SHAPING FUTURE TECHNOLOGY TEACHERS' DESIGN CULTURE THROUGH RESEARCH ENGAGEMENT

[a]MARYNA GRYNOVA, [b]OLHA TYTARENKO,
[c]VALENTYNA TYTARENKO, [d]INNA VAZHENINA,
[e]VALERII TYTARENKO, [f]IHOR SAVENKO,
[g]NATALIIA SULAIEVA

[a,b,c,d,e,g]Poltava V. G. Korolenko National Pedagogical University, Poltava, Ukraine.
[f]Hryhorii Skovoroda University in Pereiaslav, Pereiaslav, Ukraine.
email: [a]grinovamv@gmail.com, [b]ookirosir@gmail.com, [c]valentinatitarenko48@gmail.com, [d]kaf_pmm@gsuite.pnpu.edu.ua, [e]are1lav@ukr.net, [f]iv_savenko@ukr.net, [g]Sula_polt@ukr.net

Abstract: The scientific work is focused on researching the peculiarities of forming the design culture of future technology teachers. Its distinctiveness lies in its description of this process through the lens of research activities. The article examines five main questions that allow for a systematic representation of the problem. Firstly, we analysed the impact of research activities on the formation of design culture in students, as it reveals the connection between research and the development of design competencies. Secondly, we determine the most effective methods and approaches for developing design culture. Thirdly, we explore the main components of design culture and their formation within the framework of research activities. Fourthly, we demonstrate the challenges of integrating research activities into the preparation of future teachers and the possible strategies to overcome them. Finally, we analyse the influence of design culture development on future technology teachers' professional training and pedagogical activities. The significance of this article lies in the opportunity to highlight and distinguish the issue of integrating research activities, which can enhance the quality of training for future technology teachers (especially in the technology field, where design culture is a crucial component). This scientific work proposes new approaches for incorporating research activities into the educational process, essential for developing innovative educational programmes. The work helps to understand better another aspect of the issue: how the formation of design culture contributes to developing competencies in future technology teachers, which is crucial for their future professional activity. The results of this theoretical study may be used to improve educational programmes and reform the preparatory stage of teacher training in technology, which is an essential link in improving the education sector.

Keywords: Design, Design education, Design culture, Project-based learning, Gamification

1 Introduction

The topic we have raised has interested researchers for more than just the past year. However, questions remain that require detailed consideration or more profound study. In particular, it is essential to understand how participation in research contributes to developing design competencies in students pursuing a teaching education and how this affects their future professional activities. Equally important is the analysis of the effectiveness of the research methods implemented, as this allows us to identify which of them most successfully fosters the formation of design culture. Another crucial issue is the identification of the core components of design culture. This issue includes the problem of their formation, as well as the challenges that accompany this process. We also consider design culture's general development as a significant problem.

The value of this research lies in its contribution to understanding the role of research activities in improving the quality of training for future teachers. This scientific work proposes new approaches to integrating research activities into the educational process, encouraging researchers in this field to refine existing educational programmes. The results may be used not only to improve educational programmes but also to reform the training of technology teachers (which is relevant in the context of current challenges in the field of education).

2 Analysis of recent studies and publications

The issues of design education and its development prospects are represented by the works of such Ukrainian scholars as Kryvolapov & Madzihon (2002), Mykytiuk (2011), Antonovych & Vdovchenko (2012), Tymenko (2012), Prusak & Kordiaka (2013), Rudenchenko (2017), Blyzniuk (2018), Alieksieieva (2020), Shvets et al. (2021), and other domestic researchers, as well as foreign scientists, including Nelson (1999), Zhang et al. (2012), Manzini and Coad (2015), Hernandez et al. (2017), Mendoza et al. (2022), and others. Additionally, the issues of design culture and competence are covered in the works of Yavoryk (2008), McMullen (2016) and other researchers.

Povidaichyk and Povidaichyk (2021) researched improving the professional training quality of future educators. Moiseienko and Sosnytskyi (2022), in turn, emphasised the importance of involving students in research activities from the beginning of their studies.

The research aims to identify the impact of research activities on the process of forming design culture in future technology teachers, determine effective methods and approaches for integrating research elements into the domestic educational process, and assess how this influences the professional training of technology teachers.

3 Research methods

The research methods used to highlight this topic can be broadly divided into three groups: general scientific methods (analysis and synthesis of the research activity process, induction and deduction for formulating general principles of the process, comparison of the phenomenon under study in different countries of the world, abstraction and generalisation for concluding, modelling), pedagogical methods (analysis of pedagogical literature, the method of studying and generalising experience), as well as innovative and interdisciplinary methods (Design Thinking method, Big Data Analysis method, Learning Analytics method).

4 Results

The formation of design culture in future technology teachers is a complex and multifaceted process that requires integrating various knowledge, skills, and abilities and a wide range of critical competencies to adapt flexibly to a rapidly changing and interconnected world (Recomendación, 2006). Design culture includes aesthetic sensitivity, critical thinking, creativity, and the ability to innovate. Future technology teachers must effectively transmit knowledge and stimulate students to solve technological problems creatively.

Research activity is critical in forming this culture, as it develops the ability to think systematically, analyse problems, experiment, and find innovative solutions. It is crucial to consider in more detail how research activities influence this process, mainly through the experience of Ukraine and foreign countries (Sheiko, 2008).

Design, in a narrow specialised sense, is an artistic and creative process aimed at developing elements of the material and spatial environment created by industrial methods and characterised by high functionality and aesthetic appeal (Kuznetsova, 2022). The “design culture” encompasses methods and forms of organised design activities closely related to management and planning systems. It is a specific type of production of project documentation that describes the expected result of actions and the concept of the future object, whether it be an item, material environment, activity system, or lifestyle as a whole. The impact of research activities on the formation of design culture in Ukraine and the world can be described by characterising such areas of design culture development as critical thinking and analytical skills, stimulating creativity and innovative approaches, forming aesthetic sensitivity and understanding of design, and developing collaboration and interdisciplinary approach skills. Their comparative characteristics can be provided in Table 1.

Table 1: Comparative characteristics of trends in the development of component elements of design culture

Development direction	Country	Description
Development of critical thinking and analytical skills	Ukraine	Ukrainian pedagogical universities teach future technology teachers to analyse technological processes and develop innovative solutions to problems. For example, as part of their coursework and diploma theses, students conduct research at the intersection of technology and design, which helps them to think critically about design.
	Germany	In Germany, the emphasis is on project-based research, where students analyse real-world industrial problems and propose innovative solutions. This develops their critical analysis and design thinking skills.
	England	In UK universities, particularly in technology teacher training programmes, research aimed at solving environmental and social problems through design is actively used. This contributes to developing critical thinking in the context of modern challenges.
Stimulating creativity and innovation	USA	American educational programmes emphasise research projects, where students create prototypes of new products or systems using modern technologies and design methods. This approach develops their creativity and innovative thinking skills.
	Netherlands	In the Netherlands, the curricula for future technology teachers include active involvement in interdisciplinary research, which helps students develop creativity by integrating knowledge from different fields.
	Spain	Spanish universities like the University of Barcelona actively use research laboratories. These laboratories allow students to experiment with new materials and technologies, which helps to develop their creative imagination.
Developing aesthetic sensitivity and understanding of design	Ireland	In Ireland, at University College Dublin, for example, students study design as an interdisciplinary field incorporating elements of art, technology and social sciences. This helps to develop their aesthetic sensibility and understanding of the cultural aspects of design.
	Germany	Famous German design schools, such as the Bauhaus, have influenced the development of design education, where aesthetics is a crucial element. Modern programmes include research to help students better understand the role of design in society.
	England	In the UK, students actively study visual communications and graphic design, which helps them develop an aesthetic perception and understanding of the visual aspects of technological processes.
Development of cooperation skills and interdisciplinary approach	USA	In the USA, research activities often involve group work, which allows future technology teachers to learn how to collaborate with specialists from other fields, such as engineering, marketing, and social sciences. This contributes to the development of interdisciplinary thinking.
	Netherlands	Dutch educational programmes include research projects in collaboration with industrial partners and other faculties. These projects contribute to developing team skills and an interdisciplinary approach to solving design problems.
	Spain	In Spain, students are often involved in international research projects where they collaborate with colleagues from other countries, which develops their global thinking and interdisciplinary skills.
Application of new technologies in design	Ukraine	At Ukrainian universities, students are introduced to new technologies such as 3D printing and augmented reality through research activities that expand their design capabilities.
	USA	American students actively use the latest technologies, such as artificial intelligence and robotics, in their research projects, significantly affecting their understanding of contemporary design.
	England	In the UK, students use modern digital tools to work on projects related to interface design and user experience (UX/UI).

Source: compiled by the author

Developing a design culture in students is essential for forming their ability to think creatively and innovatively, perform critical analyses, and apply practical design solutions. Research activities are vital in this process, allowing students to study, analyse, and apply various design concepts and methods. In this context, information and communication technologies (ICT), such as radio, television, and modern digital technologies, including computers and the Internet, are considered powerful tools for implementing educational reforms and changes (Isah et al., 2015; Honchar et al., 2021).

Traditional and modern research methods are among the most effective methods for developing design culture. It is crucial to consider these methods in more detail and provide examples of their application in different countries.

Project-Based Learning (PBL) is a specific educational activity where students work on real-world projects. This practice allows them to apply theoretical knowledge gained during their studies. Such activities enhance their ability to solve real problems and contribute to developing critical thinking and creativity. For example, at universities in the USA, such as the Massachusetts Institute of Technology (MIT), students in engineering and design programmes work on real industrial projects. This approach enables American students to integrate the latest technologies and innovative solutions into their work. In courses at Hochschule für Bildende Kunst (HFBK, Germany), future technology teachers participate in project-based research. These studies involve collaboration with industrial partners to create new design solutions.

Design Thinking is a method aimed at analysing user needs and generating innovative solutions that best meet these needs. This approach involves future specialists progressing through several stages of educational activity: empathy, problem identification, brainstorming, prototyping, and prototype testing. For example, engineering students use the design thinking method at Delft University of Technology (Netherlands). The goal of its application is to create innovative solutions for projects related to the environmental and social challenges faced by the country. At Imperial College London (England), students in design courses actively use design thinking to develop new products and services, considering real users' needs.

The Research Labs method is a learning approach in which laboratories allow students to conduct experiments and explore new materials and technologies, contributing to their understanding and development of design culture. For example, at Stanford University (USA), some laboratories specialise in research in interactive design and new technologies, allowing students to test and implement innovative concepts. Introducing such innovative technologies into the university's educational system improves the organisation of the educational process, reduces administrative burdens, and provides easy access to

information for all interested parties (Andrusiak et al., 2024). At the University of Barcelona (Spain), students work in laboratories that focus on research in visual communications and graphic design, helping them to develop aesthetic and technical skills (Garzón Artacho et al., 2020).

The Action Research method integrates research activities with practical activities, where the researcher is actively involved in the process and uses the obtained data to improve practice. For example, at University College Dublin (Ireland), students can implement projects that include real challenges in the field of design and receive feedback to improve their solutions. In Hochschule für Gestaltung (HfG, Germany) courses, students work on projects that directly impact the community and use action research to improve project outcomes.

Gamification is a method in which game elements are used to organise the educational process. Gamification as an educational element includes the creation of game scenarios, competitions, and simulations (Perejaslavska & Smahina, 2019). For example, at Carnegie Mellon University (USA), gamification is used in the educational process to conduct simulation games. These games help students learn design principles and project management. Students at the University of the Arts London (UK) participate in competitions and game-based projects, stimulating their creativity. Such projects contribute to the development of design competencies. The Virtual Environments method uses virtual environments, which allow students to create and explore design concepts in conditions that simulate reality (without the limitations of physical resources, in absolutely ideal surplus conditions (Volynets, 2021). For example, at Delft University of Technology (Netherlands), students use virtual labs to test their designs and self-developed products in a digital environment. This stage of educational work precedes physical prototyping. At MIT Media Lab (USA), students use virtual reality to create innovative design solutions and products and test them (Zayed et al., 2022).

Learning Analytics is a method that involves using data about students' learning to improve the educational process. It allows for tracking students' progress and personalising learning. For example, at University College London (England), learning analytics tracks students' success in design projects and adjusts teaching strategies based on the collected data. At Universitat Politècnica de València (Spain), data analytics is applied to analyse the effectiveness of different design teaching methods and to implement optimal practices.

We used the following diagram (Figure 1) to illustrate the integration of these innovative approaches.

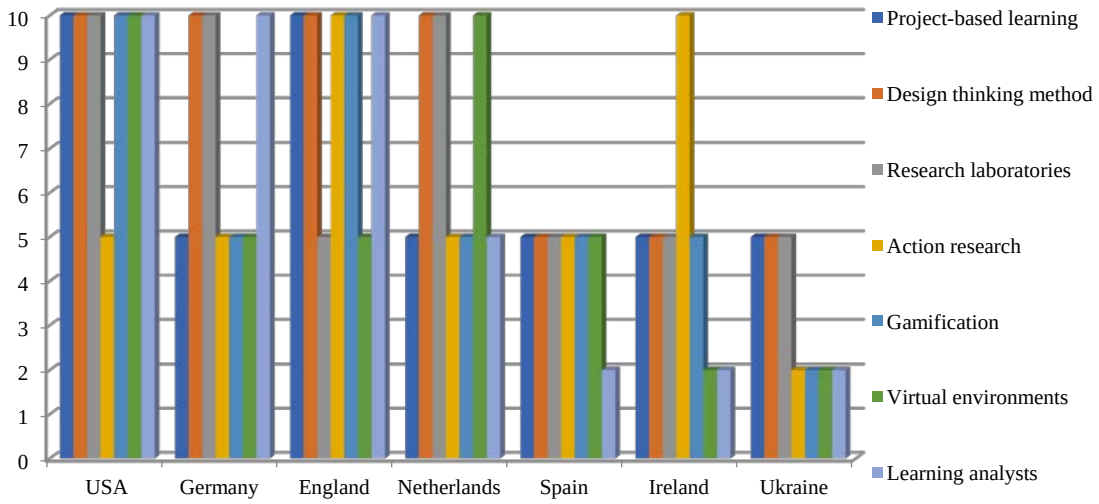

Figure 1: Analytical map
Source: compiled by the author

The question of the main components of the design culture of future technology teachers and their formation within the framework of research activities is relevant and multifaceted. It allows us to understand which key elements need to be developed in the educational process to prepare teachers capable of an innovative approach to teaching technology and how research activities contribute to this development. The main components of the design culture of future technology teachers are creativity and innovative thinking (the development of the ability to generate new ideas, experimentally test them, and implement them in practice. Within the framework of research activities, creativity is formed through participation in projects aimed at developing new pedagogical methods and technologies); technological literacy (knowledge of modern technologies and the ability to use them is the foundation for the effective implementation of design approaches in the educational process. An important role is played by the participation of students in research projects related to advanced technologies, such as 3D printing, robotics, and the Internet of Things (IoT)); aesthetic perception and design (future teachers need to understand the basics of design and aesthetics, which will contribute to the creation of a practical and attractive learning environment. This is formed through training in visual arts, graphic design, and participation in projects where visual learning materials need to be developed); sociocultural competence (considering cultural and social aspects in the study of technology. This includes developing skills in working with different groups of students and considering their cultural characteristics. Research activities allow the study of the impact of cultural factors on the perception of technology); pedagogical mastery (it is essential to combine technological knowledge with pedagogical skills, which allows for the effective transmission of knowledge. Implementing this principle is ensured through participation in pedagogical experiments, development and the introduction of new teaching methods.

When considering the issue of forming the components of design culture through research activities, one cannot overlook the introduction into educational practice of such elements as project-based activities, scientific research, international internships, and exchanges. Through the analysis of these components, design culture examines how design knowledge is formed and developed and how this knowledge influences the design activities of specialists who are its carriers (Ryzhova, 2016). Researchers should consider each component a separate unit. Therefore, project-based activities involve future

technology teachers developing and implementing educational projects to create new teaching materials or methods. This enables students to develop creativity, technological literacy, and pedagogical skills. Including scientific research in the educational process involves researching pedagogy and technology. This helps develop critical thinking, analytical, and synthesis skills and improve technological and sociocultural competence. International internships and exchanges contribute to the participation of students in international programmes, allowing them to become acquainted with advanced practices in the fields of technology and pedagogy and expand the sociocultural competence of future technology teachers.

In Ukraine, examples of educational programmes that ensure the formation of these components of design culture include the "Software Engineering and Robotics" programme (National University "Lviv Polytechnic"), the "Educational and Pedagogical Sciences" programme (Taras Shevchenko National University of Kyiv). The Lviv Polytechnic University programme combines modern technology education with pedagogical courses that prepare students for teaching (Ministry of Education and Science of Ukraine, 2024), while the Taras Shevchenko National University of Kyiv programme is focused on integrating modern technologies into education, including information technology, forming both pedagogical and technological competence. As for other countries, in the USA, the "Technology, Innovation, and Education" programme (Harvard Graduate School of Education) focuses on studying the impact of technology on education and developing innovative educational technologies; in the Netherlands, the "Educational Sciences and Technology" programme (University of Twente) is oriented towards researching and developing the latest educational technologies with an emphasis on the design and implementation of learning environments; in Taiwan, the "Master in Educational Technology" programme (National Taiwan Normal University) focuses on integrating technologies into teaching and researching the impact of these technologies on the educational process. These programmes contribute to forming a design culture through theoretical learning, practical activities, and active research (Zakharchuk, 2021).

The integration of research activities into the training process of future technology teachers is a crucial aspect of forming their professional competence. However, this process is accompanied by several challenges that may affect the effectiveness of education and professional training. Researching these difficulties and finding ways to overcome them is significant, especially in the context of rebuilding education in Ukraine after the large-scale war waged by Russia on Ukrainian territory on 24 February 2022.

Regarding the challenges of integrating research activities, it is essential to highlight the issue of resources. Effective research requires significant funding, equipment, and access to modern technologies. In many cases, Ukrainian educational institutions may not have sufficient resources, which limits the opportunities for conducting high-quality research. Due to insufficient funding or lack of access to international databases, students and teachers may face difficulties obtaining up-to-date scientific information, complicating high-level research. Teachers, who are supposed to ensure the integration of research activities into the educational process, may lack sufficient research experience, and the quality of educational services provided significantly affects students (Torres et al., 2011). This can reduce student learning quality and engagement in scientific activities. Including research activities may burden students, who already have much theoretical and practical material to study. This can lead to decreased motivation and productivity. It is also essential to consider that not all students are interested in research activities or do not see their relevance to their future professional activities, which reduces their engagement and the quality of their research work.

All these challenges can be represented in a diagram (Figure 2).

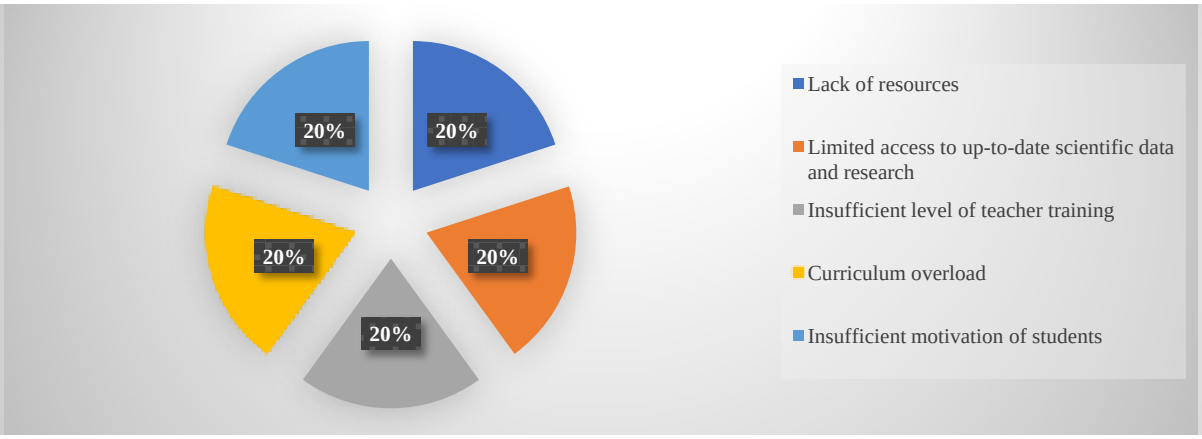

Figure 2: Difficulties of integrating research activities into the educational process of training future technology teachers
Source: compiled by the author

The issue of overcoming challenges is relevant not only for Ukraine. It has also arisen and been addressed in many developed countries. An example of successfully overcoming the challenges of integrating research activities into the educational process for training future technology teachers can be seen in Finland. The Finnish education system is known for its flexibility and focus on an individual approach. Teachers are given considerable autonomy in developing curricula, allowing for integrating research activities into the educational process without overloading students. This is achieved through a balance between theoretical knowledge and practical activities.

In the United States, involving students in research projects through particular internships and research assistantship programmes is widespread. This allows students to gain experience in fundamental research during their studies, enhancing their competence and motivation. Universities in the Netherlands actively develop cooperation with businesses, which allows students to be involved in applied research projects. Thanks to this approach, the significance of the research conducted by students is enhanced, which in turn provides them with the opportunity to acquire practical skills in their field.

The presence of such positive examples, as seen in leading countries worldwide, indicates the existence of strategies to overcome the challenges of integrating research activities into the educational process. From this, the strategy includes specific structural elements, which determine the degree of its implementation. These include increased funding and resource allocation, the improvement of teacher qualifications, collaboration with international educational and research institutions, implementing flexible educational programmes, and motivating students through project-based learning.

Ukraine should incorporate each structural element into its post-war recovery plan to ensure its implementation. Specifically, Ukraine could focus on attracting international aid and investment to develop educational infrastructure. This includes modernising laboratories, access to international research databases, and acquiring modern equipment (Almenara & Osuna, 2018).

In addition, an important aspect is the regular training and internships for teachers, particularly abroad, which will help to enhance their competence in the field of research. Such practices will allow teachers to improve students' support quality for conducting research and integrate the research component more effectively into the educational process. By implementing this practice, universities in Ukraine would have the opportunity to develop cooperation with international partners actively (Yaroshenko, 2016). This is an excellent way for students and teachers to participate in joint research projects with scientists from leading countries, gaining access to the latest knowledge and technologies. Furthermore, reforming curricula to combine theoretical learning with research activities more flexibly would help reduce student overload and increase their motivation for research. Finally, incorporating research projects into academic courses with actual tasks and the possibility of practical application of the results will increase students' motivation for scientific activities. After all, it is not only external incentives that should determine the quality of professional activity but also the desire of specialists for self-development (Ilina et al., 2019).

Considering the experience of developed countries and the specifics of post-war reconstruction, Ukraine could adapt these practices to its conditions. Necessary steps could include:

- Attracting international grants and investments for the development of educational infrastructure, which includes the purchase of modern equipment and the creation of conditions for research;
- Developing public-private partnerships in the field of education, which will allow for the attraction of additional resources and the implementation of innovative approaches to education;
- Implementing national programmes to support young researchers, including financial support, access to resources, and internships abroad, which, in turn, will help overcome the shortage of experienced researchers and teachers.
- Overall, integrating research activities into the training of future technology teachers can significantly improve the quality of education in Ukraine and contribute to the development of innovative approaches to teaching technological disciplines. Moreover, it can increase the level of independence of future workers, their awareness of the importance of prioritising tasks, and their ability to use their time with maximum efficiency (Bakhov et al., 2021).

5 Discussion

While preparing this article, we delved deeply into the topic. However, to fully address the issue of Ukraine's prospects in integrating research activities into the formation of the design culture of future technology teachers, it is necessary to consider several additional questions. These questions will help to understand the critical aspects and challenges that remain unexplored or insufficiently covered. New queries from previous ones should be answered for a thorough analysis. Among them, the first is the question of the impact of the current economic situation in Ukraine on funding research activities in education. What role does government policy play in promoting the integration of research activities into the educational process? How can the Ukrainian diaspora and international organisations be engaged in supporting research activities in Ukraine? What innovative teaching methods can be implemented to enhance the effectiveness of forming a design culture? What is the role of international exchanges and internships in shaping the design culture of future technology teachers? How can the experience of developed countries be adapted to Ukrainian realities? What success indicators can be used to assess the effectiveness of integrating research activities? How can equal access to research activities be ensured for students from different regions of Ukraine?

These questions allow us to broaden Ukraine's vision of its educational prospects and create a roadmap for overcoming the challenges associated with integrating research activities into the training of future technology teachers. This will contribute to the development of design culture and the overall improvement of the quality of education in Ukraine.

6 Conclusions

Research activity is a powerful tool for shaping the design culture of future technology teachers. It contributes to developing critical thinking, stimulates creativity, fosters aesthetic perception and understanding of interdisciplinary connections, and allows future teachers to master the latest technologies (Holovkova & Yermak, 2021). Different countries' experiences show that integrating research practices into the educational process significantly improves the quality of teacher preparation and makes them competitive globally.

The choice of effective methods and approaches for developing design culture in students depends on the learning context and the programme's specifics. Project-based learning, design thinking, research laboratories, action research, gamification, virtual environments, and learning analytics – all these methods have advantages and can be used to achieve different educational goals. It is important to adapt these approaches according to the student's needs and the educational process conditions to maximise the effect in developing design culture. Moreover, their application is practised in other countries. Adapting the experience of developed countries requires a critical approach, considering Ukrainian realities and potential challenges that may arise during its implementation (Radchenko et al., 2023). At the same time, defining success indicators and ensuring equal access to opportunities are necessary steps to evaluate and ensure the effective integration of research activities.

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Primary Paper Section: A

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