Problems and prospects of the development of creative design thinking of higher education students in the conditions of digitalization

Problemas y perspectivas del desarrollo del pensamiento de diseño creativo de los estudiantes de educación superior en las condiciones de la digitalización

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Abstract

The modern development of education is focused on acquiring special work skills: quick adaptation to working conditions, ability to work in a team, thorough knowledge of digital technologies, which are combined in the design thinking. The purpose of the article is to analyze the problems and prospects of creative design thinking of higher education students in the conditions of digitalization. The work is written on the basis of the use of general scientific cognitive research methods and special pedagogical methods: analysis, synthesis, induction, deduction, generalization, specification, abstraction, observation. The results of the study analyzed the importance of digitization of education and design thinking, the history of the concept of "design thinking" and the peculiarities of its use, problems of using digital education in design thinking. The conclusions summarize that the correct use of this technique can not only create a creative learning atmosphere but also affect its effectiveness in general. In order for the design thinking technology to be as effective as possible, we offer our own recommendations for its use: systematic identification of empathy by teachers for students, critical analysis of the application of this technique, its constant improvement, experimentation with various tasks.

Keywords: design thinking, digitalization, problems, perspectives, creativity.

Resumen

El desarrollo moderno de la educación se enfoca en adquirir habilidades especiales de trabajo: rápida adaptación a las condiciones de trabajo, habilidad para trabajar en equipo, conocimiento profundo de las tecnologías digitales, que se combinan en el pensamiento de diseño. El propósito del artículo es analizar los problemas y las perspectivas del pensamiento de diseño creativo de los estudiantes de educación superior en las condiciones de la digitalización. El trabajo está escrito sobre la base del uso de métodos generales de investigación cognitiva científica y métodos pedagógicos especiales: análisis, síntesis, inducción, deducción, generalización, especificación, abstracción, observación. Los resultados del estudio analizaron la importancia de la digitalización de la educación y el pensamiento de diseño, la historia del concepto de "pensamiento de diseño" y las peculiaridades de su uso, los problemas del uso de la educación digital en el pensamiento de diseño. Las conclusiones resumen que el uso correcto de esta técnica no solo puede crear un ambiente de aprendizaje creativo sino también afectar su efectividad en general. Para que la tecnología del pensamiento de diseño sea lo más efectiva posible, ofrecemos nuestras propias recomendaciones para su uso: identificación sistemática de la empatía por parte de los maestros hacia los estudiantes, análisis crítico de la aplicación de esta técnica, su mejora constante, experimentación con varias tareas.

Palabras clave: pensamiento de diseño, digitalización, problemas, perspectivas, creatividad.

1. Introduction

Today's information society dictates additional requirements for higher education applicants, especially valued by today's employers. In particular, it is important to develop creativity, the ability to adapt quickly to the work environment, teamwork, and a thorough mastery of modern digital products. Researchers, in particular, have found that ideally all these and many other skills develop design thinking. This method of work is fairly new, so the relevance of its research is extremely promising. Although in textbooks it is often associated exclusively with the art of design, in fact, design thinking has only a consonant name, and the horizons of its use are very wide. At the same time, the COVID-19 pandemic has opened up another side of getting education: distance education based on the use of digital technology and multimedia competence. The combination of all these components will allow to reconsider certain aspects of education and practical training of future specialists, to determine the positive and negative sides of the use of creativity in the conditions of digitalization. Therefore, the purpose of the article is to investigate the problems and prospects of creative design thinking of higher education applicants in the conditions of digitalization. Let us note that from this point of view the proposed problematic has hardly been investigated because specialists have mainly concentrated around individual problems of studying the benefits of design thinking. At the same time, a detailed consideration of this issue would shed a little lighter on the specifics of the functioning of human creativity, and imagination and the ways in which they are combined through design thinking and digital technology.

2. Literature Review

The article draws on the work of contemporary educators. Significant attention is paid to general pedagogical works. In particular, Malik & Ubaidillah (2020) investigated the peculiarities of the development of the modern learning system and analyzed innovative methods of teaching based on the use of digital technology. Cherng & Davis, 2019 highlighted the role of multiculturalism in modern educational processes. At the same time, the authors also characterized the main problems of the development of modern education. Despite this, there are few separate works devoted to the analysis of the formation of creative design thinking. For this reason, the works of American and British researchers dealing with the problems of defining the technology of design thinking both in education and in business seem weighty. In particular, Cezzar (2020) characterized the importance of design in various spheres of human activity: economics, management, education, art, etc. At the same time, the author focused on the study of graphic design. Dam & Siang (2022) investigated the specifics of using design thinking in education. They note that the effectiveness of this technique lies in its step-by-step application. Dam & Siang, 2022 also explain the popularity of using design thinking techniques in their work. Temple, 2018 characterized the methodological foundations of design thinking and described the main advantages of this competence in today's world. However, the main disadvantage of this monograph is that the author focused on highlighting the peculiarities of design thinking formation among design students (primarily graphic design). This limits the possibility to comprehend the meaning of design thinking technology for other (non-

artistic) majors. At the same time, Pande & Bharathi (2020) characterized the theoretical foundations of design thinking. However, these scholars focused on analyzing the role of this competency for professionals in the business field. Consequently, it is evident from the literature that professionals focused on the narrow use of design thinking technology. Instead of wide attention requires the problem of cooperation of different spheres of this technique, however also through a prism of development of modern educational digital technologies.

3. Methodology

This work is formed on the basis of using general scientific cognitive research methods: analysis, synthesis, induction, deduction. On the basis of the analysis, it was possible to divide the subject of the research (technology of creative design thinking) into parts (terminological explanation of the concept of "design thinking", features of the use of this technology, problems, and prospects of its implementation (coverage in the discussion)). the selected parts into a single whole, which helps to create clear conclusions on the issue under study, based on induction it was possible to highlight the main practical stages of design thinking, and the article is built based on deduction application. research The article also used By means of the historical method of research it was possible to trace the peculiarities of the use of the concept of "design thinking" through a historical prism. The paper notes that the first such definition appeared in a monograph of the same name by American Harvard University professor Peter Rowe in 1987. Some attention in the study is focused on empirical methods. For example, the main problems and perspectives of design thinking implementation as an innovative technology influencing creativity formation are highlighted with the help of the predictive research method.

4. Results and Discussion

Digitalization of education and design thinking

The challenges of today's information society are dictating new work rules. In particular, a number of advantages that employers are beginning to look for in higher education applicants are becoming important. Among these advantages that are being prioritized is media competence, which is very important for today's digitalized technology work. The foundations of this process should be laid while still in school - universities or colleges are already talking about more thorough development (Cherng & Davis, 2019). The process of digitalization of education contributes to the emergence of various methods that aim to improve the learning system. For this reason, today's innovative ways of education seek to: 1. to personalize the learning system by introducing personal, educational trajectories. 2. Promote the active use of both group and individual forms of learning. 3. Promote the strengthening of students' motivation. 4. To develop stable monitoring of education and the dynamics of learning growth in students. 5. To promote the involvement of students in different types of learning: full-time, distance, mixed. 6. accelerate the process of forming the necessary skills within the profession obtained, which is achieved through the

digitalization of the learning and educational process and automation of certain stages. 7. Facilitate the organization of a unique opportunity to work with objects (digitally) that in real life pose a threat to the life and health of students. 8. Increase interest in the student's chosen professional activity. 9. create new and expand existing opportunities for inclusion. 10. Promote the immediacy of direct and feedback between the instructor and the student. 11. Shape and support the project-based nature of teaching and learning activities, integrated practical-theoretical learning. 12. To promote promptness, the appearance of dynamic, objective assessment of the results of students' mastering the basic disciplines. 13. Tracking of educational based on means of cumulative assessment (it is said about the rating system of portfolios, etc.). 14. increasing the territorial range of accessibility of educational programs. This will allow to involve in the educational process the students living in the regions affected by the war. 15. openness and transparency of the education system both for its participants and for outside interested persons and organizations. The above problems can be solved by digitalization and its methods.

The COVID-19 pandemic demonstrated that educating students in a viral pandemic is possible with pre-prepared telecommunication and personnel infrastructure and security measures. For this reason, higher educational institutions in Ukraine have completely switched to a distance learning format since 2020. In the current situation, the electronic information educational environment plays a significant role in the organization of the educational process. At the same time, both students and teachers experience many difficulties when using digital university environments. As a result, the optimization of the electronic information environment becomes an urgent problem for many universities. Despite this, there are now many tools that are used to optimize distance education systems.

At the same time, the process of distance education system optimization is impossible without the use of design thinking methods. It is the latter that can solve the above-mentioned educational needs to the fullest extent. We believe that design-thought technology allows building this optimization process most organically and efficiently and achieving its main goal. We are talking about the comfortable and effective use of electronic information environment in universities by both students and teachers (Temple, 2018). In addition, based on conducting optimization with the help of design thinking methods, resource costs can be significantly reduced.

What is design thinking?

There is no generally accepted definition for design thinking - this method is quite new, so there are still disputes between supporters and practitioners regarding its exact definition. Due to the fact that this concept is interdisciplinary modern authors explain it in different ways. This definition first appeared in a monograph of the same name by the American Harvard University professor Peter Rowe in 1987. At the same time, upon a detailed reading of the content of this book, it becomes clear that the concept under study is used primarily in architectural design, which does not correspond to its modern understanding, which is used.

Therefore, the modern understanding of design thinking is more appropriately associated with use in the consulting business, particularly in the private firm IDEO. The firm's strategy is a good example of the transformation and use of design thinking - it was a journey from product development to the expansion of product use services, improvement strategies, and even the development of training or social programs related to its promotion (Dam & Siang, 2022). Unfortunately, proponents and early practitioners of design thinking in business did not record a clear definition, often referring solely to the experiences of designers, their experiences with principles, tools, approaches, and methods (Amatullo et al., 2021). Definitions of the type of use of multidisciplinary problem-solving design methods to overcome the innovative challenges of our time have also been proposed.

We believe that among business representatives, a detailed definition was offered by Thomas Lockwood, former president of the Design Management Institute. He, as a representative of an association of design practitioners associated with business structures, argued: design thinking is a human-centered innovation process that emphasizes observation, collaboration, rapid learning, visualization of ideas, rapid prototyping of concepts, and simultaneous business analysis (Larraz-Rábanos, 2021). There are strong objections to the nomenclature of design thinking, particularly the inclusion of the word "thinking". However, many researchers still argue about the importance of using the word "thinking". It can be misleading because the very process of design thinking involves not only a reflection but also direct action, which means that it is not worth limiting oneself to a mere definition. However, no alternative has been proposed, so "design thinking" remains an acceptable term to describe this phenomenon.

At the same time, Goldschmidt believes that design thinking is an approach to solving complex problems that is not related to a person's natural endowment (Goldschmidt, 2021). The researcher explains that it is this characteristic that distinguishes design thinking from art. Researchers at Stanford University School interpret the concept in this way as a special method of thinking that focuses primarily on human development. (Stanford d.school, 2018). Researchers at the Hasso Plattner Institute compare design thinking to an approach that influences innovative problem-solving. T. Brown describes design thinking as a discipline that, using design approaches and methods, integrates people's needs with technological capabilities and viable business strategies, turning them into customer value. Based on the analyzed terminological discussion, let us propose the actual definition of design thinking - an educational methodology designed to develop creative skills, in which anthropology is central. Despite this, the main essence of design thinking methodology lies in its human-centeredness, i.e., its focus on human beings. At the same time, design thinking includes many methods and tools, the choice of which largely depends on the goals and scope of research.

How to use design thinking technology?

Design thinking focuses on the use of basic design principles that influence the emergence of innovative new or additional products (services) (Goldschmidt, 2021). However, the key criteria for applying design thinking in education are the principles of human-centeredness, experimentation, collaboration, and complicity. The process of creative formation consists of several periods. The first stage is empathy: here takes place the definition of the main idea of the designed product. Students have to check everything that relates to the solution of the design problem. They are engaged in the analysis of available information, for this they collect all the necessary data. At this stage, it is possible to use other pedagogical innovative teaching methods: questioning, brainstorming, designing, interview method. The main criteria for the use of the brainstorming technique is a specific formulation of the question about the form, intensity of the team. The current literature proves that the use of the brainstorming technique results in students developing skills to solve typical problems in atypical creative ways (Larraz-Rábanos, 2021). Focusing is the second stage of design thinking formation, in which there is a distillation of the information obtained. The main questions that the student must decide at this stage are what exactly he or she is researching, what problem needs to be solved, etc. At this stage it is allowed to change the initial concepts, to eliminate various problems, and contradictions, to clarify details. This stage is replaced by a period of idea generation. The main mechanisms of design thinking development at this stage are brainstorming, storytelling (composing and narrating various kinds of stories), mental maps, etc. The key goal of the idea generation stage is to compose the most possible ways of solving a problem. The next stage is prototyping - the formation of a minimally viable product (or service). Here, a preliminary product (or service) is created with such qualities, which could satisfy the first possible customers. It should be noted that the use of this technique, above all, affects the economy of time. At the same stage, the first (positive or negative) feedback on the product (service) being created occurs. Note that the key characteristics of the project evaluation are its originality, functionality, uniqueness, etc. Meanwhile, technological and aesthetic factors are also important (Dam & Siang, 2022). The testing phase is the final stage for any project created. At this stage, it is important to involve the final consumers to evaluate the created product. At the same time, the re-evaluation of the corrected version can also take place here (Larraz-Rábanos, 2021).

Currently, the technology of design thinking is actively used in education as well as in business. Consequently, individuals with creative design thinking are now particularly valuable in the job market. For this reason, today's companies are competing to attract them (Schallmo, 2017). Note that mastery of this technique affects the development of both personal creativity and creative corporate culture. The latter promotes team unity around a complex problem.

Design Thinking in Digital Education: Problems of Use

Modern experts prove that design thinking can improve the learning process, make it more active and interesting for higher education applicants. The focus of standard educational methods is on content transfer. At the same time, design thinking makes learning a creative process by developing students' critical thinking and challenging them to think creatively (Dam & Siang, 2022). Teaching based on design thinking builds students' critical thinking skills, creativity. Students, when solving complex and atypical problems, tend to be curious, enthusiastic, creative, and inventive. In the design thinking technique, the main participant of the learning process becomes a human being.

The teaching and application of design thinking by education applicants faces certain difficulties. In particular, an important problem is finding and identifying truly new ideas that will be of value to potential consumers in the long run. Based on a review of the scientific literature, we can summarize that:

1. The people on whom decisions depend on have problems with proposals for innovation. For example, the heads of business structures are conservative, it is very difficult to convince them.
2. Users, who are familiar with the new product, find it difficult to characterize its benefits because there is nothing to compare the innovation with adequately.
3. It is difficult for decision-makers to foresee the benefits of the product for users.

In fact, each of the proposed problems at its core experiences only one thing - difficulty in forming new ideas. This process is well known to psychologists who study the imagination. First of all, outside the imagination, very often there are features or consequences of our imagined actions, although they can be extremely tangible (Malik & Ubaidillah, 2020). Also, human imagination tends to project contemporaneity into the future, that is, to really consider our actions, provided that the environment remains constant. The development of the environment is usually much more difficult to calculate because we are able to respond and predict first and foremost our own actions. Also, a certain clear image is formed in the imagination - the result of actions (Lewrick, et al., 2019). At the same time, one is almost incapable of recognizing that real things may look different when imagined actions are put into practice. For this reason, there is a danger of projecting the present into the future, even though many variations of events are likely. People tend to overestimate the degree to which their future event experience will be similar to their current event experience.

The use of digital technology, we believe, will partially solve these problems. The modern development of technology is an important component of the educational process. So, properly using the possibilities of information retrieval, it becomes possible to overcome potential conservatism. We believe that the mastery of media competence already at the educational level will lead to the possibility of proper presentation of the results of the work. That is, it becomes easier to make sure that the project is really relevant.

Also, the digitalization of the educational process makes it possible to take into account the wishes of more users. The informality of the setting will lead to the expression of a truthful impression, and the use of the possibilities of the Internet for comparison will be the key to the expression of advantages. So, the use of digital technology greatly facilitates the work with the audience. In addition, the development of a software product also shapes the imagination, allows you to quickly model possible solutions, and qualitatively work with the design.

Design thinking and creativity of students, in general, will form faster when using digitalization of learning. The development of media competence and exposure to the latest software developments should be an important aspect in today's pedagogy.
To make the technology of design thinking as effective as possible, we offer our own recommendations for its use based on practical work with students:

1. Systematic discovery of empathy with students.

We believe that empathy promotes understanding and acceptance of the needs and interests of each participant in the educational process. In addition, teachers, using empathy, can tailor the educational program to the capabilities of each student. When an instructor is empathic, he or she will be closer to the students. How can the modern instructor improve this skill? You should communicate more with students, find out what they are interested in, what their interests are, observe their reactions and behavior. We believe that this skill will not only improve the teacher's communication with students but will also affect the effectiveness of learning.

2. Critical analysis of our own pedagogical methods.

The point is that the modern teacher should question current ways of teaching. In addition, educators should critically analyze the teaching methods they predominantly use. This will make it possible to realize which methods are effective and which are not. For example, the educator should practically trace the effectiveness of using design thinking techniques on different groups of students. We also recommend the teacher to experiment with teaching methods more often, to improve them constantly. This will contribute to the emergence of new unique educational methods.

3. Experiment - as a basic condition for teaching

An important prerequisite for effective creative learning is continuous improvement. Teachers need to test new methods and create opportunities for feedback. Particularly for design thinking technology, this is important. This is how educators learn what students like in lectures and what they need to improve in seminars, etc.

4. Dissemination of experience with the methodology

Educators should share their experiences with other educators and be open to open discussion.

5. Original tasks – is an important condition for the formation of design thinking

For design thinking technology to be as effective as possible, teachers should come up with their own original tasks for students. A prime example is the "social project competition" task. Students should create their own projects to solve a certain problem. These problems can be diverse: global, national, or local. At the same time, the instructor can suggest their own problem for students to solve, or they can let them choose the topic they are most interested in. They can choose projects on a variety of topics: human rights, immigration, war, ecology, violence, climate change, etc.
In addition, teachers can ask students to create their own portfolios in which they present creative solutions to certain topical problems.

Another example of the use of design thinking in the humanities is the application of historical knowledge to solve urgent world problems. For example, students seek a solution to a contemporary migration problem through a study of the history of immigration to the United States. Regardless, they can use a variety of sources in such a study: historical materials, migration acts, contemporary news, blogs, descriptions of political campaigns, music, video debates, song lyrics, etc.

6. Task clarity

The teacher needs not only to come up with original and atypical tasks but also to be able to form them clearly. Tasks should be clear, understandable, and accessible to students.

Future Design Thinking: Your Own Judgments

Design thinking in digital technology is a relevant area of development for those companies that aim to successfully work on creating creative and innovative software. This process allows us to target people's preferences regarding the appearance of technological products. For this reason, the importance of studying design thinking for applicants to higher education in computer science or software engineering is growing considerably. Such development of creative, analytical, and imaginative thinking can better prepare students for the developments and challenges facing today's software development industry.

There are powerful unifying initiatives in business education emerging in the development of a large number of higher education institutions. These range from the direct introduction of design programs into modern business education to the formation of merging ventures that exist between educational institutions and private companies for

practical supplementation. At the same time, an amalgamation of new primary disciplines is taking shape, where both design and management will be taught together. Many modern business education programs for future professionals at universities contain design thinking in their offerings to educate students in business and management-related majors. Many universities have been working in this direction for a long time on their own or through affiliations with specialized programs. Note that such a dynamic industry is constantly undergoing change, as the internal capabilities of educational institutions develop, including merging design and business schools, and alliances are formed within or between different schools of higher education. This leads to "creative" experiments with curricula, and many disciplines and programs have been adapted and are undergoing change due to the increased attention to design thinking on the part of employers.

5. Conclusions

So, design thinking is an important technique in modern education, training of future specialists. The history of this concept is ambiguous because of the "young age" of design thinking its meanings and definitions researchers still have not had time to understand correctly. In particular, the word "thinking" can mislead, because it is connected only with reflection. It can mislead because the process of design-thinking is connected not only with reflection but also with direct action, that is, it is not necessary to be limited only to the definition. However, no alternative has been proposed, so "design thinking" remains an acceptable term to describe this phenomenon.

The application of digital technologies in the educational sphere will partially solve urgent problems. We believe that by properly using the capabilities of information retrieval and digital information and communication technologies, it becomes possible to overcome the potential conservatism of the educational system. Design thinking and creativity of students, in general, will be formed faster when using digitalization of education. The development of media competence and familiarity with the latest software developments should become an important aspect of modern pedagogy. Despite this application by education applicants, design thinking has some problems. For this reason, finding and identifying truly new ideas that will have value, in the long run, is an important challenge. However, the proper use of this technique can not only create a creative learning environment but also affect its overall effectiveness. In order for design thinking technology to be as effective as possible, we offer our own recommendations for its use: teachers' systematic identification of empathy for students, critical analysis of the use of this technique, constant improvement of it, experimentation with different tasks. Despite this, weighty conditions of the formation of design thinking in higher education applicants are originality and clearness of the set tasks.

6. Bibliographic references

Amatullo, M., Boyer, B., May, J., & Shea, A. (2021). Design for social innovation: Case studies from around the world. Routledge.

Cezzar, J. (2020). Teaching the designer of now: A new basis for graphic and communication design education. She Ji: The Journal of Design, Economics, and Innovation, 6(2), 213-227. https://doi.org/10.1016/j.sheji.2020.05.002

Cherng, H.-Y. S., & Davis, L. A. (2019). Multicultural Matters: An Investigation of Key Assumptions of Multicultural Education Reform in Teacher Education. Journal of Teacher Education, 70(3), 219–236. https://doi.org/10.1177/0022487117742884Cherng

Dam, R., & Siang, T. (2022). What is design thinking and why is it so popular? The Interaction Design Foundation. https://www.interaction-design.org/literature/article/what-is-design-thinking-and-why-is-it-so-popular

Goldschmidt, G. (2021). Critical design and design thinking vs. critical design and design thinking. Different Perspectives in Design Thinking, 6-20. https://doi.org/10.1201/9780429289378-2

Larraz-Rábanos, N. (2021). Development of creative thinking skills in the teaching-learning process. Teacher Education - New Perspectives. https://doi.org/10.5772/intechopen.97780

Lewrick, M., Link, P., & Leifer, L. (2019). Das design thinking Toolbook: Die besten Werkzeuge & Methoden. Vahlen.

Malik, A., & Ubaidillah, M. (2020). Students critical-creative thinking skill: A multivariate analysis of experiments and gender. International Journal of Cognitive Research in Science Engineering and Education, 8(Special issue), 49-58. https://doi.org/10.23947/2334-8496-2020-8-si-49-58

Pande, M., & Bharathi, S. V. (2020). Theoretical foundations of design thinking – A constructivism learning approach to design thinking. Thinking Skills and Creativity, 36, 100637. https://doi.org/10.1016/j.tsc.2020.100637

Schallmo, D. R. (2017). Design thinking erfolgreich anwenden: So entwickeln Sie in 7 Phasen kundenorientierte Produkte und Dienstleistungen. Springer-Verlag.

Temple, S. (2018). Developing creative thinking in beginning design. Routledge.

Vaganova, O., Ilyashenko, L., Smirnova, Z., Bystrova, N., & Kaznacheeva, S. (2019). Students' creative abilities development in higher educational institution. Amazonia Investiga, 8(22), 701-710. Retrieved from https://amazoniainvestiga.info/index.php/amazonia/article/view/822