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DESIGN THINKING FOR THE DEVELOPMENT OF CREATIVE ABILITIES OF ELECTRICAL TECHNICIANS IN VOCATIONAL COLLEGES

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Abstract

Relevance: it arises from the necessity to look for new ways and means of professional training of future specialists in the context of the renewal of the educational paradigm and the expansion of society's technological capabilities. The article reveals the urgency of the research topic, analyses existing approaches to the interpretation of the term design thinking. In the course of the scientific research, it was found that in the context of applying effective ways to form the professional competence of electrical technicians, the design thinking technology deserves attention, the use of which is a powerful effective tool for developing innovative thinking of students, what is extremely important in an era of rapid change, innovation and increased mobility in all spheres of life in the modern world.

Aim: to determine the prospects for introducing design thinking technology to develop the creative abilities of future electrical engineers in vocational colleges.

Methods: analysis and synthesis – to determine the stage of problem progress under study and the peculiarities of applying design thinking technology for the improvement of future electrical engineers' creative abilities; generalisation – to formulate conclusions and recommendations for the implementation of design thinking technology for the students' development in vocational colleges; diagnostic (testing, conversation, interview) - to find out the development level of future electrical engineers' design thinking; application of Pearson's $\chi2$ (chi-square) consistency criterion for statistical analysis of the experimental study results.

Results: A system for developing design thinking in future electrical technicians within the framework of the course "Power Supply of Enterprises and Civil Engineering Structures" has been designed to increase the effectiveness of using a modern approach to designing innovative products and developing creative abilities. To develop this system, we identified and analysed the methodological principles that characterise the design thinking process. The highlighted stages of applying the design thinking method in the professional training of future electrical technicians are focused on solving a problem situation and getting out of it, the ability to generate ideas, change and improve their project based on the identified shortcomings, and develop skills in working with digital technologies.

Conclusion: design thinking is a tool that can be used to project the future and find innovative ways to solve complex problems. It is a technology that meets all the challenges of the times, improves the quality of professional training, and contributes to the formation of the professional competence of future electrical engineers in professional pre-higher education institutions.

Keywords: *professional competence; design thinking; new educational technologies; electrical technician; training; professional higher education.*

Introduction. In the current conditions, an important task of the vocational education system is the preparation of competitive specialists characterized by flexibility and mobility in the labor market, capable of making independent decisions, transforming the social environment, and their professional activity. The competency of a specialist is a set of objectives—specific requirements for his level of preparedness. Contrary to classical education, based on the triad of knowledge, skills, and abilities, the competency-based approach assumes that the main emphasis is not just on mastering certain sums of knowledge and skills, but also on forming a systemic set of competencies that enable solving professional problems as well. Herein, the aim of education becomes not the process, but achieving a certain result by the learners.

At the modern stage of vocational education modernization, the concept aimed at organizing the educational process, whose main goal is involving students in active independent cognitive activity that models their further self-education process, is gaining wider recognition (Mykhailov et al., 2023). As a general conceptual basis for improving the organization of educational work in the educational process, competency-based, activity-based, personally oriented, and systemic approaches serve (Gurzhiy et al., 2023).

The economy of Ukraine and its development prospects dictate entirely different requirements for the future specialist. He must not only possess technologies but also have creative abilities, imagination, intuition, flexible and imaginative thinking, be able to quickly navigate changes in external circumstances, and easily adapt to constantly changing conditions. Being creative to become effective.

In this context, the problem of forming the correct emphases in the preparation of future specialists, with the aim of developing not only professional qualities but also creative potential, in the conditions of modernization of contemporary domestic education and the integration of Ukraine into the European educational space, acquires special relevance (Kowalewska & Soltysik, 2017).

The modern specialist should not be a designer, an engineer, or a project manager, but must be able to use the tools and ready-made algorithms of the services they work with for the effective presentation of the results of creative activity (Pryhodii, 2023).

Domestic scientific research in the field of vocational training of future electric technicians and the formation of the main methodological orientations was carried out in the context of: component-structural analysis of the phenomenon "Culture of logical thinking" of future electric technicians (Prodaiko, 2013); determination of the state of formation of motivation for future professional activity among future electric technicians of agriculture (Kostyuk, 2015); study of the role of self-education as an important factor in the preparation of future electric technicians (Bilyk, 2016); formation of economic culture of junior specialist electric technicians in the process of vocational training in college (Gargaun, 2019) and others.

The issues of improving education, its role in the socio-economic life of society and economic development, the formation of human potential have been dedicated to their work by numerous researchers. A significant contribution to the creation and improvement of educational technologies, the development of design thinking was made by Ukrainian and foreign scientists, including: S. Alekseeva (2020), B. Barnett and D. Evans (2019), V. Ivanova (2019), I. Kalenyuk and L. Tsimbal (2011), O. Prosina (2022), V. Tyahur (2023), A. Tkachenko and D. Plynykos (2021), N. Cross (2018), J. Kowalewska and M. Soltysik (2017), J. Liedtka (2013), and T. Ogilvie (2011) among others. The effectiveness of the design thinking technology has been analyzed in many studies, including data on the successful implementation of this methodology in primary and secondary education (Noel & Liu, 2016), as well as its application to meet the needs of students (Holiiad & Tropina, 2022). However, the features and effectiveness of the use of design thinking technology in vocational education have not been actively researched.

The purpose of the study is to identify the perspective of implementing design thinking technology to develop the creative abilities of future electric technicians in vocational colleges.

Research methods. Analysis and synthesis - to determine the state of development of the problem and the peculiarities of applying design thinking technology to develop the creative abilities of future electric technicians; generalization - to formulate conclusions and recommendations on the implementation of design thinking technology for the development of students in vocational colleges; diagnostic (testing, conversation, interview) - to clarify the level of development of design thinking among future electric technicians; application of the $\chi 2$ (chi-square) criterion for statistical analysis of the results of experimental research.

Results and discussion. There are several approaches to interpreting the term design thinking (Design Thinking), which explain and reveal its essence as a way of thinking, an approach, a method, methodology, tool, or process.

The theoretical-methodological analysis of the scientific literature has revealed that the concept of "design thinking" began to be actively used by foreign entrepreneurs and business schools at the end of the 20th and the beginning of the 21st century. They considered it in the process of project activities as a manifestation of a person's ability for intuitive pattern recognition and the generation of creative ideas, on one hand, and as a means of forming original thinking and the overall creative potential of an individual, on the other (Barnett & Evans, 2019, p. 159).

Creative thinking is limited by four main positions. Originality, the non-standard combination of ideas that express a pursuit of novelty. A creative individual is in a constant state of searching for their own, unique solution. Semantic flexibility involves the ability to see objects and subjects from an unusual perspective, which allows for the discovery of their alternative applications and the expansion of functional possibilities that are applied to practical activity. Imaginative adaptive flexibility represents the ability to change perceptions of objects in a way that reveals fresh areas hidden from ordinary observation (Ferrari et al., 2009).

Design thinking is an approach to designing innovative solutions that is human-centered. It is based on tools used by designers and is utilized with the aim of integrating the needs of people, business requirements, and technological possibilities (Kelly & Kelly, 2017, p. 43).

The tools used for design thinking (Liedtka & Ogilvie, 2011) include:

- Visualization (using visual images to represent possibilities and realize them in life);
- Empathy map (evaluating feelings and impressions from the user's point of view);
- Value chain analysis;
- Mind mapping (idea generation based on conducted research);
- Brainstorming (generation of new possibilities);
- Concept development based on the collection of innovative elements;
- Hypothesis testing;
- Rapid prototyping (realizing the concept in a physical form for research, testing, and improvement);
- Co-design with users (involving them in decision-making to meet their needs);
- Pilot testing.

Undoubtedly, design thinking and its approaches have a clear connection with conventional heuristic techniques that help solve problems under uncertainty when tasks are non-standard. An important feature of design thinking, compared to analytical thinking, is not a critical approach but a creative one, which sometimes proposes the most unconventional ideas that lead to effective problem-solving. The basis of design thinking is the ability to produce schematic images in imagination for the subsequent identification of patterns and the generation of ideas with functional and emotional content (Ivanova, 2019).

Design thinking technology is considered an effective means of developing reflection and the ability to think outside the box. Based on this, the following parameters of design thinking technology are highlighted: creative approach, teamwork, focus on people, curiosity, and optimism (Kelly & Kelly, 2017).

These characteristics enable the application of this technology in the practical professional activities of educators in higher vocational education institutions. Thus, design thinking enables understanding how the thought process is organized, to design a new model of thinking, and to learn how to generate ideas, think unconventionally, and creatively.

The main goal that can be achieved by applying design thinking technology is the development of creative abilities, which is so crucial for students of technical specialties. However, for creativity to emerge, the brain must constantly "resist monotony." Game mechanics and cases that allow generating solutions in non-standard situations are the best tools for developing the skills to resist patterns. Then, the number of bright ideas will increase. Creative and inventive people are suitable for any area of new technologies (Calvo-Morata et al., 2016).

Energy is one of the key sectors that determine the viability of a country's economy. Efficient operation of energy supply systems is necessary for the sustenance of the population, the functioning of production, and development. One of the important tasks of the sector is the strategic planning of the energy complex's development and, accordingly, the training of specialists to work in this field. Supporting the energy sector at the necessary level for the state and especially its development is impossible without the continuous training of highly qualified personnel.

The modern information society is a system that enables "mining" knowledge from a vast amount of sources, shaping, and developing the competencies of each user through teamwork based on the development of intellect, critical, and creative thinking. An effective environment for forming these competencies becomes project and research activities, where learners through activity and communication acquire the necessary new knowledge, develop competencies as a result of personal experience in solving a problem task (Kalenyuk & Tsymbal, 2011, p. 167).

Assessing the level of design thinking in educational applicants is a complex task, as it focuses on unconventional and creative solutions. However, several key indicators can be employed to gauge this aspect:

1. The ability to generate new and original ideas (the educational applicant can produce many ideas in a short time; the ideas are original and unconventional; the applicant can refine and develop their ideas) (Pontis et al., 2023).
2. Empathy and understanding of clients (the educational applicant can explore the needs and problems of clients; is able to empathize with clients and see the world through their eyes; uses knowledge about clients to make design decisions) (Davis, 1983).
3. Skills in prototyping and testing (the educational applicant can create prototypes of their ideas, which are understandable and convenient for testing; can analyze feedback from clients on their prototypes; uses feedback from clients to improve their products) (Carfagni et al., 2020).
4. Teamwork and communication (the educational applicant can work effectively in a team; can express their ideas clearly and concisely; can give and receive constructive feedback) (Kamarudin et al., 2012).
5. Creativity and innovative thinking (the educational applicant can think outside the box and find new solutions to problems; is not afraid to take risks and try new ideas; can see opportunities where others see problems) (Varianytsia et al., 2020).

Accordingly, each of these indicators can be evaluated on a four-level scale, where a low level indicates the absence of a clear manifestation of the indicator; a sufficient level – the first characteristic of the indicator is exhibited; a medium level – the educational applicant is characterized by the first and second feature of the indicator; a high level – all characteristics of the indicator are inherent in the educational applicant.

To determine the level of design thinking in electrician technicians, a comprehensive diagnostic toolkit was developed:

1. A variety of methods were employed to assess the ability to generate new and original ideas, including:

- Brainstorming, where the quantity, originality, and practicality of ideas generated by the student are evaluated;
- Portfolio assessment, to evaluate the portfolio of projects to see how capable the student is of generating new and original ideas.

2. Empathy and understanding of clients are complex skills determined indirectly through:

- Observation, noting how the future technician communicates with clients, their ability to listen carefully and understand the clients' needs, the appropriateness of questions to better understand the client, and demonstration of empathy and understanding of the client's issues;
- Interviews, conducted with the client (practice supervisor) to gather their opinion on how well the student understood the tasks set and their satisfaction with the work outcome, and how well the student grasped the needs and wishes;
- Project evaluation, assessing how well the project meets the client's needs, the extent to which the student's efforts to create a needed product for the client are evident, and whether the developed product considers the requirements of a specific target audience;
- Self-assessment, to evaluate one's ability for empathy and understanding of clients.

3. The skills of prototyping and testing the produced product can be assessed by:

- Quality analysis of the prototype, evaluating how well-made the prototype is, its adherence to functional requirements, and its user-friendliness;
- Speed of prototyping, determining how quickly the student can create a prototype, whether they can develop a prototype quickly with minimal costs;
- Analysis of the suitability of the chosen prototyping method (paper, low-fidelity, high-fidelity, 3D printing, digital);
- Review of modifications to the prototype, assessing how easily the student can make changes to the prototype and whether they can efficiently refine the prototype based on customer feedback.

4. To evaluate the level of teamwork and communication skills of the student, the following

methods were used:

- Observation, to see how the student works in a team, their clarity of expression, attentiveness to others, willingness to compromise, and readiness to take responsibility and assist others;
- Interviews, with classmates and teachers to gather their opinion on the student's teamwork and communication skills;
- Project evaluation, analyzing projects the student participated in as part of a team: the differentiation of each team member's contribution to the project, team working efficiency, and project quality;
- Testing and exercises, including Belbin's team roles, "Strength of the Team," and "Team Climate" tests for teamwork, and Rotter's, Thomas', and Firo-B tests for communication, plus exercises like "Tower Building" and "Debates";
- Self-assessment, to evaluate one's teamwork and communication skills.

5. Creativity and innovative thinking are assessed based on:

- Creativity tests (such as Torrance Tests of Creative Thinking and the "Incomplete Sentences" test);
- Observation, noting how the student generates new ideas, solves problems, and adapts to changes;
- Interviews with the student, discussing the creative process, how the student generates new ideas, and how they overcome the fear of failure.

In the initial experiment, 46 future electrical technicians, 7 college teachers, 4 industrial training masters, and 2 practice supervisors were involved. The experiment lasted 4 months. The obtained results are presented in the diagram (Fig. 1).

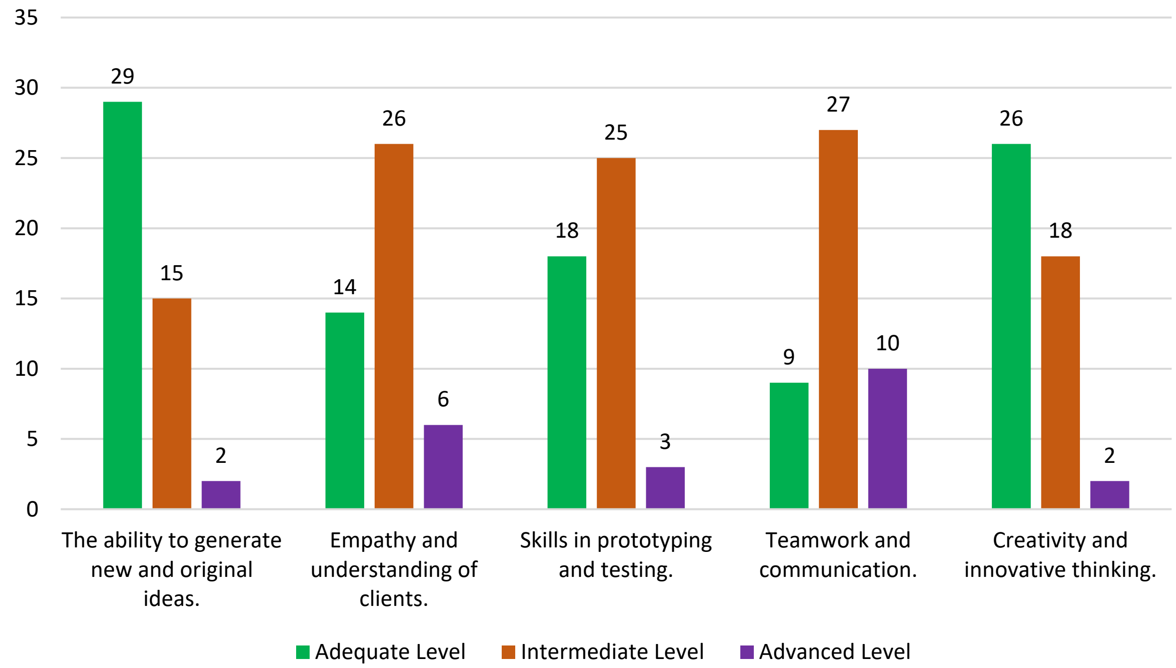

Fig. 1. Levels of Development of Design Thinking in Future Electrical Technicians (Diagnostic Stage)

It should be noted that none of the respondents demonstrated a low level of performance. Future electrical technicians are best prepared for teamwork and communication (22% of the experiment participants demonstrated a high level, 59% a medium level), and require additional attention from teachers and industrial training masters on training aspects related to the analysis of customer needs (only 13% of learners demonstrated a high level) and project development skills (61% of evaluation participants showed a medium and high level). Special attention should be given to the development of the ability to generate new and original ideas, which is interrelated with the development of creativity and innovative thinking (accordingly, a sufficient level was demonstrated by 63% and 57% of learners, with only 4% showing a high level). Thus, the results of the initial experiment indicate the need to search for an optimal design thinking technology to develop creative abilities of future electrical technicians in vocational colleges. Design thinking technology is one of the most powerful tools for stimulating creative ideas, which can be successfully implemented in the educational process of preparing electrical technicians for the energy sector. Therefore, during the formative stage of the research, a system for developing design thinking among future electrical technicians within the educational component "Electricity Supply for Enterprises and Civil Structures" was developed, which will increase the effectiveness of using the modern approach to designing innovative products - "design thinking". For the development of this system, certain methodological principles characterizing the "design thinking" process were identified and analyzed: an effective working environment, the interdisciplinary nature of project work, focusing on consumer needs, practice-oriented design, prototyping and prototype testing, and a holistic approach to product design. The characteristic features of the operation of these principles and their application in the educational context are then highlighted and discussed. An effective working environment. Creating an effective working space is one of the most important tasks in organizing "design thinking" processes. One of the main criteria for such a space is the ability to transform for a specific project task, meaning the space must be primarily mobile. At each stage of the "design thinking" process, fundamentally different tasks are solved, and thus the working environment, where the research team solves these tasks, should provoke the project team to work effectively (Quinton, 2010). For instance, at the first stage of researching a problem, the team actively uses the workspace, filling it with their research materials (notes, drawings, photos, etc.). Consequently, the simultaneous visibility of all research materials allows the team to form a holistic perception of the situation under study. Next, at the idea generation stage, interaction among team members is important, so the space should facilitate team unification. During presentations, the space should combine teams with each other, creating a common discussion space. The mobility of the space allows forming an experimental nature of work on the project. The effectiveness of operations within the educational space is also contingent upon resource provisioning, especially during the prototyping phase, where accurately visualizing the idea is critical. This underscores the importance of resources in ensuring the successful realization of educational projects, particularly at the initial stages of development.

The interdisciplinary nature of project activities is increasingly becoming a necessity in contemporary settings, demanding the development of complex interdisciplinary projects and the employment of creative methods and approaches. Such interdisciplinarity facilitates a multifaceted examination of issues, thereby enabling the identification of innovative solutions. To enhance the efficiency of project work through interdisciplinary teamwork, it is crucial for each team member to possess both specialized professional skills relevant to the specific project and experience across multiple professional disciplines, a concept known as the T-shaped personality (Barnett & Evans, 2019). The psychological context of teamwork within an educational course influences the overall dynamic of team collaboration through the emotional states of its members.

Focusing on consumer needs, the identification of these needs is based on observation and testing of consumers in their natural environments (Zhegus, 2023). A key skill at this stage is empathy, which allows researchers to see from the consumer's perspective, a research type referred to as design research. The mission of design research is to immerse fully in reality and pay close attention to everyday life and the average person to uncover "hidden" needs. In this educational course, students are tasked with research challenges aimed at gathering necessary information through design research methods.

Practice-oriented design, utilizing the design thinking approach, focuses closely on real-world problems and involves conducting research in actual conditions. Thus, students are assigned real tasks, such as studying urban environments and the people living within them, to ensure that learning is directly applicable to real-world scenarios (Kuijer, 2017).

Prototyping and prototype testing accelerate the understanding of a product's details and functions, while also helping to avoid mistakes in later development and implementation stages. Within this educational course, it is mandatory for students in teams to go through the prototyping stage and to test the prototype under real conditions to be used by potential consumers (Prototype Testing: 6 Steps to Successfully Design, Test, and Implement Your Ideas, 2022).

A holistic approach to designing a new product covers the entire process from product creation to its sale, allowing for the identification of strengths and weaknesses. Project teams of students in the course go through all stages from problem identification to product creation and promotion (Saleem, 2015). The course structure is based on the design thinking process, which is not linear but cyclical, reflecting the iterative nature of design thinking as fundamentally a research process.

The design thinking technological cycle is logical and sequential, incorporating five stages: empathy, defining the problem, ideation, prototyping, and testing (Tkachenko & Plyinokos, 2021). This methodology ensures a comprehensive and systematic approach to addressing and solving problems.

Let's consider the defined stages within the context of organizing research projects during the course "Electrical Supply for Enterprises and Civil Structures".

Stage 1 – Empathy. This stage focuses on creating human-centered solutions through immersion in studying needs. The following set of methods is used: observation, data gathering, analysis, synthesis of information about human behavior in various situations related to problem-solving. The outcome of this stage becomes the direction for seeking the needed solution. The selection of an idea for a creative project at the empathy stage starts with specifying whose and which exact need should be satisfied. At this stage, "it is worth ensuring that the problem is current, interesting, and fairly specific; finding out, by consulting the opinion of competent individuals, ways of solving it; processing various sources of information on the chosen topic, as well as identifying analogies to rely on existing experience" (Holiiad & Tropina, 2022). An example of a problem that needs to be solved by students of the course could be energy saving during the design of electrical supply.

Stage 2 – Problem Statement. To implement this stage, it is necessary to create a team consisting of representatives from different professions and social roles. Such a composition allows examining the problem from various angles, utilizing accumulated professional experience and knowledge. The simplest, hence most brilliant solutions, are born at the intersection of cultures, knowledge spheres, ideas, and experiences. For the selection of ideas, it is advisable to use scientific methods that enable the preparation of justification, collection, and systematization of information (Venn diagram, "Cartesian coordinates", method of random objects, etc.). At this stage, when the collected information is actively analyzed and interpreted, the main task for solving the problem is formulated, and the use of a SWOT analysis is recommended. All the gathered information in the form of specific tasks is grouped into four directions: strengths that can be used in the development strategy; weaknesses that can be eliminated, compensated; opportunities, open paths for development; threats and ways to protect against them.

Stage 3 – Idea Generation. The main rule for the team's discussion of the solution – propose your own solution, support the solutions of others, developing them. This principle fosters the communication culture among participants, regulating behavioral norms at the personal level. Idea generation is the process of transforming a conceptual idea into a concrete one (Cross, 2018). At this stage, brainstorming is most effective. It is the most intensive, yet the most productive stage of the team's work. To obtain the maximum number of ideas, game formats of brainstorming can be used: "Brainwriting", "5 Whys" analysis, "Mind Mapping", "Rapid Ideation", "Reverse Brainstorming", etc. Brainwriting is a method of collective idea generation based on written, not verbal communications. Instead of exchanging ideas verbally, each participant writes their thoughts on a given topic over a set period. Afterwards, they pass their written ideas to another participant, who develops these ideas further or proposes new ones. This process continues over several rounds, allowing all participants to contribute and expand the pool of ideas. The collected ideas are later discussed and evaluated, potentially leading to innovative solutions or ideas.

The "5 Whys" analysis is a problem-solving method used for brainstorming the causes of a problem by repeatedly asking "why" until the root cause is discovered. This structured approach helps teams to delve deeper into the problem to understand not just the symptoms but the fundamental causes behind them. It encourages critical thinking and a holistic understanding of complex issues, making it a valuable tool for process improvement.

Mind mapping is a creative and versatile tool for visually representing ideas or information. It begins with a central idea, theme, or topic at the core of the map. From this central point, lines or branches spread out in various directions, representing subtopics, concepts, or thoughts related to the central idea. This graphical tool aids in organizing, exploring, and conveying complex thoughts and their interconnections. Mind maps encourage non-linear thinking and provide a structured way to depict the relationships between ideas, valuable for brainstorming, planning, and understanding complex subjects.

Rapid ideation is a creative process where individuals or groups quickly generate a multitude of ideas without thorough analysis or evaluation. The goal is to stimulate free, unfiltered idea generation, focusing on quantity over quality to generate as many ideas as possible in a short period. This approach often involves setting time constraints and encouraging participants to think creatively and spontaneously. Rapid ideation can be a valuable brainstorming method, problem-solving technique, or innovation generator, allowing exploration of a wide range of possibilities and potentially leading to unique discoveries.

Reverse brainstorming is a method used to explore a problem or task by intentionally generating ideas that are opposite or contrary to the desired outcome. Instead of seeking solutions, participants in reverse brainstorming focus on identifying potential causes or factors that contribute to the problem. This process includes encouraging participants to think creatively and even humorously about how to worsen the situation. By doing so, the group can gain a deeper understanding of the underlying causes of the problem and understand what to avoid or correct to achieve the desired outcome. Reverse brainstorming can be a valuable tool for problem analysis and developing more effective problem-solving strategies.

At this stage, the focus is on mastering ways of positive interaction, generating and developing one's ideas and the ideas of team members.

Stage 4 - Prototyping. Within "design thinking," any idea or thought is quickly realized into a prototype. Prototyping and the experience gained are more important than the outcome. A prototype can be presented in the form of a drawing, diagram, infographic, cardboard, plastic construction, etc. Creating a prototype solves the task of testing the feasibility of ideas in practice. The result of this stage is the trial of the model and its refinement through physical and visual modeling.

Stage 5 - Testing. The prototype is tested, refined, simplified, allowing to get closer to the expected image of the product. At the testing stage, the team receives feedback from users in the form of reviews, requests, suggestions on using the idea.

Upon completing the formative stage of the experiment, a reassessment of the levels of design thinking development of the learners was conducted (Fig. 2).

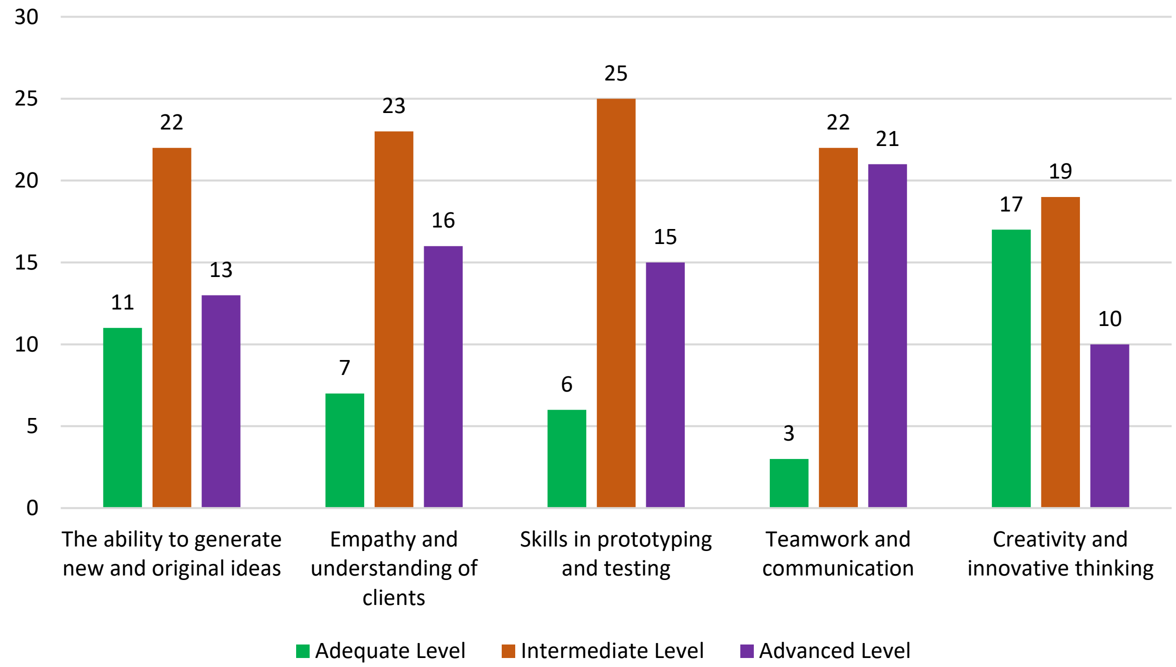

Fig. 2. Levels of Design Thinking Development in Future Electrical Technicians (Formative Stage)

Let's use the chi-square (χ^2) criterion for assessing statistically significant changes in the distribution of education seekers' design-thinking levels (Table 1).

Table 1

Evaluation results of future electrician technicians' design-thinking levels

Indicator	Sample	Sufficient Level	Average Level	High Level	Criterion Statistics $T_{actual.}$
The ability to generate new and original ideas	Initial stage ($n_1=46$)	$Q_{11}=29$	$Q_{12}=15$	$Q_{13}=2$	16,171
	Formative Stage ($n_2=46$)	$Q_{21}=11$	$Q_{22}=22$	$Q_{23}=13$	
Empathy and understanding of clients	Initial stage ($n_1=46$)	$Q_{11}=14$	$Q_{12}=26$	$Q_{13}=6$	6,877
	Formative Stage ($n_2=46$)	$Q_{21}=7$	$Q_{22}=23$	$Q_{23}=16$	
Skills in prototyping and testing	Initial stage ($n_1=46$)	$Q_{11}=18$	$Q_{12}=25$	$Q_{13}=3$	14,000
	Formative Stage ($n_2=46$)	$Q_{21}=6$	$Q_{22}=25$	$Q_{23}=15$	
Teamwork and communication	Initial stage ($n_1=46$)	$Q_{11}=9$	$Q_{12}=27$	$Q_{13}=10$	6,901
	Formative Stage ($n_2=46$)	$Q_{21}=3$	$Q_{22}=22$	$Q_{23}=21$	
Creativity and innovative thinking	Initial stage ($n_1=46$)	$Q_{11}=26$	$Q_{12}=18$	$Q_{13}=2$	7,218
	Formative Stage ($n_2=46$)	$Q_{21}=17$	$Q_{22}=19$	$Q_{23}=10$	

To calculate the chi-square (χ^2) criterion statistics, we will use the formula:

$$T_{\text{actual.}} = \frac{1}{n_1 \cdot n_2} \cdot \sum_{i=1}^{C} \frac{(n_1 \cdot Q_{2i} - n_2 \cdot Q_{1i})^2}{Q_{1i} + Q_{2i}}$$

where, $T_{actual.}$ – actual is the chi-square (χ^2) criterion statistics; n1 and n2 are the number of participants at the beginning and at the end of the experiment, respectively; Q1i and Q2i are the number of sample objects in each category; i is the category number (1 – adequate level; 2 – medium level; 3 – high level); C is the maximum number of categories (the number of levels for analysis – 3).

ased on the table data (Shvachych et al., 2017, p. 47), for $\alpha=0.05$ and the degree of freedom $\nu=C-1=2$, we determine the critical value of the criterion statistic: $T_{crit.}=5{,}991$.

It has been established that across all indicators, statistically significant changes ($T_{actual.} > T_{crit.}$) have been observed in the distribution of levels of design thinking formation among future electrical technicians.

Consequently, the application of design-thinking technology has revealed several positive effects:

- the development of logical thinking and creativity in the idea generation phase;
- increased efficiency and quality of teamwork and group interaction;
- the development of critical thinking by considering empathy, attention to details in their work;
- the game-like nature of the method makes it easier to perceive and assimilate the theoretical information of the course.
- The implementation of design-thinking technology for developing the creative abilities of future electrical technicians in vocational colleges is carried out through:
- the integration of design thinking into educational programs (including modules, courses, or projects with design thinking in the training programs of electrical technicians);
- using design-thinking methods (applying methods such as empathy, brainstorming, prototyping, testing, etc., to solve real problems in electrical engineering);
- creating a favorable environment (encouraging creativity, innovation, and teamwork in the educational process);

- engaging design-thinking professionals (collaborating with designers, engineers, and other professionals who have experience with design thinking);
- using online resources (for studying design thinking by engaging in courses, webinars, studying articles, books, and blogs);
- conducting training for educators (training teachers in design-thinking methods in their work to make the learning process more interesting and effective).

Conclusions. Therefore, design thinking is a tool that enables the design and identification of unconventional solutions to complex tasks. This mindset, thanks to technologies and techniques that facilitate the accumulation of ideas and stimulate unconventional thinking, encourages the acceptance of risky decisions, ultimately mitigating fears of failure. Design thinking is a technology that meets all the challenges of the times, enhances the quality of professional training for specialists, and supports the development of professional competence in future electricians at vocational and higher education institutions.

We see the prospects for further research in exploring the potential of various tools and methodologies of design thinking for the development of professional competence in future electricians in vocational colleges.

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ДИЗАЙН-МИСЛЕННЯ ДЛЯ РОЗВИТКУ КРЕАТИВНИХ ЗДІБНОСТЕЙ ТЕХНІКІВ-ЕЛЕКТРИКІВ У ФАХОВИХ КОЛЕДЖАХ

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Актуальність обумовлена тим, що в умовах оновлення освітньої парадигми, розширення технологічних можливостей суспільства необхідно шукати нові шляхи і засоби професійної підготовки майбутніх фахівців. Виявлено актуальність досліджуваної теми, проведено аналіз існуючих підходів до трактування терміну дизайн-мислення. У перебігу наукового пошуку встановлено, що в контексті застосування дієвих способів формування фахової компетентності техніків-електриків заслуговує на увагу технологія дизайн-мислення, використання якої є потужним ефективним інструментом для розвитку інноваційного мислення здобувачів освіти, що надзвичайно важливо в епоху швидких змін, розвитку інновацій та зростання мобільності у всіх сферах життя сучасного світу.

Мета: виявлення перспективи впровадження технології дизайн-мислення для розвитку креативних здібностей майбутніх техніків-електриків у фахових коледжах.

Методи: аналіз та синтез – для визначення стану розробленості досліджуваної проблеми та особливостей застосування технології дизайн-мислення для розвитку креативних здібностей майбутніх техніків-електриків; узагальнення – для формулювання висновків і рекомендацій щодо впровадження технології дизайн-мислення для розвитку здобувачів освіти у фахових коледжах; діагностичні (тестування, бесіда, інтерв'ю) – для з'ясування рівня розвитку дизайн-мислення майбутніх техніків-електриків; застосування критерію узгодженості Пірсона χ^2 (хі-квадрат) для статистичного аналізу результатів експериментального дослідження.

Результати: представлена система формування дизайн-мислення у майбутніх техніків-електриків у рамках навчального курсу «Електропостачання підприємств та цивільних споруд», яка дозволить підвищити ефективність використання сучасного підходу до проєктування інноваційних продуктів та розвитку креативних здібностей; для розроблення цієї системи було виявлено та проаналізовано методологічні принципи, що характеризують процес «дизайн-мислення»; висвітлено етапи застосування методу дизайн- мислення професійній підготовці майбутніх техніків-електриків спрямовані на вирішення проблемної ситуації і виходу з неї, можливості генерувати ідеї, змінювати та покращувати свій проєкт з урахуванням виявлених недоліків, формувати навички роботи із цифровими технологіями.

Висновок: дизайн-мислення є інструментом, за допомогою якого можна проєктувати майбутнє та знаходити нестандартні способи вирішення складних завдань; це – технологія, що відповідає всім викликам часу, дає змогу підвищувати якість професійної підготовки фахівців, сприяє формуванню фахової компетентності майбутніх техніків-електриків у закладах фахової передвищої освіти.

Ключові слова: *фахова компетентність; дизайн-мислення; нові освітні технології; технік-електрик; підготовка кадрів; фахова передвища освіта.*

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