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COMPARING INSTRUCTOR-DESIGNED AND AI-GENERATED STRUCTURES OF THE "INTELLIGENT SYSTEMS" COURSE: STUDENTS' ACADEMIC PERFORMANCE AND COGNITIVE LOAD

Abstract. This study presents a controlled comparative experimental investigation of instructor-designed and AI-generated course structures in higher education. The research was conducted within a bachelor-level course "Intelligent Systems" and involved 100 students randomly assigned to two parallel instructional formats. To examine how these materials influenced learning outcomes, the study employed a mixed-methods research design. The analysis included academic performance evaluation, survey data on perceived cognitive load, conceptual mapping, and content analysis. Statistical procedures involved independent samples t-tests, chi-square tests, and correlation analysis. This approach made it possible to identify how differences in instructional structure shaped students' engagement and overall learning experience.

The analysis showed that AI-generated content often includes a wider range of practical and interactive activities that are not always present in traditional course design. Students who worked with these materials showed higher cognitive load ($M = 3.5$) compared to the instructor-designed version ($M = 2.6$, $p = 0.0044$). However, this did not translate into poorer academic outcomes ($p = 0.1558$), indicating comparable learning outcomes across groups. At the same time, the group using traditional content noted greater clarity and a more predictable structure, which helped them move through the material with confidence.

The findings demonstrate that AI-generated instructional structures can function as a complementary instructional assistant rather than a replacement for instructor-designed content. Their integration requires careful pedagogical consideration, including attention to cognitive workload, the alignment of tasks with learning goals, and the instructor's role in guiding students through unfamiliar formats. The novel contribution of this study lies in empirically conceptualizing AI as a mechanism of structural instructional redesign and examining its relationship with cognitive load dynamics and measurable academic performance. The results provide methodological guidance for balanced AI-supported course development in higher education.

Keywords: educational content; artificial intelligence; AI-generated course design; cognitive load; educational content redesign; AI in education

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1. INTRODUCTION

The rapid integration of artificial intelligence into education has created new opportunities as well as challenges for both teachers and students. Although generative AI tools are increasingly used to support content creation and instructional design, existing studies often examine either the technological capabilities of AI or the pedagogical approaches in isolation, which leaves a gap in understanding how learners engage with AI-generated instructional structures and materials.

The problem statement. Despite the increasing use of generative AI tools in educational settings, there remains a substantial gap in systematic research evaluating their impact on student learning outcomes, cognitive load, and engagement. Existing studies tend to isolate either the technical capabilities of AI or pedagogical theory, rarely combining them in a comprehensive, evidence-based framework that evaluates both qualitative and quantitative outcomes. Furthermore, the field lacks insights into how students interact with and perceive AI-generated instructional formats, which is crucial for understanding its practical applicability and long-term effectiveness.

The present research offers an empirical, comparative analysis of AI-generated and instructor-designed course structures and materials.

Analysis of recent studies and publications. In recent years, the role of digital technologies in education has significantly increased, leading to a growing interest in different sources of educational content and instructional design approaches. The integration of digital technologies in education and the emergence of artificial intelligence as a tool for content creation and instructional support have sparked a debate on the efficacy and appropriateness of organic versus synthetic educational content [1], [2]. In [3], the authors examine the potential of AI in education, exploring its applications, benefits, and challenges: highlight AI's role in personalizing learning, automating assessment. The authors emphasize the importance of empirical research to substantiate AI's educational impact, suggesting a balanced approach to harnessing AI's capabilities responsibly for global educational advancement. Organic content is lauded for its authenticity and the personal connection it can foster between the educator and learner, rooted in human experience and expertise [4]. Generative AI content, on the other hand, offers scalability, adaptability, and the potential for supporting alternative structural and instructional formats at a scale difficult to achieve with human-generated materials [5],[6].

Much recent scholarship has increasingly focused on the broader implications of large language models (LLMs) such as ChatGPT for higher education. Studies [7]-[9] examine how the proliferation of generative AI influences assessment practices, academic policy, and instructional organization. The authors conclude that the integration of AI requires reconsideration of pedagogical strategies and course design principles. However, these investigations predominantly address issues of academic integrity and assessment restructuring rather than controlled comparisons of alternative course structures developed with and without AI support.

Contemporary reviews of AI applications in higher education [10], [11] demonstrate that most research remains technology-oriented, concentrating on automation, algorithmic solutions, and adaptive systems. While these studies document rapid innovation, they also emphasize the scarcity of empirical investigations evaluating the pedagogical effectiveness of different instructional organization models at the full-course level. Similarly, theoretical analyses of LLMs' transformative potential for assessment systems and instructional organization [12] highlight the need to rethink learning objectives and evaluation methods, yet they do not provide experimental evidence derived from parallel course implementations.

Research comparing these content sources has often focused on measurable learning outcomes such as retention rates, comprehension levels, and the ability to apply knowledge in

practical contexts [13]. Studies have shown mixed results, with some suggesting that organic content may be more effective in fostering deep learning and understanding, while others highlight the efficiency and accessibility of generative AI content.

The cognitive load theory provides a useful framework for evaluating educational content and instructional structure, suggesting that materials should be designed to minimize unnecessary cognitive strain while maximizing learning and retention. Few studies, however, have directly compared the cognitive load induced by organic versus generative AI-supported instructional designs, leaving a gap in understanding how these content types affect learners' cognitive processes [14].

Another area of interest is the pedagogical implications of AI-supported content and course design. The integration of AI-supported elements into traditional learning environments raises questions about the readiness of current educational frameworks to adapt to new technologies and the potential need for instructional strategies to be restructured to maximize learning outcomes. The challenge lies in ensuring that AI-supported design complements rather than replaces the nuanced and complex nature of human teaching and learning interactions [15], [16].

The research goal. The goal of this study is to compare instructor-designed and AI-generated course structures in higher education and to evaluate their effects on students' perceived cognitive load and academic performance. One primary challenge of this research involves finding a balance between the organic content and the scalability and adaptability provided by AI-supported instructional design approaches. Assessing the cognitive load associated with each type of instructional organization is another significant hurdle, as understanding the impact on learning efficiency and retention is crucial but remains underexplored in literature. The integration of AI-supported course design elements into traditional learning environments presents a further challenge, as it requires developing strategies that enhance learning outcomes without compromising the quality of human teaching and learning interactions.

It is also important to understand how students perceive and interact with both organic and AI-supported instructional formats. This understanding is essential for assessing the practical applicability of AI in the academic environment. Solving these problems involves navigating through a series of intricate questions and considerations, aiming to harness the potential of AI in education responsibly and effectively:

(1) How do organic and AI-supported instructional approaches compare in terms of learning outcomes?

(2) What is the impact of cognitive load when using organic versus AI-supported instructional designs?

(3) How do students perceive and interact with AI-generated compared to human-created materials?

2. THE THEORETICAL BACKGROUNDS

To explore the impacts of organic and synthetic educational content on student learning outcomes, this study employed a mixed-methods research design, which allowed for a comprehensive examination of both qualitative and quantitative aspects of educational experiences. The research design was informed by an experimental, comparative approach, seeking to understand the differences and effects of human-created content versus AI-generated content within an educational setting.

The study was conducted within an undergraduate foundational course "Intelligent Systems" at two public research-intensive universities in Ukraine. The course was delivered in a fully online format and offered during both spring and fall semesters across multiple academic

terms. Each cohort completed the course within one semester; the instructional period lasted approximately 14-16 weeks, followed by assessment and project completion, resulting in an overall course timeline of about 20 weeks.

A total of 100 students enrolled in the course participated in the study. The course was designed not only to deliver subject-specific knowledge but also to foster critical thinking and digital literacy skills essential for evaluating information sources.

Participants were randomly assigned to one of two parallel course versions. The first group completed the course using instructor-created materials, while the second group studied the same curriculum using AI-generated materials. Each participant interacted with only one type of content throughout the study to enable a between-subjects comparison.

During each course run, students' performance and engagement with the learning materials were monitored. Surveys and focus groups were conducted to collect subjective data on students' experiences and perceptions. In addition, semantic analysis tools were applied to examine the structure of the educational content, identify conceptual anchors, and analyze their interconnections.

Data were collected over two academic years (2022-2024) using the institutional web-based learning environment (a Moodle-type platform), through which online questionnaires were administered. To ensure the validity of the comparison, baseline demographic characteristics were examined prior to analysis. The distribution of students by university, gender, prior online learning experience, and initial attitudes toward AI in education, and semester distribution, is presented in Table 1.

Table 1

Demographic information (N =100)

Criteria	University A	%	University B	%
Gender				
Female	24	42.86	16	36.36
Male	32	57.14	28	63.64
Initial Attitude towards AI in Education				
Positive	25	44.64	20	45.45
Neutral	16	28.57	13	29.55
Negative	15	26.79	11	25.00
Online Courses Previously Taken				
0 (None)	5	8.93	8	18.18
1-2	14	25.00	11	25.00
3-5	16	28.57	8	18.18
6-9	8	14.29	6	13.64
10-…	13	23.21	11	25.00
Semester				
Fall	38	67.86	31	70.45
Spring	18	32.14	13	29.55

3. RESEARCH METHODS

In assessing student satisfaction with the educator-developed course versus the AI-generated course structure, we utilized the Student Satisfaction Survey [17], supplementing it with custom questions tailored to the specifics of our study. This approach allowed us to directly compare the effectiveness and student perceptions of traditionally designed courses with those incorporating AI-generated structural elements (1).

The survey included a series of questions designed to measure various aspects of student satisfaction, including but not limited to:

– Clarity and understandability of the course material.

- Perceived interaction within the instructional format.
- Personalization of the learning experience.
- Support and resources provided for the course.
- Overall satisfaction with the course.

To ensure a comprehensive comparison between educator-designed and AI-generated course structures, the questionnaire featured parallel questions for each course type. It also included AI-specific inquiries, such as assessments of the perceived organization, structure, and adaptability of the AI-generated instructional design.

Student feedback was obtained through a structured questionnaire based on a five-point evaluation scale. The resulting dataset was examined using summary statistics and inferential testing procedures, including comparisons of group means and relationships among variables, to identify differences between the two cohorts [18].

Upon completion of the survey, statistical methods were applied to analyze the data, identifying significant differences in student satisfaction between the two types of courses of instructional formats. This analysis aims to provide insights into the pedagogical value of integrating AI into course design and structural organization and the overall impact on student learning experiences.

To develop an analytical framework for examining the educational content created by educators and AI (ChatGPT, OpenAI), we employed conceptual mapping. ChatGPT was selected for developing the alternative course structure due to its advanced capabilities in structured text generation and logical organization of complex information. Large language models have been identified as promising tools for supporting instructional design and educational material development [6], [7], [10], [11]. Contemporary research emphasizes their ability to generate pedagogically structured content and reorganize learning materials into adaptive formats [5],[16]. Empirical studies also indicate that generative AI tools can influence learning organization, student engagement, and instructional effectiveness [23], [25].

To ensure methodological transparency, the extent of artificial intelligence involvement in the development of the alternative course version was explicitly documented. The alternative course structure was generated using an AI model based on predefined constraints, including the course title, total instructional hours, subject scope, and specified learning outcomes. The model autonomously proposed a redistribution of existing instructional elements and introduced new structural components that were absent from the original instructor-designed version. It is important to emphasize that elements such as interactive simulations, virtual laboratories, gamified components, and project-based assignments were not pre-planned by the instructor. Their inclusion resulted directly from the model's generative process. Following the generation of the alternative structure, the instructional content corresponding to the newly introduced components was also developed using the AI within the established curricular framework. The instructor's involvement was limited to technical verification to ensure compliance with institutional documentation requirements and minor formatting adjustments. No substantive structural revisions or pedagogical redesign were introduced by the human instructor after the AI-generated version was produced.

This technique involves creating visual representations to identify and illustrate the main concepts and their relationships within the course content [19]. Table 2 presents the proportional distribution of course elements, showing how the AI reorganized the course structure to equalize the total number of elements while maintaining the integrity of the course content. It provides a clear comparison between the actual course structure and the AI-proposed modifications, taking into account the innovative elements that AI might introduce. Given that the course is constrained by the total number of available hours, the AI restructured the syllabus within existing time limits, thereby reducing the quantity of certain traditional elements to make room for more interactive and technologically integrated components. By using software like

CmapTools (free for use), we visually dissected the structure of the course material, highlighting key conceptual anchors and the interconnectivity of ideas [20].

Following conceptual mapping, content analysis was conducted to systematically categorize and code the text [21]. This method allows for a detailed examination of themes, patterns, and the overall narrative structure of the courses. Through content analysis, we examined how information is presented, the sequence of topics, and the clarity of explanations provided.

The content analysis was conducted through a series of methodical steps:

1. Frequency analysis: the examination counted each topic's occurrences within the course materials. Foundational topics like "Information, data and knowledge in intelligent systems" and "Expert systems, basic concepts" were frequently mentioned in the actual course, signaling a pronounced focus on these subjects.

2. Categorization and coding: content was systematically categorized into various types, such as theoretical discussions, practical exercises, and project-based learning. Python programming and neural networks were designated as practical exercises, whereas topics like fuzzy logic systems were classified as theoretical discussions.

3. Crossover analysis, an examination between the two courses revealed shared and unique topics. The AI-generated course was noted for its inclusion of more interactive simulations and gamified elements, indicating an emphasis on engaging learning methods.

4. Contingency analysis, the relationship between content types and the course's origin (educator-created vs. AI-generated) was analyzed. It was observed that practical exercises like laboratory works predominated in the actual course, whereas the AI-proposed course favored innovative elements such as gamified elements and virtual laboratory works [22].

5. Gap analysis identified missing essential topics or skills in each course. The actual course was found lacking in interactive elements present in the AI-generated course, like virtual laboratories, highlighting an area ripe for improvement.

6. Complexity analysis delved into the content's complexity by scrutinizing the language used, the depth of topic coverage, and the integration of advanced concepts. The AI-generated course incorporated more complex tasks, such as project-based assignments, posing a higher challenge level for students.

7. Trend analysis. The evolution of the course structure across different course versions was examined. The analysis compared the original instructor-designed version with the AI-generated version and revealed a shift in emphasis toward more interactive and student-centered learning components, as reflected in the redistribution of course elements.

To measure cognitive load, we implemented a dual approach combining direct student feedback with performance-based assessments (2).

The data gathered from these methodologies were analyzed to draw contrasts between the educator-created and AI-generated courses. Statistical analysis was used to identify significant differences in the effectiveness of content delivery, cognitive load, and the integration of new knowledge. The findings provided valuable insights into the suitability of AI-generated content for student learning (3).

Table 2

Comparative distribution of course elements in instructor-designed and AI-generated versions of the "Intelligent Systems" course

Pedagogical function	Course element	Quantity in actual Course / in Percentage, %	Quantity in AI-generated course / in Percentage, %
Theoretical components	Online topics	6/28.57	5/23.81
	Self-study materials	3/14.29	3/14.29
	Laboratory works	9/42.86	4/19.05

Practical / applied learning components	Virtual laboratory works	0/.0	2/9.52
	Project-based assignments	0/.0	2/9.52
Assessment components	Control tests	2/9.52	2/4.76
Interactive and engagement components	Gamified elements	0/.0	1/4.76
	Interactive simulations	0/.0	2/9.52
	Discussion forums	1/4.76	1/4.76
	Total	21/100	21/100

4. THE RESULTS AND DISCUSSION

Table 3 indicates that the AI-proposed course includes a greater variety of educational activities, such as virtual laboratory works, interactive simulations, and project-based assignments, which are not present in the organic course (1). These additions enrich the educational process and offer students broader opportunities for learning and engagement with the material. However, despite the potential benefits, the increase in types of academic work could also lead to an increased workload for students. If not properly managed, there is a risk of overburdening students, which could negatively impact their overall well-being and their ability to effectively assimilate knowledge. Therefore, when integrating new methods and types of work, it is important to strive for a balance between innovation and maintaining a reasonable academic load.

Table 3

Learning outcomes information

	Quantity in organic course			**Quantity in AI-proposed course**		
Learning Outcome	number of students	Percentage	SD*	number of students	Percentage	SD*
Exam Scores Average						
Excellent	10	20	3.2	8	16	2.8
Good	15	30	3.9	20	40	4.5
Satisfactory	16	32	4.0	15	30	3.9
Course Completion	41	82	6.4	43	86	6.6
Laboratory Works						
Excellent	5	10	2.89	6	12	2.41
Good	20	40	0.72	18	36	0.80
Satisfactory	15	30	1.44	17	34	0.85
Virtual Laboratory Works						
Excellent				7	14	2.06
Good	absent in course			12	24	1.20
Satisfactory				14	28	1.03
Interactive Simulations						
Excellent				4	8	3.60
Good	absent in course			10	20	1.44
Satisfactory				15	30	0.96
Gamified Elements						
Excellent				5	10	2.88
Good	absent in course			13	26	1.11
Satisfactory				12	24	1.20
Discussion Forums	45	90	0.01	47	94	0.12
Self-Study Materials	40	80	0.45	38	76	0.52
Project-Based Assignments						
Excellent	absent in course			6	12	2.40
Good				14	28	1.03

Satisfactory				11	22	1.31
Control Tests Average						
Excellent	12	24	1.20	14	28	1.03
Good	18	36	0.80	16	32	0.90
Satisfactory	15	30	0.96	13	26	1.11

* SD – standard deviation

Online topics cover approximately 28.6% of the human-created course and 23.8% of the AI-proposed course, suggesting a slight decrease in emphasis in the AI course. Laboratory works are significantly higher in the human-created course at 42.9% compared to 19.0% in the AI course, indicating a shift towards other types of interactive content in the AI course. Control tests remain consistent across both courses at 9.5%, maintaining a standard assessment approach. Interactive simulations and virtual laboratory works are new elements introduced by the AI, each constituting 9.5% of the AI course, demonstrating a move towards more immersive and interactive learning experiences. Gamified elements and project-based assignments are unique to the AI-proposed course, at 4.8% and 9.5% respectively, potentially enhancing engagement and practical application of knowledge.

Common elements between both courses include online topics, laboratory works, control tests, discussion forums, and self-study materials, indicating a core structure retained by the AI. Exclusive elements to the AI course, such as interactive simulations, virtual labs, gamified elements, and project-based assignments, reflect innovative instructional strategies integrated by the AI.

The chi-square test resulted in a p-value of less than 0.05 for the difference in distribution of interactive simulations and project-based assignments, suggesting a statistically significant association between these types of content and the AI-proposed course.

These results suggest that while the human-created course focuses on traditional methods of instruction and assessment, the AI-proposed course diversifies the educational experience with new, interactive formats. The introduction of immersive simulations, virtual environments, and gamification by the AI suggests a potential for a more engaging and varied learning experience that could cater to different learning styles and preferences.

We have performed calculations that allow us to assess the impact of cognitive load when using organic versus synthetic content (2). Subjective measures of cognitive load (survey data) are the following: the mean of organic content perceived cognitive load is 2.6 with a standard deviation (SD) of 0.70. The mean perceived cognitive of synthetic content load is 3.5 with a SD of 0.53.

Objective measures of performance (exam scores) are the following: the mean of organic content performance score is 80 with a SD of 6.67.The mean of synthetic content performance score is 83.5 with a SD of 3.37.

Statistical significance (*T*-Test Results): survey data: The p-value of 0.0044 indicates a significant difference in perceived cognitive load between organic and synthetic content, with synthetic content having a higher perceived load; Performance data: the p-value of 0.1558 suggests there is no significant difference in performance between organic and synthetic content at the chosen significance level (3).

Correlation analysis: in organic content there is a moderate positive correlation ($r = 0.60$) between perceived cognitive load and performance, suggesting that as cognitive load increases, performance also tends to increase, which is not typical and may need further investigation. A low correlation in synthetic content ($r = 0.16$) suggests little relationship between the perceived cognitive load and performance.

From this analysis, we can conclude that students perceive a higher cognitive load with synthetic content, but this does not significantly affect their performance as compared to organic content (2). The significant difference in perceived cognitive load may warrant further

investigation to understand the cause and to identify ways to optimize synthetic content for better cognitive processing.

We underscore the importance of integration of AI in education, reflecting on its potential to challenges teaching methodologies and content delivery, while also considering the challenges posed by such technological advancements. This sets a thoughtful backdrop for a deeper analysis of our findings, their implications for future pedagogical strategies.

AI-Generated vs Human-Created Content

Our study underscored the nuanced implications of AI in education, particularly highlighting its capacity to enhance structural diversity and interactivity in instructional design. This aligns with existing research that has documented positive student perceptions towards AI tools in language learning, where AI aids in grammar, idea generation, and language communication [23],[24]. Additionally, AI-based tools have been shown to improve learning achievement, self-efficacy, and motivation across various educational domains, supporting the integration of AI into university curricula as an essential advancement [25] - [26], although these outcomes were not directly measured in the present study.

However, our findings also revealed some discrepancies with current studies. While the positive impact of AI on disciplines and careers is widely acknowledged, our results suggest that structural changes introduced by AI may influence cognitive load without necessarily altering academic performance, which echoes ongoing academic discussions regarding balanced AI integration [27] - [28]. However, the study also highlighted discrepancies with existing studies, particularly regarding the frequency of AI tool use and its impact on educational outcomes. While some research has suggested a lack of correlation between these factors [29], our study indicates that the effectiveness of AI in education critically depends on how and in what context AI tools are integrated. This finding challenges the notion that mere frequency of AI tool usage directly correlates with better educational outcomes, suggesting instead that the quality of interaction and the strategic implementation of AI tools play a more significant role.

Our study contributes to the ongoing discourse on the learner-instructor interaction in online learning environments by emphasizing that AI-generated structural formats can coexist with traditional pedagogical frameworks without negatively affecting performance outcomes. The contrasting perspectives on AI's role in education, coupled with our findings, suggest an evolving landscape where the benefits of AI-generated content are increasingly recognized, yet the challenges and ethical considerations demand careful navigation. Future research should aim to further investigate the relationship between AI-generated instructional design, cognitive load dynamics, and long-term learning outcomes.

Challenges and Opportunities

Integrating AI-generated content into the educational environment poses some challenges as well as opportunities. On the one hand, ensuring the accuracy and relevance of AI-generated materials requires constant vigilance. Moreover, the task of integrating this content into existing curricula requires not only logistical adaptation, but also a reevaluation of pedagogical strategies, potentially requiring further professional development of teachers.

Conversely, the emergence of AI in education opens up opportunities for structural diversification of instructional formats. The inclusion of interactive simulations, virtual laboratories, and project-based assignments demonstrates how AI-generated course structures may expand the range of learning activities within existing curricular constraints. AI-supported instructional design may provide new ways of organizing learning materials, potentially supporting more varied engagement strategies.

Cognitive Load Considerations

Our analysis shows that AI-generated content can change the dynamics of cognitive load, creating both challenges and opportunities for educational practice.

In our study, students reported a significantly higher perceived cognitive load in the AI-generated course version; however, this increase did not result in a statistically significant difference in academic performance. Research has shown that reducing extraneous cognitive load is critical for effective learning by allowing students to devote more cognitive resources to processing and understanding core material [30]. Our findings suggest that the AI-generated structural format may redistribute cognitive effort rather than directly reduce cognitive load. Moreover, these findings indicate that when designing digital learning environments that incorporate AI-generated content, the complexity and usability of such tools should be carefully considered in order to avoid excessive cognitive load for learners.

However, our results also highlight challenges in effectively implementing AI-generated content. The potential for increased cognitive load due to poorly designed interfaces or overly complex content highlights the importance of thoughtful content design and implementation. This is consistent with research suggesting that the perceived usefulness and ease of use of a learning system can significantly influence cognitive load, with systems that are perceived as useful and easy to use being associated with reduced cognitive load [31].

Additionally, research has shown the role of self-regulated learning skills in managing cognitive load, suggesting that AI-generated content should be designed to support and enhance these skills among learners [32], [33].

By summarizing these ideas, our study contributes to the ongoing dialogue about integrating AI into education. Recognizing the potential of AI to both alleviate and exacerbate cognitive load, depending on its design and implementation, we highlight the need for educational technologies that not only harness the power of AI, but also consider its impact on students' cognitive processes.

Pedagogical Implications

The integration of AI-generated structural course design into educational programs represents a change in pedagogical strategies, requiring a re-evaluation of the role of the teacher from the creator of the main content to the curator and facilitator of the learning process. As AI technologies continue to advance, educators have a critical responsibility to select, review, and integrate AI-generated structural formats and instructional components in ways that meet educational goals, promote critical thinking, and promote deep understanding of the subject matter.

This transition highlights the need to develop comprehensive pedagogical strategies that not only embrace but also optimize the use of AI in education. Such frameworks should provide guidance on how to effectively combine AI-generated structural innovations with traditional teaching methods, ensuring that the technology serves as a complement to, rather than a replacement for, human interaction and learning. The goal is to harness the power of AI to enhance structural diversity and interactive engagement [34], while maintaining the core elements of the educational experience that are unique to humans.

Moreover, integrating AI into education requires a collaborative approach to curriculum development involving educators, curriculum developers, and educational technologists. This collaboration is critical to creating a learning environment that is both technologically advanced and pedagogically sound. This requires teachers to know not only their subject areas, but also the principles of instructional design and the use of technology in education. Consequently, professional development opportunities focused on these areas are becoming increasingly important, providing educators with the skills needed to navigate the complexities of AI integration.

Additionally, the pedagogical implications of AI-generated content extend to assessment practices. Although the present study did not directly examine adaptive assessment mechanisms, the structural diversification introduced by the AI-generated course suggests potential implications for future assessment design. Successful integration of AI-generated

content into educational programs depends on a keen understanding of both the technological and pedagogical aspects of AI in education.

5. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

The conducted comparative study demonstrates that artificial intelligence can independently generate a structurally coherent alternative course model within predefined curricular constraints, expanding the range of instructional formats while preserving the core academic structure. Although both types of content can support learning, they influence students in different ways. In particular, the perception of cognitive load differed more noticeably than the final academic results. A statistically significant increase in perceived cognitive load was identified in the AI-generated version; however, no significant differences were found in academic performance, indicating that structural diversification introduced by AI does not negatively affect measurable learning outcomes.

The AI-generated content often introduces forms of activity that teachers do not always include in traditional courses, such as interactive simulations or virtual tasks. This confirms that AI functions not merely as a content-production mechanism but as a structural instructional assistant capable of proposing alternative pedagogical configurations.

At the same time, the study indicates that the successful use of synthetic materials depends not only on the technology itself but also on how teachers incorporate it into instruction. AI tools still require careful selection, adjustment, and pedagogical justification, otherwise they may complicate the learning process more than help it. Therefore, AI should be conceptualized as an instructional assistant that supports course design, routine content generation, and structural optimization, while the instructor retains responsibility for pedagogical strategy, cognitive regulation, and critical validation of learning processes.

The theoretical significance of the study lies in clarifying the relationship between AI-supported structural redesign and cognitive load dynamics in higher education. The practical significance consists in identifying pedagogical conditions under which AI-generated instructional elements may be integrated without compromising academic performance.

Further research should focus on analyzing specific teaching methods to determine which pedagogical models are most compatible with AI-supported structural design and how AI can effectively function as an instructional assistant within these frameworks. Future studies should examine the redistribution of cognitive and organizational functions between instructors and AI systems in various instructional contexts.

REFERENCES (TRANSLATED AND TRANSLITERATED)

[1] G. Spitale, N. Biller-Andorno & F. German, “AI model GPT-3 (dis)informs us better than humans”, *Sci*. Adv.9, eadh 1850, 2023. doi: 10.1126/sciadv.adh1850. (in English).

[2] A. Bozkurt, R. Sharma, “Generative AI and prompt engineering: The art of whispering to let the genie out of the algorithmic world”, *Asian Journal of Distance Education*, 18(2), 2023. doi: 10.5281/zenodo.817494. (in English).

[3] F. Kamalov, D. Santandreu Calonge, I. Gurrib, “New Era of Artificial Intelligence in Education: Towards a Sustainable Multifaceted Revolution. Sustainability”, 15, 12451, 2023. doi: 10.3390/su151612451. (in English).

[4] O. Bulgakova, V.Zosimov, “Gamified active learning and 3d technologies for enhancing students’ academic achievements”, *Information Technologies and Learning Tools*, 96, 4, 46–57, 2023. doi: 10.33407/itlt.v96i4.5380. (in English).

[5] Z. Bahroun, C. Anane, V. Ahmed, A. Zacca, “ Transforming Education: A Comprehensive Review of Generative Artificial Intelligence in Educational Settings through Bibliometric and Content Analysis”, *Sustainability*, 15, 12983, 2023. doi: 10.3390/su151712983. (in English).

[6] D. Baidoo-Anu, L. Owusu Ansah, "Education in the Era of Generative Artificial Intelligence (AI): Understanding the Potential Benefits of ChatGPT in Promoting Teaching and Learning", *Journal of AI*, 7(1), 52-62, 2023. doi: 10.61969/jai.1337500. (in English).
[7] E. Kasneci, K. Seßler, S. Küchemann, M. Bannert, D. Dementieva, F. Fischer, G. Kasneci, "ChatGPT for good? On opportunities and challenges of large language models for education", *Learning and individual differences*, 103, 102274, 2023. doi: 10.1016/j.lindif.2023.102274. (in English).
[8] W. Holmes, I. Tuomi, "State of the art and practice in AI in education", *European journal of education*, 57(4), 542-570, 2022. doi: 10.1111/ejed.12533. (in English).
[9] D. Cotton, P. Cotton & J. Shipway, "Chatting and cheating: Ensuring academic integrity in the era of ChatGPT", *Innovations in Education and Teaching International*, 61(2), 228-239, 2024. doi: 10.1080/14703297.2023.2190148. (in English).
[10] A. Tlili, B. Shehata, M. Adarkwah, M.A. et al. "What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education", *Smart Learn. Environ*. 10, 15, 2023. doi: 10.1186/s40561-023-00237-x. (in English).
[11] O. Zawacki-Richter, J. Bai, K. Lee, et al. "New advances in artificial intelligence applications in higher education?", *Int J Educ Technol High Educ*, 21, 32, 2024. doi:10.1186/s41239-024-00464-3. (in English).
[12] J. Rudolph, S. Tan, "ChatGPT: Bullshit spewer or the end of traditional assessments in higher education?" *Journal of Applied Learning & Teaching*, 6(1), 342-363, 2023. doi: 10.3316/informit.T202510270000309206156989 1 3. (in English).
[13] J. M. Lodge, K. Thompson, L. Corrin, "Mapping out a research agenda for generative artificial intelligence in tertiary education", *Australasian Journal of Educational Technology*, 39(1), 1–8, 2023. doi: 10.14742/ajet.8695. (in English).
[14] M. Watts, A. Dood, V. Ginger, G. Rodriguez, "Comparing Student and Generative Artificial Intelligence Chatbot Responses to Organic Chemistry Writing-to-Learn Assignments", J. Chem. Educ.100, 10, 3806-3817, 2023. doi: 10.1021/acs.jchemed.3c00664. (in English).
[15] P. Fidalgo, J. Thormann, "The Future of Lifelong Learning: The Role of Artificial Intelligence and Distance Education", *Education and Human Development*, IntechOpen, 2024. doi: 10.5772/intechopen.114120. (in English).
[16] H. Yu, Y. Guo, "Generative artificial intelligence empowers educational reform: current status, issues, and prospects". *Frontiers in Education*, 8, 1183162, 2023. doi: 10.3389/feduc.2023.1183162. (in English).
[17] W.H. Wong, E. Chapman, "Student satisfaction and interaction in higher education". High Educ 85, 957-978, 2023. doi: 10.1007/s10734-022-00874-0. (in English).
[18] L. Dauzón-Ledesma, J. Izquierdo, "Language Learning Investment in Higher Education: Validation and Implementation of a Likert-Scale Questionnaire in the Context of Compulsory EFL Learning". *Educ. Sci*. 13, 370, 2023. doi: 10.3390/educsci13040370. (in English).
[19] W. Matthew, C. Howell, K. Martin-Morales, S. Park, "Concept Mapping and Reading Comprehension". *Journal of Political Science Education*, 19:3, 408-431, 2023. doi: 10.1080/15512169.2023.2164861. (in English).
[20] A. Cañas, J. Alberto; P. Reiska, O. Shvaikovsky, "Improving learning and understanding through concept mapping". *Knowledge Management & E-Learning*; Hong Kong, 15(3), 369-380, 2023. doi: 10.34105/j.kmel.2023.15.021. (in English).
[21] K. Kitto, C. Manly, R. Ferguson, O. Poquet, "Towards more replicable content analysis for learning analytics". In LAK23: 13th International Learning Analytics and Knowledge Conference (LAK2023). *Association for Computing Machinery*, New York, NY, USA, 303–314, 2023. doi: 10.1145/3576050.3576096. (in English).
[22] O. Bulgakova, V. Zosimov, Y. Tselm, "Educational Module for Studying PC Architecture Using 3D Technologies". International Scientific and Technical Conference on Computer Sciences and Information Technologies, 252-255, 2022. doi:10.1109/CSIT56902.2022.10000734. (in English).
[23] J. Gayed, M. Jonson, C. Oriola, S. Jeffrey, " Cross Exploring an AI-based writing Assistant's impact on English language learners". *Computers and Education: Artificial Intelligence*, Vol. 3, 2022, 100055. doi:10.1016/j.caeai.2022.100055. (in English).
[24] M. Utami, W. Diyenti, R. Darwin, I. Indrawati, "The impact of AI writing tools on the content and organization of students' writing: EFL teachers' perspective". *Cogent Education*, 10(2), 2022. doi:10.1080/2331186X.2023.2236469. (in English).
[25] R. Yilmaz, F. Gizem, K. Yilmaz, "The effect of generative artificial intelligence (AI)-based tool use on students' computational thinking skills, programming self-efficacy and motivation". *Computers and Education: Artificial Intelligence*, Vol. 4, 100147, 2023. doi:10.1016/j.caeai.2023.100147. (in English).

[26] M. Hooda, C. Rana, O. Dahiya, A. Rizwan, S. Hossain, "Artificial Intelligence for Assessment and Feedback to Enhance Student Success in Higher Education". *Metaheuristics-based Explainable Artificial Intelligence* (XAI) Models for Real-world Problems, 5215722, 2022. doi: 10.1155/2022/5215722. (in English).
[27] A. Bozkurt, A. Karadeniz, D. Baneres, A. Guerrero-Roldán, M. Rodríguez, (2021). "Artificial Intelligence and Reflections from Educational Landscape: A Review of AI Studies in Half a Century". *Sustainability*, *13*, 800, 2021. doi:10.3390/su13020800. (in English).
[28] A. Abulibdeh, E. Zaidan, R. Abulibdeh, "Navigating the confluence of artificial intelligence and education for sustainable development in the era of industry 4.0: Challenges, opportunities, and ethical dimensions. *Journal of Cleaner Production*, Vol. 437, 140527, 2024. doi: 10.1016/j.jclepro.2023.140527. (in English).
[29] H. Chu, Y. Tu, K. Yang, "Roles and research trends of artificial intelligence in higher education: A systematic review of the top 50 most-cited articles". *Australasian Journal of Educational Technology*, 38(3), 22-42, 2023. doi:10.14742/ajet.7526. (in English).
[30] M. Klepsch, F. Schmitz, T. Seufert, "Development and validation of two instruments measuring intrinsic, extraneous, and germane cognitive load". *Frontiers in Psychology*, 8, 2017. doi: 10.3389/fpsyg.2017.01997. (in English).
[31] E. Pantano, A. Rese, D. Baier, "Enhancing the online decision-making process by using augmented reality: A two country comparison of youth markets". *Journal of Retailing and Consumer Services*, 38, 81–95, 2017. doi: 10.1016/j.jretconser.2017.05.011. (in English).
[32] A. de Bruin, J. Roelle, S. Carpenter, M. Baars, "Synthesizing cognitive load and self-regulation theory: A theoretical framework and research agenda". *Educational Psychology Review*, 32, 1–13, 2020. . doi: 10.1007/s10648-020-09576-4. (in English).
[33] A. Eitel, T. Endres, A. Renkl, "Self-management as a bridge between cognitive load and self-regulated learning: The illustrative case of seductive details". *Educational Psychology Review*, 32, 1–15, 2020. doi: 10.1007/s10648-020-09559-5. (in English).
[34] O. Bulgakova, V. Zosimov, Z. Viniarska, "Creating a Dynamic Online Learning Environment with AI Integration". IEEE 19th International Conference on Computer Science and Information Technologies (CSIT), Lviv, Ukraine, 2024, pp. 1-4, 2024. doi: 10.1109/CSIT65290.2024.10982607. (in English).

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ПОРІВНЯННЯ СТРУКТУР КУРСУ «ІНТЕЛЕКТУАЛЬНІ СИСТЕМИ», РОЗРОБЛЕНИХ ВИКЛАДАЧЕМ І ЗГЕНЕРОВАНИХ ШІ: АКАДЕМІЧНА УСПІШНІСТЬ І КОГНІТИВНЕ НАВАНТАЖЕННЯ СТУДЕНТІВ

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Анотація. У дослідженні представлено контрольоване порівняльне експериментальне вивчення структур курсів, розроблених викладачем та згенерованих штучним інтелектом, у системі вищої освіти. Дослідження проводилось в межах бакалаврського курсу «Інтелектуальні системи» та охопило 100 студентів, випадково розподілених на два паралельні формати навчання. Щоб дослідити, як ці матеріали вплинули на результати навчання, у дослідженні було застосовано змішаний дизайн дослідження. Аналіз передбачав оцінювання академічної успішності, дані опитування щодо сприйнятого когнітивного навантаження, концептуальне картування та контент-аналіз. Статистичні процедури містили t-тест для незалежних вибірок, аналізу χ^2 та кореляційний аналіз. Такий підхід дав змогу визначити, як відмінності в структурі навчального матеріалу впливають на залученість студентів та загальний навчальний досвід.

Аналіз показав, що контент, згенерований ШІ, часто містить ширший спектр практичних та інтерактивних видів діяльності, які не завжди представлені у традиційному проєктуванні курсу. Студенти, які працювали з такими матеріалами, продемонстрували вищий рівень когнітивного навантаження ($M = 3,5$) порівняно з версією, розробленою викладачем ($M = 2,6$; $p = 0,0044$). Водночас це не призвело до зниження академічних результатів ($p = 0,1558$), що свідчить про зіставні навчальні досягнення в обох групах. Разом із тим група, яка навчалась за традиційним контентом, відзначила більшу структурованість і передбачуваність матеріалу, що сприяло більш впевненому набуттю знань.

Отримані результати демонструють, що структури курсів, згенеровані ШІ, можуть виконувати роль додаткового інструменту підтримки навчання, а не повноцінної заміни контенту, створеного викладачем. Їх інтеграція потребує виваженого педагогічного підходу, зокрема врахування когнітивного навантаження, узгодження завдань із навчальними цілями та активної ролі викладача у супроводі студентів під час роботи з новими форматами. Наукова новизна дослідження полягає в емпіричному обґрунтуванні використання ШІ як механізму структурного перепроєктування навчального курсу та аналізі його зв’язку з динамікою когнітивного навантаження й вимірюваними академічними результатами. Отримані результати надають методичні орієнтири для збалансованого впровадження ШІ в проєктування курсів у системі вищої освіти.

Ключові слова: освітній контент; штучний інтелект; ШІ-проєктування курсу; когнітивне навантаження; перепроєктування освітнього контенту; ШІ в освіті

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