













ORIGINAL

Utilising digital education to enhance learning accessibility in isolated areas

Utilizar la educación digital para mejorar la accesibilidad del aprendizaje en zonas aisladas

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ABSTRACT

Introduction: in instances where conventional educational institutions are either unavailable or ineffective, online platforms offer a distinctive opportunity to obtain quality education regardless of geographical location. The advantages of online learning include flexible scheduling, access to educational content, and the capacity to communicate with instructors and other students via the Internet. Concurrently, numerous challenges are encountered by students and teachers utilising online platforms, including unstable internet connections and the need to self-organise the learning process.

Objective: to determine the role and efficacy of online learning in providing access to education in remote regions.

Method: an analytical literature review, a meta-analysis, a quality of education analysis, a learning effectiveness determination, and a statistical data analysis. Type of research is observational research, timeframe of the research is an academic semester, field of research is the educational process in higher education, platform used for the research is the higher education environment, type of statistics is descriptive.

Results: the article compares the use of standard online tools and interactive online tools to provide access to education in remote regions. The means of monitoring the results of higher education students include educational test simulators and gamified tasks.

Conclusions: a comparison of learning outcomes and self-assessment of higher education students studying mathematics and English using traditional and interactive online tools has revealed the effectiveness of the latter: interactive video lectures and online courses, virtual laboratories and mobile applications, AR and VR explanations, chatbots, forums, and online conferences.

Keywords: Distance Education; Education Access; Digital Literacy; E-Learning Resources; Learning Flexibility; Interactive Learning.

RESUMEN

Introducción: en los casos en que las instituciones educativas convencionales no están disponibles o son ineficaces, las plataformas en línea ofrecen una oportunidad única de obtener una educación de calidad

independientemente de la ubicación geográfica. Entre las ventajas del aprendizaje en línea figuran la flexibilidad de horarios, el acceso a contenidos educativos y la capacidad de comunicarse con profesores y otros estudiantes a través de Internet. Al mismo tiempo, los estudiantes y profesores que utilizan plataformas en línea se enfrentan a numerosos retos, como la inestabilidad de las conexiones a Internet y la necesidad de autoorganizar el proceso de aprendizaje.

Objetivo: determinar el papel y la eficacia del aprendizaje en línea para brindar acceso a la educación en regiones remotas.

Método: una revisión bibliográfica analítica, un metaanálisis, un análisis de la calidad de la educación, una determinación de la eficacia del aprendizaje y un análisis estadístico de datos. El tipo de investigación es un estudio observacional, el marco temporal de la investigación es un semestre académico, el alcance de la investigación es el proceso educativo en la educación superior, la plataforma utilizada para realizar la investigación es el entorno de la educación superior, el tipo de estadística es descriptiva.

Resultados: se presenta una comparación del uso de herramientas en línea estándar y herramientas interactivas en línea para brindar acceso a la educación en regiones remotas. Los simuladores de pruebas educativas y las tareas gamificadas se incluyen en los medios de seguimiento de los resultados de los solicitantes de educación superior.

Conclusiones: una comparación de los resultados de aprendizaje y la autoevaluación de estudiantes de educación superior que estudian matemáticas e inglés utilizando herramientas en línea tradicionales e interactivas nos permitió concluir sobre la efectividad de estas últimas: videoconferencias interactivas y cursos en línea, laboratorios virtuales y aplicaciones móviles, AR y explicaciones de realidad virtual, chat-bots, foros, conferencias en línea.

Palabras clave: Educación a Distancia; Acceso a la Educación; Alfabetización Digital; Recursos de Aprendizaje Electrónico; Flexibilidad del Aprendizaje; Aprendizaje Interactivo.

INTRODUCTION

Online education is an innovative method of learning that is based on the use of information and communication technologies.

One of the most important advantages of online education is its ability to provide access to education in remote regions. In rural areas, access to education is often limited by various factors, including the need for qualified teachers, the absence of educational institutions, and limited resources. Online education can help overcome these barriers by allowing students to obtain an education without leaving their homes. Thanks to online learning, students from remote regions can gain access to courses and programmes that were previously unavailable due to geographical or financial constraints. This opens up new opportunities for learning and professional development for those who were previously excluded from this process.

In recent years, online education has become a transformative force in the global educational landscape. More and more people are enrolling in online courses and programmes to gain knowledge and skills. Nevertheless, despite the numerous advantages of online education, there are several challenges that need to be addressed. These include the need for more stable internet connections in remote areas and the need for computers and other technologies. To fully realise the potential of online education in remote regions, it is important to focus on the development of infrastructure and ensure the availability of necessary resources. In light of the above considerations, studying the multifaceted aspects of online education as a means of facilitating access to education in remote regions is essential. This involves identifying the main advantages and challenges faced by students and higher education institutions.

Research aims

The purpose of online learning as a means of providing access to education in remote regions is to study online learning methods and tools for specific learning compared to traditional forms.

To assess the effectiveness of the proposed interactive online learning tools versus traditional online learning tools by comparing the level of knowledge of higher education students.

Literature review

Online learning is pivotal in providing access to education in remote regions.^(1,2) Its objective is to overcome the geographical, socioeconomic, and infrastructural barriers faced by students from remote areas.⁽³⁾ Online learning enables students to obtain an education without leaving their homes or country.⁽⁴⁾ It is essential for those residing in remote or poorly accessible locations.⁽⁵⁾

Online courses typically offer a flexible learning schedule, allowing students to study conveniently while balancing education with work or family responsibilities.⁽⁶⁾ For many students, online learning becomes more

economically accessible as they save on expenses for accommodation, utilities, and travel to educational institutions.^(7,8)

Online learning helps students develop technology skills, which are becoming increasingly important in the modern world.⁽⁹⁾ Many online platforms provide opportunities for interactive learning and feedback with students, facilitating effective learning even at a distance.⁽¹⁰⁾ Online learning allows modern technologies like virtual reality (VR), augmented reality (AR) or adaptive learning to improve education quality and increase accessibility.^(11,12)

Nevertheless, some challenges are faced by students and teachers in remote regions while using online learning. These include limited access to the Internet or inadequate technical support.⁽¹³⁾ However, with the advancement of technology and increased awareness of the benefits of online education, these problems can be resolved or mitigated.^(14,15) Overall, online learning represents a valuable instrument for enhancing the accessibility of education in remote regions. However, its successful implementation necessitates identifying and resolving various challenges and limitations.

METHOD

1. Analytical review of the literature. A review of existing research and literature on online education and its role in ensuring access to education will identify current trends, problems and areas of research.
2. Meta-analysis. A systematic analysis of the results of several studies to identify common patterns and empirical findings on the effectiveness of online education to ensure access to education.
3. Analysis of education quality. Comparing the quality of education received through online courses in remote regions to traditional methods allows us to identify differences in performance and assess the extent to which online education contributes to ensuring access to quality education.
4. Determining the effectiveness of learning. The main task is to assess the effectiveness of online education compared to traditional teaching methods by comparing academic performance, level of understanding and acquisition of competences.
5. Analysis of statistical data. Data on the availability of education in remote regions and its changes over time will be studied by comparing data on students participating in online education with those studying using traditional methods.

Criteria for using interactive online learning tools have been developed, which were used for self-assessment

1. Relevance to learning objectives. The tool must meet the learning goals and objectives. For example, if the goal is to develop skills in solving mathematical problems, then the choice should be made in favour of platforms that offer appropriate exercises and tasks.
2. User interface and usability. The tool should be intuitive and easy to use for teachers and students. It will help avoid wasting time studying instructions and simplify the learning process.
3. Content quality. The content should be highly quality, relevant, and aligned with the curriculum and standards. It must be informative, understandable and engaging for higher education students.
4. Interactivity and adaptability. The tools should provide interactive features that promote students' active participation in the learning process. They must also be adaptive and can be adjusted to students' needs and knowledge levels.
5. Assessment and feedback options. The tools should provide opportunities for assessing student progress and providing teacher feedback. It may include automated systems for checking assignments and the ability to track student progress and provide individual feedback.

Learning effectiveness through developed interactive online tools was evaluated based on the quality of learning and self-assessment results. The effectiveness of learning through developed interactive online tools was verified in humanities disciplines using the example of the discipline 'English for Specific Purposes' and in the field of technical disciplines using the example of the discipline 'Advanced Mathematics'. This part presents the percentage parameters characterising higher education candidates' preparation levels. A survey assessed the self-perceived effectiveness of higher education candidates' use of interactive online learning tools. The questionnaire provided to respondents sought to determine the perceived effectiveness of using such tools.

The learning effectiveness (E_n) of higher education students using interactive online tools was determined as follows:⁽¹⁶⁾

$$E_n = \frac{(Ck1 \cdot 100\% + Pk1) + (Ck2 \cdot 100\% + Pk2) + \dots + (Ckn \cdot 100\% + Pkn)}{k}, \% \quad (1)$$

P - results of students' learning of the discipline during mastering lectures, practical, independent work provided by the curriculum, monitoring of semester results.

C - self-assessment indicator according to the questionnaire.
 k1, k2, ..., kn - the result of a particular higher education student.
 k - number of surveyed higher education students.

In higher education, candidates studying English have access to various interactive online learning tools covering various aspects of the language, including reading, writing, speaking, and understanding. These tools use images, text, and audio in interactive video lectures.

To aid students in understanding and memorising new words and phrases, interactive practical exercises on various topics have been developed, including exercises on grammar and vocabulary. For instance, in the context of studying predicative adjectives as components of expressive - speech acts whose illocutive purpose is to express certain feelings and attitudes - the functioning of predicative adjectives as expressive is explained through the use of interactive posters according to the following criteria: a) by mode of expression - direct and indirect; b) by universality - primary, non-institutional speech acts, typical to different spheres of communication; and c) by position in discourse - initial and reactive speech acts.

To enhance communication abilities, linguistic test simulators have been developed that focus on using linguistic techniques to express acts of apology, thanks, and compliments through predicative adjectives in the structure Vcop+Adj in conjunction with nouns and verbs.

Furthermore, video lectures, interactive tasks, and test simulators covering various mathematics topics from beginner to advanced levels were developed to assess the efficacy of interactive online tools. For use during practical work, an online graphing calculator was employed, which allows for graphing functions, performing calculations, and analysing data. Additionally, mathematical modelling and geometry software was provided, enabling students to create geometric constructions, plot function graphs, and solve equations. The software provides detailed solution steps and function graphs. These tools offer a wide range of possibilities for studying mathematics online.

RESULTS

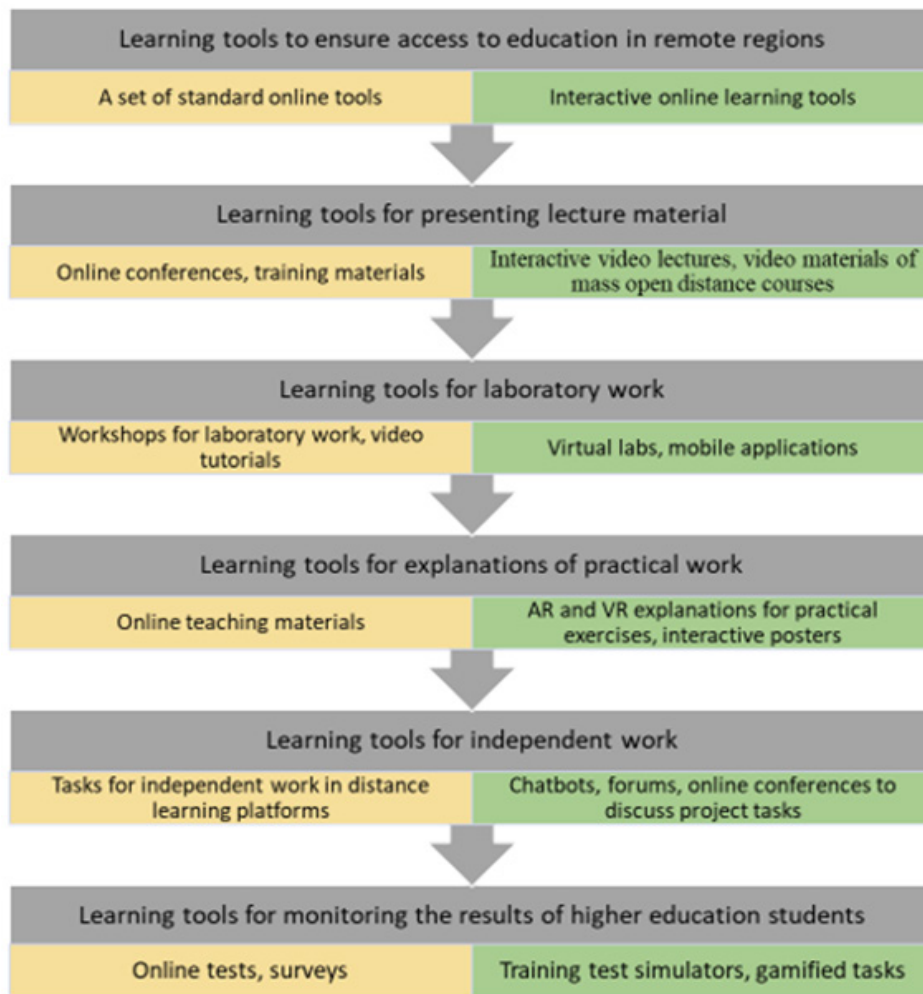


Figure 1. Comparison of using learning technologies with standard online tools and interactive online learning tools to provide access to education in remote regions

The advent of online platforms has enabled students from remote locations to access a vast array of courses and programmes that may be unavailable at local educational institutions. Modern online platforms facilitate interactive learning and provide the opportunity for feedback from instructors and other students through chats, forums, and video conferences.^(17,18,19)

In certain instances, state and international organisations have provided support in the form of special programmes and funding for the development of online education in remote areas.⁽²⁰⁾ Nevertheless, it is essential to acknowledge the limitations of online learning, including access to the Internet and technology, the quality of education compared to traditional methods, and the necessity for self-discipline for students to complete the course.

Despite these challenges, online learning tools represent a powerful means of providing access to education in remote areas.

Figure 1 shows a comparative analysis between online and traditional learning, according to different forms of learning (lectures, practical and laboratory work, independent work) to determine their relative advantages and disadvantages in providing access to education in remote areas.

Figure 2 compares the educational outcomes of higher education candidates studying English using traditional and interactive online learning tools. As illustrated in figure 2, higher education candidates' efficacy was 73 % when using traditional online learning tools. However, when interactive online tools were employed, the effectiveness of learning English increased to 87 %.

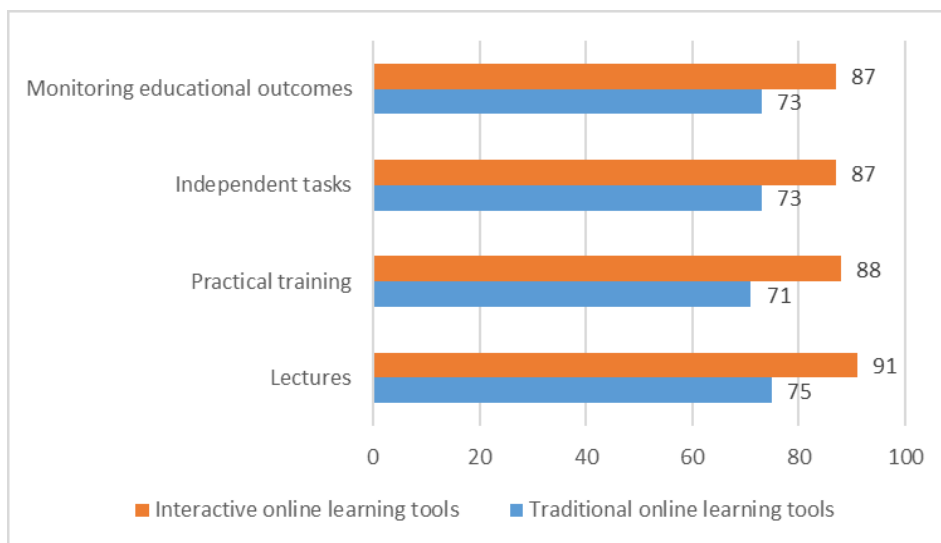


Figure 2. Comparison of the effectiveness of teaching English to higher education students using traditional and interactive online learning tools

Figure 3 compares the effectiveness of higher education candidates' learning mathematics using traditional and interactive online learning tools.

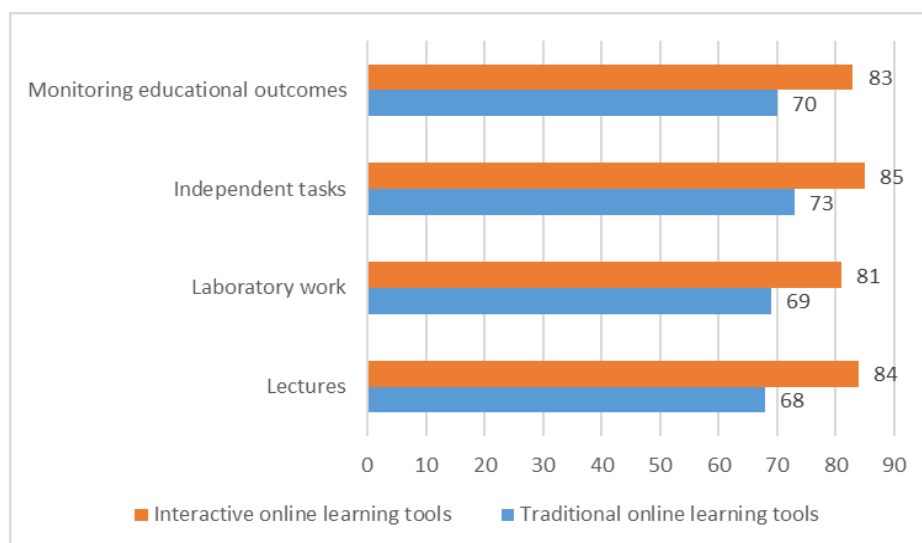


Figure 3. Comparison of the effectiveness of teaching mathematics to higher education students using traditional and interactive online learning tools

As illustrated in figure 3, the efficacy of mathematics learning by higher education candidates utilising traditional online learning tools was 70 %. In comparison, the utilisation of interactive online tools increased by 83 %.

DISCUSSION

In order to ensure access to *lecture material*, online conferences are employed, which facilitate direct interaction between the instructor and students in real-time. Students can pose questions and discuss with the instructor and other students. They provide instant access to information and the capacity to respond promptly to changes and current events. However, they necessitate coordinating a time for all participants to join, which can be challenging across different time zones. Unforeseen internet issues may disrupt learning. The learning materials allow students to study independently and according to their needs. Students can review the materials as needed to assimilate the information better. However, they do not offer the opportunity for direct interaction with the instructor or other students and require students to be independent and disciplined to study the materials without external coercion.

Interactive video lectures are educational content that provides active interaction between students, the material and the instructor. Incorporating interactive elements, such as embedded quizzes, tests, self-assessment tasks, and additional materials, enhances the engagement and excitement of the learning process for students. It contributes to an increase in their motivation and interest in the educational material. Interactive video lectures can be tailored to each student's needs and learning pace. For instance, students can choose the order of studying the material or skip previously mastered topics. Incorporating interactive tasks facilitates learning material's active application and consolidation, aiding its assimilation and retention. Embedded quizzes and tests within video lectures enable students to assess their knowledge and identify areas requiring further development. Interactive video lectures provide students with immediate feedback, for instance, by automatically checking test answers or instructor comments on specific video moments. It enables students to gain a deeper understanding of their mistakes and to enhance their knowledge.

Massive Open Online Courses (MOOCs) permit the combination of the advantages of the video format with interactive elements, such as tests, assignments, and discussion forums. Many MOOCs offer free access to learners from various countries and regions.

The practical aspects of laboratory work can be adapted to specific educational goals and course requirements. However, the availability of resources and access to equipment can present challenges in remote or under-resourced regions. Video tutorials offer a solution, allowing students to learn the laboratory work process at their own pace and from any location with internet access. They can demonstrate complex processes or techniques that are difficult to show in real time. However, they can only partially replace the experience of working with equipment and materials. Therefore, they require careful preparation and quality filming for maximum clarity and effectiveness.

Virtual laboratories allow students to perform experiments and work with equipment in a virtual environment, accessible from any location and at any time. They can be created with various scenarios and complexity levels and allow repeating experiments without restrictions.

Mobile apps provide convenient access to educational content at any time and place via mobile devices and can offer interactive tasks, tests, and exercises to deepen students' knowledge. However, they have limited capabilities for interaction with natural objects and equipment, which may be necessary for the complete execution of laboratory work.

To ensure the delivery of educational content for practical work, online methodological materials are easily accessible and can be used from any location and at any time via the Internet. A potential drawback is that they need more interactivity, which could diminish student engagement.

Augmented reality (AR) and virtual reality (VR) training for practical work enables students to interact with virtual objects and environments, simulating real-world practical situations. Interactive posters offer the possibility of visual representation of information through images, graphics, and animations, allowing students to interact with the content and receive immediate feedback.

Independent work tasks on remote learning platforms permit students to work on materials and assignments at their own pace and from any location with internet access. They provide the capability for automatic result checking and feedback.

Chatbots, forums, and online conferences for discussing project tasks provide opportunities for communication and experience sharing between students and teachers in real time. They can be used for discussing projects, problem-solving, and obtaining additional support. They promote the development of communication and collaborative skills.

Online tests and surveys are a standard method of monitoring the educational outcomes of higher education students, allowing knowledge and skills assessment at a convenient place and time for the students (annex 1). They can be structured to evaluate different aspects of knowledge, such as factual knowledge, analytical abilities, and problem-solving skills. They offer automatic processing of results and rapid feedback delivery.

However, they may need to be more effective in assessing skills that require an actual application, such as practical skills or creative thinking.

Educational test simulators permit candidates to practise their knowledge and skills in an interactive environment, improving their testing preparation. They can be customised to adapt to the candidates' knowledge level and individual needs and provide immediate feedback on the outcome of each question or task.

Gamified tasks offer a more engaging and exciting way to assess knowledge and skills, especially for younger audiences. They can stimulate competitiveness and motivation among candidates through gaming and rewards.

A study assessed the level of knowledge in higher education students in the humanities and mathematics disciplines, which form general competences. These students were observed to have studied using online learning tools and the proposed technology. The research on online learning tools was carried out over one semester for 120 higher education students. These students were divided into two groups: 60 students were taught using traditional online methods, and 60 students were instructed using interactive online methods, as outlined in the technology shown in figure 1.

Researchers S. Tudor⁽²⁰⁾ and K. Gary⁽²¹⁾ argue that large platforms such as Coursera, edX, Udemy, and Khan Academy offer online courses and educational programmes. Online platforms such as Zoom, Google Meet, and Microsoft Teams facilitate real-time communication and remote instruction, irrespective of geographical distance. Video hosting sites, including YouTube, have emerged as a popular medium for educational content, with instructors uploading lessons and materials for students to access. Creating online communities where students can communicate, ask questions, and share experiences contributes to building a supportive educational environment. These tools can effectively ensure access to education in remote areas, helping reduce spatial and temporal barriers. The conclusions of scientists are complementary to the results of this study.

Mobile apps like Duolingo for language learning and Photomath for mathematics allow students to learn anytime and from any location. Virtual reality (VR) and augmented reality (AR) technologies can facilitate the creation of immersive educational environments, enabling students to explore a diverse range of subjects and situations without leaving their homes. Platforms that employ artificial intelligence (AI) can offer tailored courses and materials, adapting to each student's knowledge level and individual needs. At the same time, E. García-Esteban, N. Dotsenko, O. Gorbenko, and A. Haleeva assert that developing interactive courses on specialised online platforms enables students to learn through completing assignments, testing knowledge, and communicating with instructors and other students.^{23,24)} Creating virtual laboratories and simulations allows students to gain practical skills and experience without leaving home, which is especially important for fields requiring experiments and practical work. Online platforms for discussing materials, exchanging ideas, and solving tasks promote active learning and the exchange of experiences among students and instructors. The research results of the mentioned scholars are in line with the conclusions of this study.

According to F. Menezes, R. Rodrigues, and D. Kanchan, adaptive learning technologies allow for customising the learning process to each student's needs and knowledge level.^(25,26) Thus, we can conclude that various methods and approaches are required to provide access to online education. The creation of video lessons and lectures accessible online allows students to receive educational content at a convenient time and from anywhere with internet access. It may include lecture recordings, expert commentary, and visual presentations.

We should agree with M. Landberg and M. Partsch that combining online and traditional learning can be a practical approach, particularly in regions with limited internet access or for providing practical lessons in a real-world format.^(27,28) Using online systems for feedback and assessment allows instructors to monitor student progress and evaluate their performance. The practical application of these methods necessitates the development of appropriate technological tools and training instructors and students in their use to achieve educational goals. This is exactly what the results of this study prove.

CONCLUSIONS

The outcomes obtained indicate that the deployment of interactive online learning tools can enhance the level of knowledge and facilitate the acquisition of competences, thereby ensuring the quality of education in remote areas.

English and mathematics exemplify this set of interactive online tools. A comparison of educational results and self-assessments of higher education candidates studying mathematics and English using traditional and interactive online tools yielded a conclusion about the latter's effectiveness: interactive online tools for delivering lecture material include interactive video lecture video materials from massive open online courses; tools for laboratory work include virtual laboratories and mobile apps; tools for explaining practical work include AR and VR explanations and interactive posters; tools for independent work include chatbots, forums, online conferences for discussing project tasks; tools for monitoring the results of higher education candidates include educational test simulators, gamified tasks.

Therefore, it is advisable to recommend online learning as a means of providing access to education in remote regions.

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The authors declare that there is no conflict of interest.

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ANNEXES

Annex 1. Self-assessment Questionnaire for Checking the Effectiveness of Interactive Online Learning Tools
Relevance to learning objectives

Rate from 0 to 1 how effectively the selected online tool helps you achieve the learning objectives.

0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
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What additional features or functions does the selected tool provide to support learning and achieve learning objectives? Please rate from 0 to 1.

0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
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User interface and usability

On a scale of 0 to 1, how would you rate the tool's accessibility for students with different levels of training and abilities?

0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
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From 0 to 1, how easy was it for you to navigate the interface of this tool?

0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
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Content quality

Please rate the extent to which the tool helps to stimulate students' interest in the material being studied from 0 to 1.

0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
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From 0 to 1, how effective is the tool in providing an individualised approach to learning?

0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
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Interactivity and adaptability

Please rate from 0 to 1 how much the tool's interactive features facilitate active participation in the learning process.

0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
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How much has using interactive tools increased your engagement and motivation in learning? Please rate from 0 to 1.

0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
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Evaluation and feedback opportunities

How effective is the feedback provided through the selected tool? Please rate from 0 to 1.

0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
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How often do you check your results and progress when using these tools? Please rate from 0 to 1.

0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
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