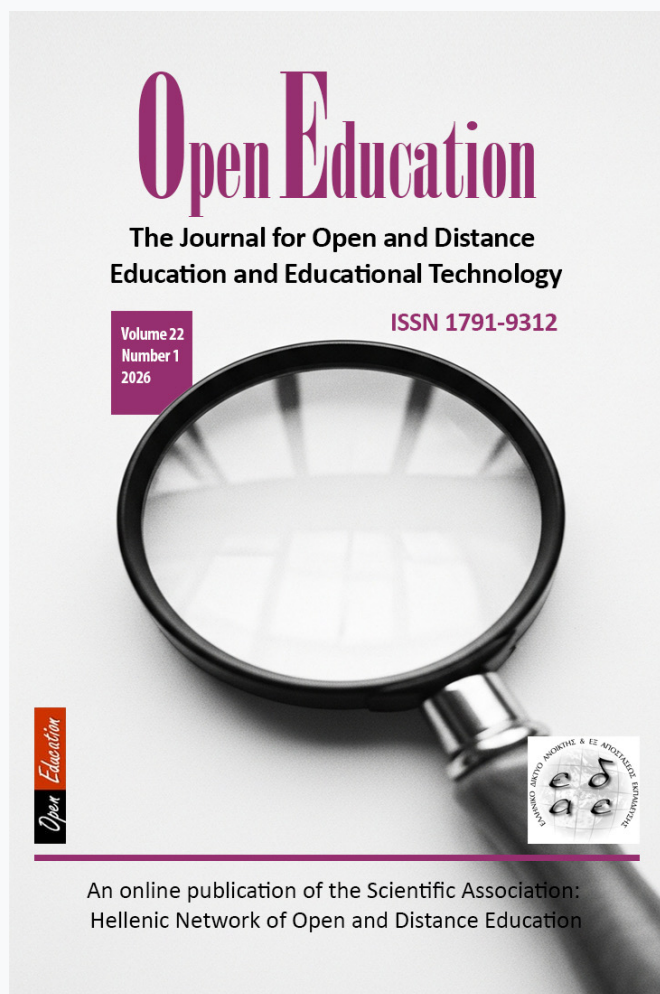


# Ανοικτή Εκπαίδευση: το περιοδικό για την Ανοικτή και εξ Αποστάσεως Εκπαίδευση και την Εκπαιδευτική Τεχνολογία

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**Design, development, and assessment of educational materials for e-learning environments aimed at the professional growth of primary school teachers, utilizing Augmented Reality**

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**Βιβλιογραφική αναφορά:**

## **Design, development, and assessment of educational materials for e-learning environments aimed at the professional growth of primary school teachers, utilizing Augmented Reality**

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### **Extended Summary**

The rapid evolution of Information and Communication Technologies (ICT) has introduced innovative pedagogical tools, with Augmented Reality (AR) emerging as a transformative force in Primary Education. AR bridges the gap between the physical and digital worlds, enhancing student engagement and spatial understanding. However, despite its potential, Greek primary school teachers often report significant barriers to its integration, including a lack of specialised training and high-quality digital resources. This study addresses this gap by designing and evaluating a specialised asynchronous e-learning programme for teachers. The educational material was developed based on the principles of Multimedia Learning by Mayer and Adult Learning Theory, emphasising the reduction of cognitive load by utilising a 'no-code' environment (Blippar) for AR content creation, allowing teachers to focus on pedagogical implementation rather than technical programming. The LMS Chamilo served as the hosting platform, integrated with H5P interactive elements to promote active participation.

A mixed-methods research design was employed to ensure a comprehensive evaluation. Initially, four experts in Distance Education (DE) and ICT assessed the material for scientific validity and pedagogical alignment. Subsequently, an experimental study was conducted with a sample of 67 primary school teachers from

Heraklion, Crete. Data were collected through pre- and post-training questionnaires , using Likert scales and open-ended questions. The statistical analysis (Paired Samples T-test) revealed a significant positive shift in teachers' attitudes towards AR. Specifically, the mean score for teachers' belief in the educational value of AR rose from 3.88 in the pre-test to 4.57 in the post-test, with a high level of statistical significance ( $p < 0.001$ ). Furthermore, qualitative findings indicated that teachers highly valued the 'ready-to-use' teaching scenarios, whilst they encountered slight technical challenges in the initial design phase. This indicates that for AR to be successfully adopted in schools, training must prioritise practical application over theoretical complexity. In conclusion, the study demonstrates that well-structured, asynchronous e-learning can effectively improve teachers' self-efficacy and attitudes towards emerging technologies, provided they are supported by high-quality resources that simplify technical barriers.

### **Keywords**

Augmented Reality, Distance Learning / Distance Education, Teacher Training / Teacher Professional Development, Educational Material Design, Primary Education, Blippar, Chamilo

### **Introduction**

In the modern digital age, integrating Information and Communication Technologies (ICT) into education is no longer optional but essential for improving the learning process. Augmented Reality (AR), as an emerging technology, offers the opportunity to connect the real world with digital objects, creating environments that foster active participation and knowledge building (Akçayir & Akçayir, 2017; Azuma, 2017). Especially in primary education, AR can transform teaching into an experiential learning process, helping students grasp complex and abstract ideas (Tsiavos & Sofos, 2020; Fokidis & Foniadaki, 2017). Despite these potential benefits, teachers have yet to fully adopt ICT in their daily teaching practices. Both international and Greek literature emphasize that simply possessing technology does not guarantee its effective use in teaching. Teachers face many challenges, including limited time,

inadequate infrastructure, and most importantly, a lack of targeted professional development (Zubair & Khan, 2020; Fokidis & Foniadaki, 2017). The need for training programs that focus not only on technical skills but also on pedagogically integrating digital technology through well-designed teaching materials is more urgent than ever. The aim of this study is to design, implement, and evaluate the pedagogical effectiveness of an asynchronous distance learning environment aimed at primary school teachers. Specifically, the research intends to examine the impact of specialized educational materials on teachers' attitudes and self-confidence regarding the integration of Augmented Reality into their teaching practices (Parmaxi & Demetriou, 2020; Tsiavos & Sofos, 2020).

The structure of this thesis is as follows: The first section discusses the theoretical framework related to augmented reality, distance learning, and adult education. The second section describes the design of the educational material for this specific case study. The third section explains the research methodology, while the fourth section presents and analyzes the research findings. Finally, the fifth section offers conclusions and recommendations for future research.

## **1. Theoretical framework**

### **1.1. Augmented Reality**

Augmented Reality (AR) is conceptually defined as the technological process that allows the superimposition of digital information (3D models, videos, sounds) onto the physical environment in real time, creating an enriched and interactive perception of the world (Chen et al., 2017; Choong, 2022; Marino et al., 2021). Within the educational process, AR is not merely a visual aid, but a tool that bridges the gap between theory and practice, offering a 'spatial coupling' of information. Its ability to semantically integrate digital content into the physical classroom context enables the creation of authentic learning environments that support the active construction of knowledge (Chen & Lin, 2020; Papanastasiou, Drigas & Skianis, 2021).

Recent research data demonstrate the effectiveness of AR in education, as it offers many benefits for students. VR technology enhances the visualisation of abstract concepts, cultivates spatial perception and promotes experiential learning through exploration (Chen & Lin, 2020; Garzón et al., 2019; Garzón et al., 2020; Li, Lee & Yang,

2019). This visualisation is vital for young learners, as it allows them to interact with three-dimensional models that would otherwise be inaccessible or invisible, such as the structure of molecules, the solar system or historical monuments. VR helps to reduce the cognitive load, allowing students to focus on the essence of the information, which leads to increased motivation and active engagement in the learning process (Akçayir & Akçayir, 2017; Joo, Kim & Kim, 2022; Papanastasiou, Drigas & Skianis, 2021).

However, the adoption of e-learning is accompanied by significant limitations and challenges. The technological complexity involved in using the applications, requirements for technical infrastructure and, above all, the absence of a sound pedagogical design can lead to counterproductive results, causing 'cognitive overload' in students (Akçayir & Akçayir, 2017; Bacca et al., 2014; Garzón et al., 2019; Ibáñez et al., 2014; Miller & Dousay, 2015). The literature emphasises that digital technology is effective only when it is organically integrated into a teaching scenario with clear learning objectives, avoiding its use as a mere means of impressing, as 'impressing' without a pedagogical foundation does not ensure long-term learning (Akçayir & Akçayir, 2017; Miller & Dousay, 2015).

In Greece, the implementation of e-learning in primary education is still at the research and pilot stage. Teachers, whilst recognising the potential of this technology, often state that they are unprepared to integrate it due to a lack of digital infrastructure and ready-made teaching materials compatible with the national curriculum (Tsiavos & Sofos, 2020; Fokidis & Foniadaki, 2017). There is, therefore, an urgent need for targeted training in content creation tools that do not require programming knowledge (no-code tools). The provision of such tools can act as a catalyst, enabling teachers to move beyond the technical aspects and focus on creating innovative educational materials that meet the needs of their students.

## **1.2. Distance Learning**

Distance Learning (DL) is conceptually approached as an autonomous and dynamic pedagogical system that supports open, flexible and multifaceted learning. Whilst traditionally defined by the physical distance between teacher and learner (Keegan, 2006), more contemporary definitions approach it as an institutionalised, formal

education system, where the learning group is geographically dispersed and interactive telecommunication systems are used to connect learners, resources and tutors (Simonson, Zvacek & Smaldino, 2019; Hodges et al., 2020).

This conceptual shift emphasises 'interactional distance' rather than geographical distance. According to Moore & Diehl (2019), transactional distance is not a measurable distance in kilometres, but a psychological and communicative gap which, if not bridged, can hinder communication and impede knowledge construction. This distance is determined by the reciprocal relationship between three variables:

- **Dialogue:** The qualitative and meaningful interaction between trainer and trainee.
- **Structure:** The extent to which the educational design and materials respond to the individual needs of the learner.
- **Autonomy:** The learner's ability to self-regulate their learning journey.

The more dialogue is encouraged and the structure is pedagogically flexible (as in the case of the Chamilo platform), the more the transactional distance is reduced, limiting the feeling of educational isolation. As Kotsidis & Anastasiades (2023) argue, the success of an ODL programme does not depend on the technology itself, but on the quality of pedagogical interaction and support that ensures the coherence of the learning experience.

A central pillar of the process is the Educational Material (EM). Within the context of Blended Learning, the EM must be highly interactive and designed in such a way as to substitute for the physical presence of the teacher, encouraging the learner's autonomy and self-directed learning (Horton & Horton, 2022; Mayer, 2020). In this study, the use of a Learning Management System (LMS), such as the Chamilo platform, provided the necessary structured framework for the implementation of asynchronous training. The asynchronous format was chosen strategically, as it allows participating teachers to manage their time autonomously, repeat activities and experiment with Augmented Reality (AR) tools without the pressure of real-time constraints, thereby facilitating their smooth digital transition.

At the same time, the role of the teacher as an educator in ODL is radically transformed: from a 'source of information' they become a designer, motivator and facilitator, guiding the learning process through the digital environment (Garrison,

2017; Martin & Bolliger, 2018; Moore & Diehl, 2019). The success of MOOCs in adult education is based on the creation of a supportive environment that promotes knowledge construction through social, pedagogical and cognitive engagement, enhancing the interaction between the user and the material (Garrison, 2017; Martin & Bolliger, 2018; Moore & Diehl, 2019).

### **1.3. Adult education**

Teacher training is approached as an ongoing process of professional development, grounded in the principles of andragogy. According to Knowles, Holton & Swanson (2020) and Tough (2018), the adult learner possesses a set of characteristics that determine the effectiveness of learning: the need for self-direction, the utilisation of their rich reservoir of experience and, above all, a readiness to learn when new knowledge is linked to solving real-life problems in their daily lives. The target group of this study, the 67 primary school teachers in the prefecture of Heraklion, Crete, embody these characteristics, as they seek professional development activities that have direct application and impact in the classroom.

However, the transition to innovative digital environments, such as those involving Augmented Reality, is often hindered by a variety of learning barriers. These may be external (lack of time, limited resources) or internal, the main ones being technological anxiety and resistance to abandoning traditional teaching practices (Bozkurt, 2019; Mezirow, 2018; Vaughan, Dell & Garrison, 2017). According to Anastasiadis (2014), professional development in ODL must recognise these barriers and provide a flexible framework that reduces learners' sense of insecurity.

In this context, Mezirow's (2018) theory of Transformative Learning is considered the most appropriate for interpreting the training process. Learning in adults is not a simple accumulation of information, but a profound process of 'critical re-evaluation' of the assumptions and beliefs that shape the way they perceive education. Professional development in VET aims at a 'transformation of perspective', in which the teacher redefines their relationship with innovation. Through this process, technology ceases to be viewed as an external, additional burden or a mere technical tool, and is now recognised as an integral, structural element of educational planning,

capable of qualitatively enhancing teaching practice and strengthening the learning experience.

Overcoming learning barriers is achieved when the training process provides 'empowering knowledge', which allows the teacher to free themselves from internalised limitations and prejudices regarding their technological competence. As Mezirow (2018) points out, this knowledge transcends the utilitarian level and functions as a means of self-awareness and empowerment, helping the learner to recognise the sources of their internal resistance. Through the process of critical reflection, teachers develop the necessary self-confidence to adopt innovative pedagogical practices, transforming technological anxiety into creative teaching action. In this transformation, the use of 'no-code' tools, such as Blippar, acts as a catalyst, allowing teachers to experience immediate success in creating their own materials, leading them to establish a new professional identity, that of the creative digital learning designer (Knowles, Holton & Swanson, 2020).

## **2. Design of the Educational Material**

### **2.1. Theoretical Framework and Design Principles**

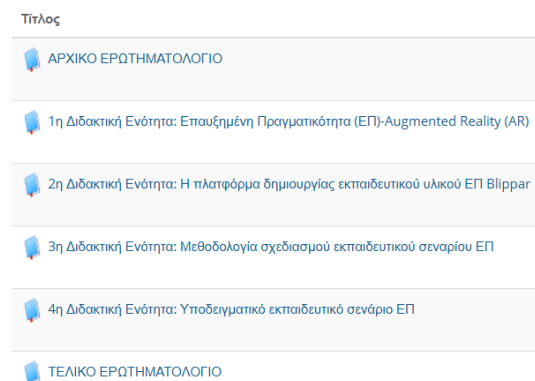
The design of the Educational Material (EM) for this training programme was based on a structured pedagogical framework, in order to respond to the specific conditions of Distance Learning (DL) and adult education (Akrítidou, 2023; Manousou, Chartofylaka & Ioakeimidou, 2020). The LMS was designed to function as a 'teacher', being self-sufficient and self-explanatory, guiding the learner towards the autonomous and self-directed construction of knowledge.

The seven basic principles of Lionarakis & Spanaka (2017), which ensure the immediacy of discourse, discovery-based learning and the clarity of teaching objectives, reinforcing the experiential approach. At the same time, the design followed the model of Anastasiadis & Kotsidis (2015) for the creation of an open and flexible learning environment via the Chamilo platform. This approach promotes learner autonomy and contributes to a significant reduction in the 'transactional distance' (Moore, 2019), ensuring pedagogical interaction despite the physical distance between teacher and learners.

## 2.2. Functional integration of the principles of multimedia learning

To achieve the learning objectives and optimise the management of the cognitive load on teachers, the principles of Multimedia Learning by Mayer (2020) and Anastasiadis & Kotsidis (2015) were functionally integrated into the design of the e-learning course as follows:

- **Principle of Segmentation:** The material was organised into small, self-contained and manageable modules. The division into short videos and texts reduced the volume of information, allowing learners to control their own pace of learning. This structure is reflected in the way the Chamilo environment is organised, where the thematic modules are presented with a clear hierarchy ([Figure 1](#)).



*Figure 1 : Application of the principle of segmentation through the organisation of training material into self-contained teaching units*

- **Principle of Signposting:** To guide learners more effectively, visual cues such as arrows, boxes and bold text were incorporated into H5P interactive objects. These cues focus attention on critical points of the Blippbuilder interface, reducing unnecessary visual searching and extrinsic cognitive load. The application of this principle is shown in **Figure 2**, where the key functional areas of the e-learning course creation platform are highlighted.



Figure 2: Use of visual cues (arrows and boxes) to guide teachers' attention to critical interface tools

- **Principle of Cohesion:** The presentation was kept simple, avoiding unnecessary decorative elements or background music that might cause distraction.
- **Principle of Spatial and Temporal Proximity:** Explanations were placed in close proximity to the corresponding visual elements, and the narration was synchronised with the appearance of the images, reducing the cognitive effort required to make the connection.
- **Multimedia Principle:** Learning was enhanced through the combination of images (screenshots) with interactive videos and narration, ensuring a multisensory experience.
- **Principle of Personification:** Direct and friendly language (first and second person) was used in the narration of the user guides, enhancing the sense of social presence.
- **Principle of Voice:** The narration was delivered using a natural human voice, which, according to theory, is more effective than a synthetic computer voice.
- **Principle of Pre-training:** Before introducing the complex functions, basic information on the concepts of AI was provided so that the teachers would have the necessary background knowledge.
- **Principle of Omission:** The simultaneous display of written text on the screen that merely repeated the narration verbatim was avoided, to prevent visual overload. The balance between visual stimuli and narration, as well as the simplicity of the slide design, are illustrated in **Figure 3**.

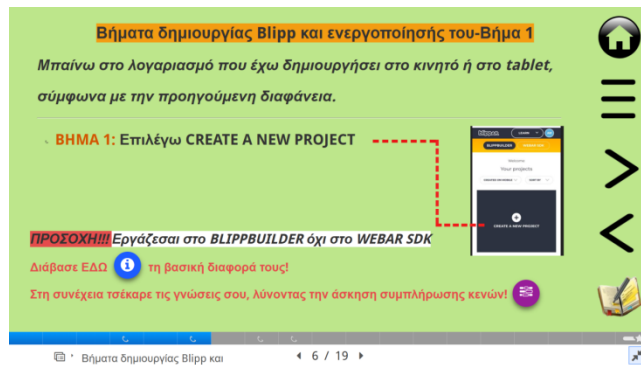


Figure 3: Application of the principles of Cohesion and Redundancy in a section of the training material

- **Principle of Modality:** The transmission of information is not based exclusively on text, but utilises a combination of visual graphics and audio narration. The incorporation of audio icons and interactive videos allows the learner to receive instructions simultaneously through both the auditory and visual channels, thereby avoiding cognitive overload. The application of this principle, which enhances deeper understanding, is illustrated in **Figure 4**.

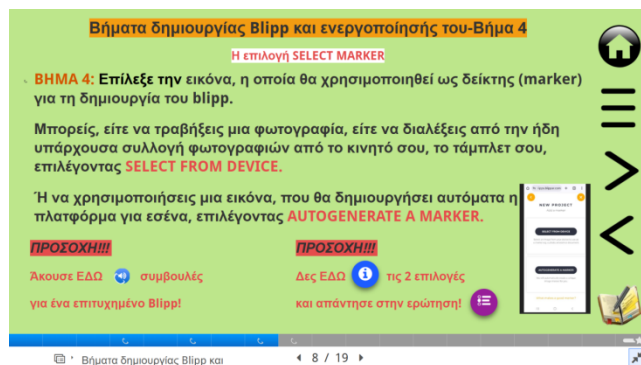


Figure 4: Combination of visual elements and audio prompts for optimal cognitive load management

### 2.3. Development tools and platforms

Modern open-source tools and innovative ‘no-code’ platforms were utilised for the development, organisation and distribution of the Educational Material (EM), ensuring the functionality and accessibility of the content.

The programme was hosted on the University of Crete’s Chamilo Learning Management System (LMS), at the following web address:

[http://chamilo.datacenter.uoc.gr/metchamilo/courses/HEPAY3HMENHPRAGMATIKOTHTASTHNEKPAIDE/index.php?id\\_session=0](http://chamilo.datacenter.uoc.gr/metchamilo/courses/HEPAY3HMENHPRAGMATIKOTHTASTHNEKPAIDE/index.php?id_session=0)

The selection of these specific tools was based on the following characteristics:

- **Chamilo:** Selected as the central LMS to create a stable, organised and familiar environment. The platform effectively supports the asynchronous nature of the training, offering tools for user management, course organisation and progress monitoring . [Figures 5](#) and [6](#) show the home page of the training course on Chamilo.



Figure 5 : Course home page – Course title

**Δημιουργός μαθήματος:** Μακράκη Ανδρονίκη Μαρία, ΠΕ79.01,

**ΜΕΕδ Επιστήμες της Αγωγής: Μουσική Παιδαγωγική**

*Λίγα λόγια για εμένα:* Γεννήθηκα και κατοκώ στο Ηράκλειο Κρήτης. Είμαι εκπαιδευτικός κλάδου ΠΕ79.01 (Μουσικής Επιστήμης) και από το 1990 εργάζομαι στην Πρωτοβάθμια Εκπαίδευση νομού Ηρακλείου. Από το 2023 υπηρετώ ως Διευθύντρια στο 1ο Δημοτικό Σχολείο Γαζού της Διεύθυνσης Πρωτοβάθμιας Εκπαίδευσης νομού Ηρακλείου.

Το παρόν μάθημα δημιουργήθηκε στα πλαίσια εκπόνησης της διπλωματικής μου εργασίας με θέμα: ΣΧΕΔΙΑΣΜΟΣ, ΥΛΟΠΟΙΗΣΗ ΚΑΙ ΑΠΟΤΙΜΗΣΗ ΕΚΠΑΙΔΕΥΤΙΚΟΥ ΥΛΙΚΟΥ ΓΙΑ elearning ΠΕΡΙΒΑΛΛΟΝΤΑ ΕΠΙΜΟΡΦΩΣΗΣ ΕΚΠΑΙΔΕΥΤΙΚΩΝ ΠΡΩΤΟΒΑΘΜΙΑΣ ΕΚΠΑΙΔΕΥΣΗΣ, ΜΕ ΘΕΜΑ: «Η ΕΠΑΓΧΕΙΡΗΜΕΝΗ ΠΡΑΓΜΑΤΙΚΟΤΗΤΑ ΣΤΗΝ ΕΚΠΑΙΔΕΥΣΗ».

Στη διάρκεια της επιμόρφωσής σου, θα κληθείς να απαντήσεις σε κάποια ανώνυμα και ολιγόλεπτα ερωτηματολόγια, για την αποτίμηση του εκπαιδευτικού υλικού που θα μελετήσεις.

Για τυχόν απορίες μπορείς να επικοινωνήσεις μαζί μου στο [nikimakraki6@gmail.com](mailto:nikimakraki6@gmail.com)



Περιγραφή μαθήματος



Μονάτες γνώσης

Figure 6 : Course home page – Details about the course creator and the training – Course icons

- **H5P:** Utilised within Chamilo to create rich interactive content. This was used to develop interactive videos and self-assessment quizzes, as shown in Figure 7, which enhance teachers' active engagement and provide immediate feedback.

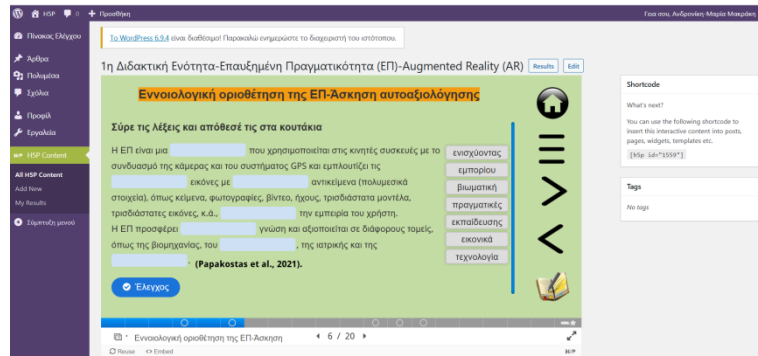


Figure 7: The HSP workspace

- **Blippbuilder (Blippar):** This was the central tool for designing Augmented Reality (AR) applications (Figure 8). It is a 'no-code' platform that allows the creation of complex AR experiences via a 'drag-and-drop' interface, which makes it easier for teachers who do not have specialist programming knowledge.

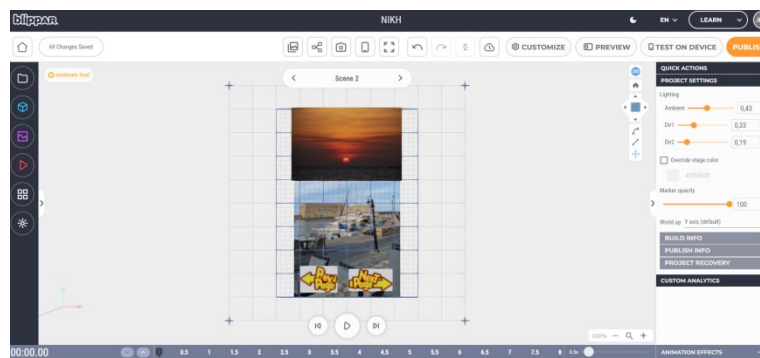


Figure 8: The Blippbuilder (Blippar) user interface

## 2.4. Structure and content of the Teaching Modules (TM)

The course was structured into four distinct teaching modules (Figure 1):

- **TU1:** Introduction to AR (definition, history, advantages).
- **TU2:** Technical familiarisation – Creating an account and the Blippbuilder design environment.
- **Module 3:** Methodology for designing an e-learning scenario.
- **DE4:** Practical application – Provision of a ready-made scenario template for immediate use in the classroom.

### **3. Research methodology**

#### **3.1. Research design**

This study adopts a mixed-methods approach, combining quantitative and qualitative methods to fully assess the effectiveness and quality of the Educational Material (EM) (Braun & Clarke, 2021; Creswell & Creswell, 2023). The use of multiple data collection tools (initial, interim, and final questionnaires) enables triangulation of data and the drawing of valid conclusions.

#### **3.2. Purpose and research questions**

The research aims to conduct distance training for Primary Education (PE) teachers on Augmented Reality (AR) and the Blippar application, and to evaluate the training programme by e-learning specialists and participants. The research questions are formulated as follows:

1. What are the initial views of the participating teachers regarding AR in education?
2. How were the initial views of the participating teachers regarding PE influenced following their training?
3. How do the teachers participating in the study assess the training programme in terms of its quality and effectiveness?
4. Is the training programme governed by the principles and methodology of ODL? (expert evaluation)
5. Has the training programme been developed in accordance with the principles of multimedia learning? (expert evaluation)

#### **3.3. Research hypotheses**

In order to determine the change brought about by the training in belief in the value of PE, the following hypotheses were tested:

- **Null hypothesis (H<sub>0</sub>):** There is no statistically significant difference in belief in the value of PE in education between the measurements BEFORE and AFTER the training.

- **Alternative hypothesis (H1):** There is a statistically significant difference in belief in the value of PE in education between the PRE and POST training measurements (an increase is expected).

### **3.4. Population and sample**

The method of purposive sampling was applied. The final sample consisted of 67 PE teachers (from an initial population of 104) working in two state schools in the Heraklion Regional Education Directorate during the 2025–2026 academic year. Furthermore, the study was evaluated by four experts in distance education (final-year students of the Postgraduate Programme 'Educational Sciences – Distance Learning using ICT (e-Learning)') who served as peer reviewers.

### **3.5. Data collection methods and statistical techniques**

A total of 7 online questionnaires (Google Forms) were used: 6 were integrated into the Chamilo platform for teachers participating in the training, and 1 was for distance education specialists. The questionnaires included closed-ended questions (5-point Likert scale) and open-ended questions.

The following were used for data analysis:

- **Descriptive statistics:** Frequencies, percentages, means (M), and standard deviations (SD).
- **Inferential statistics (Paired-Samples T-Test):** To compare views before and after the training.
- ✓ **Repeated measures ANOVA:** To compare the four teaching modules.
- ✓ **Post Hoc Pairwise Comparisons:** To identify statistically significant differences between the units.
- **Qualitative thematic analysis:** For open-ended questions using the Taguette software.

### **3.6. Ethics and procedure**

The training took place from 1 September 2025 to 30 September 2025. All ethical principles (anonymity, confidentiality, voluntary participation) were observed. The

training programme was initially evaluated by experts (15/08/2025) before being made available to teachers.

#### 4. Presentation and analysis of results

##### 4.1. Initial attitudes and change following the training – Research Questions (RQ 1 and 2)

###### 4.1.1. Initial attitudes (RQ1): The gap between knowledge and practice

Before the start of the training, the investigation of initial views revealed a significant discrepancy. Although 31% of teachers reported some knowledge of Augmented Reality (AR), its practical application in the classroom was extremely limited. As shown in **Figure 1**, 84% of participants reported never using AR in their teaching, highlighting the need for targeted professional development.

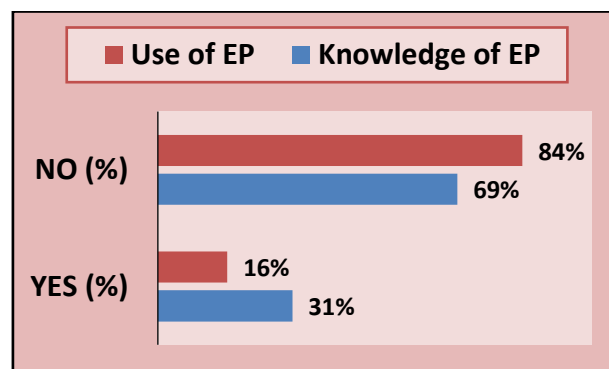


Figure 1: Previous experience and use of PBL in teaching practice

###### 4.1.2. Change in attitude (E.E.2): The effectiveness of the intervention

Following completion of the training, a comparison was made between the teachers' initial beliefs about the value of EP and their final attitudes. [Figure 2](#) shows that the initial theoretical acceptance (MO=3.88) increased significantly to MO=4.57. The t-test (Sig. = 0.000,  $p < 0.001$ ) substantiates the effectiveness of the training programme in reinforcing the participants' positive attitude, confirming the Alternative Hypothesis (H1).

- **Conclusion:** The training achieved its objective, namely to strengthen teachers' positive attitude towards the value of PE in teaching.

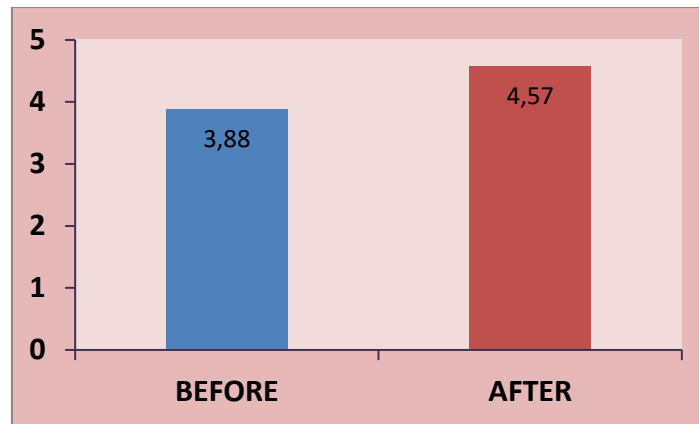


Figure 2: Comparison of mean scores for belief in the value of PE (before and after the training)

## 4.2. Evaluation of Teaching Materials (TM) – Research Questions (RQ 3, 4, and 5)

### 4.2.1. Evaluation by teachers (RQ 3)

Teachers' overall satisfaction with the Teaching Materials (TM) was particularly high. Analysis of the responses revealed that the overall average satisfaction score was MO=4.58 (out of a maximum of 5), indicating broad acceptance of the programme's quality among participants.

To investigate teachers' responses to the individual phases of the training, a comparative analysis of the four Teaching Modules (TMs) was conducted. As shown in [Figure 3](#), TU1 (Theoretical Framework) and TU4 (Practical Application and Creation) received the highest scores (MO=4.44). In contrast, TU2 and TU3, which concerned technical familiarisation with Blippbuilder and the design methodology, respectively, had a slightly lower mean score (MO=4.08). This finding suggests a tendency towards cognitive fatigue among teachers during technical analysis, which, however, was offset by the satisfaction derived from the final creation in TE4.

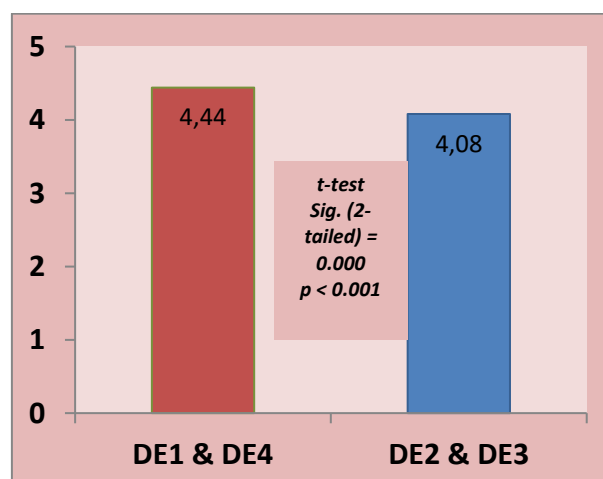


Figure 3: Comparative evaluation of the four Teaching Units by teachers

#### 4.2.2. Evaluation by the experts of the National Centre for Educational Research (NCEE) (EE4 and 5)

The evaluation by the four experts confirmed the programme's scientific and pedagogical soundness. The evaluation was based on the EDIBEA structured questionnaire, which examines the programme across ten thematic axes (scientific coherence, usability, interaction, etc.). The results, illustrated in [Figure 4](#), highlighted the following key points:

- **Scientific validity and reduced isolation:** There was universal acceptance of the scientific rigour of the content. At the same time, it was emphasised that the design succeeded in significantly reducing the learner's sense of isolation, fully adhering to the principles of Blended Learning.
- **Compliance with Multimedia Learning Principles:** The course was considered to fully align with the principles of Personalization, Modularity, Segmentation, and Signaling. This strategy helped prevent cognitive overload among participants.
- **Pedagogical benefit:** The experts concluded that the material functions effectively as a 'self-paced tutor', ensuring that the teacher can successfully self-study within the asynchronous environment of the Chamilo platform.

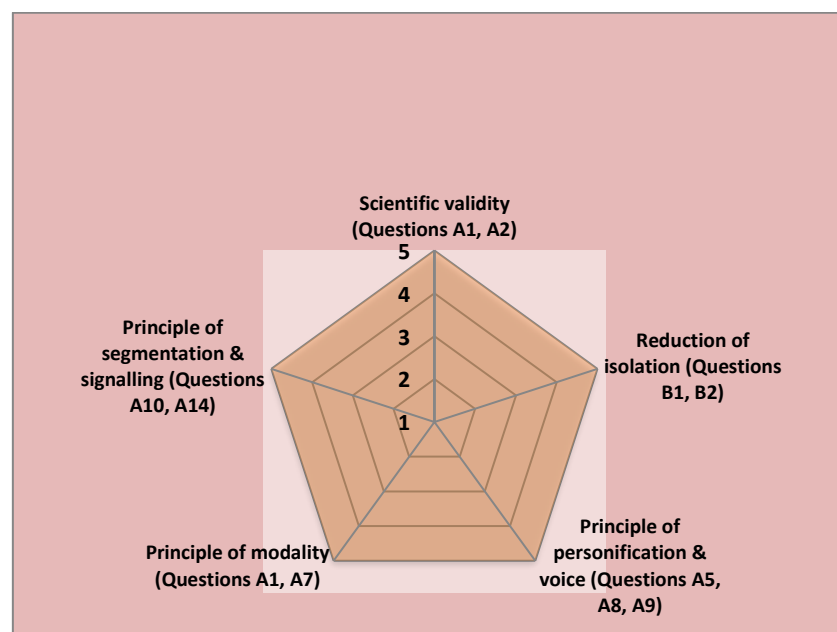


Figure 4: Summary of the evaluation by the ExAE experts, based on the EDIBEA criteria

## **5. Discussion-Conclusions**

### **5.1. Discussion of the results and conclusions for each research question**

#### **5.1.1. Initial views and the theory-practice gap (RQ1)**

Analysis of the initial data reveals a notable contradiction. Whilst teachers recognise the great pedagogical value of EP (MO=3.88), its practical implementation remains at extremely low levels (84% non-use). Significant external barriers explain this discrepancy, the main ones being a lack of technical infrastructure (88%) and the absence of specialised training (70%). This finding is fully consistent with the studies by Akçayir & Akçayir (2017) and Bacca et al. (2014), which confirm that technical complexity and cost are the main deterrents internationally. The need to address both equipment and knowledge simultaneously is supported by the TPACK model (Mishra & Koehler, 2012), which posits that technological and pedagogical competence must converge for a successful digital transition.

#### **5.1.2. Change in attitudes and the role of experiential learning (E.E.2)**

The training intervention achieved a highly statistically significant increase in teachers' belief in the value of PE, shifting from MO=3.88 to MO=4.57 ( $p < 0.001$ ). This dramatic change suggests that systematic training can overcome initial resistance and transform theoretical acceptance into a strong conviction.

This finding is supported by the international literature, which emphasises the role of experiential learning. As noted by Jumaa & Al-Mutairi (2025), gaining direct experience reduces teachers' reluctance towards new technologies. At the same time, the universal recognition of the flexibility of ODL (100%) by participants confirms the views of Lionarakis (2015) and Powell & Bodur (2019) that distance learning is the most suitable means for the professional development of adult educators, as it removes the constraints of time and place.

#### **5.1.3. Teachers' evaluation of the programme and cognitive load (E.E.3)**

Despite general satisfaction (MO=4.58), the analysis revealed qualitative differences. The superiority of DE4 (model scenario) demonstrates teachers' need for 'ready-made' and immediately applicable templates, which reduce workload (Darling-

Hammond, Hyler & Gardner, 2017; Zhao & Horney, 2020). Conversely, the relative lag in the modules on the technical use of Blippbuilder (DE2) and methodology (DE3) is consistent with the findings of Sotiriou, Gialamas & Tsiotakis (2020), who emphasise that creating e-learning content by non-experts often causes cognitive fatigue. This difficulty is explained by the theory of 'cognitive load' (Kalyuga & Sweller, 2018), in which technical details serve as an unnecessary burden when not accompanied by adequate 'scaffolding'.

#### **5.1.4. Evaluation of the EI by EAA experts (E.E. 4 and 5)**

The experts' evaluation confirmed the scientific validity and pedagogical suitability of the EU, focusing on two central pillars: the PBL methodology and the principles of Multimedia Learning.

- **Compliance with the principles of PBL (E.E.4):** About the methodology of ODL, the experts highlighted the high scientific coherence of the material and the use of diverse sources, elements essential for the construction of knowledge in environments where the teacher is not present (Lionarakis, 2015). Particular emphasis was placed on the 'friendly' and familiar writing style, which puts Holmberg's theory of 'didactic conversation' into practice (as analysed in Lionarakis, 2015). This approach was deemed crucial for reducing the 'transactional distance' and the learner's sense of isolation (Garrison, 2017; Zawacki-Richter & Anderson, 2014). Despite the positive feedback regarding usability and the clarity of objectives, there is a need to enhance social interaction and collaborative learning further to more fully support the creation of a 'learning community' (Siemens, Gašević & Dawson, 2015).
- **Application of the principles of Multimedia Learning (EE5):** Regarding the design of the material, full alignment with Mayer's (2020) principles and the model by Anastasiadis & Kotsidis (2015) was observed. The strategic use of the 'principle of Personification' (the use of avatars and second-person singular) and the 'principle of Modality' (a balanced combination of text, image, and sound) enhanced participant engagement. At the same time, the application of the principles of Segmentation and Signalling was deemed crucial for the effective management of cognitive load (Kalyuga & Sweller, 2018). This

approach ensured that teachers could focus on the essential concepts of EP, avoiding the cognitive overload often caused by the technical complexity of such tools.

At the same time, certain limitations of the research should be noted, such as the small sample size and the fact that the sample was drawn from a specific region of Greece, which limits generalisation.

Certainly, based on the findings and the need to bridge the gap between the theoretical acceptance and practical application of EP, the following measures are proposed:

- **Immediate upgrading of technical infrastructure:** Addressing equipment shortages and ensuring a stable internet connection is a prerequisite, as these factors emerged as the primary obstacle for 88% of teachers. As documented by the TPACK model (Mishra & Koehler, 2012), technological infrastructure must align with pedagogical knowledge to make the digital transition feasible.
- **Transformation of in-service teacher training:** Programmes need to be redesigned with a shift towards blended learning models. According to Powell & Bodur (2019), integrating active strategies and enhancing social interaction are essential to avoid the sense of isolation that often accompanies asynchronous learning.
- **Dual training strategy and practical support (Scaffolding):** Training programmes must strike a balance between theoretical foundations and technical training, moving from the simple provision of content to interactive learning models (Zawacki-Richter & Anderson, 2014). At the same time, the provision of highly practical materials, such as ready-made digital templates and sample lesson plans, is crucial for reducing teachers' workload and technical stress (Darling-Hammond, Hylar & Gardner, 2017; Zhao & Horney, 2020).

In conclusion, this study opens up new avenues for further investigation into the integration of EP into the Greek educational context. Specifically, it is proposed that:

- **Conducting a longitudinal study:** It is essential to investigate whether the observed positive shift in teachers' attitudes leads to the actual and consistent

use of PE in daily teaching practice over a period of time. Such a study would allow assessment of long-term knowledge retention, a critical indicator of the sustainability of these professional development interventions (Darling-Hammond, Hyler & Gardner, 2017).

- **Conducting a comparative study:** It is recommended that the research be repeated by testing alternative, simpler, and more user-friendly e-learning platforms, in addition to Blippar. Such a comparison would help clarify whether the technical difficulties (e.g., in DE2 and DE3) are inherent to AR technology or due to limitations of the specific software, thereby contributing to the further development of the technological component of the TPACK model (Mishra & Koehler, 2012).
- **Expanding the qualitative investigation:** Although the present study collected qualitative data through limited open-ended questions in the questionnaires, it is deemed necessary to conduct semi-structured interviews in the future. This approach will provide teachers with the flexibility to elaborate on their views, allowing the researcher to delve deeper into subjective experiences and the causes of cognitive load (Kalyuga & Sweller, 2018). In this way, the specific factors and obstacles that hinder the design of original PE materials will be highlighted—elements often overlooked by the rigid structures of quantitative tools (Creswell & Creswell, 2023).

## **6. Declaration of AI Use**

- The authors declare that generative artificial intelligence tools (DeepL Translator & DeepL Write) were used exclusively for language translation and editorial refinement of the manuscript.
- The AI system did not contribute to the conceptualization of the study, research design, methodology, data collection, data analysis, theoretical framing, interpretation of findings, or formulation of conclusions.
- All substantive intellectual contributions were performed solely by the authors. The authors have critically reviewed, validated, and approved the final version of the manuscript and assume full responsibility for its accuracy, integrity, and scientific content.

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## References

- Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review, 20*, 1–11.
- Akrítidou, M. (2023). Distance learning materials in support of conventional pre-school and primary education. A literature review. *Open Education: The Journal of Open and Distance Education, 12*(1), 221–240.
- Anastasiadis, P. (2014). The Pedagogical Use of ICT and Distance Education in the School of the Future. In P. Anastasiadis (Ed.), *Lifelong and Distance Education in the Digital Age* (pp. 13–58). Athens: ISIE.
- Anastasiadis, P., & Kotsidis, K. (2015). The Principles of Multimedia Learning in the context of designing educational materials for Distance Learning in Schools. In: *Proceedings of the 8th Pan-Hellenic Conference of Educators on ICT 'Utilisation of Information and Communication Technologies in Teaching Practice'*. Syros, 24–26 April 2015.
- Azuma, R. T. (2017). The convergence of augmented reality and virtual reality. In *The 16th ACM SIGGRAPH Conference on Sketches and Applications*.
- Bacca, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk. (2014). Augmented reality in education: An overview and a systematic classification. *Educational Technology Research and Development, 62*(6), 689–715.
- Bozkurt, A. (2019). From Distance Education to Open and Distance Learning: A Holistic Evaluation of History, Definitions, and Theories. In S. Sisman-Ugur & G. Kurubacak (Eds.), *Handbook of Research on Learning in the Age of Transhumanism* (pp. 252–273). IGI Global.
- Braun, V., & Clarke, V. (2021). Thematic analysis. In B. M. Frey (Ed.), *The SAGE Encyclopedia of Research Methods* (pp. 1774–1781). SAGE Publications.
- Chen, C. H., Liu, S. C., Cheng, Y. C., & Huang, H. C. (2017). Application of augmented reality to human body structures: A study of anatomical learning. *Interactive Learning Environments, 25*(6), 808–820.
- Chen, H. Y., & Lin, Y. M. (2020). The effects of augmented reality on students' learning performance and motivation in a situated learning context. *Interactive Learning Environments, 28*(7), 891–903.
- Choong, Y. Y. (2022). *Augmented Reality (AR) Usability Evaluation Framework* (NIST IR 8422). National Institute of Standards and Technology. Available at: <https://doi.org/10.6028/NIST.IR.8422>
- Creswell, J. W., & Creswell, J. D. (2023). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (6th ed.). SAGE Publications.
- Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development*. Learning Policy Institute.
- Fokidis, E., & Foniadaki, I. (2017). Tablets, Augmented Reality, and Geography in Primary School. *e-Journal of Science and Technology, 12*(3), 7-23.
- Garrison, D. R. (2017). *E-Learning in the 21st Century: A Community of Inquiry Framework for Research and Practice* (3rd ed.). Routledge.
- Garzón, J., et al. (2019). Meta-analysis of the impact of augmented reality on educational outcomes. *Educational Research Review, 27*, 1–12.

- Garzón, J., et al. (2020). An augmented reality system for learning human anatomy: A randomised controlled trial. *Anatomical Sciences Education*, 13(1), 84–93.
- Hodges, C. B., Moore, S., Lockee, B. B., Trust, T., & Bond, M. A. (2020). The difference between emergency remote teaching and online learning. *EDUCAUSE Review*. Retrieved from: <https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning>
- Horton, W., & Horton, K. (2022). *e-Learning by Design* (3rd ed.). John Wiley & Sons.
- Ibáñez, M. B., Di Serio, Á., Villarán, D., & Kloos, C. D. (2014). Experimenting with augmented reality in real scenarios in higher education. *IEEE Transactions on Learning Technologies*, 7(3), 260–267.
- Joo, Y. J., Kim, S. E., & Kim, Y. K. (2022). The effect of augmented reality on user engagement and learning performance in educational settings. *Computers & Education*, 185, 104533.
- Jumaa, M. A. A., & Al-Mutairi, A. (2025). The Impact of Teacher Training Using Mobile Augmented Reality Games on Their Professional Development. *Educational Technology Research and Development* (In press).
- Kalyuga, S., & Sweller, J. (2018). Cognitive load theory: From theory to practice. In S. M. Fiore, M. A. Rosen, & S. H. McDaniel (Eds.), *The Cambridge Handbook of Expertise and Expert Performance* (2nd ed., pp. 73–91). Cambridge University Press. <https://doi.org/10.1017/9781316675939.006>
- Keegan, D. J. (2006). On defining distance education. *Distance Education*, 1(1), 13–36. Retrieved from: <https://doi.org/10.1080/0158791800010102>
- Knowles, M. S., Holton III, E. F., & Swanson, R. A. (2020). *The adult learner: The definitive classic in adult education and human resource development* (9th ed.). Routledge.
- Kotsidis, K., & Anastasiades, P. (2023). The Social E-Learning environment: Integrating Learning Social Network use in Online professional development for K-teachers. *International Journal on E-Learning*, 23–42. <https://www.learntechlib.org/primary/p/218489/>
- Li, K. C., Lee, W. O., & Yang, K. T. (2019). Investigating the learning effectiveness of augmented reality-based mobile learning by examining the motivation and flow experience of learners. *Interactive Learning Environments*, 27(1), 108–124.
- Lionarakis, A. (2015). *Open and distance learning: Pedagogical and technological applications*. Athens: Association of Greek Academic Libraries.
- Lionarakis, A., & Spanaka, A. K. (2017). The Seven Principles of Educational Material Design. In A. Lionarakis, S. Ioakeimidou, G. Manousou, M. Niari, T. Chartofylakas, S. Papadimitriou, & A. Apostolidou (Eds.), *9th International Conference on Open and Distance Education. Learning Design* (Vol. 9, No. 6B, pp. 121–123). Hellenic Network for Open and Distance Education.
- Manousou, E., Chartofylaka, T., & Ioakeimidou, V. (2020). *Educational materials for distance education: Specifications, development and utilisation of materials—Guide* – Institute of Educational Policy (IEP).
- Marino, E., Barbieri, L., et al. (2021). An Augmented Reality inspection tool to support workers in Industry 4.0 environments. *Computers in Industry*, 128, 103444.
- Martin, F., & Bolliger, D. U. (2018). Engagement matters: Student perceptions of interaction in online learning environments. *Online Learning*, 22(1), 20–37.

- Mayer, R. E. (2017). Using multimedia for e-learning. *Journal of Computer Assisted Learning*, 33(5), 403–423. Retrieved from: <https://doi.org/10.1111/jcal.12197>
- Mayer, R. E. (2020). *The Cambridge Handbook of Multimedia Learning* (3rd ed.). Cambridge University Press.
- Miller, D., & Dousay, T. A. (2015). The use of augmented reality in P–12 education: A review of the literature. *Journal of Educational Technology Development and Exchange (JETDE)*, 8(1), 1–13.
- Mezirow, J. (2018). *Transformative learning in practice: Insights from community, workplace, and higher education* (2nd ed.). Jossey-Bass.
- Mishra, P., & Koehler, M. J. (2012). *TPACK (Technological Pedagogical Content Knowledge)*. In *Encyclopedia of the Sciences of Learning* (pp. 3351–3354). Springer.
- Moore, M. G., & Diehl, W. C. (Eds.). (2019). *The handbook of distance education* (4th ed.). Routledge.
- Papanastasiou, G., Drigas, A., & Skianis, C. (2021). Augmented Reality in Education: A Systematic Review of the Literature and Future Directions. *International Journal of Emerging Technologies in Learning (IJET)*, 16(1), 180–199.
- Parmaxi, A., & Demetriou, A. A. (2020). Augmented reality in language learning: A state-of-the-art review of 2014–2019. *Journal of Computer Assisted Learning*, 36(6), 861–875.
- Powell, J., & Bodur, Y. (2019). Online professional development: A systematic review of teacher outcomes and design considerations. *Teaching and Teacher Education*, 79, 117–128.
- Siemens, G., Gašević, D., & Dawson, S. (2015). *Preparing for the Digital University: a review of the history and current state of distance, blended, and online learning*. Athabasca University.
- Simonson, M., Zvacek, S. M., & Smaldino, S. E. (2019). *Teaching and Learning at a Distance: Foundations of Distance Education* (7th ed.). Information Age Publishing (IAP).
- Sotiriou, S., Gialamas, V., & Tsiotakis, P. (2020). Exploring the Challenges of Augmented Reality Content Creation by K-12 Teachers: A Case Study. *Themes in Science and Technology Education*, 13(1), 17–38.
- Tough, M. (2018). The future of adult learning: A review of trends and emerging themes. *Journal of Adult and Continuing Education*, 24(1), 3–18.
- Tsiavos, P., & Sofos, A. (2020). 'The use of augmented reality in education: Development and use of an application for the 'Physics – I Explore and Discover' module in Year 5 of primary school'. *Open Education: the journal for Open and Distance Learning and Educational Technology*, 15(2), 38–53.
- Vaughan, N., Dell, D., & Garrison, D. R. (2017). Principles of blended learning. In J. J. G. van Merriënboer & P. A. Kirschner (Eds.), *Ten Steps to Complex Learning* (3rd ed., pp. 317–336). Routledge.
- Zawacki-Richter, O., & Anderson, T. (2014). *Online Distance Education: Towards a Research Agenda*. Athabasca University Press.
- Zhao, Y., & Horney, M. A. (2020). Exploring teachers' technology integration decisions and classroom practices: A focus on perceived value and effort. *Educational Technology Research and Development*, 68(1), 329–354.
- Zubair, M., & Khan, M. A. (2020). Psychological barriers in online learning during the COVID-19 pandemic. *International Journal of Information and Education Technology*.