed 2022). "Future-proof occupations will require communication, managing people, creativity, and specialized knowledge."(Guffey & Loewy, 2023) Developing career skills through education, training, and experience helps to achieve the professional goals one has set for oneself and one's career advancement. The design thinking method can be successfully applied to this purpose as its core elements are problem solving, innovation and creativity, collaboration and teamwork, iterative approach and empathy.Design Thinking as a "way of thinking" in the sciences goes back to 1969 (Simon, 1996), and as a method of creative action it was discussed by Peter Rowe's book Design Thinking (Rowe, 1987), as noted by Val E. et al (Val E. et al., 2017), while its meaning was expanded by Richard Buchanan (1992), Tim Brown (2009) and Roger Martin (2009), to name a few.

Design thinking is a leading methodology for creative problem solving and innovation. It integrates creativity and imagination with analytical thinking and combinativity. It is based on convergent, divergent and lateral thinking and leads to ideas, concepts, solutions, products, articles, etc. that are unique and innovative. Tim Brown, CEO and President of IDEO, defines design thinking as "a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success."(Brown, T., n.d.) It achieves creative problem solving that is rooted in people's curiosity and creative confidence in their ability to change and improve the environment around them. Design thinking does not focus on the problem, but on finding creative solutions, the selection of which is determined by the people for whom the solution is intended. Empathy and putting the person with their experiences at the centre are hallmarks of design thinking. Tim Brown defines design thinking as "a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity" (Brown 2008).

In the context of developing students' career skills, design thinking appears to be a compatible and valuable approach and can be successfully applied to achieve this goal.

Design thinking is a process-oriented approach to problem solving that emphasizes creativity and innovation as key elements in the search for solutions and emphasizes continuous improvement and refinement of those solutions. This is user-centred thinking, requiring collaboration and teamwork. Therefore, using design thinking techniques, students learn to approach problems systematically, work in teams, communicate effectively, share ideas, and use their strengths to achieve a common goal. They understand the perspective of the end users and build empathy and empathy as key focuses in problem solving. By considering the needs of end users, students find effective solutions to real-world problems. Thinking outside the box, they generate out-of-the-box ideas, develop innovative products and articles. And applying an iterative approach enables them to test and refine their ideas and concepts based on feedback and data, leading to more effective and efficient solutions. More inspiration and insights on the use of different techniques and approaches for applying design thinking in different domains can be drawn from, for example, (Lewrick, M. et al., 2018) A methodological framework on

implementing design thinking principles in the context of Experimental Robotics classes is elaborated in (Tramonti, 2023).

Training through competitions has specific features that distinguish it from classical organisational forms of training and is an effective way to develop skills in various areas, including career skills.

In competitions, participants are usually grouped into groups, teams or squads. As a result, collaboration and teamwork skills are built, which is especially valuable in fields where cooperation is an essential component of success. Team members usually have different backgrounds, interests and experiences. This contributes to generating diverse ideas, considering different perspectives and creating innovative solutions, and to the participants themselves broadening their views, perceptions and understandings. Competitions are highly motivating for participants as they have a clearly defined objective with a specific end result and a competitive nature, which is a prerequisite for greater interest and engagement and can lead to more effective learning. Competitions offer students the opportunity to apply their skills in real-life scenarios. This practical experience enables them to better understand the practical applications of the skills they are developing. Competitions are often structured with time constraints, which can help participants develop time management skills and learn to work effectively under pressure. Competitions include feedback and evaluation from a panel of judges and referees. In this way, participants discover areas for improvement and hone their skills through constructive criticism. In the context of career development, competitions provide valuable networking opportunities where participants build relationships with other professionals in the same field and contacts and future career opportunities are created.

A suitable form of organisation that has the characteristics of a competition, and is compatible with the "design thinking" method is the hackathon. The term was coined in 1999 when the first event was held with 10 participants (Wood, 2013, OpenBSD, n.d.). Although hackathon traditionally comes from the software sector, but today it is a term that is associated with problem solving in general, not limited to software programming (Cornelissen, 2020). Hackathons are events aimed at finding creative solutions to problems that are not possible in everyday office life. A hallmark of a hackathon is that the solution is found in a short period of time, e.g. 24 or 48 hours, teams often work unconventionally and without long breaks. At the end of the hackathon there is a completed prototype. The hackathon starts with one or more problems and usually follows a specific theme. There is also an option where participants are given the freedom to choose the problem they want to solve. First suggestions and ideas can be shared before participants start working in groups on the problem. Classically, groups include about five people, who are ideally interdisciplinary. The working phase of the hackathon itself can last from a few hours to several days. The final part is a presentation of the resulting final product to each group. In some hackathons, winners are selected and prizes are awarded. In the context of career skills, hackathons provide opportunities to meet new people, make useful contacts, and meet potential employers. Some best practices in running them are provided in (Accept Mission, n.d.; Hackathon, 2021).

Relative to an educational setting, hackathon and design thinking have multiple intersections that directly correspond to building career skills in learners. Design thinking hackathons require students to solve complex problems in a short period of time by using innovative approaches, analyzing information, developing creative ideas, and testing and refining their solutions in real time based on feedback and data. The problems posed are often related to real-world scenarios and the solution finding is user-centric. Working on real-world problems gives students real insight into how to work in a professional environment. Asking problems that require design thinking and searching for solutions in a hackathon setting puts students in situations that are analogous and close to real-world situations. The time pressure, while stressful, forms in them the skills to concentrate as much as possible and sort out the essential from the unimportant details. Design thinking hackathons require students to think outside the box, generate innovative ideas and explore alternative solutions. As a result, they develop their creativity, which is a key competency and a prerequisite for professional advancement. Hackathon and design thinking are based on teamwork, which involves effective communication, sharing ideas, understanding others' perspectives, and using their personal abilities and knowledge to achieve a common goal. In this way, students form collaborative and teamwork skills that are essential for fields in which effective teamwork is critical to success. Design Thinking Hackathons require students to present their ideas to a panel of judges and audiences, thereby developing the communication and presentation skills necessary for their future success in multiple professional fields.

The possibility of developing students' career skills through design thinking is explored in a two-day hackathon with 2nd, 3rd and 4th year students studying Computer Science. The hackathon took place at the end of the PARAMETRIC AND GENERATIVE DESIGN course. The students had to develop a high-tech cyber-physical product. The students were divided into teams of four members. The teams were formed by testing with Belbin's questionnaire (Belbin, n.d.). At the start of the hackathon, the students were briefed on the regulations and conditions of the hackathon and were provided with talking points, keywords and an algorithm to follow in the form of the following guidelines. The jury was composed of IT professionals with experience in startups and in judging hackathons, so the experience was completely authentic.

Directions

HACKATHON ON PARAMETRIC AND GENERATIVE DESIGN. SOFTWARE PACKAGES FOR 3D MODELLING OF CYBER-PHYSICAL SYSTEMS

25.03.2023г.

Topic /Problem to be solved/ : To develop a conceptual design of a high-tech cyber-physical product.

Note 1 : A cyber-physical system is generally such a system that includes a mechanical part, a software part, sensors, actuator units and communication channels.

Areas:

Topics and areas in which your project can be:

- Ecology and microclimate

- Urbanisation and urban environment
- Sustainability, green technologies and renewables
- Conservation of natural resources and climate
- Transport, mobility, logistics
- Health, sport and medicine
- Interactive systems with AR, VR, ML , AI ...
- Environment and water conservation
- Pollution
- Poverty
- Behaviour modelling systems and new skills development
- Systems and platforms for innovative and interactive education and pedagogical systems
- Agri-culture and livestock production

Key methods and approaches to project development:

- Design thinking

Requirements and reference points

- Regarding the project:

- Problem globality
- Scope of application - problems and challenges
- Target group
- Steps to generate the innovative ideas
- Analysis of current solutions - benchmarking and competition /in deep tech, high tech and innovation areas/
- Product - concept and future steps for upgrade/ upgrade/

- In terms of product:

- Product purpose
- Product innovation
- Components building the product/ actuators, sensors, network devices, etc./
- Operating principle of the product
- Ways of handling the product and its components / ergonomics, maintainability of the product, serviceability, safety, serviceability /
- Materials, composition and colour of the product
- Artistic and aesthetic shaping
- Communication design elements carrying information
- Psychophysiological indicators
- Social impact of the product

- Parameters of the product in the context of the age and socio-cultural characteristics of the potential users / children, adolescents, adults, people with physical problems and deficiencies; parents, company employees, etc./

- Norms, standards and certificates related to the product
- Legal protection of the product
- Market niche

- In terms of presentation:

The project presentation should contain:

- 3D modelled physical part of the product / cyber-physical device/.
- Basic simulation in Thinkercad of the main components of the product with the accompanying software.
- Description of algorithms, flowcharts and how to interact with the product.
- Product interface concept in Figma platform
- Start-up business model based on business canvas

Evaluation criteria:

- Independent finding and processing of information
- Generation of non-standard ideas
- Proposing original solutions
- Breaking out of the usual linear way of thinking
- Examining the problem from different perspectives
- Identifying areas where improvements can be made in the context of users
- Understanding user needs and preferences
- Create products that prioritise user needs and preferences
- Drawing conclusions and inferences
- Analysis and synthesis skills

The study of the students' career skills was carried out by means of an assessment questionnaire, which included 23 questions relating to the following career skills: teamwork and collaboration, problem solving, creativity, empathy and organisation /work organisation and time management/. The questionnaire is attached in Appendix 1 of the article. The survey was conducted twice - at the beginning and after the hackathon.

The results obtained from the survey of students with the career skills assessment questionnaire are summarized in Table 1 and presented graphically in Figure 1 and Figure 2.

Table No. 1: Survey of career skills of students

Career skills	Follow-up survey			Baseline survey		
	Low Level, %	Medium Level, %	High Level, %	Low Level, %	Medium Level, %	High Level, %
	27	40	33	8	45	47
Teamwork and cooperation	42	35	23	22	40	38
Problem solving	60	35	15	22	43	35
Creativity	51	37	12	25	46	29
Organization	44	42	14	21	48	31

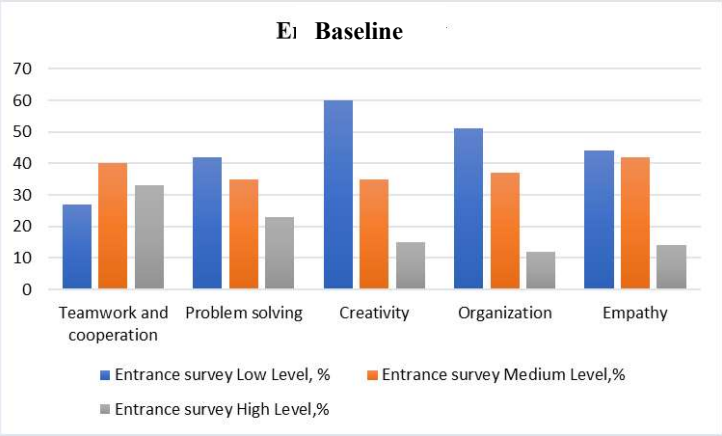

Fig. №1: Results of the entrance survey

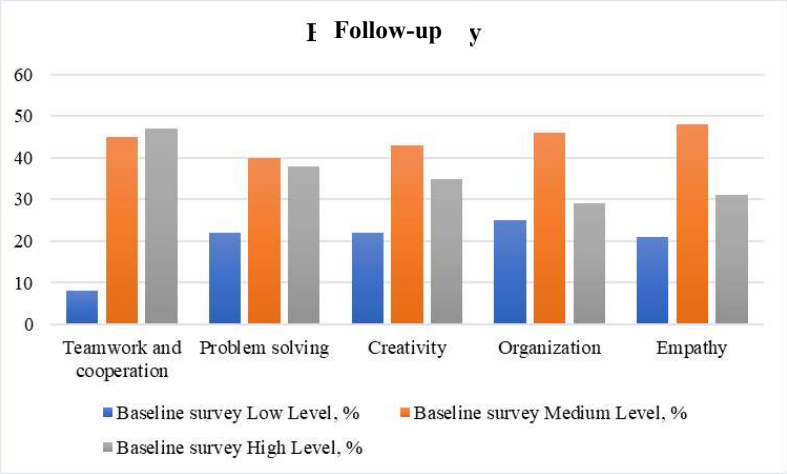

Fig. №2: Results of the baseline survey

The results of the entrance survey show that in terms of problem solving, teamwork and collaboration skills, the highest percentage of students with an average level of manifestation. In terms of creative thinking skills, organization and empathy, students with a high level of manifestation were significantly less than those with a medium and low level of manifestation. The largest difference in the percentage of students with high and low level of manifestation was in the skill of creative thinking.

From the results obtained with the baseline survey, it was found that after the design thinking hackathon, the percentage of students with high and medium level of manifestation increased in all the skills studied - teamwork and collaboration, problem solving, creativity, empathy, and organization. The greatest positive change was in the skills of creative thinking, organization, and empathy. The highest percentage of students with high levels of manifestation was in teamwork and collaboration skills.

The results thus suggest that design thinking hackathons contribute to students' formation of career skills and the

acquisition of experiences that will be useful to them in a wide range of personal and professional contexts.

After the completion of the hackathon, an exit survey of the participants was conducted in order to explore their opinion on the training and to obtain "feedback" on the following aspects related to the formation of career skills in the process of this training:

- Self-awareness
- Problem solving
- Career guidance - career field, organisation and nature of work

The exit questionnaire is attached in Appendix 2 of the paper.

The results obtained from the students' exit survey are summarized in Table №2.

№	Exit survey response	answer	
		yes	no
1.	Was the hackathon an enjoyable experience for you?	97%	3%
2.	Would you participate in such a hackathon again?	95%	5%
3.	Did the hackathon give you new starting points when looking for solutions?	92%	8%
4.	Did the hackathon change your interests in any way?	73%	27%
5.	Did the hackathon influence the way you think about finding solutions?	94%	6%
6.	Did the hackathon increase your problem solving skills?	92%	8%
7.	Would you like similar hackathons to be held in other subjects?	95%	5%
8.	Did the hackathon influence your idea of what you would like to do professionally	75%	25%
9.	Did the hackathon require a high level of attention, commitment and concentration from you?	98%	2%
10.	Has learning about the design thinking method changed your approach to problem solving in the future?	95%	5%
11.	Will it be easier for you to find solutions to a problem in the future?	92%	8%
12.	Did you discover any new aspects when looking for solutions to a problem?	95%	5%
13.	Did you feel satisfied with your participation in the project?	95%	%
14.	Were you surprised at yourself for successfully completing the project tasks?	89%	11%
15	Did the project work bring you pleasant emotions?	97%	3%
16.	Would you choose a profession related to the same field as the project you developed?	81%	19%
17.	Would you choose a profession with a similar nature of work?	89%	11%
18.	Would you be comfortable with your future profession having a similar work format	88%	12%
19.	Did the hackathon increase your self-confidence	80%	20%
20.	Would you engage in activities requiring similar work dynamics?	86%	14%
21.	Did the hackathon change your self-image in any way?	78%	22%

Figure 3 shows the results of the questions related to the students' opinion on the training /question 1, question 2, question 7, question 9, question 15/.

The results show that the training conducted through design thinking hackathon is highly approved by the students. Over 95% of them rated the conducted hackathon as an enjoyable experience which increased their engagement, interest, attention and concentration. They indicated that they would like to organize other courses and would participate again.

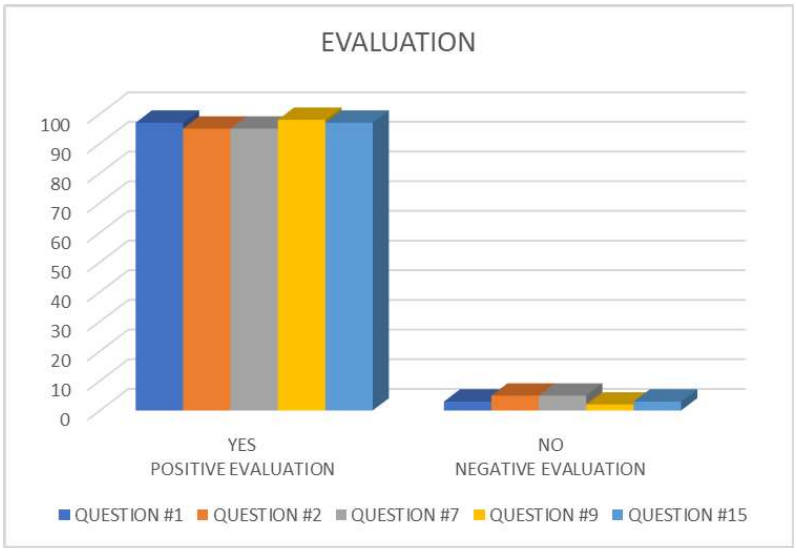

Figure №3 Exit survey - evaluation of the training

Figure 4 presents the responses to the questions related to the students' self-assessment of their problem-solving skills during the hackathon /question 3, question 5, question 6, question 10, question 11, question 12/.

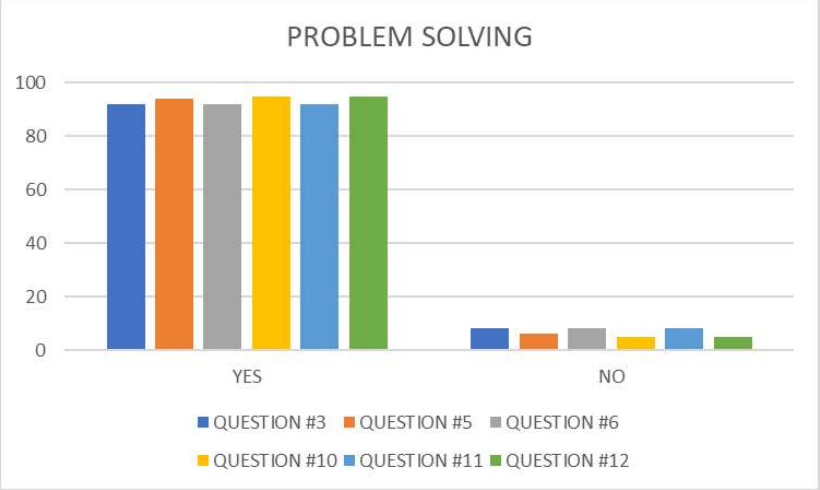

Figure 4: Output survey - problem solving

Between 92% and 95% of the students indicated that the design thinking hackathon helped them to discover new aspects and gave them new starting points in their search for solutions, changed their way of thinking and their approach to problem solving, thus contributing to the enhancement of these skills.

The exit survey also explored the possibility of using a design thinking hackathon to increase students' self-awareness as an important aspect of career skills. Figure 5 presents the results of this study.

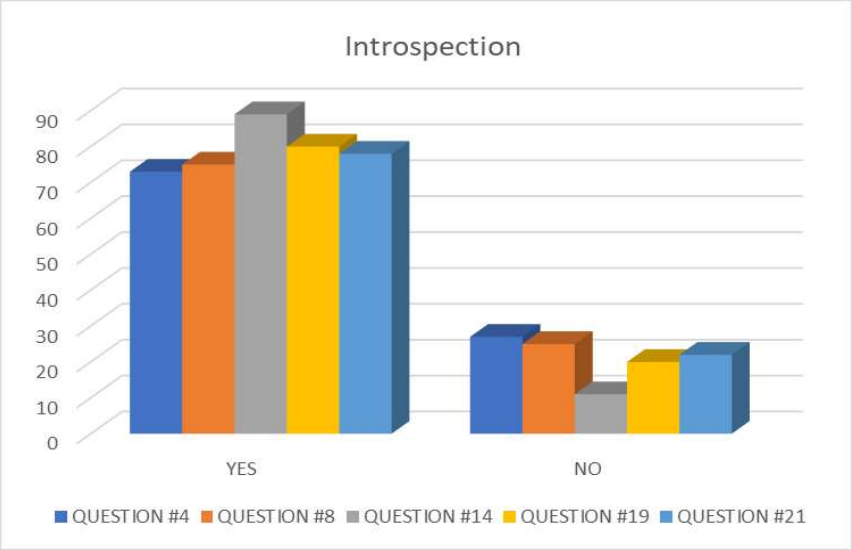

Figure 5: Output questionnaire - self-knowledge /Introspection/

Over 80% of the students indicated that as a result of their project work during the hackathon, they had increased their self-confidence, discovered new interests, and changed their perception of themselves and what they would like to do. This gives reason to believe that training through design thinking hackathons contributes to increasing the level of self-knowledge of students.

The design thinking hackathon in many aspects resembles the real working environment in a number of professional fields. Therefore, the exit survey includes questions to explore students' opinions about such a work organization/question #13, question #16, question #17, question #18, question #20/. The responses to these questions are presented in Figure 6.

Between 86% and 89% of students indicated that they liked this type of dynamic and nature and would like their future work to have a similar format. 95% of the students stated that they felt satisfaction from participating in the hackathon and working on the project.

The results obtained give reason to believe that the hackathon was useful in terms of the nature, dynamics and organization of work and helps in the career guidance of students. By linking the training with such a format,

which is close to the modern real working atmosphere, they successfully developed their career skills.

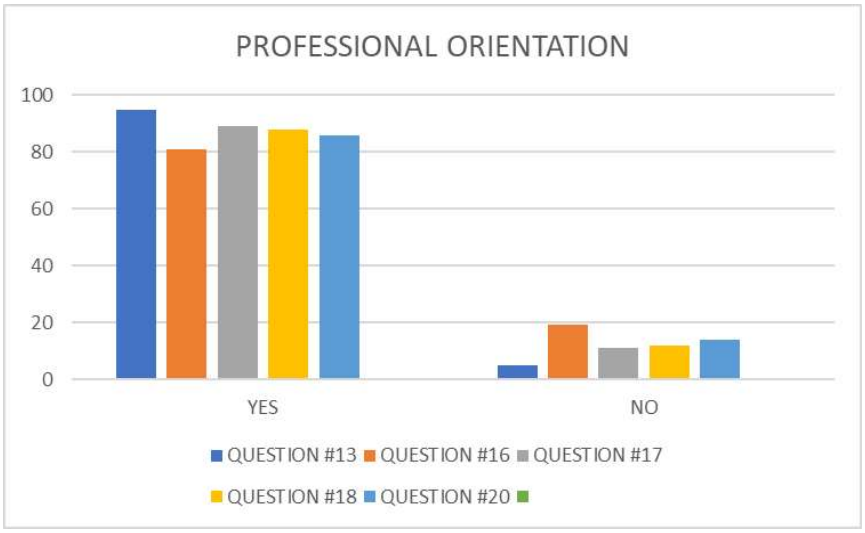

Figure №6 exit survey - career guidance

Conclusion

In the process of conducting design thinking hackathons, students generate multiple ideas and explore a wide range of possibilities; think systematically; evaluate and analyze proposed solutions to determine which ones are most feasible and effective; design products that are oriented to the needs and preferences of potential users and thus build empathy and empathy; reflect on their progress and their own mindset; avoid conflict and manage their emotions; maintain engagement and motivation regardless of emergent Therefore, design thinking hackathons appear to be an effective way to develop valuable career skills and experiences in students that will contribute to their future professional development.

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Appendix 1. SURVEY

To assess career skills

Instructions: The proposed questionnaire contains statements, each of which has five possible response levels - never, rarely, sometimes, often and always. Choose the one that you feel applies most to you. There is no right or wrong answer, so be as honest as possible.

1. I am always on time and rarely miss deadlines
2. When I make a decision, other people's feelings about it don't concern me.
3. When I start to do something, I try to finish it without distraction
4. I can be counted on when there is work to be done
5. I step back to see the big picture before I try to analyze a problem
6. I think creatively and offer solutions that others have not thought of
7. When more people think about an issue better solutions are found
8. I understand how my role fits into a larger team
9. I prefer to work on a task by myself rather than explaining to others what needs to be done
10. When there is a common task to solve, I can work with anyone as long as they are helpful.
11. When solving a problem, I freely exchange information with others
12. I feel the need to learn about new and unfamiliar things
13. If a particular job is unfamiliar to me, but I enjoy it, I desire to learn everything about it in order to achieve excellence
14. I think that implementing my ideas can lead to progress in a particular field
15. When searching for solutions to a problem, I point out the logic of my point of view and its advantages
16. I prefer to leave the responsibility for solving a problem to others
17. People who surround me strongly influence my mood.
18. I take my friends' problems to heart.
19. I regularly write to-do lists and check off those that are completed
20. I get very excited if I need to tell people unpleasant news.
21. I can communicate positively in difficult or challenging situations
22. I get upset at the sight of a suffering animal.
23. The helplessness of old people depresses me.

Appendix 2. EXIT SURVEY

The proposed survey explores psychological aspects of learning through hackathons for design thinking. The questionnaire contains 21 questions to be answered with YES or NO. Choose the answer that most applies to you.

1. Was the hackathon an enjoyable experience for you?
2. Would you participate in a similar hackathon again?
3. Did the hackathon give you new starting points when looking for solutions?
4. Did the hackathon change your interests in any way?
5. Did the hackathon influence the way you think about finding solutions?
6. Did the hackathon increase your problem solving skills?
7. Would you like to see similar hackathons conducted in other academic disciplines?
8. Did the hackathon influence your idea of what you would like to do professionally?
9. Did the hackathon you conducted require a high level of attention, commitment and concentration?
10. Did learning about the design thinking method change your approach to problem solving in the future?
11. Will it be easier for you to find solutions to a problem in the future?
12. Did you discover new aspects when searching for solutions to a problem that arose?
13. Did you feel satisfied by participating in the project?
14. Were you surprised at yourself for successfully completing the project tasks?
15 Did the project work bring you pleasant emotions?
16. Would you choose a profession related to the same field as the project you developed?
17. Would you choose a profession with a similar nature of work?
18. Would you be comfortable with your future profession having a similar format of work?
19. Did the hackathon increase your self-confidence?
20. Would you engage in activities requiring similar work dynamics?
21. Did the hackathon change your self-image in any way?