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Neuroscientific Foundations of Multimedia Technologies in Vocational Education

Iryna Androshchuk
Doctor of Science in Pedagogy, Full Professor, Professor of the Department of Technology and Professional Education and Decorative Arts, Khmelnytskyi National University, Khmelnytskyi, Ukraine.
ivandroshchuk@ukr.net,
https://orcid.org/0000-0002-8054-5574

Olena Murzina
Doctor of Pedagogical Sciences, Associate Professor, Associate Professor of the Department Mathematics and Informatics, Luhansk Taras Shevchenko National University, Lubny City, Ukraine.
elena_murzina@ukr.net,
https://orcid.org/0000-0002-6968-5525

Viktor Shakotko
PhD in Pedagogy, Senior Lecturer of the Department of Technology and Professional Education, Oleksandr Dovzhenko Hlukhiv National Pedagogical University, Hlukhiv, Ukraine. vv0304@gmail.com,
https://orcid.org/0000-0002-3004-5045

Vasyl Shunkov
PhD in Chemistry, Associate Professor, Associate Professor of the Department of Medical and Biological Chemistry, National Pirogov Memorial Medical University, Vinnytsya, Ukraine. svshunkov@gmail.com, https://orcid.org/0000-0002-3130-2250

Abstract: *This article explores the use of multimedia technologies in vocational education. These technologies support the effective design and implementation of pedagogical content and methods aimed at achieving educational objectives through multimedia hardware, software, and interactive applications. An empirical four-week study involving 60 first-year undergraduate students evaluated an AI-supported multimedia approach using ChatGPT and ELSA Speak within a multisensory learning framework. Compared with conventional multimedia instruction, the AI-supported approach resulted in greater improvements in vocabulary acquisition (28.5% vs. 11.2%), speaking performance (32.2%), student engagement, and emotional intelligence, particularly emotion management. The findings suggest that integrating AI-supported multimedia technologies may enhance learning outcomes, cognitive engagement, and student motivation in vocational education.*

Keywords: *multimedia technologies; information; educational material; interactive methods; neuroscience.*

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Liudmyla Shanaieva-Tsymbal
PhD in Public Administration, Associate Professor, Associate Professor of the Department of English Philology, National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine. almi2004@ukr.net,
https://orcid.org/0000-0002-4571-3827

Svitlana Yatsiv
PhD in Pedagogy, Associate Professor of the Department of English Philology, Faculty of Foreign Languages, Vasyl Stefanyk Carpathian National University, Ivano-Frankivsk, Ukraine.
svitlana.yatsiv@cnu.edu.ua, https://orcid.org/0009-0009-6695-8768

Borys Maksymchuk
Full Professor, Doctor of Science in Pedagogy, Professor of the Department of Physical Education, Sports and Human Health, Izmail State University of Humanities, Izmail, Ukraine.
0674256781@ukr.net, https://orcid.org/0000-0002-4168-1223

1. Introduction

The priority area of educational digitalisation is the development and implementation of multimedia technologies within vocational education (Bond et al., 2018). The integration of multimedia offers considerable potential for optimising training in various fields. However, multimedia tools should be applied systematically to maximise the effectiveness of learning. It is also essential to analyse the pedagogical principles underlying their use in vocational education.

According to Synytsia (2014), multimedia technologies in vocational education enable the effective organisation of teaching and learning. This contributes to the achievement of broader educational objectives.

Habib and Soliman (2015) argue that multimedia technologies are closely associated with innovative methodological approaches to vocational education.

These resources represent effective instructional tools that support the development of students' core competencies. Recent advances in artificial intelligence have shifted educational practice from the passive use of multimedia resources towards interactive AI-supported learning environments that facilitate cognitive processing and student engagement. Despite their increasing adoption, evidence of their effects on emotional intelligence, vocabulary acquisition, and speaking skills in vocational education remains limited.

Therefore, this study aimed to evaluate the effectiveness of an AI-supported multisensory approach to English language teaching by examining its impact on emotional intelligence, vocabulary acquisition, speaking skills, and student engagement.

2. Key Features of Multimedia Use in Vocational Education

Various software resources, including e-textbooks, digital books, and other teacher-created materials, contribute to the effectiveness of vocational education. They provide students with relevant educational content that addresses their academic interests and learning needs. Such tools also facilitate interpersonal communication in the virtual learning environment.

The Internet, one of the most widely used sources of information, supports both teachers and students throughout the learning process. Multimedia learning technologies integrate technical tools with instructional materials. Their use in vocational education broadens opportunities for more intensive and enriched learning.

This article analyses the effectiveness of multimedia technologies in vocational education from the perspective of cognitive load theory (Sweller, 2011). This theory reveals the limited capacity of working memory and highlights the need to reduce extraneous cognitive load when using AI-based learning tools. At the same time, dual coding theory explains how visual and verbal information can be combined to enhance learning processes (Paivio, 1990). This process relies on complementary processing channels that support memory formation and retrieval.

Special emphasis is placed on the concept of inter-brain coupling in educational interaction. It refers to the synchronisation that may occur between students, interactive content, and teachers during learning activities. This phenomenon is often discussed in relation to mirror neuron systems and social interaction in educational contexts. Such synchronisation may support the transition from passive perception of video materials to more active modelling of professional skills. It is also associated with increased attentional engagement and motivational processes, which help reduce cognitive fatigue in digitally intensive learning environments.

The use of multimedia technologies in education is characterised by several key features. These include classrooms equipped with computers and access to dedicated spaces with multimedia projectors. In the teaching and learning process, widely used applications such as Microsoft Teams, Word, Excel, PowerPoint, Outlook, OneNote, and OneDrive are integrated, as they are essential digital tools for students in today's society.

The incorporation of video materials further enhances learning by visualising content and supporting the acquisition of new knowledge. Overall, teachers who employ multimedia technologies in their classes have extensive opportunities to enrich and improve the educational

process through more interactive, visual, and flexible instruction. For example, they can design and deliver lectures in more innovative and engaging ways than those offered by traditional methods (see Figure 1).

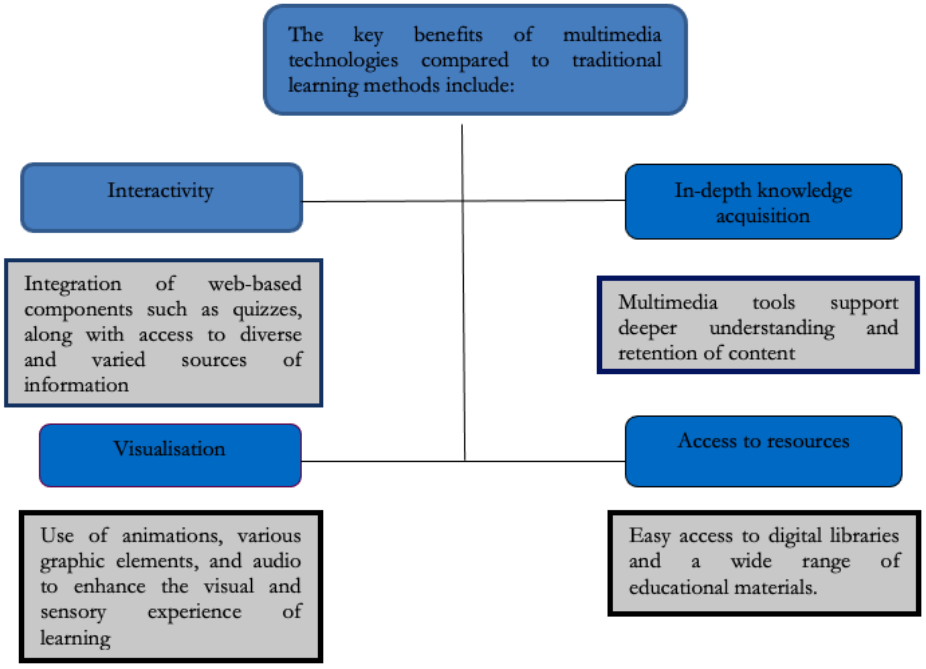

Figure 1. Cognitive information processing model of AI-supported learning: Interaction of visual and auditory channels and memory systems
Source: The authors' own conception

Skalych (2015) argues that multimedia technologies integrate verbal and visual-sensory information, thereby enhancing students' motivation to learn. Incorporating multimedia tools into lessons allows teachers and students to save time, enrich the educational experience, and simplify content delivery. Given that these tools are accessible to all learners, they contribute to more active and self-directed learning.

Multimedia technologies can be categorised based on their mode of interaction and application. They include online platforms, asynchronous and synchronous tools, audio clips, video segments, animated graphics, and virtual objects. Their increasing use in vocational education reflects the necessity of integrating such tools across academic disciplines.

As stated by Kucher et al. (2022), the introduction of multimedia technologies presents both benefits and limitations. For instance, the use of a multimedia projector requires careful preparation, namely, organising lessons and selecting suitable digital materials. In vocational education, students are expected to work with large volumes of scientific information, as research activity is an essential component of professional training.

As a result, students need a solid understanding of theoretical content and the ability to process various diverse forms of information. Internet technologies tend to exceed expectations by enhancing student motivation and promoting learner autonomy. Multimedia technologies also increase learners' interest at both conscious and subconscious levels through interactivity, visualisation, and the structured presentation of information.

The main features of multimedia technologies include a) storage and processing of data in digital form, b) interactivity, and c) integration of different types of information such as text, graphics, and hypertext. While visual channels are not necessarily the most critical, they are among the most powerful in multimedia contexts. Interactive use of keyboards and mice in multimedia learning materials engages motor activity, thereby supporting memory development.

These technologies are inherently learner-centred. Their primary aim is to support the development of professional skills by combining traditional and advanced teaching approaches. Their effectiveness depends on their ability to address students' educational needs and learning interests.

Zhelanova (2022) highlights the notable teaching potential of such technologies at all educational levels. They support learners' cognitive development and contribute to the formation of artistic culture.

Currently, the integration of multimedia technologies represents one of the most promising strategies for advancing vocational education. However, sustained progress depends on key prerequisites, such as teacher training and the development of methodological and material resources.

The interactivity of multimedia technologies increases student involvement in the educational process. They rely on a wide range of resources: video, audio, and animation help sustain students' attention to the material, while diagrams, graphs, and videos simplify complex concepts and abstract ideas. As a result, students are motivated to learn at their own pace, revisit challenging concepts, and progress when they feel ready.

It is, therefore, crucial to address funding, equal access, and comprehensive teacher training to maximise the potential of multimedia technologies (see Table 1).

Table 1. Prerequisites for the effective implementation of multimedia technologies

Condition	Description
1. Advanced tools	Equipping educational institutions with advanced technologies
2. Network access	Secure internet access for using educational videos and distance learning platforms
3. Professional development	Organising training sessions, seminars and courses on multimedia technologies in education
4. High-quality learning resources	Creating and implementing interactive and educational resources to meet students' educational needs
5. Effective evaluation	Assessing the effects of multimedia on learning outcomes

Source: The authors' own conception

Multimedia technologies rely on enhancing perception through the presentation of information via multiple sensory channels. They also incorporate artistic elements into interface design to support intuitive navigation (Luzik et al., 2019).

3. Empirical Research

The study was conducted at a higher education institution in Kyiv. The sample comprised 60 first-year bachelor's students enrolled in the course "Foreign Language for Professional Purposes" (English proficiency level: B1). Participants were required to be full-time students, possess basic computer literacy, and provide informed consent for the processing of personal data. Students who missed more than 15% of classes or had prior experience using specialised AI applications for language learning on a regular basis were excluded from the study. Participants were randomly assigned to either the experimental group (EG, n = 30) or the control group (CG, n = 30).

Intervention Programme and AI Tools. The empirical study lasted four weeks and consisted of a 36-hour training course, including 12 hours of lectures and 24 hours of practical classes. In the experimental group (EG), instruction was based on a multisensory approach supported by two AI tools.

ChatGPT (GPT-4) was used as a personalised conversational tool to simulate professional dialogue in both spoken and written formats. It supported contextual vocabulary practice in realistic communicative situations. The ELSA Speak platform was used to provide real-time pronunciation feedback and support learners in overcoming language barriers.

The structure of multisensory activities involved the simultaneous activation of visual and auditory channels. Students interacted with the AI graphical interface, received auditory feedback, and generated their own speech responses, which minimised extraneous cognitive load. In the CG, training relied on a traditional methodology using static multimedia presentations and standard audio materials without elements of interactive, AI-adaptive dialogue.

Assessment Tools and Criteria. Emotional intelligence was assessed using an adapted instrument based on the Mayer–Salovey–Caruso Emotional Intelligence Test (MSCEIT). The instrument assessed four components:
1) identification of emotions,
2) use of emotions to stimulate thinking,
3) understanding of emotions, and
4) emotional management.
Assessments were conducted at baseline and immediately after the intervention.
Vocabulary acquisition and speaking skills were measured using criterion-referenced tests (scored on a 10-point scale). The criteria for assessing speaking were as follows: 1) speech speed (number of words/minute), 2) lexical variety, and 3) phonetic accuracy.

Motivation and engagement were recorded through structured classroom observation using engagement checklists. The criteria included initiative in dialogue, sustained attention, and speed of task engagement. In addition, a post-course questionnaire using a 5-point Likert scale was administered.

4. Results

A comparative analysis conducted following completion of the 36-hour course revealed clear differences between the experimental and control groups. Students in the experimental group (EG), who received AI-supported instruction using ChatGPT and ELSA Speak, demonstrated greater improvements in language competence than those in the control group (CG). The mean vocabulary test score increased by 28.5% in the EG, compared with 11.2% in the CG. Similarly, speaking performance improved by 32.2% relative to baseline, reflecting the benefits of interactive, real-time language practice supported by AI tools.Analysis of the classroom observation records demonstrated a marked improvement in students' concentration and engagement within the EG. The mean engagement score increased from 3.2 to 4.5 on a five-point scale, representing a 40.6% improvement. By the end of the intervention, students also demonstrated faster task engagement and fewer observable signs of cognitive overload.With regard to emotional intelligence, assessed using the Mayer–Salovey–Caruso Emotional Intelligence Test (MSCEIT), the greatest improvement was observed in the Emotion Management component. In the EG, performance on case-based tasks increased from 51% to 73%. These findings suggest that interaction with AI-supported learning tools may have reduced speaking anxiety compared with conventional teacher-led instruction, thereby contributing to a more psychologically supportive learning environment.

5. Discussion

The findings suggest the effectiveness of combining visual and auditory learning channels. According to the dual coding theory, such integration promotes better retention of information, while controlling cognitive load helps avoid overloading working memory.

A detailed analysis of multimedia use in professional education indicates that the most commonly employed tools include:

- Presentations – used to visually convey information with audiovisual support.
- Animated videos – the process of simulating motion through the rapid display of consecutive frames that capture specific phases of an object’s change in state or position.
- Video players – software programmes that allow users to edit and manage videos.
- Multimedia applications – digital tools designed to develop specific skills and competencies.

The use of multimedia technologies at all levels of the educational process has significant pedagogical potential. It contributes to learners' cognitive, cultural, and creative development while supporting artistic awareness. Currently, implementing multimedia technologies is one of the most promising trends in the digital transformation of vocational education.

To further advance this approach, several conditions should be met. These include professional development of vocational education teachers, improvement of methodological and software resources, and enhancement of material and technical support.

The principles of multimedia technologies include the ability to present information through multiple media that humans can perceive. They also include the presence of artistic interface design and clear navigation tools. Recent studies have demonstrated the advantages of integrating multimedia into vocational education (Jin, 2025). Students may develop decision-making abilities and improve their capacity to evaluate different problem-solving strategies. They also foster algorithmic thinking and problem-solving skills. Motivation improves through the acquisition of new knowledge, among other benefits.

The authors' methodology for using multimedia technologies in vocational education highlights their potential to support teachers' creativity and instructional flexibility. In particular, interactive tools positively affect the interaction between teachers and students. They allow educators to conduct lessons more engagingly and effectively, while also enhancing students' comprehension and retention of material.

The course provides participants with the opportunity to acquire comprehensive knowledge of multimedia and interactive technologies. It familiarises participants with advanced educational equipment and digital teaching tools. The programme includes training in software packages for specific interactive whiteboards, as well as universal interactive technologies. According to the curriculum, the course consists of 36 hours, including 13 lecture hours and 23 practical hours.

The primary objective of the course is the development of information and communication competencies among vocational education teachers. These competencies serve as a foundation for addressing subject-specific, methodological, and instructional tasks through the use of multimedia and interactive technologies. They also enable participants to develop advanced methods for creating electronic educational materials for teaching and student development.

The course objectives include demonstrating the effectiveness of advanced technologies for preparing educational materials in subject-specific teaching. The course also aims to develop skills in using multimedia and interactive applications, including importing and exporting various types of information. Another objective is to present criteria for selecting and applying interactive digital educational resources in accordance with educational standards. The course also seeks to expand participants' use of electronic educational resources.

The programme comprises theoretical and practical components. A significant portion of the practical sessions supports active and effective learning. The programme may be delivered full-time, part-time, or through distance learning formats (approximately 4–6 academic hours per day). Knowledge is systematically assessed through portfolios, discussions, and review of theoretical material. The final assessment consists of presenting and defending an individual graduation project, namely, a portfolio of multimedia and interactive didactic materials developed during the course.

During lessons, teachers should consider two main forms of interaction with professional development participants. The first involves the completion of practical tasks related to the topics studied. The second involves the development of a thematic project in the form of a portfolio containing multimedia and interactive educational and methodological materials. The submitted portfolio must have a unified theme and design style. It should be presented as an integrated project with an interactive organisational structure for the materials.

To ensure the successful completion of practical work, it is recommended to provide each participant with materials, in electronic or printed form, including task instructions, templates, or examples. Instructors should support participants' initiatives and encourage exploration of

additional material to enhance creativity and motivation, including tasks of an advanced level. Instructors should use the most relevant tools identified through discussion during practical work. They should also take into account participants' professional knowledge. A binary assessment system ("pass/fail") may be considered appropriate.

The study identified several principles reflecting the effectiveness and limitations of using multimedia tools for teaching. Although multimedia-based learning does not solve all problems, it occupies an important place among 21st-century teaching methods. Multimedia technologies allow students to work with learning materials in varied ways. They can independently choose how to study the content, benefit from the interactivity of information technologies, and collaborate with their peers. In this regard, students become active participants in the educational process. Multimedia technologies, electronic publications, and educational resources help students better develop their abilities and meet their learning needs.

The use of multimedia technologies positively affects several aspects of learning. It stimulates cognitive skills, including perception and understanding of information. It also contributes to increased student motivation. It develops students' individual and collaborative learning skills. It promotes deep learning and thorough understanding of the material.

The use of multimedia video materials in education enables instructors to provide students with comprehensive and accurate information about educational phenomena and processes. It enhances visualisation within the learning process. It also addresses students' educational needs and learning interests. It reduces instructors' involvement in routine technical tasks related to assessment and feedback. It also facilitates more effective feedback processes. It also allows for comprehensive and systematic assessment and recording of objective performance.

According to the dual coding theory, information is processed through two relatively independent systems: 1) verbal (auditory/speech) and 2) non-verbal (visual). When learning material is presented through both channels simultaneously, for example text or spoken explanations combined with images or diagrams, two related cognitive codes are formed. This enhances memorisation since the information is stored in two forms and can be mutually activated during recall.

However, the effectiveness of this process depends on coherence between the channels. If verbal and visual information are redundant or contradictory, the learning effect is reduced.

From a neurocognitive perspective, multimedia technologies contribute to a better adaptation of teaching methods to students' cognitive abilities. Interactive elements support attentional focus, especially when the content corresponds to students' cognitive needs. In turn, clickable objects and real-time questions promote active participation.

Multimedia technologies facilitate the presentation of information through visual materials and images. Repeated exposure to visual information may stimulate cognitive processes associated with short-term and long-term memory. Complex concepts are better retained when visual images and diagrams connect them to real-world objects and phenomena.

Motivational videos, images with positive emotional content, and inspiring music can create favourable learning conditions and boost students' interest in the topic. They make the learning process more engaging and accessible, thereby enhancing its effectiveness. Finally, the use of multimedia methods encourages students to develop independent perspectives and critical thinking skills. At the same time, it helps maintain the coherence of the lesson and leads to better learning outcomes.

6. Conclusion

Educational digitalisation involves the progressive integration of information technologies and digital teaching tools alongside traditional instructional approaches. Consequently, teachers should be equipped not only with subject-specific expertise but also with the digital competencies required to use innovative educational technologies effectively.

The findings indicate greater improvements among students who received AI-supported instruction. The experimental group demonstrated a 28.5% increase in vocabulary test scores (from 6.3 ± 1.2 to 8.1 ± 0.9 on a 10-point scale), compared with an 11.2% increase in the control group. Student engagement also improved, and positive changes were observed in emotional intelligence, particularly in the Emotion Management component, which increased by 22%.Overall, the findings suggest that integrating AI-supported multimedia tools within a multisensory learning framework may enhance language learning, student engagement, and emotional intelligence compared with conventional multimedia instruction. Further research involving larger samples and more comprehensive outcome measures is warranted to confirm these findings.

Statement on the Use of Artificial Intelligence

The authors declare that artificial intelligence tools were used to improve the readability of the text. However, they remain fully responsible for interpreting the findings and formulating the conclusions.

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