Advanced technological solutions for distance learning: leveraging open-source H5P interactive tools and emerging technologies

Olena H. Kuzminska[1,2], Maksym V. Mokriiev[1], Olena G. Glazunova[1], Joanna Markowska[3], Valentyna I. Korolchuk[1] and Tetiana V. Voloshyna[1]

[1]*National University of Life and Environmental Sciences of Ukraine, 15 Heroyiv Oborony Str., Kyiv, 03041, Ukraine*
[2]*Kryvyi Rih State Pedagogical University, 54 Universytetskyi Ave., Kryvyi Rih, 50086, Ukraine*
[3]*Wrocław University of Environmental and Life Sciences, Norwida 25, 50-375 Wrocław, Poland*

Abstract
The widespread introduction of distance learning in the conditions of quarantine restrictions caused by COVID-19 has significantly increased the need to modernize the resource-and-organizational as well as methodological support of the educational process. This paper presents a comprehensive study of the possibilities of using open-source H5P tools to support distance learning in higher education institutions, with particular emphasis on their integration with emerging technologies. The authors analyzed the state of research regarding the development and introduction of interactive didactic H5P tools in higher education institutions and identified insufficient use of this tool in Ukrainian institutions despite successful foreign practices. Based on the results of the comparative analysis of the functionality of various means to support distance learning, including Moodle and Google Workspace, the study demonstrates that H5P offers wider possibilities for creation, use and distribution of interactive educational elements. Recent evidence from post-2018 studies indicates that H5P tools, when combined with active pedagogies, significantly increase behavioral, cognitive, and emotional engagement among learners. The integration with advanced technologies such as AI, VR/XR, and Large Language Models enables adaptive feedback, personalization, and immersive learning experiences. A questionnaire conducted among 58 academic staff members from the National University of Life and Environmental Sciences of Ukraine and Wrocław University of Environmental and Life Sciences revealed that while 63.6% of respondents considered H5P appropriate for their courses, 100% indicated the need for methodological assistance. The study identified critical success factors including diverse activity deployment, collaborative learning integration, and comprehensive accessibility frameworks. These findings underscore the transformative potential of H5P when strategically integrated with robust instructional design and emerging technologies, while highlighting the necessity for specialized training on pedagogical design of H5P content and ongoing institutional support.

Keywords
distance learning tools, H5P, interactive content, active learning, higher education, adaptive learning, virtual reality, artificial intelligence, learning management systems, educational technology

1. Introduction

As new information technologies and digital tools are developed and disseminated, technologies for the development, delivery and use of educational content are being enriched to ensure the quality of

AREdu 2025: 8th International Workshop on Augmented Reality in Education,
co-located with the 6th International Conference on History, Theory and Methodology of Learning (ICHTML 2025),
May 13, 2025, Kryvyi Rih, Ukraine
o.kuzminska@nubip.edu.ua (O. H. Kuzminska); m.mokriiev@nubip.edu.ua (M. V. Mokriiev); o-glazunova@nubip.edu.ua (O. G. Glazunova); joanna.markowska@upwr.edu.pl (J. Markowska); korolchuk@nubip.edu.ua (V. I. Korolchuk); t-voloshina@nubip.edu.ua (T. V. Voloshyna)
https://scholar.google.com.ua/citations?user=M-cfBgUAAAAJ (O. H. Kuzminska);
https://scholar.google.com/citations?user=CFUBdw8AAAAJ (M. V. Mokriiev);
https://scholar.google.com/citations?user=BujWYRcAAAAJ (O. G. Glazunova);
https://upwr.edu.pl/wyszukiwarka-pracownikow?query=Joanna+Markowska (J. Markowska);
https://www.researchgate.net/profile/Valentyna-Korolchuk (V. I. Korolchuk);
https://scholar.google.com/citations?user=r_Zs_IYAAAAJ (T. V. Voloshyna)
0000-0002-8849-9648 (O. H. Kuzminska); 0000-0002-6717-3884 (M. V. Mokriiev); 0000-0002-0136-4936 (O. G. Glazunova); 0000-0001-8032-9508 (J. Markowska); 0000-0002-3145-8802 (V. I. Korolchuk); 0000-0001-6020-5233 (T. V. Voloshyna)

e-learning, taking into account: students' learning styles and age characteristics [1, 2], the available resources and competence of the subjects of the educational process [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16]. However, during the mass transition to distance learning [17, 18, 19, 20] in the conditions of COVID-19 [21, 22, 23], the problem of providing quality education [24, 25, 26] is relevant, which, in our opinion, requires the training of specialists who will be able not only to use ICT in educational activities, but also acquire competences in e-learning management [27]. Analysis of the attitude of teachers and students to the opportunities and problems associated with the introduction of distance learning [28] is the basis for the assumption of actualizing the need to develop interactive teaching materials and educational content as a means of ensuring quality student-centered education [29, 30, 31, 32, 33]. The creation of interactive didactic materials and methods of their use in the educational process will contribute to the involvement of students in active learning: students can create resources independently or "interact" with the teacher to increase motivation, better understanding of learning material, practical skills, evaluation of their own learning activities, etc.

From a technical point of view, the use of tools to create interactive didactic materials was limited by the need for computer programming skills [34]. However, with the development of H5P technology, an open-source Internet tool, the creation of such materials does not require special training. Recent research evidence from 2020-2025 demonstrates that H5P-based solutions significantly enhance learner engagement, with studies showing boost in interaction frequency, engagement duration, and participation depth, especially when activities are diverse and strategically deployed [35, 36]. Furthermore, the integration of H5P with emerging technologies such as artificial intelligence and extended reality (XR) has opened new possibilities for creating adaptive, immersive, and personalized distance learning environments [37, 38].

Therefore, **the purpose of this study** is to identify the potential of H5P to support distance learning in higher education institutions and to analyze the teachers' needs as for its application in educational practice.

Research tasks:

1. To investigate the functionality of H5P for the feasibility of using the H5P service to create and distribute interactive content.
2. To analyze the needs and readiness of the academic staff of the National University of Life and Environmental Sciences of Ukraine (NULES) and Wrocław University of Environmental and Life Sciences (WUELS) to create and use interactive didactic H5P materials in the educational process.

2. Related work

H5P (https://h5p.org/) is a module with a library of learning resources developed in HTML5, which is integrated for direct use in publishing systems (namely: Wordpress, Drupal) and learning management systems (such as Canvas, Moodle or Blackboard). The latter allows you to create interactive learning elements (development can be done by both teachers and students, for example, when doing independent work), which can be used at different stages of e-learning to form both general and subject competences of students.

The conducted analysis of research and publications on the use of H5P service in education is the basis for expressing an assumption about the effectiveness of the use of this service in the process of training specialists regardless of the educational program and specialty.

Santos et al. [39] represent the method of using the H5P service as a tool for gamification of practical skills (students' laboratory work) on local network administration, which provides a fast, intuitive and attractive for students method of applying the Flip-Game Engineering and Technology methodology (Flip-GET), developed by researchers at the University of Cadiz.

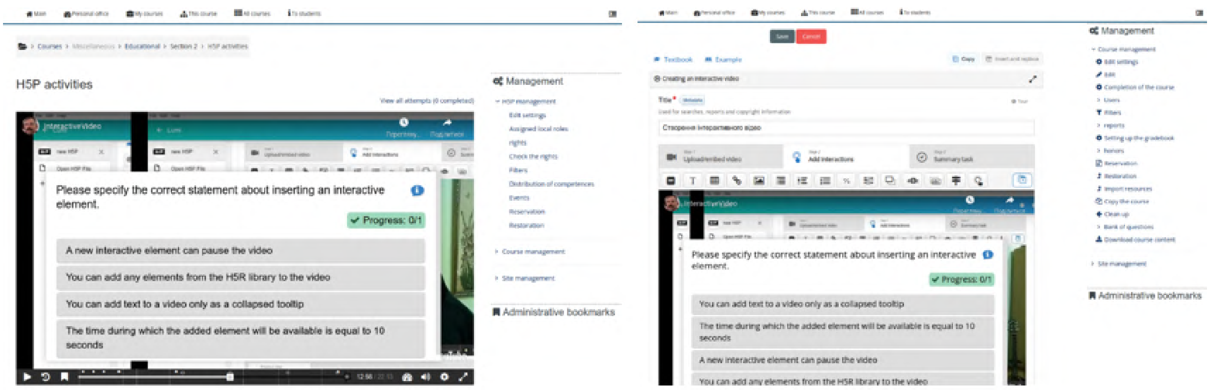
Methodology and practical cases of H5P application in the process of learning English in higher education institutions in Japan and Indonesia are presented in [40]. The experience of using H5P didactic materials in the study of chemistry [41] is an example of the transformation of video into an interactive educational resource. The results of a study of the use of H5P in the training of future specialists in biological sciences [42] indicate that this platform is an effective and universal tool for forming students' critical thinking, independence and confidence in mastering educational material in problem-oriented learning. Methodical recommendations for creating an interactive H5P video for the implementation of personalized and active learning are given in [43, 44]. The experience of using H5P tools for the implementation of blended learning [45] and development flipped classroom framework [46] based on learning management systems highlights the need for additional research on the application of these tools in the educational practice of Ukrainian higher education institutions.

Recent systematic reviews and meta-analyses have further substantiated the effectiveness of H5P in various educational contexts. Abusalim et al. [47] demonstrated that H5P tools can increase academic achievement by 28% and self-confidence scores in second language acquisition. In STEM education, Maceiras et al. [48] found that while H5P interactive videos showed promise for immediate learning outcomes and engagement, traditional lectures yielded better long-term retention, suggesting the need for blended approaches. The integration of H5P with AI-driven adaptive learning systems has shown particular promise, with Naseer and Khawaja [49] reporting a 35% increase in student engagement and 22% reduction in cognitive overload when H5P content is combined with personalized AI feedback mechanisms.

3. Results

H5P is an open tool for creating, distributing and reusing educational interactive content, based on HTML5, CSS and JavaScript technologies, which does not require additional software for its work, therefore will work in all modern browsers, operating systems and devices.

Since H5P technology is integrated into a number of learning management engine drivers, such as Moodle, Canvas, Blackboard, Brightspace, and a variety of web content management systems, such as Wordpress and Drupal, integration into the higher education environment does not require additional costs at the technological level (environmental administration) and organizational – teachers can create educational content in a convenient for them environment with the ability to save and reuse. Figure 1 shows an example of creating and demonstrating the "interactive video" module directly in the Moodle environment (implemented in the training and information portal of NULES).



a) b)

Figure 1: Example of an educational interactive H5P element in the Moodle environment (a – educational video viewing mode, b – interactive video editing form).

In the absence of a learning environment in an educational institution with which H5P technology is already integrated, interactive learning content can be created and stored in the commercial cloud (https://h5p.com) or in the community one (https://h5p.org) [50]. To use the H5P cloud, you need to register, after which users have the opportunity to post their own projects, optimize downloaded videos, adjust the parameters of educational analytics for students using individual projects, share materials on other sites and use additional features. The https://h5p.org site is an open resource for creating interactive materials, testing them, and commenting on resources created by other users. In addition, the

Lumi desktop application has been developed for teachers who prefer to create offline learning content. In any of the three described options, the program interface is identical, simple and clear. So far, templates have been developed to create 49 types of H5P content (https://h5p.org/content-types-and-applications). They can be approximately grouped into three main categories: game content (Games), multimedia content (Multimedia), and methods of testing students' knowledge (Questions).

Since a number of higher education institutions use learning management systems that have their own modules for creating interactive didactic materials to deliver educational content and organize e-learning (blended, distance learning), a comparative analysis of H5P, LMS Moodle and Google Workspace functionality was additionally conducted (table 1). As you can see from table 1, H5P technology has many more unique interactive learning elements than those that Moodle and Google Workspace can offer. In addition, H5P can be integrated into other learning management systems to expand their functionality and increase the freedom of teachers to use pedagogical technologies and disseminate their own learning content. It should be noted that unlike Moodle, in which H5P is fully integrated, integration with Google Workspace involves embedding individual elements from the site https://h5p.com. You can also download the created H5P element to a local computer as a file and then distribute it not only in learning management systems, but also on the sites of publishing systems to which this technology is integrated.

Table 1: Comparative analysis of H5P, Moodle and Google Workspace functionality (not all the available H5P functionality is considered).

Purpose	Program	Module	Features
Folding text blocks ("accordion")	H5P	Accordion	Ability to create a hidden (folded) text block with image formatting, etc.
	Moodle	Absent	Implementation using HTML, CSS or Bootstrap classes
	GWorkspace	Absent	
Interchangeable pictures swapping	H5P	Agamotto	Using simulation of dynamic change in time on the map, in space, zooming out/zooming in
	Moodle	Absent	
	GWorkspace	Absent	
Recording audio messages	H5P	Audio Recorder	Recording audio messages directly from the browser
	Moodle	Function in ATTO	The corresponding functionality is implemented in the built-in ATTO editor
	GWorkspace	Absent	
Creating flash cards	H5P	Dialog Cards, Flashcards	Several solutions are available
	Moodle	Absent	
	GWorkspace	Absent	
Creating test questions	H5P	12 types of questions	Drag and Drop, Drag the Words, Essay, Fill in the Blanks, Find Multiple Hotspots, Find the Hotspot, Image pairing, Image Sequencing, Mark the Words, Multiple Choice, Single Choice Set, True/False Question
	Moodle	15 types of questions + informal types of questions	Implementation of standard types of questions: Calculated, Simple Calculated, Drag and drop into text, Drag and drop markers, Drag and drop onto image, Calculated Multichoice, Essay, Matching, Embedded Answers (Cloze), Multiple Choice, Random Short Answer Matching, Select missing words, Short-Answer, Numerical, True/False
	GWorkspace	9 question types (in Google Forms)	Short answer, Paragraph (Essay), Multiple choice, Checkboxes, Dropdown, File upload, Linear scale, Multiple choice grid, Checkbox grid
Holding tests	H5P	Quiz	You can choose from only 6 types of questions; available mixing of questions, sample questions; not recommended for final testing

Continued on next page

Table 1 – continued from previous page

Purpose	Program	Module	Features
	Moodle	Quiz	Full-fledged testing with lots of settings, automatic checking and review of ratings; possible reuse of questions in different tests
	GWorkspace	Forms	Standard Google form with Google spreadsheets connected to display test results
Timeline creation	H5P	Timeline	Create a timeline with slides on timestamps
	Moodle	Absent	
	GWorkspace	Absent	
Interactive book creation	H5P	Interactive Book	Multi-page resource with an ability to embed almost any of the other elements of H5P on any page, including test questions
	Moodle	Book	Multi-page resource with text, graphic information, embedded video, audio; without the possibility of testing
	GWorkspace	Absent	
Interactive video creation	H5P	Interactive Video	Feed interactive material directly in the video clip; with a possibility to add test questions
	Moodle	Lesson	Video feed by separate clips with a possibility of adding test questions
	GWorkspace	Absent	
Construction of an individual trajectory of studying the topic	H5P	Branching Scenario	Ability to write a transition script depending on the pchoice of transition and answers to questions
	Moodle	Lesson	
	GWorkspace	Absent	
Panoramic image creation	H5P	Virtual Tour (360)	Panoramic image with the possibility of transition and explanations of the elements in the picture
	Moodle	Absent	
	GWorkspace	Absent	

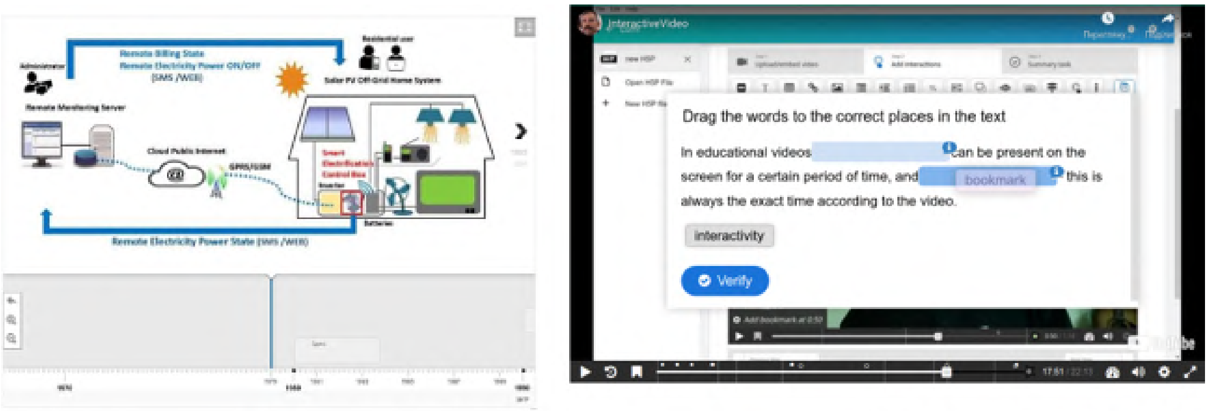
Recent developments in educational technology have demonstrated the significant potential of integrating H5P with advanced technologies. According to systematic reviews conducted between 2023-2025, the integration of H5P with artificial intelligence enables personalized feedback systems that analyze learner performance in real-time, providing tailored feedback and dynamically adjusting curricula [49, 51]. Studies have shown that AI-driven H5P systems can achieve:

- 28% improvement in conceptual mastery compared to 14% in traditional approaches
- 35% increase in student engagement with 22% reduction in cognitive overload
- 40% increase in retention rates through frequent engagement with AI-generated feedback

Furthermore, the combination of H5P with Extended Reality (XR) technologies, including Virtual Reality (VR) and Augmented Reality (AR), has created new possibilities for immersive learning experiences [52, 53, 54, 55, 56, 57, 58, 59, 60, 61]. Zhang et al. [38] found that XR-enhanced H5P content significantly improves student motivation, knowledge retention, and skill development, particularly in STEM education.

To determine the feasibility of using H5P technology for the development of didactic teaching materials and the readiness of teachers to use them in the educational process (the second task of the study), specialized training of the academic staff of NULES and WUELS was conducted. Within the "Distance Learning Tools" course (https://elearn.nubip.edu.ua/course/view.php?id=3000) the representatives of the center of distance learning technologies NULES developed (https://elearn.nubip.edu.ua/course/view.php?id=216) a "Fundamentals of working with H5P" module, in which the teachers had the opportunity to get acquainted with the functionality and features of using H5P technology, as well as to develop separate didactic materials (figure 2).

To determine the attitude of the academic staff to the use of H5P technology in educational practice, a questionnaire was conducted (https://forms.gle/CgVpKWYkqgaUUhm16).



a) b)

Figure 2: Examples of created interactive elements (a – timeline, b – interactive video with a question on top of the video).

58 faculty members of NULES (46 members) and WUELS (12 members) were embraced by the questionnaire, who train future specialists in the field of technical sciences (41.7%), natural sciences (32.6%) and social sciences (25.7%). The vast majority of respondents are middle-aged people (5.7% – up to 25 years; 30.8% – 25-35 years; 41.3% – 35-45 years; 19.4% – 45-55 years; 2.8% – over 55 years old) with a sufficient level of digital competence (68.3% defined their own level of digital competence as sufficient; 25.6% – high; only 6.1% – basic). All respondents stated that they have experience in using e-learning resources, with 76.4% developing e-content independently. 100% of respondents supported the statement that the use of interactive educational content helps to increase students' learning motivation; 91.3% agree that the study material needs to be adapted to the learning styles and needs of the students. Therefore, it is possible to make assumptions about the high degree of readiness of the academic staff to use interactive content in the educational process. At the same time, H5P technology is new for the vast majority of respondents (awareness of specialized training was determined): to the question "Do you know about H5P technology?" 14.1% gave an affirmative answer, and only 1.2% stated that they have experience in developing their own didactic materials.

Upon completion of the training, 63.6% of respondents answered the question "Do you consider it appropriate to use didactic H5P materials in your own e-learning courses?" in the affirmative, especially if there is sufficient and quality methodological support (100% of respondents need methodological assistance). 27.1% refused because, in their opinion, the development of H5P materials for the discipline they teach (mainly in the natural sciences) requires additional equipment, for example, for video recording, and their use is restricted under the copyright law. Only 9.3% of the surveyed teachers gave the negative answer.

Given the broad functionality of H5P, in the final questionnaire, researchers were asked to assess on a 5-point scale the pedagogical feasibility of using individual interactive H5P elements (table 1) in the learning process (group I questions) and the complexity of their independent development (group II questions). Having created a matrix with four quadrants and reflecting the complexity of development (x-axis) and pedagogical expediency of application (y-axis), the authors visualized the attitude of the academic staff to the development and use of H5P didactic tools in the educational process (figure 3).

According to the academic staff surveyed (figure 3), the most optimal (high pedagogical expediency and ease development) is the use of different types of questions that can be added to the educational content. Not much more difficult to develop, but also appropriate, is the use of full-fledged tests. It should be noted that H5P developers do not recommend using such tests for final assessment, but only for the current test of knowledge and self-assessment of students. It should be noted that the pedagogical expediency of using educational elements with a script game ("Branching Scenario"), interactive video ("Interactive Video"), interactive book ("Interactive Book") is high, despite the relative complexity of their creation. Creating such interactive elements requires more prior training, digital competence, and

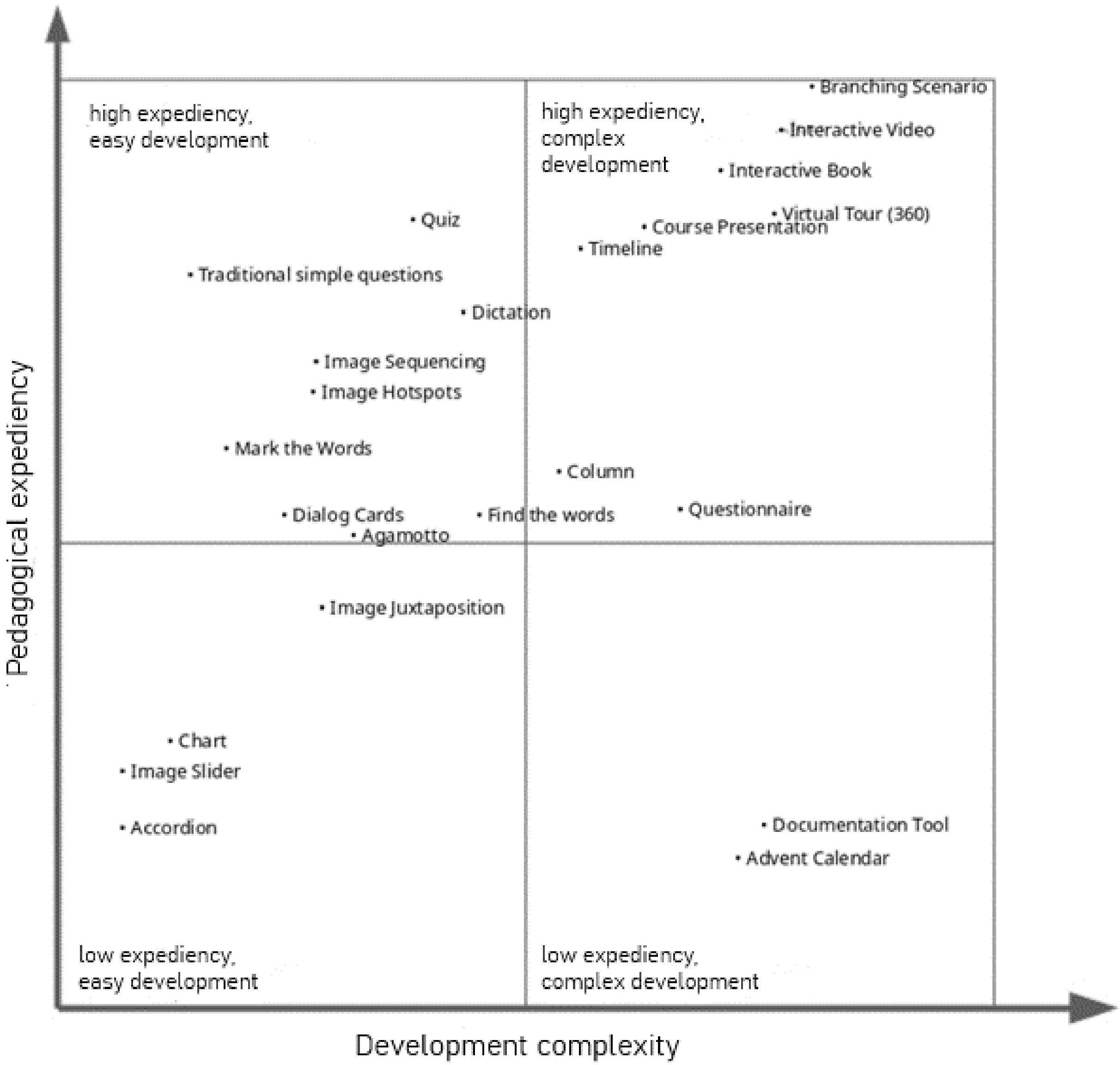


Figure 3: Matrix of correlation of development complexity and educational effect from application of separate elements of H5P technology.

implementation time from the teacher.

In general, the academic staff, according to the questionnaire, praised the educational effect of using H5P technology to support distance learning and noted their willingness to use it in the learning process. The need for additional training related to the pedagogical design of e-learning courses and methodological support in the use of interactive didactic H5P materials in teaching specific disciplines was also identified. The latter is defined as prospects for further research.

4. Conclusion

The massive transition to distance learning caused by the COVID-19 pandemic has highlighted the need for additional research to ensure the quality of education under quarantine restrictions. In this context, many factors favor the usage of the H5P service to create and disseminate interactive content as a means of strengthening the motivation and involvement of students in active learning. It is evidenced by:

- openness: H5P is an open-source software;

- integration with learning management systems such as: Moodle, Canvas, Blackboard;
- wide range of templates: 49 templates have been developed so far, based on which you can create materials of different complexity and degree of interactivity;
- choice of operating mode: you can work with interactive learning material on your own learning site, in the https://h5p.com cloud environment or in the desktop application;
- personalized use: teachers and students can store the created materials in personal environments or portfolios.

The results of comparing the H5P service with the Moodle and Google Workspace learning management systems are grounds for claiming that the development of interactive didactic content using H5P meets the requirements for innovative educational resources, expands the functionality of learning management systems and increases teachers' freedom to use pedagogical technologies.

Our empirical findings align with recent meta-analyses showing that H5P-based solutions can increase student engagement by 30-38% across different educational contexts, with particularly strong effects in STEM and medical education. The integration with emerging technologies such as AI, VR/XR, and Large Language Models further amplifies these benefits, enabling adaptive feedback systems that reduce cognitive overload by 22% while improving retention rates by up to 40%.

The questionnaire, conducted upon the completion of specialized training of the academic staff of NULES and WUELS, shows a high degree of readiness of the academic staff to use interactive content in the educational process if they are provided with technical and methodological support.

Among the various options for didactic content that can be created using H5P, teachers prefer to use interactive elements using educational video. However, given the complexity of independent development of such elements, the need to create a bank of educational video with the involvement of specialists in its shooting and editing is relevant. Instead, teachers have shown willingness to actively create a variety of test questions, as the proposed H5P templates significantly expand the functionality of LMS Moodle and Google Workspace.

Consequently, noting the potential of H5P as a tool to support distance learning in a broad context, the results of this study can be used by administrators and teachers of institutions of higher education to make a decision on the application of this technology in a specific HEI. Methodology of creating and using of interactive didactic H5P materials to support distance learning and professional development of the academic staff of Ukrainian and Polish higher education institutions are included in the prospects for further research.

Future research should focus on: (1) developing comprehensive accessibility frameworks for H5P content that ensure inclusivity for all learners; (2) conducting large-scale randomized controlled trials to validate long-term learning outcomes; (3) exploring optimal strategies for integrating collaborative learning approaches with H5P and advanced technologies; and (4) addressing technical challenges related to exam integrity and content security. As distance education continues to evolve, the thoughtful convergence of interactive content, adaptive technologies, and inclusive design principles, with H5P serving as a foundational platform, will be crucial for creating transformative learning experiences.

Declaration on Generative AI

The authors have not employed any generative AI tools.

References

[1] M. Umryk, Using Active E-Learning to Accommodate the Net Generation of Learners, in: E. Smyrnova-Trybulska (Ed.), E-learning & Lifelong Learning, Studio NOA for University of Silesia in Katowice, Katowice-Cieszyn, 2013, pp. 101–113. URL: https://open.icm.edu.pl/items/ed8d7c53-cc40-473e-af0c-b107d24dfa3f.

[2] M. Kolchanova, T. Derkach, T. Starova, Conditions for creating a balance between learning styles on the example of the material of the discipline “Ecological Chemistry and Environmental Monitoring”, E3S Web of Conferences 166 (2020) 10028. doi:10.1051/e3sconf/202016610028.
[3] O. Kuzminska, M. Mazorchuk, N. Morze, O. Kobylin, Digital Learning Environment of Ukrainian Universities: The Main Components to Influence the Competence of Students and Teachers, in: V. Ermolayev, F. Mallet, V. Yakovyna, H. C. Mayr, A. Spivakovsky (Eds.), Information and Communication Technologies in Education, Research, and Industrial Applications - 15th International Conference, ICTERI 2019, Kherson, Ukraine, June 12-15, 2019, Revised Selected Papers, volume 1175 of *Communications in Computer and Information Science*, Springer, 2019, pp. 210–230. doi:10.1007/978-3-030-39459-2_10.
[4] O. Lavrentieva, V. Pererva, O. Krupskyi, I. Britchenko, S. Shabanov, Issues of shaping the students' professional and terminological competence in science area of expertise in the sustainable development era, E3S Web of Conferences 166 (2020) 10031. doi:10.1051/e3sconf/202016610031.
[5] P. P. Nechypurenko, V. N. Soloviev, Using ICT as the Tools of Forming the Senior Pupils' Research Competencies in the Profile Chemistry Learning of Elective Course “Basics of Quantitative Chemical Analysis”, in: A. E. Kiv, V. N. Soloviev (Eds.), Proceedings of the 1st International Workshop on Augmented Reality in Education, Kryvyi Rih, Ukraine, October 2, 2018, volume 2257 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2018, pp. 1–14. URL: https://ceur-ws.org/Vol-2257/paper01.pdf.
[6] K. V. Vlasenko, O. O. Chumak, I. V. Lovianova, V. V. Achkan, I. V. Sitak, Personal e-Learning Environment of the Maths teacher' online course as a means of improving ICT competency of a Mathematics teacher, Journal of Physics: Conference Series 2288 (2022) 012038. doi:10.1088/1742-6596/2288/1/012038.
[7] K. V. Vlasenko, I. V. Lovianova, T. S. Armash, I. V. Sitak, D. A. Kovalenko, A competency-based approach to the systematization of mathematical problems in a specialized school, Journal of Physics: Conference Series 1946 (2021) 012003. doi:10.1088/1742-6596/1946/1/012003.
[8] O. Kuzminska, M. Mazorchuk, N. Morze, M. Prokopchuk, H. Danylchuk, Integrating digital competencies of researchers into Ph.D. curricula: a case study on open science education, in: S. Papadakis (Ed.), Proceedings of the 11th Workshop on Cloud Technologies in Education (CTE 2023), Kryvyi Rih, Ukraine, December 22, 2023, volume 3679 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2023, pp. 195–208. URL: https://ceur-ws.org/Vol-3679/paper36.pdf.
[9] K. Vlasenko, O. Chumak, I. Sitak, O. Chashechnikova, I. Lovianova, Developing informatics competencies of computer sciences students while teaching differential equations, Espacios 40 (2019) 11. URL: https://www.revistaespacios.com/a19v40n31/a19v40n31p11.pdf.
[10] Z. P. Bakum, O. O. Palchykova, S. S. Kostiuk, V. O. Lapina, Intercultural competence of personality while teaching foreign languages, Espacios 40 (2019) 24. URL: https://www.revistaespacios.com/a19v40n23/a19v40n23p24.pdf.
[11] Z. Bakum, K. Morozova, Didactical conditions of development of informative-communication competence of future engineers during master preparation, Metallurgical and Mining Industry 7 (2015) 164–167. URL: https://www.metaljournal.com.ua/assets/Journal/english-edition/MMI_2015_2/025Morozova.pdf.
[12] I. V. Lovianova, N. Y. Hrebin-Krushelnytska, R. Y. Kaluhin, A. V. Krasnoshchok, O. O. Kozhukhar, Formation of digital competence of specialists in socionomic professions as a pedagogical problem, in: S. Papadakis (Ed.), Proceedings of the 11th Workshop on Cloud Technologies in Education (CTE 2023), Kryvyi Rih, Ukraine, December 22, 2023, volume 3679 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2023, pp. 209–223. URL: https://ceur-ws.org/Vol-3679/paper40.pdf.
[13] N. Dmitrenko, V. Panchenko, O. Hladka, I. Shkola, A. Devitska, Cultivating Communication Skills in Times of Crisis: The perceived impact of SEL techniques in formative assessment on the communication competence of pre-service teachers in Ukraine, International Journal of Emotional Education 16 (2024) 96–100. doi:10.56300/MAIN4950.
[14] M. V. Moiseienko, N. V. Moiseienko, O. O. Lavrentieva, Developing pre-service teachers' digital competence through informatics disciplines in teacher education programs, in: S. O. Semerikov, A. M. Striuk (Eds.), Proceedings of the 6th International Workshop on Augmented Reality in

Education (AREdu 2023), Kryvyi Rih, Ukraine, May 17, 2023, volume 3844 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2023, pp. 45–52. URL: https://ceur-ws.org/Vol-3844/paper11.pdf.

[15] O. S. Pylypenko, T. H. Kramarenko, Structural and functional model of formation of STEM-competencies of students of professional higher education institutions in mathematics teaching, Journal of Physics: Conference Series 2871 (2024) 012004. doi:10.1088/1742-6596/2871/1/012004.

[16] T. A. Vakaliuk, O. D. Gavryliuk, V. V. Kontsedailo, Selecting cloud-based learning technologies for developing professional competencies of bachelors majoring in statistics, in: A. E. Kiv, S. O. Semerikov, A. M. Striuk (Eds.), Proceedings of the 11th Illia O. Teplytskyi Workshop on Computer Simulation in Education (CoSinE 2024) co-located with XVI International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd 2024), Kryvyi Rih, Ukraine, May 15, 2024, volume 3820 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2024, pp. 13–24. URL: https://ceur-ws.org/Vol-3820/paper030.pdf.

[17] B. Stauffer, What's the difference between online learning and distance learning?, 2020.

[18] D. Y. Bobyliev, E. V. Vihrova, Problems and prospects of distance learning in teaching fundamental subjects to future Mathematics teachers, Journal of Physics: Conference Series 1840 (2021) 012002. doi:10.1088/1742-6596/1840/1/012002.

[19] M. J. Syvyi, O. B. Mazbayev, O. M. Varakuta, N. B. Panteleeva, O. V. Bondarenko, Distance learning as innovation technology of school geographical education, in: O. Y. Burov, A. E. Kiv (Eds.), Proceedings of the 3rd International Workshop on Augmented Reality in Education, Kryvyi Rih, Ukraine, May 13, 2020, volume 2731 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2020, pp. 369–382. URL: https://ceur-ws.org/Vol-2731/paper22.pdf.

[20] O. V. Korotun, T. A. Vakaliuk, A. M. Makhno, Tools for Teaching the R Programming Language to Bachelors of Computer Science in the Period of Distance Learning, in: E. Smyrnova-Trybulska, N.-S. Chen, P. Kommers, N. Morze (Eds.), E-Learning and Enhancing Soft Skills: Contemporary Models of Education in the Era of Artificial Intelligence, Springer Nature Switzerland, Cham, 2025, pp. 309–330. doi:10.1007/978-3-031-82243-8_18.

[21] A. L. Miller, Adapting to teaching restrictions during the COVID-19 pandemic in Japanese universities, Educational Technology Quarterly 2022 (2022) 251–262. doi:10.55056/etq.21.

[22] M. Velykodna, Psychoanalysis during the COVID-19 pandemic: Several reflections on countertransference, Psychodynamic Practice 27 (2021) 10–28. doi:10.1080/14753634.2020.1863251.

[23] M. Velykodna, I. Frankova, Psychological Support and Psychotherapy during the COVID-19 Outbreak: First Response of Practitioners, Journal of Intellectual Disability - Diagnosis and Treatment 9 (2021) 148–161. doi:10.6000/2292-2598.2021.09.02.1.

[24] O. Aleksandrova, I. Hroznyi, N. Vinnikova, N. Chuvasova, Control of the quality assurance system at the modern Ukrainian university, Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu 2019 (2019) 153–162. doi:10.29202/nvngu/20192/18.

[25] L. A. Savchenko, K. Y. Savchenko, A. A. Marchenko, R. A. Pylnik, Innovative technologies of pedagogical diagnostics as a means of improving the quality of future specialists' education, Espacios 39 (2018) 20. URL: https://www.revistaespacios.com/a18v39n49/a18v39n49p20.pdf.

[26] A. V. Ryabko, T. A. Vakaliuk, O. V. Zaika, R. P. Kukharchuk, I. O. Kukharchuk, I. V. Novitska, A novel neuro-fuzzy approach for evaluating educational programme quality and institutional performance in higher education, in: S. O. Semerikov, A. M. Striuk, M. V. Marienko, O. P. Pinchuk (Eds.), Proceedings of the 7th International Workshop on Augmented Reality in Education (AREdu 2024), Kryvyi Rih, Ukraine, May 14, 2024, volume 3918 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2024, pp. 102–124. URL: https://ceur-ws.org/Vol-3918/paper031.pdf.

[27] N. Morze, O. G. Glazunova, O. Kuzminska, Training of E-learning Managers at Universities, in: N. Bassiliades, V. Ermolayev, H. Fill, V. Yakovyna, H. C. Mayr, M. S. Nikitchenko, G. Zholtkevych, A. Spivakovsky (Eds.), Information and Communication Technologies in Education, Research, and Industrial Applications - 13th International Conference, ICTERI 2017, Kyiv, Ukraine, May 15-18, 2017, Revised Selected Papers, volume 826 of *Communications in Computer and Information Science*, Springer, 2017, pp. 89–111. doi:10.1007/978-3-319-76168-8_5.

[28] G. A. El Refae, A. Kaba, S. Eletter, Distance learning during COVID-19 pandemic: satisfaction, opportunities and challenges as perceived by faculty members and students, Interactive Technology and Smart Education 18 (2021) 298–318. doi:10.1108/ITSE-08-2020-0128.

[29] Z. Homanová, T. Havlásková, H5P interactive didactic tools in education, in: EDULEARN19 Proceedings, 11th International Conference on Education and New Learning Technologies, IATED, 2019, pp. 9266–9275. doi:10.21125/edulearn.2019.2303.

[30] S. L. Malchenko, D. V. Mykoliuk, A. E. Kiv, Using interactive technologies to study the evolution of stars in astronomy classes, in: A. E. Kiv, M. P. Shyshkina (Eds.), Proceedings of the 2nd International Workshop on Augmented Reality in Education, Kryvyi Rih, Ukraine, March 22, 2019, volume 2547 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2019, pp. 145–155. URL: https://ceur-ws.org/Vol-2547/paper11.pdf.

[31] S. L. Malchenko, V. S. Poliarenko, Y. O. Prykhozha, Interactive technology use during the study of the Universe, Journal of Physics: Conference Series 2611 (2023) 012013. doi:10.1088/1742-6596/2611/1/012013.

[32] Y. Okopna, N. Morska, O. Stakhova, L. Voinalovych, O. Protas, O. Kravchenko, Analogy of tasks of traditional and interactive approaches to students' education in higher education institutions, Systematic Reviews in Pharmacy 11 (2020) 287–289. doi:10.31838/srp.2020.8.43.

[33] A. Zhdaniuk, O. Tarasova, M. Moiseienko, A. Stepanyuk, An interactive online trainer for primary school computer science education: Design, implementation, and theoretical foundations, in: S. O. Semerikov, A. M. Striuk (Eds.), Proceedings of the 7th Workshop for Young Scientists in Computer Science & Software Engineering (CS&SE@SW 2024), Virtual Event, Kryvyi Rih, Ukraine, December 27, 2024, volume 3917 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2024, pp. 139–151. URL: https://ceur-ws.org/Vol-3917/paper33.pdf.

[34] L. V. Lehka, S. V. Shokaliuk, Quantum programming is a promising direction of IT development, in: A. E. Kiv, S. O. Semerikov, V. N. Soloviev, A. M. Striuk (Eds.), Proceedings of the 1st Student Workshop on Computer Science & Software Engineering, Kryvyi Rih, Ukraine, November 30, 2018, volume 2292 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2018, pp. 76–82. URL: https://ceur-ws.org/Vol-2292/paper07.pdf.

[35] M. M. Mahmud, A. S. Lokman, S. F. Wong, C. R. Ramachandiran, S. F. Zakaria, F. Tazijan, N. H. C. Mat, N. M. Lin, Application and Distribution of Interactive HTML5 Content within Online Courses to Increase Learner Engagement, in: 2025 6th International Conference on Information Technology and Education Technology, ITET 2025, 2025, pp. 46–60. doi:10.1109/ITET65804.2025.11101641.

[36] T. Jacob, S. Centofanti, Effectiveness of H5P in improving student learning outcomes in an online tertiary education setting, Journal of Computing in Higher Education 36 (2024) 469–485. doi:10.1007/s12528-023-09361-6.

[37] M. A. Feijoo-Garcia, Y. Zhang, Y. Gu, A. J. Magana, B. Benes, V. Popescu, Exploring Extended Reality (XR) in Teaching AI: A Comparative Study of XR and Desktop Environments, in: Proceedings of the International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, volume 1, 2025, pp. 472–482. doi:10.5220/0013141000003912.

[38] Y. Zhang, M. A. Feijoo-Garcia, Y. Gu, V. Popescu, B. Benes, A. J. Magana, Virtual and Augmented Reality in Science, Technology, Engineering, and Mathematics (STEM) Education: An Umbrella Review, Information 15 (2024) 515. doi:10.3390/info15090515.

[39] D. R. Santos, C. R. Cordon, M. Palomo-Duarte, Extending H5P Branching Scenario with 360° scenes and xAPI capabilities: A case study in a local networks course, in: 2019 International Symposium on Computers in Education (SIIE), 2019, pp. 1–6. doi:10.1109/SIIE48397.2019.8970117.

[40] J. A. Wicaksono, R. B. Setiarini, O. Ikeda, A. Novawan, The Use of H5P in Teaching English, in: Proceedings of the First International Conference on Social Science, Humanity, and Public Health (ICOSHIP 2020), Atlantis Press, 2021, pp. 227–230. doi:10.2991/assehr.k.210101.049.

[41] D. Zeller, Y. Gökkuş, R. Kremer, C. Bohrmann-Linde, H5P-Videos in der chemiedidaktischen Lehre, CHEMKON 28 (2021) 245–248. doi:10.1002/ckon.202100010.

[42] S. Manacek, B. Figg, T. Hicks, A. Scheirmann, H5P Interactive Video: An Opportunity to Personalize

Learning, in: E. Langran (Ed.), Proceedings of SITE Interactive Conference 2020, Association for the Advancement of Computing in Education (AACE), Online, 2020, pp. 520–526. URL: https://www.learntechlib.org/p/218196.
[43] R. Singleton, A. Charlton, Creating H5P content for active learning, Pacific Journal of Technology Enhanced Learning 2 (2019) 13–14. doi:10.24135/pjtel.v2i1.32.
[44] S. Thurner, S. Schön, L. Schirmbrand, M. Tatschl, T. Teschl, P. Leitner, M. Ebner, An Exploratory Mixed Method Study on H5P Videos and Video-Related Activities in a MOOC Environment, International Journal of Technology-Enhanced Education (IJTEE) 1 (2022) 1–18. doi:10.4018/IJTEE.304388.
[45] P. Sinnayah, A. Salcedo, S. Rekhari, Reimagining physiology education with interactive content developed in H5P, Advances in Physiology Education 45 (2021) 71–76. doi:10.1152/advan.00021.2020.
[46] J. Wehling, S. Volkenstein, S. Dazert, C. Wrobel, K. van Ackeren, K. Johannsen, T. Dombrowski, Fast-track flipping: flipped classroom framework development with open-source H5P interactive tools, BMC Medical Education 21 (2021) 351. doi:10.1186/s12909-021-02784-8.
[47] N. Abusalim, M. Rayyan, S. Alshanmy, S. Alghazo, M. N. Al Salem, Revolutionizing Pedagogy: The Influence of H5P (HTML5 Package) Tools on Student Academic Achievement and Self-Efficacy, International Journal of Information and Education Technology 14 (2024) 1090–1098. doi:10.18178/ijiet.2024.14.8.2137.
[48] R. Maceiras, J. Feijoo, V. Alfonsin, L. Perez-Rial, Effectiveness of active learning techniques in knowledge retention among engineering students, Education for Chemical Engineers 51 (2025) 1–8. doi:10.1016/j.ece.2025.01.003.
[49] F. Naseer, S. Khawaja, Mitigating Conceptual Learning Gaps in Mixed-Ability Classrooms: A Learning Analytics-Based Evaluation of AI-Driven Adaptive Feedback for Struggling Learners, Applied Sciences 15 (2025) 4473. doi:10.3390/app15084473.
[50] H5P Group, Create and Share Rich HTML5 Content and Applications, 2025. URL: https://h5p.org/.
[51] T. Hedi, S. Nouzri, Y. Mualla, A. Abbas-Turki, Artificial Intelligence Agents for Personalized Adaptive Learning, Procedia Computer Science 265 (2025) 252–259. doi:10.1016/j.procs.2025.07.179.
[52] T. H. Kramarenko, O. S. Kochina, The use of immersive technologies in teaching mathematics to vocational students, Journal of Physics: Conference Series 2611 (2023) 012006. doi:10.1088/1742-6596/2611/1/012006.
[53] T. A. Vakaliuk, S. I. Pochtoviuk, Analysis of tools for the development of augmented reality technologies, in: S. H. Lytvynova, S. O. Semerikov (Eds.), Proceedings of the 4th International Workshop on Augmented Reality in Education (AREdu 2021), Kryvyi Rih, Ukraine, May 11, 2021, volume 2898 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2021, pp. 119–130. URL: https://ceur-ws.org/Vol-2898/paper06.pdf.
[54] N. O. Zinonos, E. V. Vihrova, A. V. Pikilnyak, Prospects of Using the Augmented Reality for Training Foreign Students at the Preparatory Departments of Universities in Ukraine, in: A. E. Kiv, V. N. Soloviev (Eds.), Proceedings of the 1st International Workshop on Augmented Reality in Education, Kryvyi Rih, Ukraine, October 2, 2018, volume 2257 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2018, pp. 87–92. URL: https://ceur-ws.org/Vol-2257/paper10.pdf.
[55] O. O. Lavrentieva, I. O. Arkhypov, O. P. Krupski, D. O. Velykodnyi, S. V. Filatov, Methodology of using mobile apps with augmented reality in students' vocational preparation process for transport industry, in: O. Y. Burov, A. E. Kiv (Eds.), Proceedings of the 3rd International Workshop on Augmented Reality in Education, Kryvyi Rih, Ukraine, May 13, 2020, volume 2731 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2020, pp. 143–162. URL: https://ceur-ws.org/Vol-2731/paper07.pdf.
[56] R. O. Tarasenko, S. M. Amelina, Y. M. Kazhan, O. V. Bondarenko, The use of AR elements in the study of foreign languages at the university, in: O. Y. Burov, A. E. Kiv (Eds.), Proceedings of the 3rd International Workshop on Augmented Reality in Education, Kryvyi Rih, Ukraine, May 13, 2020, volume 2731 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2020, pp. 129–142. URL: https://ceur-ws.org/Vol-2731/paper06.pdf.

[57] O. B. Petrovych, A. P. Vinnichuk, V. P. Krupka, I. A. Zelenenka, A. V. Voznyak, The usage of augmented reality technologies in professional training of future teachers of Ukrainian language and literature, in: S. H. Lytvynova, S. O. Semerikov (Eds.), Proceedings of the 4th International Workshop on Augmented Reality in Education (AREdu 2021), Kryvyi Rih, Ukraine, May 11, 2021, volume 2898 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2021, pp. 315–333. URL: https://ceur-ws.org/Vol-2898/paper17.pdf.

[58] V. V. Babkin, V. V. Sharavara, V. V. Sharavara, V. V. Bilous, A. V. Voznyak, S. Y. Kharchenko, Using augmented reality in university education for future IT specialists: educational process and student research work, in: S. H. Lytvynova, S. O. Semerikov (Eds.), Proceedings of the 4th International Workshop on Augmented Reality in Education (AREdu 2021), Kryvyi Rih, Ukraine, May 11, 2021, volume 2898 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2021, pp. 255–268. URL: https://ceur-ws.org/Vol-2898/paper14.pdf.

[59] S. P. Palamar, G. V. Bielienka, T. O. Ponomarenko, L. V. Kozak, L. L. Nezhyva, A. V. Voznyak, Formation of readiness of future teachers to use augmented reality in the educational process of preschool and primary education, in: S. H. Lytvynova, S. O. Semerikov (Eds.), Proceedings of the 4th International Workshop on Augmented Reality in Education (AREdu 2021), Kryvyi Rih, Ukraine, May 11, 2021, volume 2898 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2021, pp. 334–350. URL: https://ceur-ws.org/Vol-2898/paper18.pdf.

[60] D. A. Karnishyna, T. V. Selivanova, P. P. Nechypurenko, T. V. Starova, V. G. Stoliarenko, The use of augmented reality in chemistry lessons in the study of "Oxygen-containing organic compounds" using the mobile application Blippar, Journal of Physics: Conference Series 2288 (2022) 012018. doi:10.1088/1742-6596/2288/1/012018.

[61] T. H. Kramarenko, O. S. Pylypenko, M. V. Moiseienko, Enhancing mathematics education with GeoGebra and augmented reality, in: S. O. Semerikov, A. M. Striuk (Eds.), Proceedings of the 6th International Workshop on Augmented Reality in Education (AREdu 2023), Kryvyi Rih, Ukraine, May 17, 2023, volume 3844 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2023, pp. 117–126. URL: https://ceur-ws.org/Vol-3844/paper03.pdf.