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ORIGINAL

Adapting Pedagogy in the Post-Pandemic Era: The Role of Hybrid Learning in Shaping Educational Quality

Adaptar la pedagogía en la era pospandémica: El papel del aprendizaje híbrido en la configuración de la calidad educativa

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ABSTRACT

Introduction: the pedagogical practice of the pandemic and post-pandemic periods shows a significant impact of hybrid forms of education on the quality of education. The study aims to determine their effectiveness and identify the most effective pedagogical transformations for further implementation in pedagogical practice.
Method: the study used questionnaires, a comparison of learning outcomes, a pedagogical experiment, and a statistical evaluation of the results of the pedagogical experiment. Three levels of effectiveness of post-pandemic transformations in pedagogy are outlined: low, medium and high. The questionnaire revealed that an increase in the share of independent work, work with digital learning tools, mixed forms of learning outcomes assessment have an average impact on the quality of learning, while the restriction of social contacts due to the prevalence of distance learning formats, a sharp transition to online learning, an increase in the workload of teachers and a reduction in practice for natural science have a negative impact and should be excluded from the educational process.
Results: the article compares the impact of hybrid forms and post-pandemic transformations on the quality of education for the control and experimental groups before and after the experiment. It is determined that the mixed form of learning, open educational resources, and adaptive technologies for personalisation of learning are the most effective hybrid forms that can be enforced in the post-pandemic period.
Conclusions: the analysis of the learning outcomes of higher education students in the testing group after the experiment showed that implementing the outlined hybrid forms of education increases the number of students with excellent, already good and good learning outcomes and decreases the number of students with low levels of learning.

Keywords: Post-Pandemic Transformations; Hybrid Forms of Learning; Quality of Education; Blended Learning; Use of Open Educational Resources; Adaptive Technologies For Personalised Learning; Higher Education; Vocational Training; Skills Of The Future; Adaptive Educational Environment; Innovative Tools.

RESUMEN

Introducción: la práctica pedagógica de los periodos pandémico y pospandémico muestra un impacto significativo de las formas híbridas de educación en la calidad de la enseñanza. El estudio pretende determinar

su eficacia e identificar las transformaciones pedagógicas más efectivas para su posterior implementación en la práctica pedagógica.
Método: el estudio utilizó cuestionarios, una comparación de los resultados del aprendizaje, un experimento pedagógico y una evaluación estadística de los resultados del experimento pedagógico. Se esbozan tres niveles de eficacia de las transformaciones pospandémicas en la pedagogía: bajo, medio y alto. El cuestionario reveló que el aumento de la proporción de trabajo independiente, el trabajo con herramientas digitales de aprendizaje y las formas mixtas de evaluación de los resultados del aprendizaje tienen un impacto medio en la calidad del aprendizaje, mientras que la restricción de los contactos sociales debido a la prevalencia de los formatos de aprendizaje a distancia, la brusca transición al aprendizaje en línea, el aumento de la carga de trabajo de los profesores y la reducción de las prácticas de ciencias naturales tienen un impacto negativo y deberían excluirse del proceso educativo.
Resultados: el artículo compara el impacto de las formas híbridas y las transformaciones pospandémicas en la calidad de la educación de los grupos de control y experimental antes y después del experimento. Se determina que la forma mixta de aprendizaje, los recursos educativos abiertos y las tecnologías adaptativas para la personalización del aprendizaje son las formas híbridas más eficaces que pueden aplicarse en el periodo pospandémico.
Conclusiones: el análisis de los resultados de aprendizaje de los estudiantes de educación superior del grupo de prueba después del experimento demostró que la aplicación de las formas híbridas de educación esbozadas aumenta el número de estudiantes con resultados de aprendizaje excelentes, ya buenos y buenos y disminuye el número de estudiantes con bajos niveles de aprendizaje.

Palabras clave: Educativos Abiertos; Tecnologías Adaptativas Para el Aprendizaje Personalizado; Educación Superior; Formación Profesional; Competencias del Futuro; Entorno Educativo Adaptativo; Herramientas Innovadoras.

INTRODUCTION

Innovative educational transformations during the COVID-19 pandemic have included the emergence of hybrid forms of learning based on adaptive teaching methods that combine online education with traditional technologies. The advantages of post-pandemic transformations are the flexibility and personalisation of educational trajectories, the flexibility of learning and the use of a wide range of digital learning tools. However, due to the new reality, education faces several challenges: uneven access to education, a decrease in the quality and quantity of social interaction, and a heavy workload of academic staff and higher education students.

Therefore, the study of the impact of post-pandemic transformations and hybrid forms of education on the quality of education is an urgent task for modern pedagogy. It is necessary to investigate the impact of such formats in terms of the sustainability of the quality of educational outcomes and the maintenance of the level of training.

There is a need to study the most effective forms of combining online and offline learning, maintaining the level of communication interaction, ensuring equal access to education, and providing professional support for academic and teaching staff. A comprehensive study of these issues should aim to improve the quality of education and ensure comfortable learning conditions for all participants in the educational process.

The study focuses on the impact of post-pandemic transformations in pedagogy and hybrid forms of education on the quality of education.

Literature review

The active development of hybrid forms of learning and their implementation in pedagogical practice is a topic of discussion among educators and researchers. The global pandemic has created several challenges for the design, procedure and methodology of higher education, affecting the scope of personal experience, outcomes and quality of university education worldwide.[1,2] The factors for improving the quality of learning in the context of post-pandemic transformations are flexibility,[3] increasing accessibility,[4] and personalisation of learning.[5] However, several problems should be taken into account when studying the impact of hybrid forms and post-pandemic transformations, namely a decrease in communication skills and socialisation,[6] a negative impact on motivation to learn,[7] the need to increase the level of digital competence of academic staff.[8]

Researchers point out effective ways to implement hybrid forms of learning in the context of post-pandemic educational transformations, namely: open access to technology[9] and the availability of educational

and methodological literature and seminars, professional development courses for teachers.[10] Taking into account social,[11] technical,[12] digital,[13] methodological[14] and pedagogical[15] aspects lead to the balanced implementation of hybrid forms of learning in the context of post-pandemic transformations. An online and offline model of blended learning for engineering materials and basic moulding technology has been developed.[16] This teaching mode allows students to actively participate in learning and teaching to take full advantage of online teaching, improve teaching quality, and promote teaching reform.[17] The diversity of content has been identified as one of the strengths of the digital storytelling method.

It is outlined that effective digital transformation of the educational community requires introducing models based on artificial intelligence.[18] Alternative models that contribute to the digital transformation of educational content have been identified.[19,20] For data analysis, machine learning algorithms are the primary data processing methods in predictive analytics.[21] Machine learning algorithms are combined to form a hybrid approach to data mining to improve model accuracy.[22,23] The article reveals the hybrid approach of a machine learning model for analysing student data to analyse the risk of students using electronic gadgets during online learning.[24] Many higher education sectors worldwide have implemented various digital platforms and systems to ensure continuity of education during the COVID-19 pandemic.[25] The methods used include both asynchronous and synchronous learning by providing e-learning solutions that address the current pandemic crises, including the inconveniences caused by quarantine and lockdown.[26] The traditional model of education can no longer meet the educational needs of society,[27, 28] so educators must explore the deep integration of information technology and teaching to build a new student-centred learning model.

METHOD

The study was conducted at the Dmytro Motornyi Tavria State Agrotechnological University, the National Academy of the Security Service of Ukraine, and Oleksandr Dovzhenko Hlukhiv National Pedagogical University during the academic years 2022–2024. The methods used were questionnaires, a comparison of learning, a pedagogical experiment, and a statistical evaluation of the learning outcomes of the control and experimental groups according to Pearson's x 2. The study took into account the indicators of the first stage of the questionnaire and the second stage - the comparison of learning outcomes of higher education students.

The first stage of the pedagogical experiment was a survey among the academic staff of the above-mentioned higher education institutions. The purpose of the survey was to determine the effectiveness level of post-pandemic transformations' impact on the quality of education. The survey involved 78 teachers of higher education institutions.

During the second stage, the learning outcomes of 256 higher education students were compared. During the experimental study, the control group of 128 people used educational transformations such as increasing the share of independent work, working with digital learning tools, and using mixed forms of learning outcomes assessment. While the experimental group of 128 people used a blended learning approach, open educational resources and adaptive technologies to personalise learning). A statistical assessment of the learning outcomes of the control and experimental groups was carried out, and Pearson's x 2 criterion was used to test statistical significance.

RESULTS

The pandemic and the introduction of restrictions that affected educational processes, among other things, led to the introduction of hybrid forms of education and became a powerful impetus for post-pandemic transformations in pedagogical science. Figure 1 shows a classification scheme of the impact of post-pandemic transformations on the quality of education. It was compiled based on a survey of teachers of the higher education institutions where the experiment was conducted.

Post-pandemic transformations in pedagogy were divided by the level of effectiveness. According to a survey of teachers, a high level of effectiveness in terms of the quality of education was demonstrated by the blended learning environment, open educational resources and adaptive methods for creating personalised learning technologies that combine the benefits of digital technologies and provide an opportunity to individualise the learning process. Forms of learning of medium effectiveness included an increased share of independent work, work with digital learning tools, and hybrid forms of assessment of higher education students' results. These forms, although practical, need to be reviewed in some aspects, such as possible decreased engagement and the need for careful selection of the quality of knowledge assessment methods. The restriction of social contacts due to the prevalence of distance learning formats, the sharp transition to online learning, the increased workload of teachers and the reduction of practical aspects of conducting classes for higher education students in the natural sciences were identified as pedagogical transformations with a low level of efficiency, which reduce the level and quality of professional competences and worsen the feedback between students and teachers.

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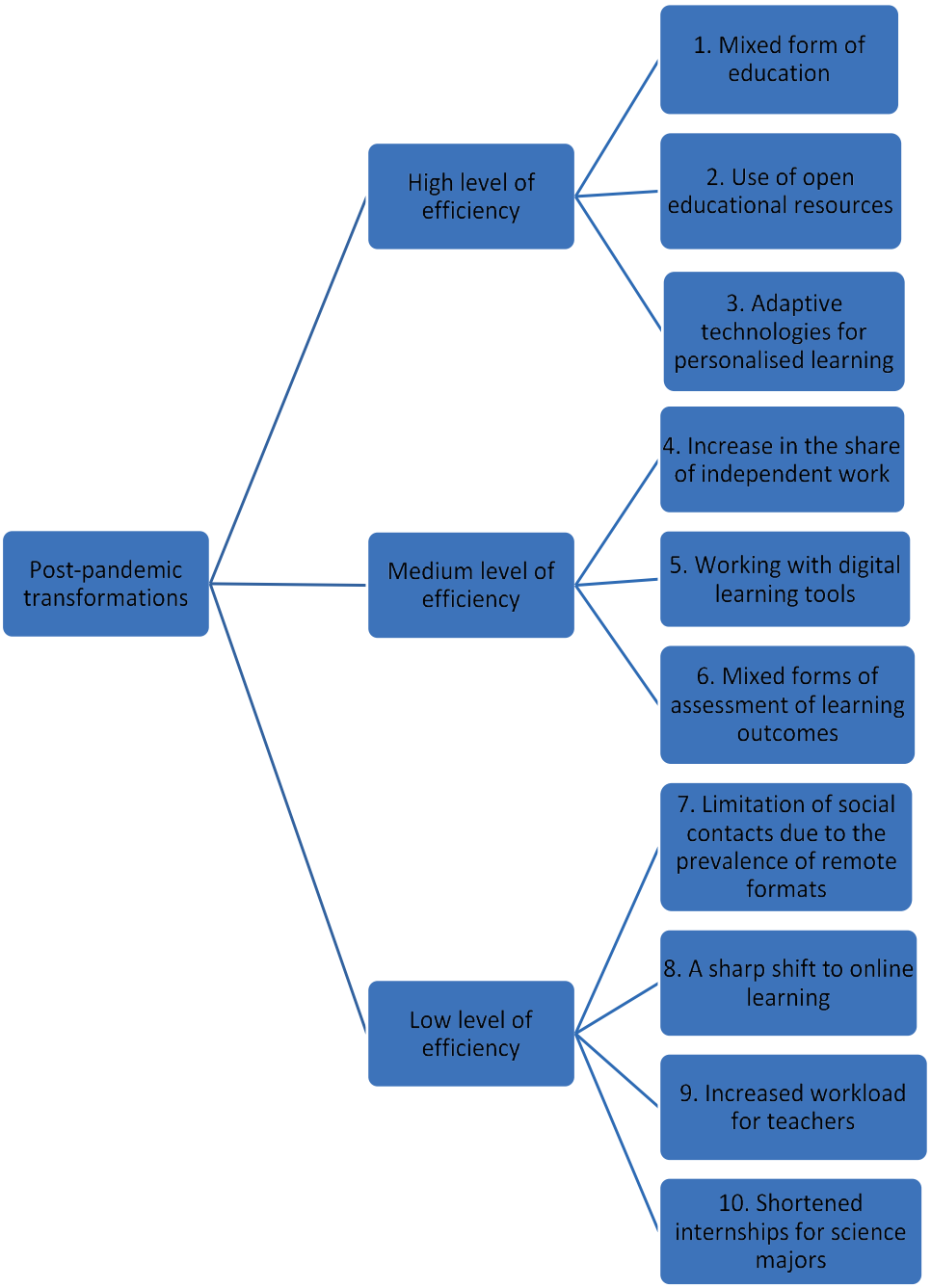

Figure 1. Determining the level of effectiveness of the impact of post-pandemic transformations and hybrid forms of education on the quality of education

The teacher questionnaire was developed based on four criteria assessed on a 100-point scale. The criteria were *access to* education regardless of the location of higher education students; *quality of education*, which consisted of learning outcomes and the level of competences; *social and moral factors, i.e.* the interaction of students with each other and with teachers, motivation and support of teachers and *support of academic staff*, both methodological and digital and professional development during the implementation of hybrid forms of education.

The post-pandemic transformations were assessed according to the effectiveness of their application: high, medium, and low.

High-level indicators characterise equality of access, communication interaction, the effectiveness of combining different formats, and the confident use of digital tools. Medium-level indicators outline the need to increase the range of information and communication tools for learning, the need to refine teaching methods, the basic level of social interaction, and the need for support for teachers. The low-level indicators limit access to technology, show poor learning outcomes, lack of interpersonal communication, and difficulties in developing learning tools for teachers.

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Table 1 presents the results of determining the effectiveness level of post-pandemic transformations' impact on the quality of education, which are distributed by level in percentage terms. In figure 1, each type of post-pandemic transformation is marked with a number corresponding to its number in table 1.

Table 1. Results of determining the level of effectiveness of the impact of post-pandemic transformations on the quality of education

No. transformations	At the beginning of the pandemic transformation			As a result of post-pandemic transformations			Increase		
	LL. %	ML. %	HL. %	LL. %	ML. %	HL. %	LL. %	ML. %	HL. %
1	10,30	48,60	41,10	8,45	42,45	49,10	-1,85	-6,15	+8,00
2	11,60	51,40	37,00	9,70	45,10	45,20	-1,90	-6,30	+8,20
3	19,40	44,60	36,00	8,20	47,30	44,50	-11,20	+2,70	+8,50
4	18,40	53,41	28,19	14,16	54,04	31,80	-4,24	+0,63	+3,61
5	19,40	51,60	29,00	12,00	55,45	32,55	-7,40	+3,85	+3,55
6	20,40	51,49	28,11	12,15	54,32	33,53	-8,25	+2,83	+5,42
7	49,40	28,60	22,00	61,24	28,76	10,00	+11,84	+0,16	-12,00
8	48,40	32,60	19,00	64,26	28,62	7,12	+15,86	-3,98	-11,88
9	49,40	36,60	14,00	62,50	32,35	5,15	+13,10	-4,25	-8,85
10	47,40	41,60	11,00	61,15	29,85	9,00	+13,75	-11,75	-2,00

Notes: LL. ML. HL - low, medium and high levels of effectiveness of post-pandemic transformations in education

The results of determining the level of effectiveness of the impact of post-pandemic transformations on the quality of education showed a significant increase in the high level of effectiveness for transformations 1–3 (blended learning, use of open educational resources, adaptive technologies for personalised learning). The average increase in medium and high levels of effectiveness in the survey was scored by transformations 4–6 (increasing the share of independent work, working with digital learning tools, mixed forms of learning outcomes assessment). Transformations 7–10 (limiting social contacts due to the prevalence of distance learning formats, a sharp shift to online learning, increasing teachers' workload, and reducing the practice of natural science) scored high negative growth at high and medium levels. Figure 2 shows a visualisation of the results of determining the level of effectiveness of the impact of post-pandemic transformations on the quality of education.

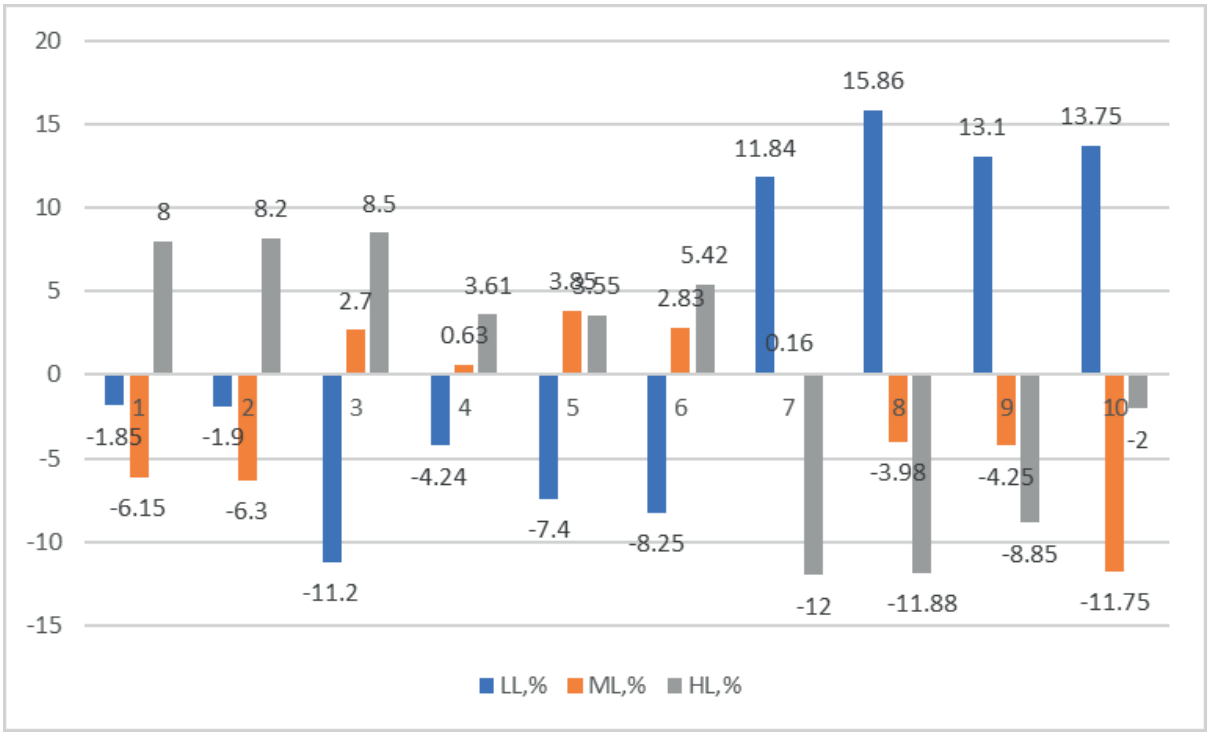

Figure 2. Visualisation of the results of determining the effectiveness level of post-pandemic transformations' impact on the quality of education

Notes: LL, ML, HL – low, medium and high levels of effectiveness of post-pandemic transformations in education.

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Figure 2 schematically shows the positive or negative gains for all strategies according to their effectiveness levels. At this stage of the experiment, transformations 1–6 require further investigation, while 7–10 can be excluded due to negative impacts.

The next stage of the experimental study was to determine the impact of post-pandemic transformations on the quality of learning outcomes. The learning outcomes of the control and experimental groups were statistically assessed, and Pearson's x^2 was used to test statistical significance.

The assessment of learning outcomes was carried out in accordance with the European Credit Transfer System and graded at the levels of excellent (A), very good (B), good (C), satisfactory (D), sufficient (E), and unsatisfactory (FX) according to the total semester learning outcome.

Table 2 compares the impact of hybrid forms and post-pandemic transformations on the quality of education for the control and experimental learning groups before experimenting. Tables 2 and 3 use the following notations: EF (EG, CG), number of students – empirical frequency of grades received by higher education students in the control and experimental groups (CG and EG, respectively). The degree of freedom for this sample is v=5, with critical x2 values for v=5 being ρ(0,05) ≥ 11,07 and ρ(0,01) ≥ 15,085.

Table 2. Comparison of the impact of the use of hybrid forms and post-pandemic transformations on the quality of education for the control and experimental groups before the experiment

Learning outcome	EG. %	EF (EG). number of students	CG. %	EF (CG), number of students	$(EF_{EG} - EF_{CG})2$	$(EF_{EG} - EF_{(CG}))^2/ EF_{CG}$
Excellent	6,25 %	8	7,81 %	10	4	0,40
Very good	12,50 %	16	11,72 %	15	1	0,07
Good	17,19 %	22	15,63 %	20	4	0,20
Satisfactory	26,56 %	34	27,34 %	35	1	0,03
Enough	27,34 %	35	25,78 %	33	4	0,12
Unsatisfactory	10,16 %	13	11,72 %	15	4	0,27
Total amount	100,00 %	128	100,00 %	128		1,08

Notes: EG. CG. % – the percentage of students in the experimental and control groups, respectively; $EF_{EG.}$ $EF_{CG.}$ – the empirical frequency for the experimental and control groups

It is determined that x^2 before the experiment is not in the zone of significance, so the results do not significantly impact the quality of learning.

Table 3 compares the impact of hybrid forms and post-pandemic transformations on the quality of education for the control and experimental groups after the experiment.

Table 3. Comparison of the impact of the use of hybrid forms and post-pandemic transformations on the quality of education for the control and experimental groups after the experiment

Learning outcome	EG. %	EF (EG). number of students	CG, %	EF (CG), number of students	$(EF_{EG} - EF_{CG})^2$	$(EF_{EG} - EF_{(CG}))^2/ EF_{CG}$
Excellent	14,84 %	19	8,59 %	11	64	5,82
Very good	25,78 %	33	10,94 %	14	361	25,79
Good	28,13 %	36	17,19 %	22	196	8,91
Satisfactory	17,19 %	22	29,69 %	38	256	6,74
Enough	8,59 %	11	22,66 %	29	324	11,17
Unsatisfactory	5,47 %	7	10,94 %	14	49	3,50
Total amount	100,00 %	128	100,00 %	128		61,92

Notes: EG, CG, % – the percentage of students in the experimental and control groups, respectively; $EF_{EG.}$ $EF_{CG.}$ – the empirical frequency for the experimental and control groups.

It is determined that x^2 after the experiment is in the zone of significance, so the results significantly impact the quality of learning.

Figure 3 presents a general visualisation comparing the impact of hybrid forms and post-pandemic transformations on the quality of education for the control and experimental groups before and after the experiment.

In the course of the experiment, it can be concluded that in the control group, the average indicator of the impact of the use of hybrid forms and post-pandemic transformations on the quality of education for higher education students at all levels was approximately the same in the control and experimental groups. After the experiment, the indicators of the control group remained approximately the same. In the experimental group, the number of higher education students with very good and good grades increased, and the number of students with satisfactory, sufficient and unsatisfactory grades decreased. This indicates the high effectiveness of blended learning methods, open educational resources, and adaptive technologies for personalising learning.

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Figure 2. General visualisation of comparing the impact of hybrid forms and post-pandemic transformations on the quality of education for the control and experimental groups before (Figure a) and after (Figure b) the experiment

DISCUSSION

The effectiveness of using hybrid forms of education was investigated at the School of Information and Communication Technologies of the University of Phayao. The study aimed to investigate the context of students' self-regulated learning styles in hybrid learning situations, to study the clusters of students formed by self-regulated learning styles in hybrid learning situations, and to assess the corresponding cluster of self-regulated learning styles in hybrid learning situations.[32] The paper presents a hybrid learning model during the COVID-19 pandemic for students of Agricultural Systems Engineering who have completed the Embedded System course at the King Mongkut Institute of Technology Ladkrabang, Thailand. The researcher presented a hybrid learning model during COVID-19, where students were focused on the same understanding and accompanied by learning as active learning shapes project-based learning.[30] The standard features of research on the effectiveness of hybrid learning methods are the increased availability of learning resources through digital platforms, the use of adaptive and digital technologies, and the individualisation of the educational process

The study aims to assess the dynamic changes in the effectiveness of digital foreign language education programmes in Ukraine during the pandemic restrictions (2020–2021). The comparison of various aspects of digital learning is implemented to assess the individual quality and effectiveness of transforming the traditional process of learning foreign languages into a distance and hybrid online format using digital technologies.[31] Integrating online and offline education has become a new educational form of research and practice. Currently, in integrating online and offline education, there are problems with teachers' information literacy, learning implementation, and student initiative. In order to promote the effective integration of online and offline education in the new era, it is necessary to establish a hybrid teaching mindset, improve the information literacy of education actors, actively build a standard development mechanism for online and offline integration education, and establish student learning and management. A system adapted to online and offline integration enriches online and offline classes and shares learning resources.[32] However, it should be noted that online learning cannot always replace the classroom format, so improving educational outcomes depends on the level of digital training of academic staff.

The work aims to present the development of environmental education methodology in a hybrid format.

Among the activities developed were: creating a collaborative panel using the Padlet tool, creating the first stage of the Environmental Education Project Portfolio, and presenting the socio-historical, economic and environmental aspects of the Espírito Santo area in Rio DOS. The development of the learning unit proved to be a relevant starting point for the learning process in the advanced and specialisation courses, given the emphasis on everyday aspects for a critical reflection of reality experienced through potential shared moments of formation in a virtual learning environment, together with a face-to-face meeting to complete the curriculum component. The difference between different forms of education is explored through a gap analysis model that shows current educational practice and an ideal e-learning environment that can serve as a sustainable form of distance education. In addition, emergency distance education's shortcomings are discussed to bridge the gap and transform this form of learning into a permanent but sustainable distance education system. Recommendations and solutions are provided to support distance education in the post-COVID-19 phase.[33] Hybrid learning increases teachers' workload, so it is necessary to implement comprehensive teacher training, including professional, moral, and psychological training.

The COVID-19 pandemic has had a significant impact on education systems around the world. Online resources were used instead of face-to-face classes and interaction. The study aimed to compare the impact of hybrid and virtual chemistry laboratories on student learning, engagement and the development of core engineering competences. Using hybrid models offers flexibility in the learning process, allowing students to be prepared for future challenges in the post-covid era.[34] Introducing hybrid forms of learning in the context of post-pandemic transformations requires searching for combined options and mitigating the pandemic's effects by finding compromised educational levels for all participants in the learning process.

CONCLUSIONS

The introduction of hybrid forms of learning and post-pandemic transformations in pedagogy have shown their viability as factors of influence of the COVID-19 pandemic. The study outlines a mixed form of learning, the use of open educational resources, adaptive technologies for personalising learning, an increase in the share of independent work, work with digital learning tools, mixed forms of learning outcomes assessment, limited social contacts due to the prevalence of distance learning formats, a sharp transition to online learning, an increase in the workload of teachers and a reduction in practice for natural science. The level of effectiveness of these hybrid forms of education and post-pandemic transformations in pedagogy is determined: low, medium and high. The survey identified educational transformations with medium and high efficiency. The next step was to determine their impact on learning outcomes. The statistical test revealed that blended learning, open educational resources, and adaptive technologies for personalised learning are the most effective hybrid forms of learning and can be viable educational forms in the post-pandemic period, provided they are systematically implemented.

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