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Fostering Leadership in Technology Education: Enhancing Design Culture Through Research Engagement of Future Educators

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The research aims to reveal the specifics of involving future technology teachers in Ukraine in research work. The significance of the research work is that a future teacher gains knowledge not only to teach students but also to develop professionally, which is impossible without involving future teachers in research and scientific activities. For the purpose of the research, the following aspects have been considered: the essence of research activity in the preparation of future teachers of technology, forms and methods of conducting research and development activities, analysis of using research work in the training of future technology teachers in the context of Ukrainian higher education institutions, consideration of problematic aspects of implementing research and development activities in the training of future teachers, recommendations for implementing research work in the training of future teachers. The results of the research are significant for determining the level of training future technology teachers for research activities. This makes it possible to identify the problematic aspects of students' training, the possibility of introducing scientific and research activities into the educational process, and the state of research activities in the training of future technology teachers in general. Accordingly, important issues were considered that will help the administration of higher education institutions in Ukraine to improve the quality of education and make the training of future teachers more comprehensive. The ways of introducing research activities into teacher education in technology were suggested and the means of including them in such activities were proposed. In addition, it was taken into account that modern scientific and research activities are often reproduced in a virtual form; therefore, future teachers can actively participate in online conferences, forums, and seminars, and conduct studies in the format of a survey on social networks. Therefore, the present research is essential both for technology students and for teachers and managers of higher education institutions, which will significantly improve the quality of technology education.

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The issue of involving future technology teachers in research is relevant in Ukraine due to the fact that modern educational activities are mainly outlined by theoretical knowledge. In particular, students of pedagogical universities are often provided with only information related to the subject they will teach, and, therefore, they receive a limited amount of knowledge. At the same time, the issue is increasingly being raised that education should also have a practical focus since a future teacher must possess professional competencies that are related not only to the work of a teacher but also to the implementation of professional skills in the relevant field. Thus, we cannot only assume that a technology teacher works with students all the time because he or she may also want to create artistic products or design things (Litt, 2020).

This problem is also acutely relevant to research activities. Future teachers should be familiar with the fundamentals of science and research work in order to better fulfill their own potential and assist students in achieving their goals. In particular, a teacher can help a student write a paper for the Junior Academy of Sciences and conduct their own research, and for this, they need to know the basics of research. Additionally, the educator should be able to properly conduct research and document the findings in order to engage pupils with the content and present it more accurately (Llorent-Vaquero, 2020).

However, taking into account the teaching load of future technology teachers, we cannot accurately determine whether they are involved in research and what is its quality. This leads to the need for a more detailed study on this topic.

The purpose of the research is to identify the impact of research work on the training of future technology teachers, to clarify the forms and methods of such work, to analyze the use

of research work in the training of future technology teachers in the context of Ukrainian higher education institutions, to consider the problematic aspects of introducing scientific and research activities in the training of future teachers, to develop recommendations for the introduction of research work in the training of future technology teachers in Ukraine.

Literature Review

The issue of involving future technology teachers in research work in Ukraine is covered in the scientific works of such Ukrainian researchers as Honchar et al. (2021), Lukianova et al. (2023) and other domestic scholars, as well as such foreign scientists as Hepp et al. (2015), Santos (2016), Timoštšuk and Tinn (2015), etc. Thus, according to researchers Rolf and Knutsson (2021), technology teacher training with the use of research work is currently carried out infrequently, and if such training is carried out, it is mainly with the help of information technology.

Method

The research methods used in the work are as follows: general scientific (description of the essence of research work, analysis and synthesis of the use of research work in the training of future teachers, comparison of the use of research work in teacher training and their involvement in different higher education institutions of Ukraine, generalization of the research results) and empirical (content analysis to identify the features of training future technology teachers in research work, taking into account different curricula) (Table 1). The questionnaire on the training of future technology teachers is shown in Table 1. Features of training future technology teachers in research work.

Table 1

Features of Training Future Technology Teachers in Research Work

No. s/n	Question	Answer
1	Do you know what R&D and R&D activities are?	
2	Does your institution conduct research and development activities at?	
3	Are research activities carried out mostly during studies, outside of studies, in parallel?	
4	What forms of research work are available to you?	
5	What research methods are used?	
6	Does research and development activity have an impact on improving design culture?	
7	Do you have any suggestions for improving research and development activities in your training?	

Results

The training of technology teachers is a complex process that involves the formation of their knowledge and skills of design culture, mastering professional and special competencies, understanding the features of presenting materials to students of different age groups (Byram, 2021). They should understand the peculiarities of contemporary design and architecture, technology, and fine arts, possess aesthetic sensitivity, be able to see beauty everywhere, and be aware of the differences between contemporary art and the art of previous periods. All of this requires them to be well-trained and have a wide range of knowledge that will allow them to successfully teach students and motivate them to achieve higher performance. In particular, this cannot be achieved without the teacher's participation in various activities aimed at

developing knowledge and skills in scientific and research activities (Creswell & Creswell, 2018).

The research activities are crucial to the quality training of technology teachers and the formation of their design culture. This is due to the fact that such activities are aimed at developing critical thinking, forming system analysis skills, and strengthening the ability to use creative and original approaches in any field of activity. It stimulates the adoption of original solutions and allows for experimentation, which is necessary for the development of a full-fledged personality of a technology teacher with design culture skills.

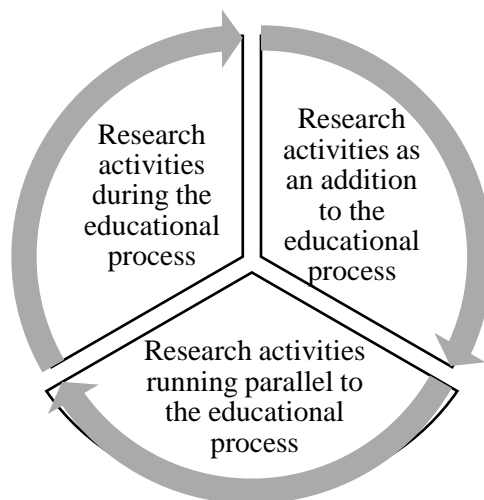
The importance of research work in the development of design culture is also determined by the fact that design, in general, is a creative process of artistic direction aimed at transforming elements of the material world with the help of relevant tools into other elements of the material world characterized by functionality, aesthetics, ergonomics. At the same time, design culture is distinguished by project work, which is aimed at planning and managing real and abstract resources to achieve the desired result in terms of space arrangement. Such culture contains a distinct concept, which is aimed at creating a completely new and unusual product (Perrine, 2020).

At the same time, research work in design culture involves a set of activities aimed at developing new knowledge and applying it in the manufacture of a new product (Cohen et al., 2018). When training technology teachers, such work may be in the form of applied work aimed at gaining new knowledge to create new products, research and development work aimed at designing new products and determining aspects of their functioning, technological work aimed at creating new technologies for manufacturing products.

At the same time, research activities involve the development of skills and their consolidation in research work and conducting research under the guidance of teachers (Hepp et al., 2015). The forms of research activities used in the training of future technology teachers are shown in Figure 1. Forms of research activities in the training of future technology teachers.

Figure 1

Forms of Research Activities in the Training of Future Teachers of Technology



Research activities during the educational process involve the performance of such works that are part of the educational activity. This includes such works as practical assignments, term

papers and qualification papers, research papers, and internship reports since such works contain elements of scientific and research work. Research activities as an addition to the educational process, involve participation in scientific projects, scientific clubs, conferences, seminars, competitions, and olympiads, where scientific and research activities are carried out during extracurricular time. Research activities running in parallel to the educational process involve participation in research and development of their own research papers for grants, which involves thorough scientific and research work without interrupting studies (Holliday, 2024).

In particular, if a higher education institution plans to carry out such activities, it should create a department dealing with such activities on the basis of a university unit, to which responsible teachers should submit research programs, registration cards for research, and accounting cards at the beginning of each year; after such activities are carried out, reports and information cards on the work done are submitted to the departments (Rolf & Knutsson, 2021).

Modern methods of conducting scientific and research activities during training technology teachers are often combined with traditional methods. As for the modern methods, special attention should be paid to the method of the exploratory laboratory, the essence of which is that students are given a laboratory where they can explore new materials and conduct research, which is important for future teachers who want to teach children to work with different materials and create original products.

The active search method means that the student actively participates in various research activities and performs scientific work, which allows them to gain knowledge in a practical way. In particular, students can develop product designs and conduct surveys on their advantages or disadvantages (Lukianova et al., 2023).

Future educators should be able to think critically; therefore, gamification techniques are crucial. Its essence lies in the fact that, working with game elements, students can model products and, taking into account their functionality, determine which product will best fulfill its mission during the game. This method is interesting since it involves creative thinking and the development of non-standard solutions, and given the graphics in modern games, this use is close to a realistic situation. This has a positive impact on the design vision of the technology teacher (Rudenko, 2017).

The method of learning analytics involves analyzing student performance data based on the calculation of performance indicators while working with special design programs. The method is predicated on the idea that when a student works with the programs, their performance steadily increases, leading to a more comprehensive understanding. This makes it possible to improve the learning strategy and gradually offer students more effective learning tools. Based on the indicators, the teacher can decide to increase or decrease the time for student practice and they can also change the type of task and even increase the workload (Millard & Hargreaves, 2015).

The virtualization method involves using special calculations and statistical data, entering the parameters of the planned product, entering functional indicators, and designing a future product within a virtual environment. The use of this method makes it possible to accurately calculate the parameters of the product and determine its ergonomic properties. The advantage of this method is that entering product parameters and possible influencing factors into the system makes it possible to determine whether the product will meet a certain concept, whether

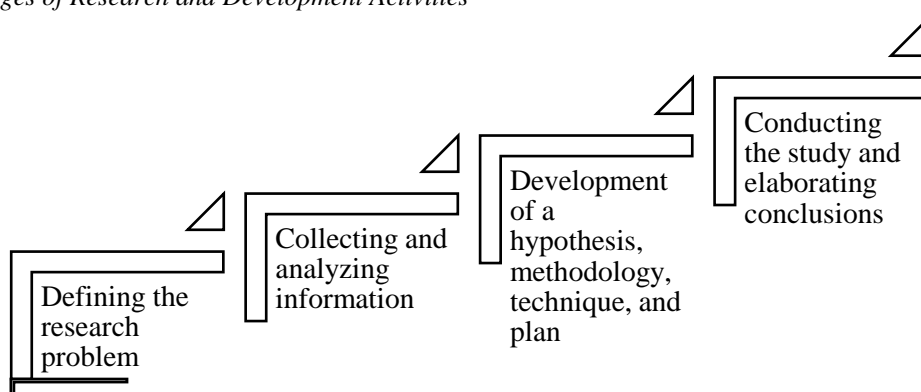
it will withstand the load, and whether the material will be resistant to external factors. At the same time, virtualization allows for the design of a product and its accurate drawings, which will help a student create a product faster based on computer calculations than if they used manual calculations (Santos, 2016).

The virtualization method is closely related to the modeling method. The modeling method involves only the creation of a product in a computer system without taking into account the factors of influence. It is used to create an object or an analog in a computer system that should correspond to the future product. At the same time, it is often possible to determine whether a product can be created according to the specified parameters only with the help of a model (Neuman, 2023)

In general, research and development activities involve the following stages, as shown in Figure 2. Stages of research and development activities.

Figure 2

Stages of Research and Development Activities



All these stages are closely interconnected, and if at least one of them is not followed, the research activity will not lead to the desired results. At the same time, this activity is interesting and multifaceted since it makes it possible to obtain results that can be used in various fields of activity. Mastering research activities enable the future technology teacher to learn to initiate new ideas, test the proposed practical experience, think modern and original, and form new approaches to technology and design culture (Neudachyna, 2019).

Such skills are often formed through such forms of research work as research projects, international conferences, and scientific research. At the same time, a future teacher must possess modern technologies for effective research and timely communication with colleagues, as well as skills in working with 3D printers, modern layouts, product design tools, and modern design programs. Graphic design skills are crucial since they enable to successfully design a product and make its design interesting. Accordingly, it helps to stimulate future students to become students in research.

Research activities can influence the formation of a design culture among students by introducing various methods and approaches to incorporating scientific and research work into students' educational activities. This is possible during international internships, practices in leading companies, and international exchanges. As a result, students gain knowledge of product design, learn to spread design culture, develop knowledge of information retrieval and

its inclusion in a research plan, learn to do research, and engage in research activities. At the same time, they successfully implement educational projects with the inclusion of their applications in international scientific and research grants (National University of Civil Defence of Ukraine, 2024).

Future technology teachers, participating in research activities and carrying out research work, learn to effectively create educational materials based on their own developments, help students make non-standard decisions and show their own creativity during pedagogical practice, successfully implement their own technological literacy, and acquire new pedagogical skills. In addition, at the stage of training, they acquire the ability to combine pedagogical technologies with modern information and communication technologies and they can think critically, analyze and combine the information received into a single whole, and develop skills of interaction with different social groups.

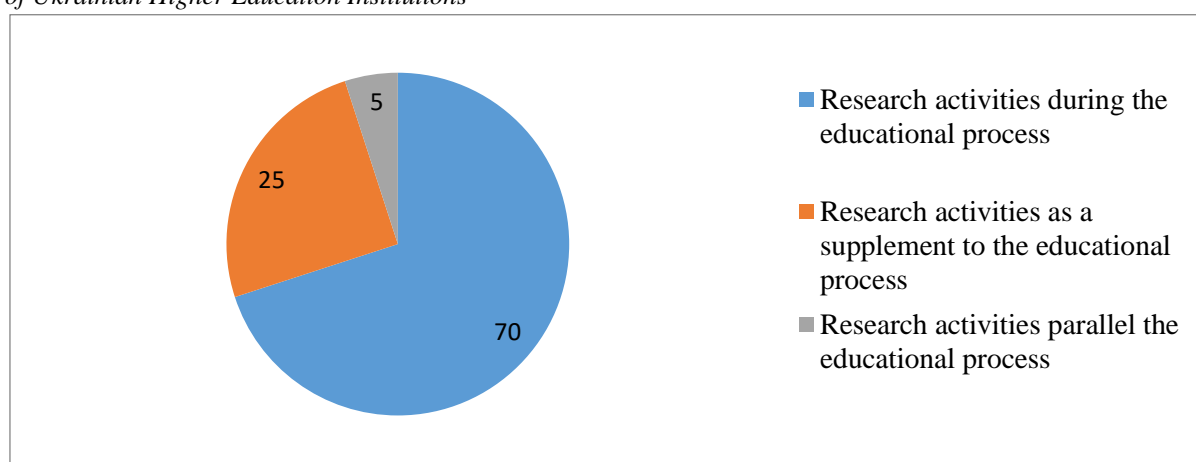
Regrettably, international internships and international exchanges are rarely used as a tool for developing design culture in conjunction with research, which is caused by the limited budget of higher education institutions and the complexity of forming such research programs. However, such events are effective in transferring to students the latest experience in the peculiarities of design culture, the state of modern science, and the development of research activities since students receive direct information about the trends in the training of future technology teachers.

In Ukraine, technology teachers are trained at the following leading higher education institutions: Open International University of Human Development “Ukraine” (specialty “Design”), Vinnytsia Mykhailo Kotsiubynskyi State University (specialty “Fine Arts, Decorative Arts, Restoration”), Oleksandr Dovzhenko Hlukhiv National University (specialty “Labor Training and Technology”), Kyiv National University of Technology and Design (specialty “Design”).

The content analysis of the official websites of these educational institutions has revealed that research activities are carried out mainly during the educational process. The results are shown in Figure 3. Percentage ratio of forms of research activities in the training of future technology teachers on the example of Ukrainian higher education institutions.

Figure 3

Percentage Ratio of Forms of Research Activities in the Training of Future Teachers of Technology on the Example of Ukrainian Higher Education Institutions



While mastering professional skills during the period of training and pedagogical practice, students also study research and development activities in the course of the mandatory discipline “Fundamentals of Scientific Research”. However, research activities at each institution have their own specifics.

The Open International University of Human Development “Ukraine” in the specialty “Design” offers students to conduct research work in the format of participation in conferences and seminars. In addition, students are encouraged to participate in international educational programs. At the same time, a certain list of Polish institutions is offered for cooperation, which limits the international exchange of students.

On the basis of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, specialty “Fine Arts, Decorative Arts, Restoration”, research activities are provided in the form of seminars and conferences. Thus, students can write abstracts for scientific publications, which will then be published in the university’s journal “Actual Problems of Training a Teacher of Labor Education and Technology: Theory, Experience, Problems: A Collection of Scientific Papers” or participate in conferences under the auspices of a supervisor.

On the basis of Oleksandr Dovzhenko Hlukhiv National University, students majoring in “Labor Education and Technology” can take part in the scientific circle “Innovative Teaching Technologies in the Professional Activity of a Teacher”. This club provides students with knowledge of modern teaching technologies, creative approaches to teaching, and problem solving. Participation in the club allows students to master the features of scientific and research work as well as research activities.

Kyiv National University of Technologies and Design, majoring in “Design”, engages students in research and development activities through their participation in conferences and seminars, as well as during their participation in scientific schools such as “Design, Ergonomics and Technical Aesthetics”, “Scientific basis of development, creation and fixation of the internal shape of shoes and assortment”, “Computer Graphic Spatial Design”, “Development of theoretical foundations of new technologies for the production of fine fiber materials”. Students can also take part in research laboratories, including the “Center for the Collective Use of Scientific Equipment”, “Additive Manufacturing Technologies” (3D Printing) and the “Analytical and Research Testing Laboratory “Textile-Test”. Therefore, this educational institution pays particular attention to the research activities of students in extracurricular time.

For confirmation of the obtained results, students were offered to take an electronic survey “Features of training future technology teachers in research and development work”. The empirical study involved 26 students of the respective specialties of the analyzed educational institutions, who are students of the 4th year of study. After analyzing their answers, it was found that to the question *Do you know what research and development activities and research work are?* 18 students answered in the affirmative (69%), 4 students did not know the answer (15,5%), and 4 students answered “I don’t know” (15,5%).

The question *Do you conduct research and development activities at your institution?* allowed us to get the following answers: “Yes” – 15 students (57%), “I don’t know” – 8 students (31%), “No” – 3 students (12%). *Is the research activity carried out mostly during studies, outside of studies, in parallel?* as the question revealed that almost all students (22 students) answered about studies as the main period of conducting it.

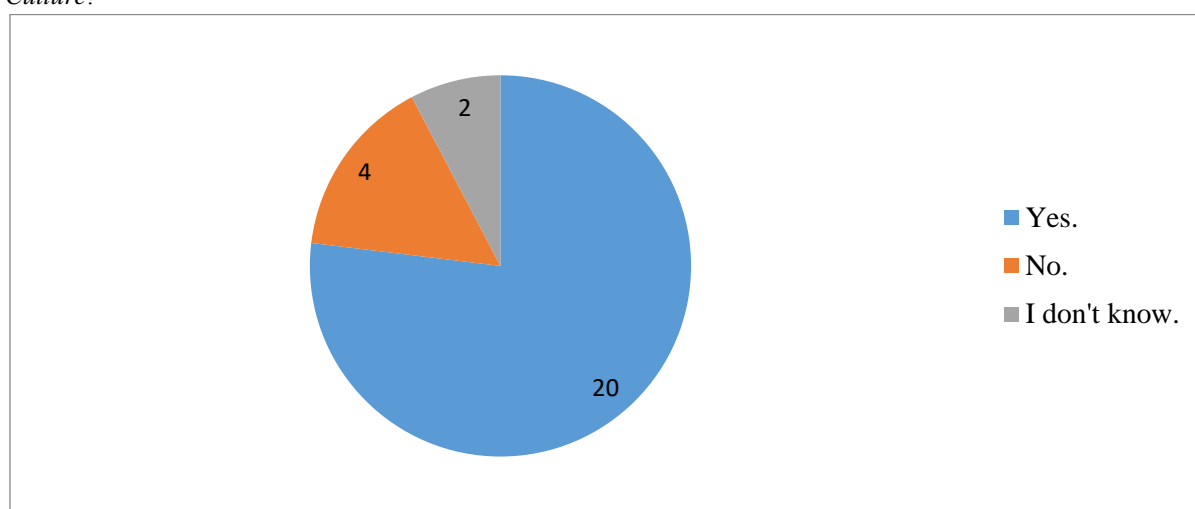
The question *What forms of research work are available to you?* provided us with such indicators as term papers and qualification papers, conferences, forums, seminars, and scientific circles. To the question *What methods of research activities are used?* students said that they are traditional with elements of gamification.

Question *Do you have any suggestions for improving research and development activities in your training?* provided us with results that students support the ideas of scientific clubs and scientific laboratories.

The answer to the question *Does research and development have an impact on improving the design culture?* is shown below in Figure 4. Respondents' answers to the question *Does research and development have an impact on improving the design culture?*

Figure 4

Respondents' Answers to the Question "Does Research and Development Have an Impact on Improving Design Culture?"



The results obtained indicate the need to develop research and development activities in Ukraine. In particular, the experience of the United States and Western European countries shows us the success of international internship programs, cooperation with leading technology and research companies, and scientific laboratories (Careers Service Briefing, 2024). Students are actively involved in research projects at various levels, and they are encouraged to participate in research activities there (Carlsson, 2020). This allows students to increase their competence as well as to form a sufficient level of motivation (Honchar et al., 2021; Millard, 2020).

Accordingly, our state can also expand the types of research and development activities and introduce at least an increase in the number of scientific clubs. In particular, it is advisable to modernize scientific laboratories, motivate students to conduct studies, and involve students in participating in grants (Kember, 2016). This situation can be remedied or improved by increasing expenditure on education and science, providing financial assistance to young scientists, attracting international grants and investments, and developing international cooperation.

Discussion

The study of this issue has helped identify a number of challenges that impede the development of research and development activities in the training of technology teachers. First of all, it is an insufficient amount of scientific work in higher education institutions since not all students are aware of the possibilities of scientific and research activities and the essence of such work (Timoššuk & Tinn, 2015). In addition, the economic situation of our country, which strives to develop science and education; however, the funding for such areas is limited, and it is not sufficiently taken into account. However, not all higher education institutions have the opportunity to conduct international exchanges or organize international programs for students, and as a result, the quality of training suffers. At the same time, we do not see a coherent system of involving young professionals in research and development activities within the framework of technology teacher education (Simón et al., 2017). Only solving these issues will make it possible to expand the professional competencies of technology teachers and form a design culture with the help of the formed scientific and research knowledge.

Conclusion

The research results indicate the importance of introducing research and development activities in the training of future technology teachers for the formation of their design culture. This has a positive impact on the development of critical thinking, creates a vision of the beautiful and aesthetic, has a positive impact on the development of original problem-solving skills, allows for thorough scientific work, and forms an understanding of research activities. Such teachers will help children acquire knowledge of technology, design, and fine arts. In addition, the experience of other countries shows that the following forms and methods of research and development are important in the training of future technology teachers: international internship programs, cooperation with leading technology and research companies, and scientific laboratories.

We can also mention such successful methods of scientific and research activities in the training of students as gamification, active search, modeling, virtualization. Research and scientific laboratories are also important since they contribute to the formation of practical knowledge and skills in searching for scientific information. Their implementation in the training of future technology teachers, as well as increased spending on education and science, financial assistance to young scientists, attracting international grants and investments, and developing international cooperation, will allow for greater involvement of students in scientific and research work.

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