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Adaptation of augmented reality technologies to the educational process of training graphic designers

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Abstract. *The relevance of the study is driven by the need to update the content and tools of professional training for graphic designers in the context of the digital transformation of the educational environment. Given the growing role of interactive and visually oriented technologies in the field of communications, the integration of augmented reality (AR) into educational programs is gaining particular importance. The* ***aim*** *of the article is to provide a scientific justification for the implementation of AR technologies in the training of specialists in graphic design, taking into account the specifics of professional activity and the current demands of the visual content market. The* ***methodological basis*** *includes structural-functional and competence-based approaches, supported by methods of comparative analysis, systematization of educational models, theoretical modeling, and empirical generalization of AR integration practices. The study also considers the specifics of cognitive load in visual environments and the features of spatial thinking in design*

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activities. ***Results.*** *The study analyzes the didactic conditions and technical prerequisites for the effective application of AR in design education, classifies educational models for the development of professional competencies using AR, and identifies key barriers to the implementation of such technologies. The scientific novelty lies in the proposed system of conceptual parameters for building AR-based learning environments aimed at developing design skills in a digital context.* ***Conclusions.*** *It has been proven that the full integration of AR into the content of professional designer training requires the methodological adaptation of curricula, the modernization of technical infrastructure, and the enhancement of instructors' digital competence. Recommendations have been formulated regarding the structural integration of AR into interdisciplinary educational modules and the implementation of typical interaction models and scenarios. Prospects for further research include the development of tools for quantitatively assessing the effectiveness of AR components, as well as the experimental analysis of their impact on the development of creative thinking and visual design skills within a virtualized educational environment.*

Keywords: *visual communication, digital educational technologies, interactive learning, professional competence, design environment.*

Адаптація технологій доповненої реальності до освітнього процесу підготовки графічних дизайнерів

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Анотація. *Актуальність дослідження зумовлена потребою в оновленні змісту та інструментарію професійної підготовки графічних дизайнерів у контексті цифрової трансформації освітнього середовища. З огляду на зростаючу роль інтерактивних і візуально-орієнтованих технологій у сфері комунікацій, інтеграція доповненої реальності (AR) у навчальні програми набуває особливої значущості.* ***Метою*** *статті є наукове обґрунтування можливостей впровадження AR-технологій у підготовку фахівців у галузі графічного дизайну з урахуванням особливостей професійної діяльності та актуальних вимог ринку візуального контенту.* ***Методологічну основу*** *становлять структурно-функціональний та компетентнісний підходи, використано методи порівняльного аналізу, систематизації освітніх моделей, теоретичного моделювання та емпіричного узагальнення практик AR-інтеграції. У процесі дослідження враховано специфіку когнітивного навантаження візуального середовища та особливості просторового мислення в проєктувальній діяльності.* ***Результати.*** *У ході наукової роботи проаналізовано дидактичні умови та технічні передумови ефективного застосування AR у вивченні дизайну, класифіковано освітні моделі формування професійних компетентностей із використанням AR, виявлено основні бар'єри її впровадження. Науковою новизною є запропонована система концептуальних параметрів побудови AR-середовищ, орієнтованих на набуття дизайнерських навичок у цифровому контексті.* ***Висновки.*** *Доведено, що повноцінна інтеграція AR у зміст професійної підготовки дизайнерів потребує методичної адаптації навчальних програм, оновлення технічної бази та підвищення цифрової компетентності викладачів. Сформульовано рекомендації щодо структурної інтеграції AR у міждисциплінарні освітні модулі, впровадження типових сценаріїв і моделей*

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взаємодії. Перспективи подальших досліджень полягають у розробленні інструментів кількісного оцінювання ефективності AR-компонентів, а також в експериментальному аналізі їх впливу на формування креативного мислення та візуального проєктування в умовах віртуалізованого освітнього середовища.

Ключові слова: *візуальна комунікація, цифрові освітні технології, інтерактивне навчання, професійна компетентність, дизайнерське середовище.*

Problem statement. In today's dynamic development of digital technologies, there is a growing need to update educational approaches to training specialists in the field of graphic design, who must possess not only traditional means of visual communication but also the latest interactive tools. One such technology is augmented reality (AR), which opens up new opportunities for visualization, modeling, and immersion in the professional environment within the educational process. However, its effective implementation in the professional education system requires a comprehensive understanding of methodological, technical, and didactic aspects.

The problem lies in the insufficient adaptability of educational programs to the specifics of using AR as a means of integrating theoretical knowledge and practical activities of future graphic designers. Modern training courses rarely provide for the systematic use of AR technologies, which reduces their relevance to market requirements and limits the opportunities for students to master innovative formats of visual design. In this context, scientific substantiation of pedagogical conditions and methods that ensure the effective inclusion of AR in the process of professional training, as well as the development of interactive interaction models

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capable of stimulating the growth of creative potential and critical thinking of applicants, becomes relevant.

Analysis of the latest research and publications. Analysis of scientific works devoted to the adaptation of AR technologies to the educational process of training graphic designers allows us to distinguish four key content areas.

The first area focuses on the pedagogical potential of AR technologies in the development of professional competencies of designers. In the work of O. Krutova, it is emphasized that AR is not only a visual tool, but also a didactic tool for the formation of creative thinking, in particular through interactive packaging as an object of educational analysis [1]. S. V. Borisova examines in detail the structure of professional competencies, pointing out the importance of digital tools, in particular AR, for the development of design and compositional thinking [2]. N. E. Kolesnyk, T. V. Shostachuk, and A. P. Maksymchuk explore the combination of theoretical foundations of design with AR tools that stimulate creativity and dynamic thinking [3]. Publication N. E. Kolesnyk, G. V. Kunytsya, D. R. Pogosyan complements this approach with an example of acquiring skills in working with animation and visual content based on AR and multimedia technologies [4]. A. Meshko emphasizes the importance of artistic and graphic activity, which AR transforms from passive perception into creative and active interaction [5]. In this direction, it is advisable to further study the typology of competencies that are formed precisely thanks to AR and to develop models for their assessment in the educational process. The second direction covers the practical experience of implementing AR in the creative practices of designers. V. Kozik, V. Mykytenko, and T. Belyanska outline real cases of interaction between designers and augmented reality technology, emphasizing its advantages for creating interactive branding [6]. A. Huda et al. characterize AR as a means of preparing for the requirements of Industry 4.0, indicating its importance

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for adapting students to the labor market [7]. N. Derevyanko and O. Zalevska analyze the integration of additive technologies into the graphic design learning process, where AR contributes to the innovative understanding of objects [8]. The issue of determining the competency models of adaptation of design students to the changed requirements of the industry requires further development. The third direction is related to the development of students' multimedia and visual skills through AR content. H. Chemerys, A. Vynogradova, H. Briantseva, and S. Sharov propose a strategy for implementing immersive technologies into the professional training of future designers, focused on multi-channel information perception [9]. T. I. Mohamed and A. Sicklinger demonstrate the structure of integrated courses, where AR and VR are used to model the design environment in hybrid learning conditions [10]. N. Hu considers a practical model of integrating AR into the graphic design curriculum, focusing on increasing the effectiveness of learning [11]. It is advisable to further study the methods of optimizing multimedia content in AR for different stages of professional training.

The fourth direction concerns the instrumental and technical aspects of implementing AR in design. Ö. Koçak, R. M. Yılmaz, S. Küçük, Y. Göktaş analyze the potential of augmented reality for learning, recording the experience of designers and teachers in implementing it in the educational process [12]. T. Korani, M. Saas, and S. Tan reveal the concept of augmented reality technology as an educational space for integrating visual objects in real-time in the context of graphic design training [13]. It is worth continuing to create universal technical scenarios and recommendations for integrating AR into LMS (Learning Management System) systems to optimize designer training.

In general, the analysis shows that AR is not only a tool for technological enrichment of the educational environment, but also a catalyst for updating the

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professional training of designers, which requires further comprehensive methodological and practical study.

Identification of previously unsolved parts of the overall problem. Despite the existence of individual studies in the field of professional training of graphic designers, key aspects of integrating AR into the educational process remain unresolved. The potential of AR in the formation of design competencies has not been sufficiently studied, there are no generalized educational models that would take into account the principles of visual interaction, adaptability, reflection, and project thinking. There is a shortage of methodically structured scenarios for using AR in educational courses, and there is also a lack of empirical data on its impact on the cognitive and professional results of education seekers.

Additional barriers are the lack of personnel, limited technical resources of educational institutions, and the lack of integration of AR with learning management systems. The proposed article is aimed at overcoming these challenges by arguing the didactic conditions and models of AR application, identifying problems, and developing practical recommendations. This approach makes it possible to expand the methodological and applied research base and create a basis for further systematic implementation of AR in design education.

Formulating the goals of the article (task statement). The purpose of the article is to scientifically substantiate the possibilities of adapting AR technologies to the educational process of training graphic designers, taking into account the specifics of professional activity and the requirements of the visual communications market.

To achieve this goal, the following tasks have been set:

1. To analyze the educational potential of AR as a tool for professional training of future graphic designers in the higher education system.

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2. To determine the didactic conditions and technical prerequisites for the effective implementation of AR technologies in training courses related to digital design, composition, and visual thinking.

3. To analyze the educational models for the formation of design competencies using AR and identify the most effective principles for their integration into the educational process.

4. To reveal problems that complicate the full integration of AR technologies into the content of training programs for training designers, in particular those related to methodological support, and the availability of personnel and material and technical resources.

5. Formulate scientifically based recommendations for improving the content and technological support of the educational process, taking into account the AR capabilities.

Presentation of the primary research material. AR technologies expand the boundaries of the traditional educational environment, creating prospects for immersion in the modeling of objects, space, and interaction, which is relevant for the professional training of future graphic designers. In higher education, where the formation of visual thinking, spatial imagination, compositional literacy, and digital design skills are key elements of the educational process, AR technologies can become an effective means of integrating theory and practice. AR increases motivation for learning due to interactivity and creates conditions for personalized learning through the visualization of complex concepts and the ability to reproduce educational situations in a simulated environment. This necessitates the assessment of its educational potential taking into account the goals and content of professional design training (Table 1).

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The potential of AR in the training of graphic designers lies in creating conditions for active learning through practical interaction with objects of the virtual environment, which contributes to the deeper assimilation of knowledge and the development of professional skills.

Table 1

Pedagogical functions of AR in the training of graphic designers

Function	Content description	Examples of implementation in design education
Visualization of abstract concepts	Promotes a deeper understanding of compositional principles, color theory, and spatial depth	Interactive color scheme models, perspective building in an AR application
Creating training simulations	Simulates professional situations in a virtual environment for skills training	Virtual presentation of layouts in 3D space, evaluation of UX/UI solutions
Support for adaptive learning	Allows you to adjust the difficulty and pace according to the level of the learner	Interactive AR tasks with hints for independent work
Development of interdisciplinary connections	Stimulates the integration of knowledge in IT, art and pedagogy	Projects at the intersection of graphic design and AR application programming
Formation of digital literacy	Develops the ability to work with the latest technologies and virtual tools	Using AR platforms (Adobe Aero, ZapWorks) in course design

Source: systematized by the author based on [1, p. 236; 3, p. 648-649; 6, p. 94; 9; 12, p. 19-20]

Thanks to the functions of visualizing abstract concepts, simulating real design situations, and supporting individualization of learning, AR allows students

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to consolidate complex concepts through interactive experience. Involving AR in the educational process creates opportunities for the integration of interdisciplinary knowledge and the development of digital literacy, which meets the current requirements of the modern labor market in the field of graphic design. In the practice of Ukrainian higher education institutions, AR is beginning to be introduced as an element of innovative methods of training designers. Thus, the Kyiv National University of Technologies and Design has introduced courses that involve the use of AR to create interactive projects within the framework of training specialists in visual arts [14]. Similar practices are also implemented at the Ukrainian Academy of Printing, where students use AR technologies to visualize printed products and advertising layouts during educational projects [15]. In addition, the Prometheus platform of mass open online courses offers a course “Augmented Reality” aimed at developing their own AR programs, which is useful for designers who seek to integrate AR into their projects [16].

The integration of AR technologies into the process of forming professional competencies of graphic designers requires systematic consideration of educational factors that ensure the productive use of virtual content. The conditions for the effective implementation of AR in educational courses cover several levels of interaction: cognitive, instrumental, organizational-platform, technological, and evaluative-reflective. Each of them forms a critical environment within which AR can be not only an interactive addition but also a full-fledged carrier of didactic content (Table 2).

The described conditions cover various aspects of creating an effective AR-oriented learning environment. At the cognitive level, it is important to include AR in such forms of activity where the student is not a passive observer, but interacts with the professional context, modeling graphic objects in real space. The

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instrumental environment involves providing means for dynamic editing of AR content, which allows students to directly influence the result and immediately see the consequences of their decisions. The organizational and platform component guarantees the functionality of integrating AR into the e-learning system, helping to automate the assessment and storage of projects.

Table 2

Conditions for effective integration of AR into graphic design education

Educational level of AR influence	**Specific implementation condition**	**The functional essence of the condition**	**Implementation example**
Cognitive environment	Contextual integration into professional situations	Engaging students in virtual simulations of real-world design tasks to develop thinking	AR model of packaging layout as part of a consumer product design exercise
Instrumental environment	Ability to change and manipulate the visual object	The student does not just view the AR object, but changes its shape, colors, and structure	Using Adobe Aero to create logos with visual color testing
Organizational base	AR compatibility with educational content platforms	Integrate AR tasks into LMS to ensure consistent storage and assessment of results	AR tasks in Moodle with automatic validation of 3D compositions
Visualization technology	3-D dynamic representation of knowledge	Demonstrating complex concepts in space and motion for deeper understanding	AR explanation of the concept of compositional balance with moving elements
Evaluation and reflection system	Real-time feedback	AR guarantees immediate visual feedback to the student's actions,	AR interface that shows the correct placement of

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		stimulating self-correction and analysis	graphic elements immediately after editing

Source: systematized by the author based on [4, p. 360-361; 8, p. 72-73; 10, p. 11141-11143]

The technological component is of particular importance in design education since the visualization of complex compositions, color solutions, and structural changes in space is key to the formation of visual thinking. The effectiveness of AR tools increases significantly when real-time feedback functions are included, which allow students to independently analyze and correct the results, thereby increasing the level of reflection and visual literacy. In the modern professional education of graphic designers, there is a shift in emphasis from knowledge transfer to the development of competencies, which involves not only mastering the theory but also the ability to apply it in new situations. AR technologies support such approaches by creating conditions for modeling real professional contexts, visual experimentation, and flexible feedback. In this regard, the analysis of educational models that use AR for the systematic construction of competency-based learning, in particular through the implementation of the principles of interactivity, visual immersion, design, and adaptation, is relevant.

The competency-based approach in graphic design is developing the ability to work with visual solutions, understand the principles of composition, operate with color and form, evaluate visual effects, and effectively communicate through the image. The AR integration into learning within such models makes it possible to implement active forms of interaction, provide personalized experiences, simulate professional situations, and develop critical thinking (Table 3).

The presented models demonstrate key strategies for using AR as a tool for building a competency-based educational space in the training of graphic designers.

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They include contextual modeling of professional tasks, support for reflective interaction, individualization of learning trajectories, and integration into collective visual practices. The educational effect is achieved by combining the AR component with an active form of content acquisition, when the learner does not just observe, but directly acts in a simulated environment.

Table 3

Educational models using AR to build designers' competencies

Educational model	Characteristic	AR component implementation principle	Effect for the formation of competencies
Situational-contextual model	Learning takes place through simulated professional situations	Creating AR scenes that simulate working with mockups, interfaces, etc.	Developing decision-making skills in realistic design scenarios
Project-oriented model	The basis is the implementation of a full-fledged educational project	AR is used as a means of presentation, testing, editing	Formation of creative thinking, planning, presentation skills
Adaptive model	Taking into account the applicant's level of preparation and learning style	AR content changes according to user actions	Increasing the efficiency of learning material and independent work
Interactive-reflective model	Orientation towards feedback and reflection	AR provides instant visual feedback and the ability to compare solutions	Development of analytical thinking, self-assessment, argumentation
Collaborative model with AR elements	Working in groups using a shared AR environment	AR interface supports collaborative editing, commenting, and presentation	Developing communication and team skills

Source: systematized by the author based on [2, p. 99-100; 9; 13]

Thus, elements of the situational-contextual model have been successfully tested at the Kharkiv State Academy of Design and Arts within the educational and

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professional program “Graphic Design”. Students study the basics of form creation, in particular, layout and packaging modeling, which allows them to analyze the impact of different forms and materials on the perception of an object in real space [17]. Another example is a project-oriented model within the “Modern Teacher” program of the Projector educational platform. In this course, developed with the teachers from the Lviv National Academy of Arts, students create educational materials using AR technologies, which allows them to combine theoretical knowledge with practical skills in graphic design [18]. Thus, AR not only enriches the designer’s toolkit but also transforms the very nature of the educational process – from the reproduction of knowledge to its immersive, situationally, and personally colored mastering, which is the essence of the competency approach in the training of visual communications specialists. Despite the active introduction of digital technologies into professional education, the full integration of AR into the content of curricula for training designers is accompanied by problems that significantly reduce the effectiveness of its application. First of all, methodically developed approaches to the development and implementation of AR components in training courses. Most of the available materials are fragmentary or experimental, which makes their systematic use within the framework of educational standards impossible. There are no approved scenarios for immersion in the AR environment, methods for formative evaluation of the results of interaction with AR objects, as well as scientifically substantiated models for integrating AR into interdisciplinary modules [12, p. 28].

A serious obstacle remains the shortage of personnel - most teachers of design disciplines do not have practical skills in creating or adapting AR content [5, p. 91]. There is a lack of systematic training for specialists in digital pedagogy who are able to use ready-made tools to integrate AR into the pedagogical process in accordance

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with the competency model. This complicates the implementation of educational tasks that involve creative or research AR projects.

Also, a significant limiting factor is the limited material and technical base [1, p. 237]. Not all educational institutions are equipped with modern mobile devices that support AR platforms, and software solutions are often commercial or do not integrate with existing learning management systems [9]. This creates fragmentation of the environment and makes it impossible to use it at the level of an academic group or stream.

To improve the content and technological support of the educational process in the training of graphic designers using AR, it is advisable to implement the following scientifically based approaches: introduce structural integration of AR components into curricula based on interdisciplinary modules; develop typical methodological scenarios for using AR in training courses taking into account levels of professional competence; adapt AR software to distance and blended learning systems (LMS) with support for assessment and analytics functions; create a system for improving the skills of teachers in the field of digital pedagogy with an emphasis on AR technology; update the material and technical base through the implementation of universal, mobile AR solutions with open access or educational licenses. These steps will contribute to the systemic integration of AR into the educational process and increase its effectiveness in acquiring the professional competencies of designers.

Conclusions. AR has significant potential for the formation of professional competencies of future graphic designers, in particular, due to the ability to visualize complex concepts, model design situations, and develop digital literacy. The effectiveness of AR applications within project-oriented and context-simulation learning models is substantiated.

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Key barriers to AR implementation are identified: lack of methodological scenarios, shortage of teachers with digital skills, low technological equipment of higher education institutions, and weak integration of AR into LMS environments.

It is recommended to integrate AR into academic disciplines based on interdisciplinary approaches, create typical scenarios for using AR in design education, update the material and technical base, and ensure the training of teachers in the field of AR pedagogy.

Prospects for further research are related to the development of methods for assessing the impact of AR on the level of development of design competencies, as well as to the experimental analysis of the implementation of AR into the structure of educational modules.

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