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Critical Immersive-Triggered Literacy as a Key Component for Inclusive Digital Education

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Abstract: The present empirical study investigates, analyzes, and discusses the affordances and limitations of an augmented reality (AR)-based educational intervention for the critical digital awareness of secondary school students through a sociocultural framework of instruction. The design of the educational intervention focuses on the empowerment of students' critical digital skills in the new media produsage ecosystem in parallel with the development of target language skills through content and language integrated learning (CLIL) in a mobile augmented reality (MAR)-based transnational educational setting. This study focuses on examining the usefulness rather than the digital use of MAR from a socio-constructivism perspective with 77 participants from diverse socio-cultural backgrounds and educational settings. More specifically, an investigation of the potential of internalization of new knowledge through immersive-triggered inclusive educational practices is carried out, examining the effectiveness of the universal design for learning principles (UDL) as a pedagogical framework for AR-based instruction related to long-term memory retention, the synthesis of meaningful learning instances, and the creation of new knowledge. The study findings suggest that AR-based instruction, if incorporated into a robust pedagogical framework, can enhance attention and long-term memory retention, provide meaningful, inclusive learning opportunities, and facilitate digital well-being in the ever-evolving complex learning ecosystem. This study concludes by proposing the term of critical immersive-triggered literacy (CIT Literacy), defined as a skill development framework that triggers learners' attention and facilitates digital well-being for meaningful learning instances via immersive technologies.

Keywords: immersive technologies; critical immersive-triggered literacy; MAR; language learning; CLIL; instructional design; inclusive education; augmented reality; digital literacy; UDL

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1. Introduction

The latest trends in technologies have revolutionized the way we experience the world and gain new knowledge, providing unlimited, diverse, multicultural, and multimodal interaction opportunities. The Internet of Things (IoT), "the things that think" [1], can transform real-world objects into intelligent virtual ones. Given this interoperability of technologies, new generations not only have access to spaces but also to new knowledge and information resources derived from beyond their local or conventional educational settings, as they make use of sensors and actuators of a very interactive digital environment.

As the authors of [2] note, we should explore students' engagement with the digital world not through the dimension of its uses but rather through its *usefulness*. The researchers posit that what we should be developing is not digital natives but *digitally aware* students. In light of this, critical digital and media literacy refers to the skillset of analyzing, deconstructing, reconstructing, and critically evaluating information quality, validity, and reliability [3]. To add to this, they must explore the world by not only consuming information but also constructing new knowledge and creating new artifacts in the new produsage ecosystem [4], which leads to what [5] defined as a need for *digital fluency* rather than literacy. On the premise that the new era calls for a global perspective of what the

world has to offer and how the new generation can reap its benefits, the English language and linguistic competences as a common global communication tool play a crucial role in the successful delivery and exchange of ideas in the feedback loop.

Another element of serious consideration of this digital native generation of today is that they tend to suffer from the multiple screen syndrome that deprives them of deep learning instances while online. They tend not to concentrate on a single piece of information, and they are characterized by impatience and superficial access to information while scrolling down to new media platforms with great speed. As such, despite generation Z being considered tech-savvy and having access to information and new knowledge on-demand [6], according to Media Literacy Index 2022, there is low resilience to fake news and disinformation, especially in the Balkan region [7]. In light of this, access to digital information is not enough. There is a need for a deeper engagement that will trigger the devotion of attention to what the digital resources have to offer. Developing digital attention skills to cope with information overload and digital distraction can diminish obstacles that keep learners from achieving cognitive effectiveness. Engagement with immersive technologies, and especially augmented reality (AR), allows for supplementary digital information to be superimposed on real-world objects towards specific objectives that provide useful hints and tips to the learner in order to accelerate the process of mastering specific skills and thus achieve the predefined learning objectives. In addition, the AR approach hinders the mental distraction of the user that may be caused by meaningless web browsing or poor information retrieval either in formal or informal learning environments.

Studies and meta-analyses have shown promising results in educational settings that have incorporated mobile augmented reality (MAR) technology using AR-enriched interactive textbooks that optimize real-world experiences with the addition of authentic explorations, interactions, and collaborations [8,9]. Accordingly, in the special education context, assistive technologies can also play a crucial role in facilitating the learning process of learners that may be either physically or cognitively challenged by the integration of multimedia [10–14].

Nevertheless, the literature on this subject reveals that there is a gap in defining a common robust framework among educators that leverage emerging technologies in K-12 education. There is a need for a universal design that will ensure a well-designed, purposeful implementation of immersive-based educational interventions instead of one-off prototypes which constitute a practice that hinders the development of a mutual understanding regarding common design elements and effectiveness [15–18]. In addition, the authors of [19] contend that there is a necessity for a framework that blends the technological, pedagogical, and psychological elements that influence the outcome of educational interventions with the most widely adopted learning analytics techniques. In the English as a foreign language (EFL) context, a review of the studies in the field reveals that these focus on specific language skills, short-term implementation periods, and homogeneous learner attitudes [20], while AR-based collaborative learning and social interaction in the digitally connected world has not been examined on a broad scale. As [21] contends, research in this field will be needed to further highlight and align the affordances of AR with instructional decisions that will provide sound implications linked with both theory and pedagogy.

2. Review of Related Work

The following section presents an exploration of related work with a focus on distinct factors to be considered in leveraging augmented reality in education through a holistic approach. More specifically, there is a review of (a) the identified usefulness of educational technology and AR for inclusive education; (b) studies on AR educational interventions in the EFL secondary education context; (c) the pedagogical framework that AR can be incorporated into to address critical digital literacy in the new digital status quo; and (d) the social-constructivism aspect of AR for opportunities to build new knowledge through collaboration in a participatory culture. Insights gained based on what the literature

suggests, and what needs to be further examined formed the research questions of the present study.

2.1. Educational Technology and AR in Education

According to [22], there are some factors that teachers and students consider when designing or implementing novel AR learning activities and environments, namely (a) accessibility, meaning the availability of devices that support the AR app operability for the whole classroom; (b) technology evolution, focusing on what can actually be used in the classroom, as some AR apps are still in the development stages and bugs are still being fixed; (c) space requirements, for cases where open or large spaces are required for the AR content to be projected from different angles; (d) teacher support, ranging from digital skills and need for guidelines and training to school's administration and IT department support for solving technical issues with the school firewall blocking the applications; (e) suitability to audience and goals, with a purposeful selection of apps that suit the students' needs, curriculum and teaching goals; (f) pedagogical approaches, considering how to pair AR experiences with other instructional practices for meaningful learning; and (g) contextualizing the content, focusing on how AR technology can support the learning goals.

Regarding teacher readiness, [23] posits that there is a need for teachers' professional development on technological pedagogical models, such as TPACK (technological pedagogical content knowledge), to promote student learning in a growing technological world and design and develop teaching and learning processes according to the needs of the students [24]. The author of [25] references the TPACK framework [26], outlining how content and pedagogy, namely how the teacher imparts that content, must form the foundation for any effective educational technology integration in order to enhance the students' learning experience. Specific technological tools (hardware, software, applications, and associated information literacy practices) should be utilized to instruct and guide students toward a more robust understanding of the subject matter. As such, Kurt suggests that in order for teachers to make effective use of educational technologies, educators should be open to certain key ideas, including (a) how concepts can be represented using technology; (b) how students' different skills level on the conceptualization of content can be addressed; (c) how technologies can narrow the gap of diversity in background and prior knowledge; and (d) how to strengthen students' existing knowledge and help them acquire new knowledge.

Research conducted by the authors of [27] found that AR applications that presented vocabulary in the target language in a foreign language educational context with 3D image, sound, and movement allowed students to visualize the learning content, thus achieving a higher performance and enjoyment while learning. The researchers also point out the importance of content in using AR. They suggest that future should studies explore appropriate learning content to support and inform teachers so as to benefit from it while stressing the need for teacher training and guidelines for teachers to incorporate AR tools in the classroom [28,29].

The importance of teacher training and guidelines is also highlighted by [19]. The researchers present the "Augmented Reality Learning Analytics" (ARLEAN) ethical framework, tailored to the specific characteristics that AR applications have, and focused on various learning subjects with the intention of providing guidelines to instructional designers and educational technologists on the effective integration of immersive technologies in educational settings, thus optimizing learning outcomes. The researchers posit that the core of this framework blends the technological, pedagogical, and psychological elements that influence the outcome of educational interventions with the most widely adopted learning analytics techniques. As researchers in [15] note, most of the AR educational applications are one-off prototypes, which constitutes a practice that hinders the development of a mutual understanding regarding the common design elements and the effectiveness of these alternative educational practices.

Such practices, while providing the foundations to evaluate the strengths and limitations of AR educational interventions, deprive the researchers of the generalization of the outcomes as the sample sizes are small and the research is carried out in specific contexts and scientific fields. To this end, as [17] also contends, the evolution of a universal digital ecosystem where a large amount of data is utilized may better inform the research directions and the respective practices. In light of this, the authors suggest that contemporary education requires analytical thinking skills in conjunction with the use of an LMS, and that "the integration of AR technology can facilitate the simulation of real-world problems and support the deconstruction of the different concepts that govern these fields" (p. 5). Following this premise, the proposed framework and system offer them the means to undertake a simulated experience that complements the learning process and promotes in-depth knowledge development.

2.2. AR in the EFL Context

In the context of adolescent foreign language learners, MAR technologies enable learners to instantly access various learning resources [30]. The researchers of [31] designed an AR-based context-aware ubiquitous learning environment called Handheld English Language Learning Organization (HELLO), aiming at enhancing 7th-grade EFL learners' speaking and listening skills, with the intent of contextualizing English learning environment by combing conventional technologies (e.g., sensors and ubiquitous computing, information technologies) and emerging technologies in the connectivity era. The post-listening and speaking test scores suggest that the experimental group performed significantly better than the control group in all the learning tasks, improving their communication skills. The participants' interviews showed positive attitudes toward the AR-based learning environment as it could not only benefit their new linguistic knowledge acquisition but also motivate them to continue developing their communicative competence in the future.

In 2014, the authors of [32] investigated learners' achievement, attitude, and cognitive load levels in the EFL context by utilizing an AR book created with the aid of marker-based technology. The materials were additionally supported by English pronunciation. The findings reveal that the cognitive load levels and anxiety of students are low when engaged in the process of self-directed learning in an AR-based learning context. The implementation phase was short (four sessions) and was carried out under the guidance of teachers in computer laboratories to ensure digital skills capability. In 2017, the authors of [33] also conducted a study focusing on the aspect of reading comprehension where augmented reality game-based learning was incorporated to create a sort of augmented 3D book to enrich students' learning experience. In this study, 51 students participated in the activity in pairs using a tablet which involved answering reading comprehension questions after exploring different scenes in a book where the AR application superimposed virtual imagery to illustrate certain aspects of the book. In this study, the students were found to show more enjoyment as compared to that achieved when solely reading from a book. An interesting thing to note was that for more "opinion"-based comprehension questions, students provided more informed, stronger, and longer answers as compared to the control group, which only read the book without the use of augmented reality.

In more recent studies, Ref. [34] conducted a survey with a mixed method, recruiting students that were split into experimental and focus groups to discuss the effect of AR applications on secondary school students' reading comprehension and learning permanency. The findings reveal that the experimental group students showed a higher level of reading comprehension and learning permanency. The students also reported that they experienced satisfaction from their participation in AR-based reading activities and low anxiety levels. Ref. [35] conducted a study based on the ARCS learning motivation theory [36], namely attention, relevance, confidence, and satisfaction, to support situational classroom learning and improve the performance and foreign language learning effectiveness with the use of augmented reality. The English learning scenario was supported by the HD Reveal

Aurasma platform and app with the intention of enhancing language input and output with airport situation-related conversation themes. The experimental results, as in previous studies, revealed that the real-life AR scenarios enhanced student confidence in learning English and improved learner satisfaction.

Nevertheless, to date, studies in the EFL context that leverage AR technologies focus on a short-term implementation period, in specific educational settings, with students that bear homogeneous socio-cultural attitudes. Additionally, the evaluation of their use in an educational setting does not present a theoretical framework that supports the pedagogical decisions made. This might be reflected the educators' and researchers' focus on the kind of novelty to be used in the classroom, incorporating and evaluating the AR interventions instead of focusing on how its affordances are aligned with the pedagogical decisions made [21,37].

The researchers [21] also note that in a systematic review conducted between 2014 and 2019, the incorporation of AR interventions in the EFL context focused on specific language skills. More specifically, they found that among the skills that have been investigated concerning the application of AR technology in language learning, vocabulary represents the most investigated topic area (23.9%), followed by reading (12.7%), speaking (9.9%) and writing (8.5%), whilst a substantial number of manuscripts focused on generic language skills (9.9%); however, communication building skills are still at an early stage in AR surveys. To this end, the authors employed the KSAVE (Knowledge, Skills, Attitudes, Values, Ethics) 21st century skills framework proposed by [38] with four dimensions and 10 categories of skill building, as follows:

- *ways of thinking*, regarding (i) creativity and innovation, (ii) critical thinking, problem-solving, and decision-making, and (iii) learning to learn and metacognition;
- *ways of working*, with communication and collaboration (teamwork) skills' building;
- *tools for working*, focusing on ICT and information literacy, which includes research on sources, evidence, bias, etc.;
- *living in the world*, with a focus on citizenship, life and career, and personal and social responsibility including cultural awareness and competence.

Additionally, AR-based collaborative learning and social interaction in the EFL context in the digitally connected world have not been examined on a broad scale. According to the global education monitoring report 2020 [39] and the UNESCO 2030 Agenda [40] for sustainable development, inclusive education systems should focus on creating more inclusive and equitable societies, ensuring that 'all means all' and 'no one is left behind'; thus, coupled with the need of the contemporary learner for interaction in a digitally connected multicultural context, further research on this topic is needed.

2.3. Critical Digital Awareness in Education

Digital literacy is not only essential to explore, participate in, and benefit from digital opportunities in today's global connectivity age, but also to ensure an awareness of exposure to risks and threats in everyday digital environments related to personal data and privacy protection [41]. Ref. [42] stresses the importance of incorporating media literacy in school curricula as a component of security competence, critical media consumption, and well-being. As [43] notes, despite broad claims that current students are digital natives, technology skills are not universal among all young children [44]. In 2011, in response to the ever-evolving need for educational innovation in the digital era, UNESCO created a curriculum to enable the educational community to better understand the role of media. It focused on the acquisition of media literacy as "a set of essential competencies (knowledge, skills, and attitudes) that allow citizens to engage with media and other information providers effectively and develop critical-thinking and lifelong-learning skills for socializing and becoming active citizens" [45] (p. 187). As [46] notes, students may be resistant to the process of interrogating and examining their media literacy practices; as such, it is the media literacy educators' responsibility to shift their interest from students' "tool competence"—that is, their ability to use sophisticated technology—to "digital citizenship",

a concept closely related to media literacy that focuses not only on the necessity of internet safety but also on the rights and responsibilities of students as communicators on the internet and in real life.

As [47] notes, building these skills moves "audiences from awareness to action, from passivity to engagement, from denial to acceptance of responsibility for what each of us can do . . . as participants in our media-dominated society" (p. 275). The European Commission Report [48] suggests that one of the main curriculum approaches to digital competences' building in primary and secondary education is "[a]s a cross-curricular theme: digital competences are understood to be transversal and are therefore taught across all subjects in the curriculum. All teachers share the responsibility for developing digital competences" (p. 28). Thus, it is essential that educators cultivate youths' digital literacy to help them to effectively and creatively use existing ICT in our technology-driven society [49]. The need for media literacy educational practices and lifelong media literacy development raises the issue of teachers' preparedness to introduce media literacy classes into secondary and high school curricula. In addition, there is a need for the development of new forms, models, and teaching methods to implement media educational innovations.

2.4. AR for Collaboration, Communication, and Social Skills

In a recent study, Ref. [43] identified some obstacles during the implementation of their survey on social-constructivism mixed-group learning with AR, namely (a) language barriers, (b) online privacy concerns, (c) a lack of private virtual space for groups, and (d) limited opportunities for students to practice digital ethics and responsibility. Participants' language barriers and low-performance skills, along with pre-existing digital skills, were identified as factors to pre-assess and be considered in a future design to customize learners' experiences accordingly. Additionally, the study's results revealed the importance of the design involving the contextual representation feature of AR as a crucial contributing factor to students' development of digital literacy practices. The researchers stated that "to enable contextual representation with AR technology in the individual and group AR artifacts, students creatively used different digital tools to communicate and share with audiences their understanding and personal connection with a particular object or place" (p. 1428).

Recent literature notes that the globalization aspect calls for intercultural competences as part of modern foreign language teaching and learning [50–52]. The researchers note the need for a multidimensional construct that consists of three interrelated aspects, namely intercultural sensitivity, intercultural awareness, and intercultural adroitness as part of the language learning process that relates to the affective, cognitive, and behavioral aspects, respectively. A meta-analysis conducted by the authors of [53] revealed that, to date, the interventions address only the cognitive and affective aspects. The researchers identified the need for immersive formats that address the conative level that is in alignment with modern pedagogic principles that [54] describes as essential competences and action-oriented learning in an era of connectivity and co-construction. In the context of MAR, the interoperability of technologies and collaboration functionalities can provide a new prospect for this competence building to flourish as far as a strategic design and latency issues are addressed.

3. Methods and Materials

Based on the review of related work, while there are many cases of leveraging AR-based instruction in a variety of educational settings and disciplines, these seem to focus on specific contexts and fields, and homogeneous groups of learners regarding age, sociocultural background, and level of English. In the EFL context, there have been efforts to incorporate AR technologies for building specific receptive and productive skills. Media literacy skills' development through the content and language integrated (CLIL) [55] approach has also been a field of interest, but there are no cases identified for leveraging AR affordances for critical digital awareness. To this end, the present study will explore how immersive technologies can contribute to these skills' building in the consumption

and creation of new media. The context for this investigation is learners bearing diverse demographics with the intention of investigating whether AR can provide a rich and inclusive learning experience, as dictated by the Universal Design for Learning (UDL) principles [56]. As such, the overall question raised is whether immersive technologies and especially augmented reality can enhance high school learners' critical digital awareness in an inclusive multicultural EFL context. To achieve this, the following research questions were set to guide the ensuing discussion:

RQ1: Do UDL principles provide a pedagogical framework for AR-based instruction to long-term memory retention in the CLIL context?
RQ2: How can AR-triggered attention enhance L2 linguistic competence?
RQ3: Can AR support diverse sociocultural learning contexts for critical digital literacy?

The main aim of this educational intervention is to apply an empirical study to examine how immersive technologies can benefit the Generation Z and the one that succeeds it, Generation Alpha, for target language skills' building, in the new globally connected world where learning, literacy, and life skills are interwoven to achieve wise choices in their future personal and professional life. The diagram in Figure 1 explicitly displays the levels of skills' development that the present study aims for within the pedagogical framework of the UDL principles coupled with AR-based instruction.

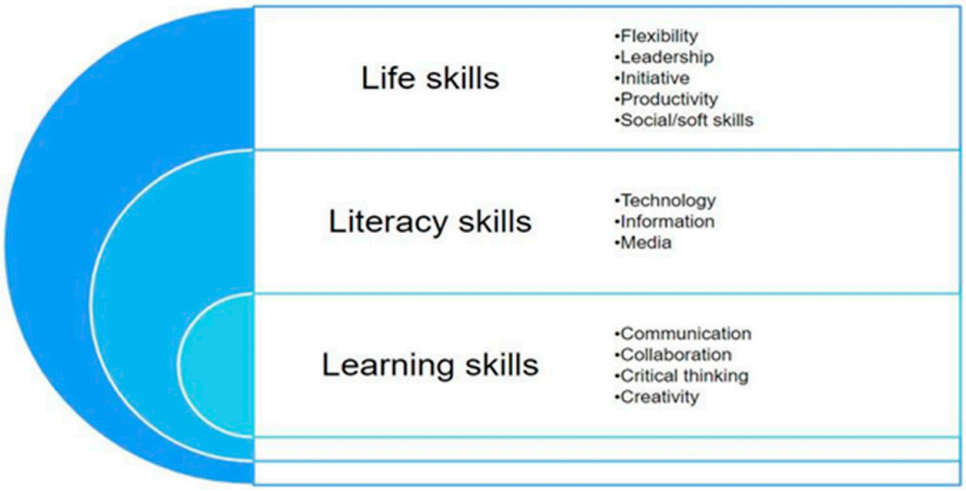


Figure 1. Levels of the 21st century skills' building.

More specifically, the new patterns of learning are not limited to distinct skills' building but to a holistic approach with the ultimate goal of building a skillset that promotes lifelong skills and competences. The three levels of skills involve (a) learning skills, the 4Cs skills, namely communication, collaboration, critical thinking, and creativity; (b) literacy skills, including computing and ICT literacy, and information and media literacy skills; and (c) the broader concept of life skills that include socio-cultural awareness and soft skills, flexibility, leadership and initiative, and productivity.

3.1. Participants

A transnational empirical study was designed for 77 secondary school students (39 female and 38 male) from Greece, Bulgaria, and Romania, aged 13 to 17, in an EFL educational setting. Semi-structured participant selection involved inviting Bulgarian and Romanian EFL teachers to participate in an educational intervention designed by a Greek researcher who is also an EFL educator. The Media Literacy Index 2022 [7] ranked the three countries in cluster 4 out of 5, with cluster 1 presenting the highest digital awareness. After being invited by teachers, the participants were recruited based on their willingness to participate in a blended learning (BL) study. The only requirement was that their prior linguistic competence in the target language (L2) be close to level B1 or higher based on the Common European Framework of Reference (CEFR) as defined by the Council of

Europe [57]. The goal of the COE is to promote methodological innovations and new approaches to designing teaching programs for reaching the communication threshold. Table 1 is a summary of the participants' demographics.

Table 1. The participants' demographics.

Category	Demographics	*N* of Students	Special Characteristics
Country	Greece	28	Participants from rural areas in Kavala, Northern Greece, from a variety of nationalities.
	Bulgaria	23	Participants from the capital city of the country, from a variety of nationalities.
	Romania	26	Participants from a town most of them attending vocational school, all Romanian.
Age	13–14	40	10 participants with past AR experience.
	15–16	15	4 participants with past AR experience.
	17	22	4 participants with past AR experience.
Gender	Male	38	No predetermined equal distribution.
	Female	39	No predetermined equal distribution.
Level of English CEFR	A2+	10	Participants with a lower-than-expected level but with a strong willingness to participate.
	B1/B2	52	Most participants fall into the prerequisite level of L2.
	B2+/C1	13	Above the prerequisite level of L2.
	C2	2	Remarkably high level of L2.

3.2. Research Design

The research design of the AR-based educational intervention can be analyzed based on the project-based content and language integrated learning (CLIL) approach, with the content focusing on digital and media literacy to strategically incorporate activities that enable the parallel development of the aforementioned skillset in a holistic approach. There was a manual for the instructors to follow, allowing for a common framework for the incorporation of the AR-based CLIL approach. The four major components of CLIL, the 4Cs as [55] contends, namely content, (subject matter), cognition (learning and thinking processes as well as creativity), communication (mediating ideas, thoughts, and values), and culture, (developing intercultural understanding and global citizenship), are explored based on AR-enriched materials.

3.3. Research Instruments

This study included (a) pre- and post-course surveys; (b) a journal kept by the instructors for classroom observations and the checking of reactions and feelings; and (c) formative, alternative (project-based), and summative assessment to allow for improvements during the implementation and evaluation of the whole intervention at the final stage. A pre-course survey was conducted to check students' digital profile and linguistic competence in L2, which consisted of 30 questions with the addition of 1 question for open comments or requests. The first part of the survey (five questions) was related to their demographics, including age, country, nationality, gender, and level of English, which, for the present study, were an important factor to investigate due to the diversity in cultural backgrounds, the mobility of populations in the Balkans, educational systems and practices in each country, and age and L2 competence correlation. The second part of the survey consisted of ten questions, including two open questions, focusing on their digital profile, competences, and previous acquaintance with AR-based learning instances. The third part explored their pre-existing media literacy skills, with 10 closed and 6 open questions investigating the participants' skills to navigate online environments, their media preferences, their beliefs, their ability to check the validity of information, and their interaction and engagement in the digital world.

The pre-course survey informed the design and development of materials and the selection of the asynchronous LMS platform and AR app to be leveraged, complying with what the literature suggests for maximizing learning opportunities [15,17]. The participants'

responses allowed them to have a voice and share their preferences on the type of AR assets and activities they would like to work on during the implementation phase, which was an important factor as they assumed responsibility for their learning process.

Given the novelty of the learning design for the intended learners, there was a consistent observation of their reactions and feelings, which was kept in a journal throughout the intervention. The grouping of materials was offered in units on an LMS platform based on [17]'s suggestions that the AR educational applications should not be a one-off prototype, and [15]'s stressing of the importance of the integration of AR technology in the learning process in conjunction with the use of an LMS platform to facilitate contemporary education for analytical thinking skills and promote in-depth knowledge development. Each unit provided step-by-step scaffolding, from raising awareness of the subject matter and building skills and competences to reaching high levels of creativity through content development.

The post-course survey was not merely based on the participants' perceptions of knowledge gained but on their reflection on their progress based on scores of their assessment processes. It consisted of 37 questions to assess the participants' change in knowledge, skills, and attitudes in five distinct sections, namely demographics (5 questions), digital skills (6 questions), media literacy skills (8 questions), communication, collaboration, social, and soft skills (10 questions), and language competence building (8 questions). The assessment tools used during the intervention, apart from the final product content creation, included webtools such as Quizziz, WordWall, LearningApps, Padlet that could be embedded in the AR content. The surveys were developed on Google Forms. Correlations were measured via IBM SPSS version 28.0. Apart from keeping a record of the spontaneous expression of feelings and reactions, key points of the post-course survey were also listed in the instructors' journal to facilitate the observations' focus. Due to the diversity of the participants, demographics played an important role as, in addition to the age and level of English disparities, it was important to investigate whether there were participants who had prior MAR learning experiences and whether this condition could affect their performance and change in new knowledge and skills' building.

3.4. The Immersive Triggered Educational Intervention

Based on what the literature suggests and in order to fill the research gaps, there was an effort to design an educational intervention that further explores AR affordances within a pedagogical framework to address the needs of students of three different educational settings and countries. The students interacted for four months on a project on critical digital and media literacy skills' enhancement, with materials being developed in English and the subject matter purposefully enhanced with multimedia elements added to the enriched AR book created on the ARTutor web authoring platform [58]. ARTutor consists of a web-based application that acts as an AR authoring tool and an accompanying mobile application that is used to access and interact with educational AR content. The specific platform was selected based on its affordances as an open-source AR educational tool that does not require any advanced coding skills; its functionalities can address educational needs as it accommodates a variety of augmentations, ranging from images, 3D models, audio, video, and embedded links, and its compatibility with a wide range of mobile devices facilitates the creation of real classroom conditions [20,59,60].

For the CommuniTIES—Media Literacy in Practice course, a text and a static presentation of digital and classroom printed material in the form of a booklet were created and enriched with 11 augmentations that include AR assets such as images, infographics, auditory augmentations, videos, and links that facilitate the implementation of the Universal Design for Learning (UDL) principles [56] in the EFL learning setting. There was a strategic development of materials based on factors that the literature suggests with the intention of adding AR-based explanatory interactive digital content to traditional learning resources. More specifically, the UDL principles for multiple means of representation, engagement, and action and expression, the TPACK framework [26], and [25]'s suggested key ideas

for an effective use of technologies informed the amount and the complexity level of the content and the pedagogy behind the specific technological tools utilized and their added value [20]. Table 2 presents an analytical description of the activities in the enriched booklet with an indication of the page, the corresponding learning goals, the AR assets that added value to the material based on UDL-provided learning and assessment opportunities, and the additional external tools used.

Table 2. The prototype implementation activities, learning goals, AR assets, tools used, and added value based on UDL principles.

Activity	Learning Goal	AR Asset	Tool Used	Added Value Based on UDL
1. My Media Landscape (p. 5)	Familiarize with types of mass media and explore media consumption trends.	Infographic	Web source	Visualization of results based on statistical information/curated feedback—*engagement, self-regulation.*
2. Media Literacy Core Concepts (p. 6)	Enumerate and illustrate on MIL core concepts.	Auditory augmentation	Voice recorder	Further oral explanations of abstract concepts/personalized learning inclusive for SEN students/listening skills enhancement—*perception, communication, and expression.*
3. MIL Core Concepts game (p. 7)	Check understanding.	Educational game	wordwall.net	Edutainment/alternative formative assessment approach—*recruiting interest, sustaining effort, and persistence.*
4. Evaluating news articles (p. 8)	Identify key strategies for MIL and develop fact-checking skills.	Infographic	Web source (Image from MCLA Library)	Visualization of strategies with pointers to enhance memory retention—*perception, language, and symbols, provide guides and checklists.*
5. Types of fake news (p. 9)	a. Categorize the types of fake news according to intentions. b. Enhance vocab and L2 prefix nuances.	Auditory augmentation	Voice recorder	Additional information and examples of content and language nuances (CLIL)—*comprehension, bridge concepts with analogies.*
6. Clickbait explained (p. 11)	Analyze content, and deconstruct and reconstruct meaning.	Video	YouTube	Multisensory material to explain abstract notions with examples—*long-term memory enhancement.*
7. Pseudoscience vs. Science (p. 12)	a. Differentiate content that is not curated but is a misinterpretation of scientific studies. b. Analyze, compare and contrast concepts in L2.	Infographic	Web source	Visualization of text that clarifies misunderstanding/L2 vocabulary enhancement—*language and symbols, executive function.*
8. The Millionaire Game/Play and Learn (p. 13)	Check understanding.	Educational game	Learningapps.org	Individualized formative assessment to reach mastery of content—*recruiting interest, sustaining effort, and persistence.*

Table 2. *Cont.*

Activity	Learning Goal	AR Asset	Tool Used	Added Value Based on UDL
9. The Wheel of Emotions (p. 14)	a. Analyze the power of format in the media. b. Illustrate the nuances of synonyms. c. Apply critical-thinking skills to check emotions.	Image	Plutchik's Wheel of Emotions image	Visualization and illustration of vocab on emotions nuances/color intensity related to the visual impact on emotions—*perception, language and symbols, comprehension.*
10. MIL interactive Game (p. 15)	a. Apply new knowledge to real-life contexts. b. Evaluate L2 reading comprehension, critical-thinking skills and media literacy competences.	Interactive game	Quizizz.com	Reflective summative assessment, high-order critical thinking, problem solving—*recruiting interest, sustaining effort and persistence, self-reflection.*
11."Collaborative Digital Wall"—Consumption and creation of information based on MIL key strategies through collaborative learning (p. 2)	a. Develop digital, social, soft, and critical-thinking skills. b. Evaluate new knowledge. c. Create new content. d. Reflect on the learning process.	Interactive digital wall for collaborative /Participatory learning experience	Padlet.com	Social constructivism learning in online environments. Interactive digital wall for collaborative learning/collection of artifacts/reflection (ePortfolio)—*self-reflection, communication, action, and expression.*

In light of this, the study was conducted in a BL environment for four months, including synchronous sessions that lasted 60 min each, with sessions every week per country and twice a month transnationally. The asynchronous sessions were implemented on an LMS platform where the content was purposefully grouped and introduced into distinct modules before synchronous sessions on a flipped learning mode, including clearly defined goals and steps to be taken to achieve the intended learning outcomes. The interactive AR materials were available on the platform and could also be downloaded so that students had the option to either access the material digitally or in a printed form. Regardless of the format they opted for, the AR assets were accessible and visible.

More specifically, the BL mode of competence building through AR tools provided the learners with the following: opportunities for autonomy, self-regulation, self-assessment, and online interaction with peers at the pre-session asynchronous phase of learning; collaboration, pooling of ideas, decision making, and work sharing during the synchronous sessions phase; and practice and consolidation, reflection, metacognition, and knowledge transfer to create new artifacts (ePortfolio) in the after-sessions phase. The learning instances of the intervention that facilitated the development of the abovementioned competences are illustrated in Figure 2, as adapted from [61].

Following the premise that the students were to use the AR app in a BL mode, the considerations that had arisen while designing the educational intervention had to be addressed at a very early stage of the implementation process in order to relieve possible stress and anxiety. The pre-course survey guided this process as the data revealed a potential lack of digital skills and unfamiliarity with the new technology. Only 18 out of the 77 participants had had previous experience with AR-based learning, that is, 76.6% of the participants were not acquainted with the use of AR-based learning affordances. To add to this, potential connectivity issues and conditions of using the app, a lack of coordination skills, and the digital divide had to be addressed. Another issue to take into consideration was the fact that students should be aware of the AR added value as a learning experience, as the initial enthusiasm and motivation due to the novelty of the technology would soon fade out. In light of this, there was an introductory session for all participants with clear instructions on how to download the app, delving into privacy and security concerns, as

well as a demonstration of how to use the AR booklet, and a discussion of its functionalities and how to make valuable use of the platform based on learning preferences.

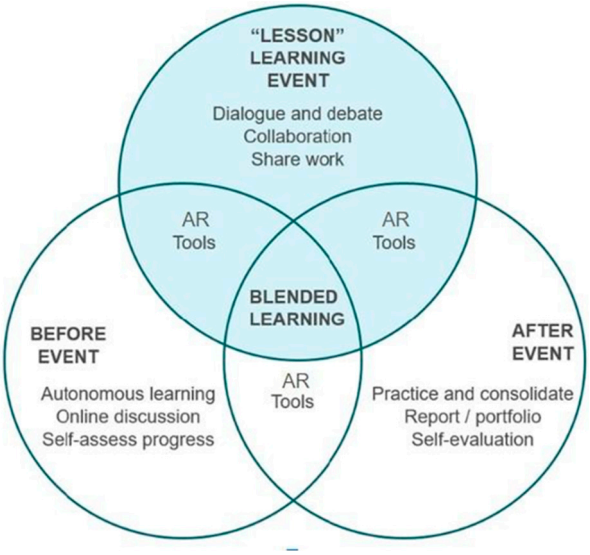


Figure 2. The events of competence building through AR tools within a blended learning environment.

3.4.1. The Asynchronous Sessions

The LMS platform provided a space for the learners to explore the course content and AR-based materials at their own time and pace. The asynchronous sessions encouraged the participants to introduce themselves before the beginning of the course and share their thoughts and expectations before each synchronous session, establishing a community of inquiry [62] that would interact in a multicultural context. On the premise that in most studies conducted to date, the participants originated from a common educational context, this new reality of diverse student populations coming together to collaborate on an innovative AR-based educational intervention should be strategically addressed to eliminate possible shyness or fear of the unknown audience. To add to this, the participants varied in age, cognitive level, and skills, which was an additional consideration but very interesting to explore. In light of this, the asynchronous platform offered the participants ample opportunities to have access to the AR-based materials, which, coupled with the multimodality of content presentation, lessened anxiety and stress before exposure to their peers. The added value of the AR-based materials on the asynchronous platform included assets that comply with the UDL principles providing the following:

1. Multiple means of representation of the learning objects through video and auditory assets with further explanations to facilitate individual learning preferences, and personalized learning instances in alignment with the UDL framework for the grouping of content, comprehension, and bridging concepts with analogies. In Figure 3, there is an example of an auditory augmentation with additional information and examples of content and language nuances within the CLIL context of instruction.
2. Infographics with pointers, color cues and dual coding explanations, providing a visualization of the learning items and size adjustment for the accommodation of learning styles and needs (see Figure 4). This augmentation type is in alignment with the UDL framework for perception, language and symbols, and provision of guides and checklists on how to resist misleading information, low-quality content, and biases on website articles.

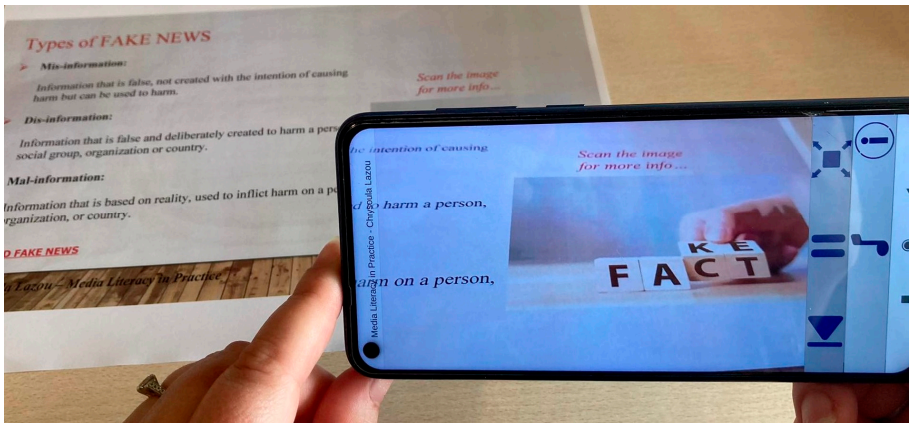
3.4.2. The Synchronous Sessions

The synchronous sessions on a national and transnational level provided the learning environment with an opportunity to (a) clarify questions, misconceptions, and/or ambiguous learning objects; (b) build a rapport and teamwork competences; (c) peer-tutoring

opportunities in a mixed-ability learning context; and (d) productive debate and dialogue for problem-based learning instances. As [63] posits, there is a growing consensus that if educators aspire to develop critical thinkers and learners, they must provide active, engaging, and collaborative learning experiences. AR-based collaborative learning activities used in this intervention included the following:

1. Worksheets that provoked team discussion and reflection through AR-based feedback on their work and an AR-based collaborative wiki space to share discussion findings with the rest of the class, thus facilitating (a) awareness raising, (b) knowledge building, (c) the development of productive skills in the target language, and (d) reflection and metacognition. Figure 5 illustrates a synchronous group activity worksheet with AR-based feedback for self-checking and discussion, and speaking skill-triggering affordances based on official statistics.
2. Team-based gamification within the AR app that served multiple goals for (a) edutainment and social-constructivism knowledge building, (b) assessment, (c) group decision making and peer tutoring, and (d) sustaining interest and engagement.
3. Opportunities for exposure to authentic international press and articles, building L2 receptive and productive skills, and enhancing metacognition based on the AR infographic-triggered literacy.

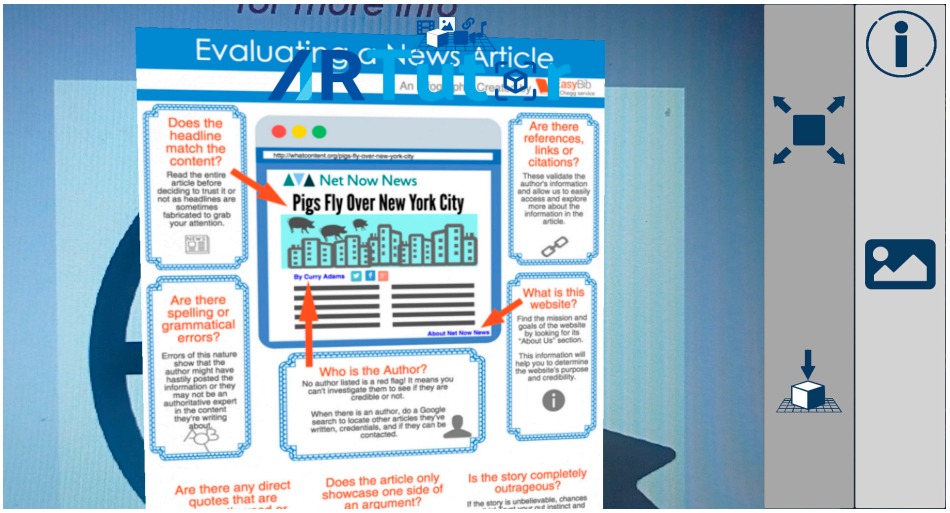
(**a**)



(**b**)

Figure 3. User manipulation of the content of an auditory augmentation on printed material. (**a**) displays the printed material that includes a trigger image enriched with an auditory augmentation and (**b**) displays the user experience (UX) upon targeting the image with the app.

(a)

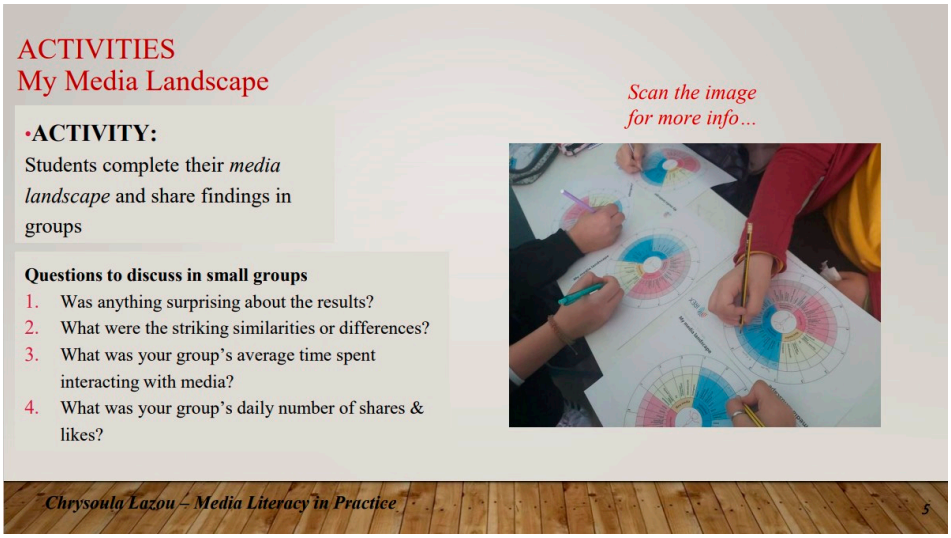


(b)

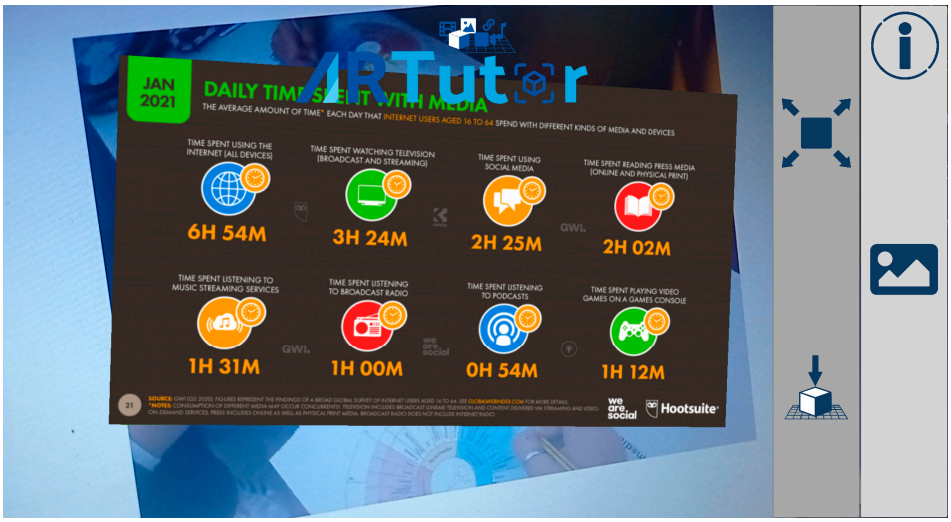
Figure 4. Augmentations with infographics, pointers, and visuals. Figure (**a**) displays the checklist as a text and the trigger image that leads to (**b**) with the overlaying digital content displayed on the app. The pointers in this figure refer to the first three questions of the checklist: cross-checking the title with the content; the byline (author), and the website/links.

3.4.3. The Collaborative Process for Content Creation

The participants worked on a mixed-ability social constructivism approach through the AR-based materials and worksheets to (a) have access to feedback on their team-work-based activities, building skills and competences on the 21st century skillset framework, and (b) create new content as a reflection and metacognition process of the educational intervention. There was a purposeful splitting of students into groups to promote and examine two main factors: (i) the peer-tutoring and assessment opportunities in mixed-ability learning setting, and (ii) transnational and multicultural interaction skillset building. To this end, the AR-based collaborative digital wall for group work, peer assessment, reflection, and collection of artifacts (ePortfolio) was a point of reference throughout the educational intervention. The content creation phase involved the employment of a variety of digital tools to build two artifacts:



(a)



(b)

Figure 5. Constructivism group-based synchronous activity (**a**) with AR feedback on statistics (**b**).

1. An informative digital storytelling video with the use of AR-based tools. More specifically, while other tools for collaboration and equal contribution were also employed, the main tool that the students decided to work on was an AR-authoring tool, Blender.org. [64], which is an open-source piece of software. The features that Blender supports include animations, simulations, video editing, VFX (visual effects), and story artist, to name a few. The students followed all the steps of storytelling creation, from decision making on the design, script writing, audio, and voice-overs, to organizing files with materials and sources concerning copyright and intellectual property, and leveraged the tool's affordances to develop their creativity based on new knowledge and skills. The message that the storytelling conveyed was an informative five-tip step addressing the audience on digital and media literacy awareness (see Figure 6). The artifact was uploaded onto the project's website on Google Sites, allowing for collaborative work, and on the YouTube channel [65] that the students created to communicate their work with peers and the public.

Figure 6. The participants' creation of informative digital storytelling. The animation was uploaded on the project's YouTube channel and website.

2. Reflective film making. The students created a film sharing their experiences of transnational interaction, collaboration, and their learning journey, starting from the reasons for working on the specific thematic area of digital awareness based on statistics of resilience, to disinformation and types of misleading information, their media and civic engagement to share emotions, and new knowledge reflection. The film was also uploaded onto the project's YouTube channel [66] (see Figure 7) and embedded onto the website.

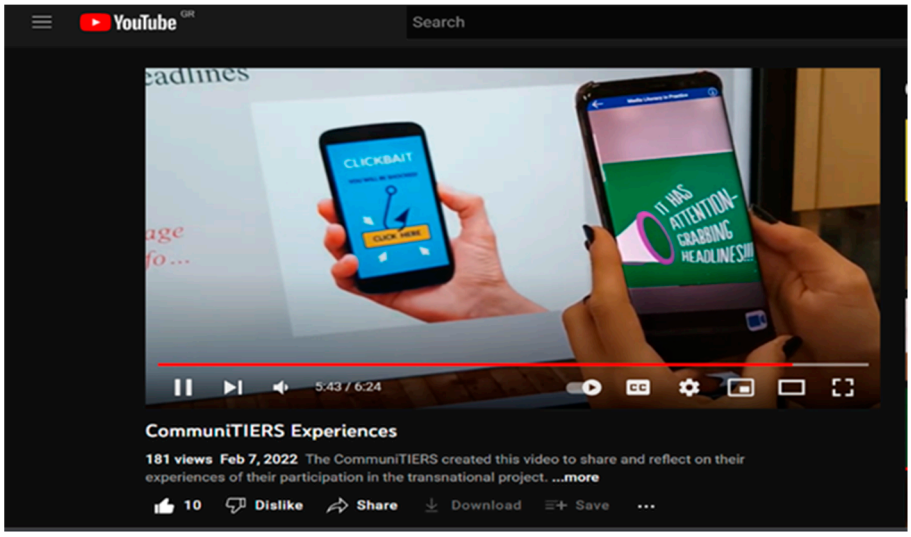


Figure 7. The participants' creation of reflective digital storytelling. In this, the students explain how they used the AR app to have access to digital information overlaying their printed material, CommuniTIES YouTube channel (2022).

4. Results

The surveys were designed to respond to the research questions and make recommendations for a future study given the novelty of technology whose use in education is still "shapeable". In alignment with the measurable results, the instructors' and participants' observations can further shed light on the emotions and reactions to the use of innovative technologies in educational settings.

4.1. The Online Survey Results

The pre-course and post-course surveys, coupled with the assessment methods and student reaction observations in this empirical study, shed light on the research questions posed. The diverse demographics of the participants were of major consideration to the researcher from two perspectives: (1) the age and cognitive level difference, and (2) the cultural background and disparities in the learners' practices in their educational settings. With regard to their age–level of English correlation, the pre-test Chi-Square test was $p = 0.047$, that is, $p < 0.05$. This age–level of English correlation before the AR-based sessions informed the design of the intervention and selection of AR assets to build a robust educational environment for mixed-ability students (see Table 3). The results of the post-course age–level of English survey contribute significantly to the study findings as this correlation is no longer valid. The total scores of assessment (post-tests) of the students' linguistic skills showed no correlation with age using the Chi-Square results $p = 0.420$ ($p > 0.05$), as displayed in Table 4. As such, while most of the initial numbers of participants' level of L2 were close to the prerequisite level, that is, B1 (n = 52) according to the CEFR, with 10 participants slightly below this level, the post-tests showed that there was a considerable improvement in their performance, while the two high-performance participants remained at the same level. It is noted that the post-tests focused on subject-related questions in addition to the alternative assessment methods.

Table 3. Age–level of English correlation.

		Level of English (CEFR)				
		B1	**B2**	**C1**	**C2**	**Total**
Age	13.00	3	7	8	0	18
	14.00	3	5	13	1	22
	15.00	0	2	6	1	9
	16.00	0	4	2	0	6
	17.00	2	11	9	0	22
Total		8	29	38	2	77

Table 4. Age–level of English correlation after the intervention.

Chi-Square Tests	**Value**	**Df**	**Asymptotic Significance (2-Sided)**
Pearson Chi-Square	12.324	12	0.420
Likelihood Ratio	13.720	12	0.319
Linear-by-Linear Association	0.063	1	0.801
N of Valid Cases	77		

In the pre-course survey, the participants were asked if they had ever worked with AR materials in their educational setting. Out of 77 participants, 76.6% (n = 59) stated no previous experience with AR in their learning process. In the post-course survey, the participants were asked to state if they liked the AR experience and what type of augmentations they favored and facilitated their learning the most. There were 98.7% positive responses to this question, with only one student stating no added value to personal learning using the AR app. Another significant finding is that despite the small percentage of previous AR-based instruction and no age–AR experience correlation, it was observed that students who had previous AR experience in their educational environment benefitted more in their linguistic output, which means that the persistence in leveraging AR-based instruction can improve performance skills more than in one-off interventions.

Regarding AR-specific assets that facilitated the participants' learning and alternative assessment of both content and language and skills development (Table 2), there is a clear

preference for games (81.8%) n = 63, followed by videos (62.3%) n = 48, audio explanations (32.5%) and an equal preference for infographics and wikis (31.2%), as illustrated in Figure 8. Nevertheless, 16 students stated only a single AR media preference. More specifically, 13 students showed no preference for games despite the high-score general preference, and 6 students out of the 13 stated that the auditory augmentations facilitated their learning process more and that they would like to have more AR audio assets included in their materials. There was no age, nationality, or linguistic competence correlation between these participants' demographics, which proves the need to respond to multiple means for the representation of content according to learning styles and needs as dictated by the UDL principles.

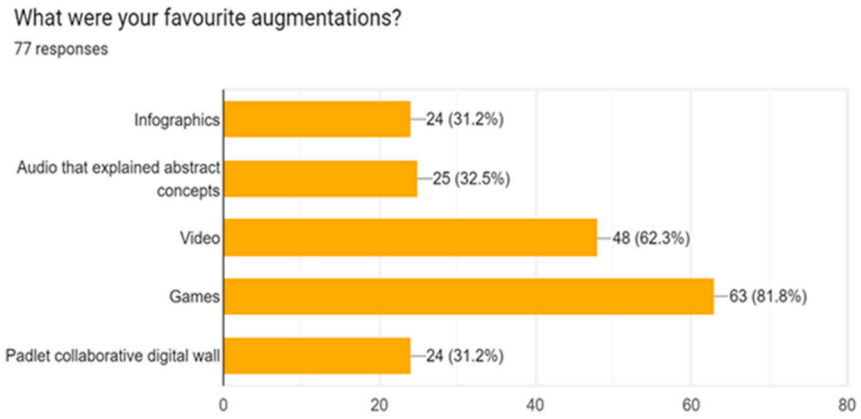


Figure 8. The participants' augmentation preferences as learning components.

Another important finding proved to be that the LMS platform was an integral part of the whole intervention. The AR-enriched materials could be accessed through the platform at all stages of the BL mode of instruction and learning, namely before, during, and after the session. The responses on its usefulness show that 81.9% of the participants (n = 63) stated that they benefitted either "much" or "very much" on a five-point Likert scale, with "not at all" or "very little" receiving only 5% (n = 4). As for the results of the question on the usefulness of the introductory forum before the sessions, 88.3% of the participants stated that it helped them build bonds and release stress before the first synchronous session, with 68.8% (n = 53) selecting the "Agree" option and 19.5% (n = 15) the "Strongly agree" option of the five-point Likert scale. It should be noted that the participants had not yet been introduced to the AR application and the guidance and demonstration session.

With regard to critical digital skills development, the participants' response on the usefulness of the auditory augmentation on the media literacy core concepts yielded the following results, as illustrated in Figure 9: 78% of the participants (n = 60) stated a high score of usefulness, with 16 participants registering answers in the middle of the scale, and 1 participant stating "a little". In the open questions option, it was noted that the participants stressed the importance of the auditory augmentations as a simulation of a one-to-one tuition opportunity in an asynchronous mode with the affordance of listening to their instructors' familiar voice as an important element of delivery of content in a personalized learning instance.

As aforementioned, AR infographics with pointers, visuals, and color cues, and AR-based gamification facilitated the spotting of disinformation and the development of the participants' critical digital literacy skills. The participants, based on measurable and observable criteria, that is, (a) their experiences during the intervention, (b) the self-checking assessment, and (c) the feedback received from their peers and instructors, were asked to state their self-evaluation on new knowledge and skills. As depicted in Figure 10, these measurable results bring a wider range of responses. More specifically, despite the participants' observable progress, with only six participants stating not much progress in identifying quality information in the digital world compared to course pre-tests, 22.1%

(n = 17) and 37.7% (n = 29) had a better or much better performance, respectively. A considerable 32.5% (n = 25), which accounts for one-third of the participants, made sufficient progress but did not reach high-performance scores.

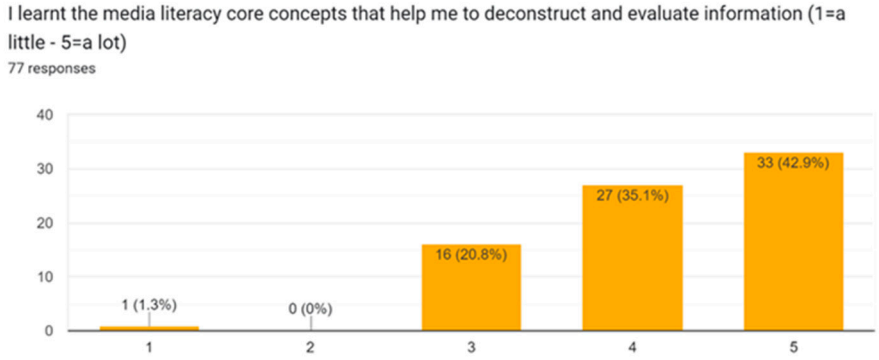


Figure 9. The participants' responses on the usefulness of the auditory augmentations on media literacy core concepts.

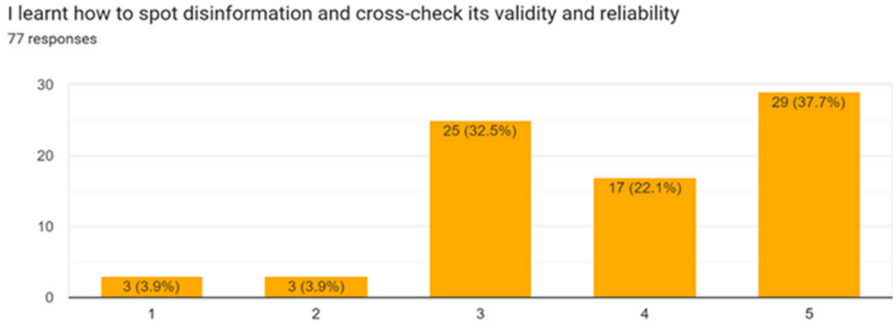


Figure 10. The participants' responses on their critical digital literacy performance improvement based on their assessment scores.

Regarding creative digital skills' enhancement on a social-constructivism approach, the responses on the effectiveness of the AR-based materials on learning how to behave in digital spaces received a high score on participants' confidence in the appropriateness of behavior based on the internalization of practicing the netiquette principles with 97.4% (n = 75) for post-course learning outcomes. As such, although the pre-course survey revealed that approximately 52% of participants ignored the netiquette principles, 27% were not sure and only 21% were aware, the educational intervention on the specific learning object had a highly effective result. It is important to mention that the social and soft skills aspect of the intervention could not be merely attributed to the use of the AR app but is rather a strategic combination of the pedagogy behind the whole intervention, of which the AR materials constitute a significant component.

Receptive skills in the target language through AR-based multimedia exposure were also noticeable during the intervention. The participants stated that the auditory augmentations had a beneficial effect on their listening skills, reaching 83% of positive responses (see Figure 11).

With regard to their L2 reading skills, the survey revealed that their AR-enhanced exposure to new knowledge of vocabulary and text comprehension influenced their exposure to international news and information-seeking preferences, as there is a level of English–international news exposure correlation with $p = 0.036$, $p < 0.05$. The list of activities as aforementioned and displayed in Figure 8 proved to have improved their L2 skills regarding text comprehension and the deconstruction and reconstruction of meaning with the aid of the AR materials. On the premise that language practice occurs in an authentic sociolinguistic context, that of international news exposure with peers from diverse

settings and native language, it was found that deep L2 learning instances in the specific intervention did not occur in isolation but within a broader sociolinguistic framework.

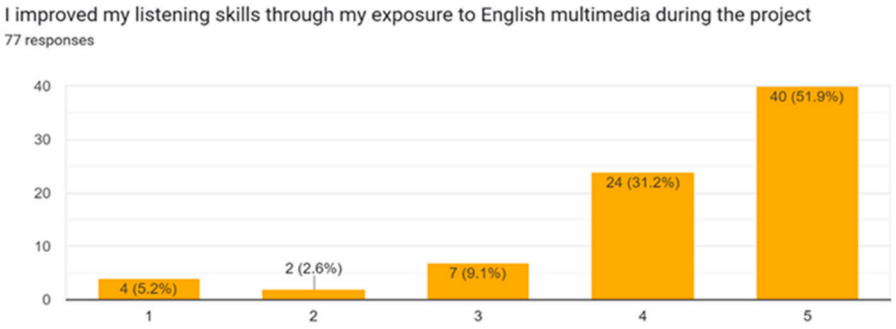


Figure 11. The participants' responses on listening skills' improvement through AR-based multimedia in English.

4.2. The Collaborative Process for Content Creation

In both cases of media production, there was a distribution of distinguished roles, and an unfolding of skills and talents. It was observed that the students could recall with ease texts and content that they had learnt through the AR materials, adding their personal experiences to the final product. The process was the culmination of diverse group dynamics affordances, with peer-tutoring and scaffolding facilitating learning goals' achievement to reach digital fluency. Although most tools and practices were not very common in their use among participants, the peer-tutoring process supported digital and creativity skills advancement. This alternative assessment, a project-based approach, complies with the UDL framework for action and expression while allowing for skills and talents to flourish in a very safe, stress-free, and inclusive learning setting.

4.3. Participants' Responses to the Survey Reflection Open Questions

The participants' responses to the post-course reflective questions can be summarized as (a) their experience with the AR-based learning opportunities, and (b) the socio-linguistic context of interaction on an international level leveraging the cutting-edge technologies incorporated in the intervention. With regard to the first factor, the participants expressed a positive attitude to the novel technology as an added value to their learning experience. Some participants stated a lack of compatibility with their devices that had to be faced. The specific participants stated that the instructors and peer support in the synchronous sessions providing them with the necessary devices was very important as it eliminated learning instances of exclusion. During the asynchronous sessions, this gap was surpassed with the use of family members' devices. Upon solving technical and practical issues of exclusion that could lead to discouragement, the participants expressed a preference for this mode of instruction, stating that they would like to enjoy it in other school subjects as well.

There was a preference for unlimited access to the auditory augmentations as it was very beneficial for the comprehension of abstract notions without having to rely on written text comprehension or to search for extra mp3 files in their materials. They additionally noted that they liked listening to their instructor's recordin as a simulation of one-to-one tuition. Nevertheless, most of the responses showed a preference for visuals, games, and videos as the multimodality facilitated the encoding of learning objects and transfer to long-term memory, which was particularly helpful in achieving high scores in their assessment tests. This can be mainly attributed to the different learning styles that the AR experience can accommodate. The participants specifically noted that using their personal devices to check their learning progress was very enjoyable and engaging, but also helpful to reflect on their progress and make personal decisions on further steps for improvement to reach the mastery of content. Students' responses to the post-course survey were further investigated

and cross-checked with the teachers' journal notes as part of a qualitative survey process to ensure the validity and reliability of the findings.

With regard to the sociolinguistic factor, it was mainly observed that some students with average performance and participation in the conventional classroom provided more eloquent responses and opinion sharing in their interactions with their peers and were more actively engaged in the media production phase. The high-performance students stated that the most important factor of their engagement, apart from the novelty of technology that they liked to explore as a new means of learning, was the opportunity of the peer-tutoring process and the opportunity to support other peers enhanced their interest in involvement and provided them with metacognition opportunities, in addition to self-esteem, confidence, and satisfaction.

5. Discussion

The present empirical study explores the AR-based BL instructional design as a key component for inclusive patterns of critical digital skills' enhancement for secondary school students on a transnational, multicultural level. The research questions posed focused on how immersive technologies can promote inclusive educational practices in the EFL context with the investigation of (a) the effectiveness of the UDL design as a pedagogical framework for AR-based instruction to long-term memory retention; (b) the AR-triggered attention as a key component for linguistic competence and content internalization; and (c) the AR-based instruction for social and soft skills' enhancement in transnational CLIL learning environments. The pre- and post-course surveys and assessment methods yielded fruitful results on the questions posed with measurable outcomes. The instructors' observations on the students' reactions and feelings towards the innovative educational intervention, despite bearing subjective elements of investigation, are also important, leading to findings that should be considered for future research. Each research question is discussed in the following sections.

5.1. The UDL Framework—Designing for Needs in the AR-Based Intervention

As the literature suggests, the design system's analysis of its distinct components, such as the technology employed, the pedagogy, and the learning environment that an intervention takes place in, is of major importance to evaluate its outcomes. The AR pattern for designing for needs, based on Maslow's [67] motivation model for a holistic approach on addressing needs in education and learning, can be further analyzed into the following five levels that align with the critical media consumption roadmap:

a. *Access:* the comfort its ergonomics provides, responding to the learners' need for immersive-triggered experience without disorientation;
b. *Analysis:* the interpretability of the design that caters for the user interface (UI) making sense to their needs;
c. *Evaluation:* the content usefulness so that the learner obtains value from the immersive experience;
d. *Creation:* the delight that all immersive components may trigger for meaningful user experience (UX);
e. *Action:* the transcendence experience that lifts the learner above passivity, surpassing the limits of ordinary experiences and leading to user participation (UP) for creativity, new artifact creation, and self-actualization.

Taking into consideration all of the components that contribute to a needs-responsive design, and with the UDL concept map as a reference point to guide the creation of materials with the ARTutor tool [20], the present intervention proved to have been based on a robust pedagogical framework that informed the AR-based instructional design for both the synchronous and asynchronous sessions. The participants' learning styles, diverse background knowledge, and prior educational practices barriers needed to be addressed, and it was crucial to investigate the effectiveness of cutting-edge technologies within a safe, inclusive learning environment. Given that there are no reported empirical studies

that focus on the development of AR-based materials within a UDL instructional design framework to respond to such diverse contexts nor previous studies on the use of the specific AR tool in the EFL context, the present study may add to the literature and inform future studies.

With regard to the research question, the findings on the level of the target language and critical digital skills' development during the implementation process showed that the design of AR materials based on the UDL principles can support long-term memory retention. More specifically, the participants' pre-tests and post-tests results showed a significant improvement in skills and knowledge that they could apply to the creation of new content. This can be attributed to the fact that they could track their own learning outcomes and explore problematic or difficult learning topics that require attention, as the recent literature suggests [19]. Another important factor was the length of the implementation process as most studies are too short in time to allow for and/or to measure long-lasting benefits. It was also observed that more reluctant and shy participants built confidence and improved their performance output, especially in the last production phase of the intervention during which learners had to reflect on what they had learnt and create new content. These findings, according to participants' responses, were attributed to the following aspects:

- the learners' prolonged engagement with the AR-based activities;
- the multimodality of the AR assets providing meaningful learning instances through AR-triggered auditory and audiovisual assets;
- the visualization of feedback on their activities;
- the contextualization of abstract notions and their bridging with analogies;
- the playful manner of checking progress based on gamification;
- group interaction and common goal setting;
- the initial learners' decision on the type of materials they would like to work on.

These distinct characteristics identified by the participants and instructors converge with the UDL principles for the "what", "why" and "how" of learning. More specifically, the AR-based materials developed and the technology functionalities offered an opportunity for:

A. Multiple means for representation for resourceful and knowledgeable learning via:
    - grouping of information, with each AR asset focusing on a specific learning instance;
    - resizable learning objects, texts, and images;
    - bridging concepts with analogies;
    - highlight patterns;
    - use of infographics and concept maps.
B. Multiple means of engagement for purposeful learning:
    - variety of activities and source of information;
    - involvement of learners in setting their own goals for media consumption and production;
    - differentiation of the degree of difficulty;
    - use of real-life examples and situations;
    - elevation of the frequency of self-reflection;
    - creation of collaborative learning groups through the collaborative digital board embedded in the app.
C. Multiple means for action and expression for strategic and self-directed learning:
    - highlighting patterns;
    - providing alternatives for time, speed and motor action;
    - access to alternative keyboards and touch screens;
    - within-app use of web tools, animations, and digital collaborative boards;
    - providing guides and checklists.

Another important factor that was identified as a supportive element for long-term memory retention was the unlimited access and flexibility of the BL mode of teaching and learning. The participants attributed their high scores to the availability of resources within the LMS platform. The grouping of content into bite-sized learning objects per module organized their learning process and provided opportunities for learner autonomy and time management, diminishing information overload and anxiety. This finding was also very important as it suggests the need for the integration of AR-based learning instructional design within a broader learning environment for meaningful learning experiences.

5.2. AR-Triggered Attention for Sociolinguistic Competence

The multimodality aspect of the AR-based instruction incorporated within the BL environment coupled with the mixed-ability group work, despite initial disparities in skills and knowledge, provided a suitable environment for the EFL transnational learners to benefit from. The findings of the post-course surveys and peer and instructors' observations regarding the second research question showed that the LMS platform that hosted the AR materials and asynchronous learner–content and learner–learner interactions advanced learners' manipulation of content and linguistic competence. As such, working from the bottom of Bloom's taxonomy as revised by [68], with the specific critical immersive-triggered (CIT) literacy framework for meaningful learning instances, the students could synthesize information, internalize new knowledge, and reach high-order critical-thinking skills to create new content. More specifically, learners developed skills through:

- unlimited, asynchronous access to AR content and interaction with peers in the target language;
- AR auditory explanations on nuances of the target language, the media literacy concepts, types of misleading information, and strategies to collaboratively explore digital content validity;
- the visualization and dual coding of the subject matter that empowered learners of lower L2 linguistic competences to comprehend, internalize new knowledge and achieve meaningful output;
- the strategic grouping of content in units through the AR-enriched learning objects added to the platform that allowed for step-by-step knowledge and skills' building;
- AR-based formative assessment for individual (self-assessment) and peer assessment opportunities;
- critical digital skills empowerment through peer exploration of tools for collaborative content consumption and creation;
- team challenges on AR gamification that provided peer learning instances as they had to make decisions based on elaboration and justification of their recommended answers before team answer submission.

The participants reported that the AR-based collaborative process of learning within the BL environment had a beneficial effect as it allowed for time to (a) explore new knowledge at their own time, and (b) interact with their peers, pool ideas, and get supportive feedback when needed. The instructors' observations are in alignment with [22]'s suggestion that AR-based instruction encourages more balanced group dynamics, reducing the dominance of group leaders in collaborative educational settings. The demographic diversity on a transnational level has additionally played a significant role on the premise that (a) the group members came from different educational settings and had no physical everyday contact as in conventional classroom circumstances. As such, the partial digital "anonymity" aspect unfolded and activated more shy or reserved learners. (b) English was the only means of interaction and as such there were limited opportunities for a shift to the learners' mother tongue. This condition enhanced [69]'s sociocultural theory for second language development coupled with the ZPD component for scaffolding and peer-tutoring opportunities as a mediation process for the internalization of meaningful and long-lasting learning experiences. (c) The sparsely distributed learners were committed to accomplishing a common goal through an innovative learning process not conventionally experienced

in their prior learning practices, through the added value of the AR informed environment with multisensory stimuli.

5.3. Social-Constructivism in AR Learning Settings for Digital Fluency and Well-Being

Regarding the third research question posed, the survey findings suggest that the new sociolinguistic context of today's learners, given the advances in technologies and global connectivity, and cutting-edge technologies are the new framework that learners interact, they are more acceptive of the "new" and they bear a new social imprint where values and norms of conduct are less dictated by place of origin and social position [6]. Diverse group dynamics within project-based learning allow for a holistic development of skills as dictated by the 21st century digital competences' development framework. As such, learners may reach a broader level of life skills' empowerment, that in addition to specific literacy and learning skills, equally consider the importance of social and soft skills, initiative, flexibility, and mutual understanding and support.

In light of this, emerging technologies can support a focus not only on digital literacy skills, but digital intelligence, or otherwise, digital fluency [5], as they provide students with a breadth of tools and depth of skills and offer a diverse set of opportunities to master digital fluency. Through the production phase of the intervention that entailed digital storytelling, the students leveraged AR technology to create new knowledge, new challenges, and new problems and to complement these with critical thinking, complex problem solving, and social intelligence to solve the new challenges. On the premise that digital fluency requires excellent communication skills, new media literacy, and cognitive load management to address the issues, the successful completion of the task as a product of their collaborative work proves that the building of more complex skills leads to curiosity, communication, creation, data, and innovation fluency. As [5] contends, "[l]earners should be prepared not only to take on the jobs of the future but also to be entrepreneurs, activists, researchers, and lifelong learners" (n. p.) as the author supports that the main aim is that they will have the skills to solve the big, bold problems of the future. In addition to linguistic knowledge, the AR-based mobile learning material supported the participants in gaining content knowledge and being able to refer to information provided in the AR-based experiences in their media components' production, with some of them elaborating on their own experiences.

5.4. Limitations and Recommendations for Future Research

The AR-based intervention and study constitute an effort to investigate the usefulness rather than the use of immersive technologies in a multicultural learning setting, based on an inclusive learning design that fosters multimodality and the accommodation of diverse learner needs and preferences. Despite being conducted within the EFL context, based on CLIL, the subject matter, that is, media literacy, was not the exclusive focus area of the study. Limitations to be considered in the present study include the number of participants since, though these provide a broader scale for investigating the AR intervention's effectiveness, the results rely mostly on the quantitative surveys, their performance on formative assessment, their involvement in the creation of the final products, and their reflection on their learning progress, while observations, especially in the synchronous sessions, were limited to the main questions that the instructors posed on their journal for note-taking on reactions and attitudes, and, in alignment with the post-course survey, to cross-check the reliability of the students' performance. In addition, the present study does not include a control group to compare the results on the premise that the effectiveness of MAR technologies for the experimental group compared to the control group is addressed in previous studies discussed in the literature review. The focus was on the sociocultural and demographic diversity recruitment of high school students based on their willingness to participate, which might involve only highly motivated students. Though it was noticed that shy and introverted students in the conventional classroom setting benefitted from

the AR-enriched learning context, this assumption may be a recommendation for more extensive future study in other types of diverse settings.

Another consideration to be carefully addressed is the use of students' mobile devices. Learners determine what to see, hear, do, and access, promoting and responding to student-centered learning demands as the capabilities of smartphones today are approaching those of microcomputers, while the variety of applications enables the accomplishment of many different tasks [70–73]. Nevertheless, not all devices bear the same characteristics and affordances, which may lead to cases of different quality of experiences that cannot be foreseen, especially when the learners need to access the AR materials at their own time and space. To add to this, students' exposure to screen time should also be investigated and carefully addressed to prevent age inappropriateness and unhealthy consequences. These considerations may be a deterrent to practitioners and AR-based content designers and developers. Flexibility, pedagogical inclusion opportunities, and considerations on digital well-being for all users and learners should be accommodated for by the education stakeholders involved.

6. Conclusions

The present research is an investigation of the incorporation of AR technologies within transnational educational settings with the aim of proposing a framework of design that is aligned with contemporary learner needs for autonomy and self-actualization through an interdisciplinary social-constructivism approach. This study supports the notion that the ultimate goal is knowledge construction and learner self-actualization and, as such, the teacher should first and foremost identify the pedagogical characteristics of technology applied to maximize the learning opportunities. Many teachers are enthusiastic about technology-enhanced teaching and learning opportunities and may wish to put them into practice. Nevertheless, if the implementation is not purposeful, and there is a poor learning experience with no added value with the only objective of utilizing new technology, "the novelty effect", as [74] notes, plays a short-term "learner enthusiasm" role that may soon be abandoned. In light of this, there is a need for teacher training to complementarily combine teachers' digital and instructional skills, the latter being a good knowledge of pedagogical approaches and learning principles that do not merely satisfy Bloom's taxonomy lower levels. Pedagogy-based instruction makes immersive technologies a useful tool for teaching and learning by transforming the way educational content is delivered, experiencing subject matter or abstract concepts in a way that may not otherwise be easily discernible, thus diminishing the confines of the classroom. The findings of the present study that may inform and contribute to the literature and future related work can be summarized as follows:

1. The UDL framework coupled with the five levels for designing for needs that involve a meaningful user interface (UI), user experience (UX), and user participation (UP) in an AR-based learning environment can have a positive impact on learners' long-term memory retention and the transfer of knowledge to a new context. This universal instructional design for needs proved to be an effective approach to address learners with diverse demographic characteristics and learning preferences, especially considering the population mobility and connectivity of today's world. Teachers and instructional designers must consider the curriculum pre-requisites along with the specific group of learners' needs. This study's results suggest that the design of a course based on the UDL principles coupled with the AR attention-triggering that provides meaningful contextualization of specific learning objects minimizes the need for continuous changes to address diverse learners' needs.
2. The persistent deployment of AR-based interventions when and where needed within a broader learning environment, that is, in conjunction with an LMS platform, can (a) complement the learning process and promote in-depth knowledge development [15,17,22], and (b) enhance the social-constructivism aspect of AR-based learning for competences' and skills' development in the connectivity era. The proposed CIT

literacy can be realized in BL environments, providing learners with (a) meaningful, specific learning objects individual learning instances for better internalization of knowledge through multisensory experiences, and (b) social interaction and constructivism learning opportunities that promote the sense of belonging and co-presence in the digitally connected world.

3. The AR immersive-triggered framework for attracting students' attention to specific learning objects can have a positive impact on their linguistic competence building in L2, maximizing opportunities for optimizing their receptive and productive skills. This finding was particularly observed in cases of students with low or average performance. Similarly, it was observed that shy and less extroverted students were more active participants in the learning process. High-performance students may not have displayed better results in their L2 performance in isolation but improved their holistic competences' performance in a social-constructivism learning setting. More specifically, the students stated that their self-esteem and confidence had improved through their opportunities for acting as peer tutors, but not as group leaders, thus interacting in purposeful sociolinguistic contexts, and reflecting on their own creative potentials in a mixed-ability group dynamics schema.
4. While visual augmentations prevail in the AR-based learning context, auditory augmentations that derive from the instructors' intentional supplementary support to address diverse learning styles or special needs have a positive impact on most students while additionally providing inclusiveness. The need for one-to-one tuition that cannot be supported within the traditional classroom can be remediated through the intentional personalized instruction that the AR applications' functionalities support.
5. The AR-based framework needs to be in alignment with specific intended learning goals through scaffolding that facilitates the learning process rather than cause stress and anxiety due to the novelty of the technology. New generation learners opt for autonomy and self-actualization on the premise that they are aware of the "what", "how", and "why" of learning that immersive-triggered literacy contexts provide. As such, superimposed digital information towards specific objectives during the learning process provides the learner with useful transmedia content in order to accelerate the process of mastering specific skills and thus achieve the pre-defined learning objectives.

In conclusion, immersive technologies that have been leveraged in a variety of fields, including education, can play a transformative role for the attainment of education for all [40] in the Industry 4.0 era on the premise that they are purposefully used. It is of the utmost importance that educators and instructional designers take into consideration a pattern for designing for needs that focuses on the usefulness of the AR-based educational intervention that is based on the UDL principles and includes a five-level approach for addressing needs, namely (a) the comfort its ergonomics provides, responding to the learners' need for immersive-triggered experience without disorientation; (b) the interpretability of the design that caters for the user interface (UI) making sense to their needs; (c) the content usefulness so that the learner obtains value from the immersive experience; (d) the delight that all immersive components may trigger from a meaningful user experience (UX); and (e) the transcendence experience that lifts the learner above passivity, surpassing the limits of ordinary experiences and leading to user participation (UP) for creativity, new artifact creation, and self-actualization.

7. Contribution to the Literature

On the premise that there is a need to cope with the information overload of the new transmedia era, a new type of literacy is proposed, the critical immersive-triggered (CIT) literacy, which allows for the internalization of cognitive skills through attention-drawing multisensory functionalities on specific learning objects. In the Metaverse era, the incorporation of activities that lead to CIT literacy can facilitate digital attention in the learning process and lead to the synthesis and creation of new content. AR technologies

that provide the learner with specific digital information over real-world objects without interrupting the learning process are a key element to cope with the so-called "information pollution", a term suggested by the Council of Europe [75]. Taking into consideration that the new generation of digital natives have on-the-spot access to information, but at the same time must cope with information overload and digital distraction, the present proposal of the term critical immersive-triggered (CIT) literacy allows for the development of skills that facilitate the learners' attention towards meaningful learning instances via immersive technologies and self-reflection competence building within an intercultural linguistic context. AR-based learning instances that cross specific subject contents and cultural contexts can boost a holistic approach to learning that enables a better and more critical understanding of the individual presence in the world and in interaction with others. Future recommendations for research directions would be on interdisciplinary institutional participation and collaboration in AR-based material development for holistic learning opportunities and curriculum updates in the secondary school educational context.

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