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Steam integration of Petrykivka painting in design courses with the development of parametric ornaments

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Abstract. *In the educational paradigm, STEAM education is considered an innovative approach to training specialists in creative industries that integrates science, technology, engineering, art, and mathematics. The article substantiates the feasibility of implementing STEAM principles in the professional training of designers by engaging national artistic heritage – Petrykivka painting – as a fundamental cultural code of Ukrainian visual art. It is noted that the use of digital technologies and parametric modeling in the educational process enables the integration of traditional artistic techniques with modern design tools, fostering a new type of creative thinking.* ***Purpose.*** *The purpose of the study is to determine the theoretical and methodological foundations for integrating Petrykivka painting into design courses and to develop a pedagogical model for creating parametric ornaments using digital tools.* ***Methods****. The methodological framework includes systemic, culturological, and activity-based approaches, as well as methods of*

comparative analysis, pedagogical modeling, computer design, and experimental verification of the effectiveness of the proposed solutions. ***Results.*** *The study resulted in a conceptual model of STEAM-integrated traditional ornamental art in the educational process, promoting the development of creativity, digital competence, and aesthetic awareness among future designers. An authorial algorithm for creating parametric ornaments was proposed, based on the principles of modularity, symmetry, and variability, enabling the combination of elements of the Petrykivka style with parametric technologies. Experimental testing proved the effectiveness of the integrative approach in developing professional and interdisciplinary competencies.* ***Conclusions.*** *It is emphasized that STEAM integration of national artistic traditions into design courses not only contributes to the innovative development of art education but also strengthens students' cultural identity, expanding the possibilities for their creative self-expression in a digital environment.*

Keywords: *vocational education, digital technologies, creativity, cultural identity, pedagogical modeling.*

STEAM інтеграція петриківського розпису в курсах дизайну з розробленням параметричних орнаментів

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Анотація. *У освітній парадигмі STEAM-освіта розглядається як інноваційний підхід до підготовки фахівців творчих індустрій, що забезпечує інтеграцію науки, технологій, інженерії, мистецтва та математики. У статті обґрунтовано доцільність упровадження принципів STEAM-освіти у професійну підготовку дизайнерів шляхом залучення національної художньої спадщини – петриківського розпису – як базового культурного коду українського візуального мистецтва. Зазначено, що використання цифрових технологій і параметричного моделювання в освітньому процесі дає змогу поєднати традиційні художні техніки з сучасними засобами проєктування, формуючи новий тип креативного мислення.* ***Мета*** *дослідження полягає у визначенні теоретико-методологічних засад STEAM-інтеграції петриківського розпису в навчальні курси дизайну та розробленні педагогічної моделі створення параметричних орнаментів із використанням цифрових інструментів.* ***Методи.*** *Методологічну основу дослідження становлять системний, культурологічний і діяльнісний підходи, а також методи порівняльного аналізу, педагогічного моделювання, комп'ютерного проєктування та експериментальної перевірки ефективності запропонованих рішень.* ***Результати.*** *У результаті дослідження сформовано концептуальну модель STEAM-інтеграції традиційного орнаментального мистецтва в освітній процес, що забезпечує розвиток креативності, цифрової компетентності й естетичної свідомості майбутніх дизайнерів. Запропоновано авторський алгоритм створення параметричних орнаментів, побудований на принципах модульності, симетрії та варіативності, що дозволяє поєднати елементи петриківського стилю з параметричними технологіями. Експериментальна апробація довела ефективність інтегративного підходу у формуванні професійних і міждисциплінарних компетентностей.* ***У висновках*** *підкреслено, що STEAM-інтеграція національних художніх традицій у курсі дизайну не лише сприяє*

інноваційному розвитку мистецької освіти, але й підсилює культурну ідентичність здобувачів, розширюючи можливості їхнього творчого самовираження в цифровому середовищі.

Ключові слова: *професійна освіта, цифрові технології, креативність, культурна ідентичність, педагогічне моделювання.*

Problem statement. Currently, art education is undergoing transformation due to the active introduction of digital technologies and interdisciplinary approaches to training specialists in the creative industries. One of the promising areas of innovative development of the educational process is STEAM education, which combines science, technology, engineering, art, and mathematics, ensuring the development of students' ability to think creatively, experiment, and integrate knowledge from different fields. At the same time, the current task remains the search for effective ways to combine traditional artistic techniques with modern digital design tools.

Petrykivka painting, as a phenomenon of Ukrainian decorative and ornamental art, is a unique cultural code that combines artistic tradition, aesthetic principles and national identity. However, its potential as a teaching tool in modern design courses remains underexploited, especially in the context of digital and parametric technologies.

The problem is that existing approaches to integrating traditional art into design education mainly focus on reproducing samples rather than on creative rethinking through modern technological means. Pedagogical models that would allow the development of interdisciplinary competencies in future designers, combining cultural heritage, digital creativity, and innovative thinking, remain insufficiently developed.

Therefore, it is relevant to study the theoretical and methodological foundations of STEAM-integration of Petrykivka painting into the educational

process for training designers using parametric technologies, which will contribute to the development of creativity, aesthetic perception, and the digital culture of future specialists.

Analysis of recent research and publications. The integration of STEAM education and the use of national artistic traditions in design courses is the subject of active scientific discussion. In particular, O. Kurtseva [1] explores the eclecticism of Ukrainian ornament in the design of educational websites in Ukraine, emphasizing that the use of traditional motifs fosters students' creative thinking and the development of visual culture in the digital environment. W. Liu and O. Kolisnyk [2] analyze parametric modeling as an innovative approach in graphic design and emphasize its potential to combine digital technologies with artistic heritage, thereby expanding the possibilities for design creativity. M. Nesterenko and co-authors [3] consider STEM education as an effective means of developing interdisciplinary competencies and practical skills of students of pedagogical universities, emphasizing the need for practice-oriented learning. T. Posnova, V. Ziatkovskyi [4] and A. Ovchatova [5] analyze the implementation of STEAM principles in the national education system of Ukraine, drawing attention to the prospects for modernizing the content of education, strengthening interdisciplinary connections and the need for systemic support for innovative programs. N. V. Soroko, L. A. Mykhailenko, O. G. Rokoman, and V. I. Zaselskiy [6] investigate electronic platforms and pedagogical models for the development of creative abilities, demonstrating that integrating digital resources into STEAM education increases students' motivation and supports individual development trajectories. O. Kudria [7] analyzes STEAM projects in technological education in the field of design and decorative arts, emphasizing the importance of combining digital technologies and creative methods for training a new generation of specialists. V. Solovey, V. Hlukhaniuk, and I. Shymkova [8] consider STEAM projects in the training of future teachers, emphasizing the importance of practice-oriented learning and

interdisciplinary interaction. I. Shymkova, S. Tsvilyk and V. Harkshevskyi [9] investigate the development of creative abilities through the STEAM approach and believe that its implementation contributes to the formation of creative thinking and innovative pedagogical culture. M. G. Bertrand and I. K. Namukasa [10] emphasize that STEAM education develops transferable skills that enhance students' readiness for professional activity in a rapidly changing environment. D. Febriansari, Sarwanto and S. Yamtinah [11] point to the high potential of a combined educational model that integrates STEAM and design thinking to train specialists in both engineering and creative professions. O. Skaskiv, N. Chuprina [12] investigate the introduction of elements of traditional art into modern design collections, emphasizing the importance of cultural heritage as a source of inspiration for new artistic and design solutions. V. Usov [13] considers STEAM as an innovative technology of design education, emphasizing the importance of integrating artistic, engineering and technological components for the formation of creative and technically competent specialists in the field of design. I. Caetano, L. Santos and A. Leitão [14] consider computer design as the basis for the development of parametric, generative and algorithmic modeling, emphasizing that such approaches form a new paradigm in the creative process, where the designer interacts with the algorithm as a partner in creating a form. R. Danhaive and C. T. Mueller [15] demonstrate that generative modeling based on machine learning allows for expanding the design space and carrying out structural optimization of projects, opening up prospects for the automation of aesthetically and functionally balanced solutions in digital design.

The above-mentioned studies provide a scientific basis for the development of practical and theoretical approaches to integrating national artistic traditions, digital technologies, and parametric design into the educational process of design courses.

Identification of previously unresolved parts of the general problem. Despite the significant number of studies on integrating STEAM education and

applying national artistic traditions in design courses, several aspects remain worthy of further study. Existing works mainly focus on individual technological solutions, comparisons of digital platforms, and demonstrations of individual examples of the use of Petrykivka painting, while a comprehensive analysis of the integration of traditional art with parametric modeling in the educational process of design courses remains insufficient.

Special attention should be paid to developing methods for integrating digital technologies with national artistic heritage, and to the impact of these approaches on creativity, digital competence, and students' aesthetic consciousness. Most studies are limited to theoretical models or individual experiments in educational laboratories, without considering comprehensive implementation in the educational process, which creates gaps in understanding the effectiveness of the integrative approach. The reasons these aspects remain unresolved are limited empirical data on the practical application of parametric modeling in combination with Petrykivka painting, the dispersion of pedagogical approaches, and the lack of systematic methods for implementing STEAM projects in design courses. The study of these issues will help determine the real effects of combining national artistic traditions and digital tools on the educational process and the development of professional skills among future designers.

Formulation of the objectives of the article (task statement). The purpose of this study is to theoretically substantiate integrating Petrykivka painting into design courses based on STEAM principles and the development of parametric ornaments using digital technologies.

To achieve this goal, the following tasks are planned:

1. To analyze the ways of combining traditional Petrykivka ornament with modern digital tools in design training courses;

2. To identify the characteristic patterns, compositional features and structural elements of Petrykivka painting, which can be used to create parametric ornaments;

3. To create an algorithm for generating parametric ornaments based on Petrykivka painting motifs, which combines traditional compositional principles with digital technologies and can be used in various design projects;

4. To develop recommendations for the effective combination of Petrykivka painting with digital tools for creating parametric ornaments and educational design projects.

Presentation of the main material of the study. The integration of national artistic traditions into modern STEAM education provides a wide range of opportunities for students in design specialties to develop creativity, digital competencies, critical thinking, and aesthetic awareness. Petrykivka painting, as one of the most striking examples of Ukrainian decorative and applied art, has a rich symbolic, compositional and coloristic potential that can be transformed for the digital environment, including through parametric modeling and algorithmic generation of ornaments.

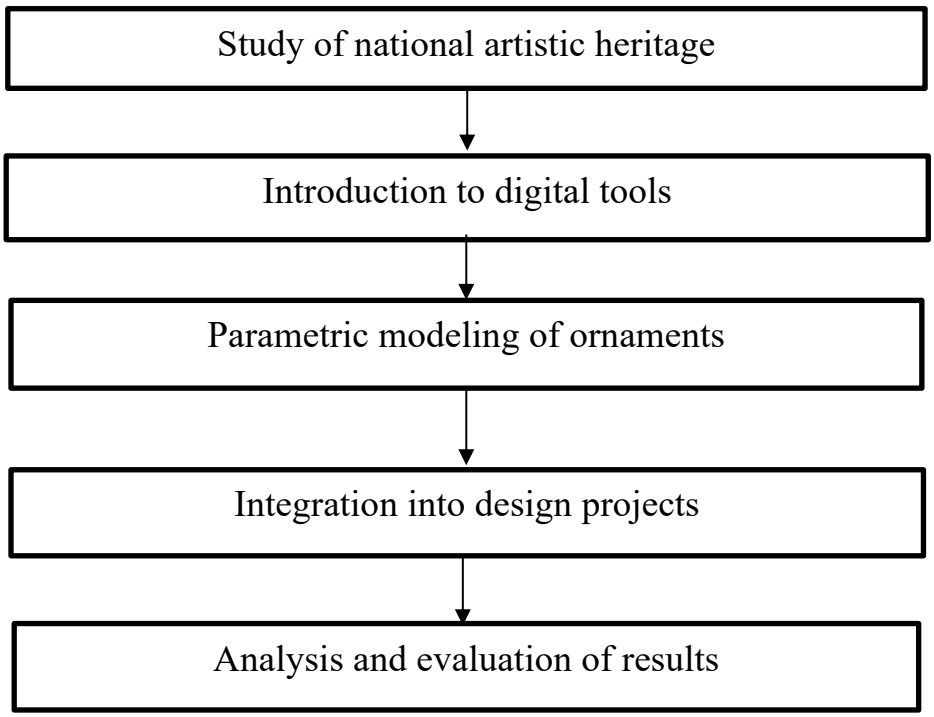
In the educational process, combining traditional art with digital tools enables students to develop interdisciplinary competencies. For example, using parametric modeling in graphic editors fosters logical and algorithmic thinking, and working with digital tablets and 3D modeling programs enhances technical literacy and practical visualization skills. The principles of STEAM education – the integration of science, technology, engineering, art, and mathematics – ensure the development of the ability to generate innovative design solutions that simultaneously meet aesthetic and functional requirements.

In particular, in practical design projects, students can create digital parametric ornaments that adapt Petrykivka painting motifs for decorative panels, interior elements, UI/UX design, or textile collections. Such cases demonstrate how traditional artistic principles – rhythm, modularity, compositional dynamics – are effectively combined with modern digital methods, strengthening both the creative and technical training of future designers.

The use of parametric modeling based on Petrykivka painting motifs enables the creation of variable ornaments that combine traditional compositional principles with the capabilities of digital technologies. The use of digital tools ensures the modularity, symmetry, and adaptability of compositions, allowing students to experiment with form, rhythm, and color across various design projects. Each stage of work is aimed at developing creative thinking, digital competencies and the ability to apply the acquired knowledge in practical design activities [9, p. 180]. Figure 1 shows the sequence of stages for integrating the Petrykivka painting into the design course educational process.

Figure 1

Stages of integrating Petrykivka painting techniques into design courses using digital technologies and STEAM principles



Source: developed by the author

At the first stage, students study the national artistic heritage, get acquainted with the history and characteristic elements of Petrykivka painting, and analyze traditional compositional techniques and color solutions. The second stage consists

of getting acquainted with digital tools: graphic editors, parametric modeling programs, and other technologies that enable transforming traditional motifs into digital form. The next stage includes parametric modeling of ornaments, providing modularity, symmetry, and principles for traditional painting, with the ability to automatically generate different composition options. The fourth stage involves integrating the created digital ornaments into real design projects, such as graphic compositions, textile patterns, decorative objects, or layouts. The final stage includes analysis and evaluation of the results: a critical discussion of the resulting compositions, an assessment of their aesthetic value, and an evaluation of the accuracy and creativity of reproducing traditional motifs in the digital environment.

The integration of all stages allows students to develop a systemic understanding of the interaction between traditional art and digital technologies, while simultaneously developing the creative and technical skills necessary to create adaptive parametric ornaments across various design projects.

The introduction of digital tools into the study of traditional art provides variability and modularity in ornaments, allowing you to experiment with composition, color combinations, and forms without losing the authenticity of the style. Thanks to this, students learn to evaluate their own work critically and their classmates' work, discuss compositional solutions, and improve them based on feedback, thereby increasing their aesthetic and professional competence [10, p. 50].

The implementation of STEAM education principles in these projects involves the integration of science and technology for the analysis and generation of parametric models of ornaments, the use of engineering approaches for structural planning of compositions, the use of art for creative expression and aesthetic processing of forms, as well as mathematical concepts for building symmetry, rhythm and proportions in ornaments. For example, students create digital panels and textile elements in which Petrykivka painting motifs are adapted through

parametric modeling, or develop interior and graphic compositions using algorithmic generators of shapes and colors.

An essential aspect of the educational process is identifying the key principles and structural elements of Petrykivka painting that can be used to create parametric ornaments. The analysis of the Petrykivka painting allowed us to identify characteristic patterns, compositional features and structural elements that can be used to create parametric ornaments. The main structural elements include flowers, leaves, curls, spirals and geometrized motifs that can serve as a modular base for building variable compositions.

The compositional principles of Petrykivka painting include symmetry, rhythmic alternation of motifs, balance of colors and proportions, and a dynamic arrangement of elements in space. Compliance with these principles in parametric modeling ensures harmony and integrity of the created ornaments.

The color patterns of traditional painting combine contrasting and harmonious colors within the traditional palette, allowing you to preserve the stylistic identity of the motifs. The use of these patterns in a digital environment allows students to create variable ornaments that adapt to modern design tasks, while preserving the characteristic features of the national artistic heritage. Students become acquainted with characteristic motifs and analyze the patterns of their construction and the interaction of color accents. Systematization and classification of traditional forms lay the foundation for transferring motifs into digital form, taking into account the modularity, symmetry, and variability of compositions. At the same time, students master the use of specific digital tools to transform traditional motifs into parametric models. Such programs include Rhino with the Grasshopper plugin, Fusion 360, FreeCAD, and OpenSCAD, which provide modularity, symmetry, and compositional flexibility. The use of these tools allows students to experiment with the form, color and structure of ornaments, while maintaining the authenticity of the style and developing technical and design competence.

The combination of theoretical knowledge with practical skills develops students' interdisciplinary competencies, creativity, and technical literacy. It allows them to create original design solutions that reproduce the national artistic heritage in a modern digital environment. The use of such methods enriches the educational process and contributes to the popularization of Ukrainian culture by integrating traditional art with modern technologies [11, p. 216].

The use of methods for integrating Petrykivka painting with digital tools enables students to undertake various design projects while mastering modern technologies and preserving traditional artistic principles. Parametric modeling, working with color and composition, stimulates the development of creative and technical competencies, and the created digital panels, graphic compositions and decorative elements contribute to the popularization of Ukrainian cultural heritage in a modern design environment [12, p. 63].

Key methods and software tools have been identified for integrating Petrykivka painting with digital tools [13], enabling students to implement modern design projects using traditional motifs. Table 1 presents the primary methods of integrating technological solutions for creating parametric ornaments, as well as the expected results of their application in educational projects (table 1).

Table 1

Methods of integrating Petrykivka painting with digital tools

Combination method	Used digital tools	Expected result	Application example
Digital scanning of traditional motifs	Scanner, Photoshop	Obtaining the basic digital form of the ornament	Creating the basis for parametric modeling
Creating vector contours	Illustrator, CorelDRAW	Modular elements for compositions	Use in graphic compositions and textiles
Parametric modeling	Grasshopper, Rhino	Automatic generation of ornament variations	Development of variant patterns for decorative objects

Color experiments	Photoshop, Krita	Selection of harmonious palettes	Application in textile and packaging design
Integration into design projects	Canva, Figma	Using ready-made ornaments in layouts	Creation of posters, packaging, and interior elements

Source: author's own development

The integration of Petrykivka painting with digital tools into design courses enables the combination of traditional artistic motifs with innovative modeling methods. The proposed methods provide a comprehensive approach to implementing design projects and contribute to the preservation of national cultural heritage in digital form [14, p. 293]. At the same time, the use of parametric technologies and modern graphic programs increases students' digital literacy, stimulates the development of systemic thinking and analytical skills, and also forms their readiness for creative experimentation. As a result of integration, cultural heritage acquires new forms of visualization, and the educational process becomes interdisciplinary.

Based on the processed literature data, we propose an algorithm for creating parametric ornaments based on the principles of modularity, symmetry, and variability. The algorithm includes the following stages: analysis of artistic motifs in Petrykivka painting, creation of basic elements in vector form, and parameterization of modules with the ability to adjust proportions, rotations, the number of repetitions, and color. The final stage is the construction of symmetrical or fractal structures and the coordination of digital composition with the aesthetics of traditional painting. The sequence of stages ensures an organic integration of decorative stylistics with parametric modeling technologies, expanding the possibilities of artistic expression and developing students' ability to individualize design solutions.

Thus, the use of parametric methods in the educational process contributes to the development of spatial and analytical thinking among future designers, as well

as skills in structural modeling and in working with form, rhythm, and color. The combination of digital tools with the principles of traditional composition stimulates creativity and forms sustainable skills in working with ornamental form.

The results of testing STEAM methods in the study of ornamental art, presented in scientific sources [15], confirm the effectiveness of this approach for the development of professional competencies of applicants to design education programs. The data indicate an increase in technical training, analytical skills, and students' ability to creatively interpret ornamental heritage through parametric modeling creatively.

Therefore, the results indicate that integrating Petrykivka painting with digital technologies is an effective means of developing professional, analytical, and cultural competencies in future designers. This approach ensures the preservation of national values, supports the continuity of artistic tradition and contributes to the innovative development of art education.

Conclusions. The study demonstrated the effectiveness of integrating Petrykivka painting into educational design courses using digital technologies and STEAM principles. Digital scanning, parametric modeling, and color experiments contribute to the formation of technical literacy, systemic and analytical thinking, aesthetic perception, and the ability to generalize among students.

Working with parametric ornaments allows students to experiment with form, rhythm, and color, while preserving the characteristic features of traditional Petrykivka painting. The combination of digital tools with the principles of modularity, symmetry, and compositional variability fosters creativity, critical thinking, and readiness for innovative design activities.

Organizing the educational process around these principles fosters the development of interdisciplinary competencies and the comprehensive application of knowledge in practical tasks. Further research should focus on scaling digital

techniques to other design and decorative arts courses and on assessing their impact on the long-term development of students' professional and cultural competence.

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