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"Helping Nemo!"—Using Augmented Reality and Alternate Reality Games in the Context of Universal Design for Learning

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Abstract: This article reports on the main experiences gained from a teaching intervention which utilised the alternate reality game 'Helping Nemo' in an augmented reality environment for formative assessment. The purpose of the study was to explore the ways in which the affordances arising from the combination of alternate reality games and augmented reality, situated in the context of Universal Design for Learning, might facilitate students' learning amongst the aspects of engagement, participation, and response to students' variability. The study took place in a public primary school located in a rural area of Cyprus. A second-grade class consisting of 24 students aged 7–8 years old was selected to comprise the sample. A qualitative research approach was adopted. The data collection methods included classroom observations and focus groups with the students. Findings gained from the teaching intervention suggest that the creation of a multimodal environment that draws on the principles of Universal Design for Learning and combines the affordances of alternate reality games and augmented reality for formative assessment contributes towards higher levels of engagement and participation in learning of all students, including bilingual students, students with learning disabilities, and students who are currently disengaged.

Keywords: augmented reality; alternate reality games; inclusive education; multimodality

1. Introduction

Today's teachers have to find innovative and creative ways of responding to two interconnected realities. These realities entail students' immersion in a constant interaction among different digital media from a young age and the increasing diversified nature of students' educational needs. Regarding the 'first' reality, current students consist of 'a generation of students who, raised on interactive games, expect the same kinds of interactive experiences from their educational media' [1] (p. 34). It is well known that literacy is not a static concept but constitutes a social practice which is constantly evolving [2,3]. Students' interactive experiences are related to the evolving nature of literacy, as nowadays literacy is no longer confined to one medium [4]. On the contrary, students engage in a multimodal matrix utilizing a multiplicity of modes to communicate.

Multimodality encompasses anything that extends traditional script 'interactions with video, the Internet, popular music, and even modes of student dress' [5] (p. 259). It is situated within a wider context, namely the context of a participatory culture that has been created through new media [6]. This participatory culture seems to be reframing and reshaping the very notion of learning as well as the skills needed for the students of the 21st century. At the same time, it is recognised that classrooms can be characterised as an amalgam of diversity [7–9] and that educators have an

ethical responsibility to respond to this diversity [10,11]. Supporting all students during the learning process irrespectively of gender, religion, socio-economic status, disability, and race reflects the notion of inclusive education, which is concerned with promoting equal access and participation to education [12,13]. The contemporary multimodal landscape provides educators with a variety of means that align with students' everyday interactive experiences and diverse needs.

In particular, research shows that technologies such as augmented reality (henceforth AR) applications, games, and AR books can provide educators with new opportunities and contemporary ways to engage their students in learning [14–16] due to the wide range of their potential affordances such as 2D and 3D illustrations, hearing sounds, and being involved in tactile activities [17].

Despite the increasing interest for the integration of immersive technologies such as AR within the field of education, there is still a dearth of studies exploring AR-related learning processes in-depth, meaning that the ways in which students learn through the application of AR have not yet been adequately researched and comprehended [18]. Nevertheless, it is of vital significance to be aware of potential pitfalls such as technological determinism [19], which involves the use of technology for the sake of technology, leaving pedagogical approaches aside. As Bronack [20] (p. 114) argues regarding immersive media: 'Whereas each of these categories of immersive media includes sophisticated and engaging tools ... it is not the tools, themselves, that are important; Rather, it is the pedagogical approaches and psychological constructs each enables that matter most'. In relation to this, during the last years serious alternate reality games (henceforth ARG) have begun to gain popularity within the educational field [21–23]. Serious ARG, as the name suggests, engage players in an alternate, fictional reality. They can be defined as interactive narratives in the form of puzzle-solving [24]. In the context of ARG, different platforms and means of communication can be used for collaborative puzzle-solving such as blogs, e-mails, websites, phone calls, text messages, books, instant messenger (IM) conversations, TV, newspaper adverts [25,26] and we would add AR applications. In this respect, ARG's affordances depend highly on the platforms and means used within ARG. Therefore, combining the affordances of AR and ARG might provide educators with more possibilities for designing engaging learning environments for students.

At the same time, pedagogical approaches and frameworks involving AR and ARG need to take into account students' variability, which is of utmost significance for responding to the principles of inclusive education. According to Meyer, Rose and Gordon [27] variability 'derives from a multiplicity of factors including biology, family context, cultural background, history with schooling, socioeconomic status, moment-to-moment internal and external changes, and, most importantly, the context in which the learner is functioning' (p. 54). The researchers have underlined that despite the high degree of learners' variability, variability can be perceived in a systematic and meaningful way for educators; particularly by considering the brain's networks for learning. They offered a categorisation of these networks: (a) *affective networks* that monitor the internal and external environment to set priorities, motivate, and engage learning and behaviour; (b) *recognition networks* that sense and perceive information in the environment and transform it into usable knowledge; (c) *strategic networks* that plan, organize, and initiate purposeful actions in the environment (p. 29).

By drawing on the predictability of these networks and on the importance of the learning context in perceiving students in specific ways (e.g., as engaged or disengaged, capable or not able to learn) Meyer et al. [27] developed the framework of Universal Design for Learning (henceforth UDL). UDL involves three main principles: (1) the principle of engagement (the why of learning) which corresponds to affective networks, as what motivates students and keeps them engaged differs for each student; (2) the principle of representation which corresponds to recognition networks. For instance, students with learning disabilities (e.g., dyslexia), sensory disabilities (e.g., blindness), and students from different cultural backgrounds require the presentation of information in different ways (e.g., visual, auditory) for accessing and understanding the content; (3) the principle of action and engagement, which corresponds to the strategic networks as there are many differences concerning the ways that students function strategically. For example, a student might be skilled in articulating a creative

idea but have difficulties in implementing this idea. Another might be skilled in writing but have difficulties in oral presentation. In essence, the perspective of UDL provides us with 'a way to shift our understanding in how all people learn' (p. 50) while its principles take into consideration the variability of all students "including learners who were formerly relegated to the 'margins' of our educational systems but are now recognised as part of the predictable spectrum of variation" (p. 50). In other words, UDL is strongly interlinked to inclusive education which embraces diversity [28] by recognising that differences in the classroom do not create barriers but opportunities.

Based on the above, it was suggested that combining the affordances of alternate reality games (ARG) and augmented reality (AR) applications within UDL can offer students a dynamic inclusive learning environment. To this end, this article focuses on the utilisation of a serious alternate reality game enhanced with augmented reality as a contemporary multimodal approach in educational settings in the context of UDL.

The scope of the case study described in the article is threefold. It aims to explore: (i) students' engagement in learning when utilising ARG and AR; (ii) the ways in which students perceived their participation in the learning process; and (iii) the ways in which the affordances provided by the combination of ARG–AR in the context of UDL respond to students' variability. The paper first describes the theoretical background underpinning the study, then the study methodology and main findings, and finally, the study implications for teaching and research.

2. Theoretical Background

2.1. Inclusive Education

Inclusive education has been described as a social movement that attempts to tackle exclusionary practices in the educational landscape [12,13]. Though the term 'inclusive education' is perplexing as it is open to multiple interpretations and practices [12,29], what lies in the core of this term is that inclusion constitutes an essential element of truly democratic educational practices [30]. It can be perceived as a continuous process for ensuring that learning opportunities contribute to individuals' social inclusion in every aspect of society [31].

According to the UNESCO Guidelines for Inclusion [31], inclusion stresses the fact that student needs should be taken into account a priori, that diversity in education should be valued, and that each individual has the right of access to education and equal participation in learning without being segregated. In this study, inclusion is perceived 'as a process of increasing participation of students within and reducing their exclusion from, the cultures, curricula, and communities of neighbourhood centres of learning' [32] (p. 34–35). Many factors influence the attempts to achieve inclusive education, including teachers' and students' attitudes towards diversity, as well as policies and legislations [33]. It could be suggested that one of these factors involves the utilisation of multimodal, inclusive approaches to learning.

2.2. Multimodal Learning and Students' Engagement and Participation in Learning through the Prism of Universal Design for Learning

In this paper, multimodality is adopted from the field of social semiotics that places emphasis on the utilisation of modes as meaning-making resources and on the socio-cultural communicative practices in which they take place [34,35]. According to the New London Group [9] essential modes of meaning are *linguistic mode* (elements of the language including semantic, syntactic, pragmatic and phonological aspects of the language), *audio mode* (sound effects, music), *optical mode* (images, page layout), *gestural mode* (body language, gestures), *spatial mode* (environmental concepts, being able to understand a map), and *multimodal ways*.

The term 'multimodal ways' (or multimodality) encompasses the dynamic interaction between two or more of these modes and plays a catalytic role in youth communication practices [36]. Another important term in relation to modes is 'affordances', which refers to the different potential and

limitation modes for making meaning [37]. Hence, a multimodal perspective focuses on the diversity and multiplicity of modes that people use for creating, representing, distributing, and communicating their meanings [38,39]. It is in this context that multimodal learning becomes possible; through the interaction between the multiplicity of modes, the continuous process of constructing and reconstructing new meanings occurs [40]. As Binder et al. [41] argue, learning and meaning-making processes in the 21st century are multimodal due to the dynamic spaces created through blogs and other digital media.

Multimodal learning can be empowering for all students as it takes into consideration students' variability [42,43]. In particular, research has shown that multimodal approaches are strongly interlinked to students' engagement and active participation in the learning process [44,45]. Engagement and participation are at the core of educational practices focusing on promoting inclusive education [46,47]. Both notions constitute complex theoretical constructs. In this paper, we view these terms through the prism of Universal Design for Learning (UDL) [27], in an attempt to place their complexity in a framework useful for educational practice.

UDL constitutes a pedagogical framework that places as a top priority the design of an accessible content delivery system for all learners. It draws on three main principles: *'engagement'* (the 'why' of learning'), which focuses on the ways in which students can be engaged or motivated to participate in the learning process; *'representation'* (the 'what' of learning) which 'provides multiple means of representation', and *'action and expression'* which focuses on the different ways that students can use to express themselves in the classroom environment and provides guidelines for physical action, expression, and communication [27].

The UDL principles go deeper than merely focusing on physical access to the classroom; they focus on access to all aspects of learning. This is an important distinction between UDL and a pure access orientation [48] (p. 3). Hence, with regards to 'access to all aspects of learning' UDL seems to focus on participation and interaction during the learning process, as social constructivism supports. UDL can create opportunities for engaging students in the learning process as it takes into consideration that students do not constitute a homogeneous population and different needs have to be met and considers these needs a priori [49]. In particular, UDL principles are founded on the idea that learning has to accommodate a wide range of diverse needs and place emphasis on the dynamic interaction that can emerge through use of digital technologies [50].

Taking into account the aforementioned, multimodal learning is not optional but seems to be a prerequisite in order to broaden the horizons of students' engagement and equal participation in learning, promoting in this way the implementation of inclusive education. Given this pre-requirement, the affordances of serious ARG and AR can be utilised for providing students with participatory, interactive, and engaging multimodal experiences in educational settings.

2.3. Contemporary Multimodal Learning: Augmented Reality and Serious Alternate Reality Games

Augmented reality (AR) can be defined as 'an emerging form of experience in which the real world (RW) is enhanced by computer-generated content, which is tied to specific locations and/or activities. In simple terms, AR allows digital content to be seamlessly overlaid and mixed into our perceptions of the real world [16] (p. 119). AR can broadly be categorised into two types: image-based AR and location-based AR [18]. Location-based AR recognises where the user is positioned and provides virtual information which seamlessly blends with the physical environment of the users (e.g., the game Pokemon Go developed by Niantic). Image-based AR utilises graphics identification techniques to identify plain images within the real world and then provides to users synthetic information or other elements intersecting with the plane images [51].

Within the educational field, AR has been used in a variety of ways and within different sectors of education. Educational uses of AR can be classified into five broad categories [16]: AR gaming; discovery-based learning; objects modelling; skills training; AR books. AR gaming can provide educators with new opportunities and interactive ways to engage their students in learning. For instance, 'games using marker technology often include a flat game board or map which becomes

a 3D setting when viewed with a mobile device or a webcam' [16] (p. 128). AR games can also be used for the creation of virtual people and objects, which can, in turn, be connected with specific places in the real world (ibid).

An example of the use of AR gaming in education is the study of Dunleavy, Dede, and Mitchell [52]. The researchers used an AR video game called 'Alien Contact!' for engaging students throughout the learning process. The game's purpose was to discover why aliens had come to earth and landed on a specific area. Students were divided into different teams with distinguished roles, and each team had to collect evidence through solving problems. The study's findings revealed that AR gaming was highly engaging for the majority of the students, though some limitations regarding the use of AR and teachers' training in the implementation of AR were also present. Though this game is defined as an AR game, elements of alternate reality games are also present.

Alternate reality games (ARGs), also defined as 'immersive gaming', constitute a combination of narrative and puzzle-solving [24], incorporating a multiplicity of media and gaming features to engage players in a story which unfolds based on the players' ideas and/or actions. According to Gurzick et al. [53] stories and storytelling constitute a basic feature of ARGs. The story of an ARG evolves through multiple, overlying sub-plots and the players' collaboration concerning decision-making in solving puzzles related to the stories. More specifically, an ARG creates a game space by distributing information in the blend of online–offline environments for involving players in this gamified story-space [54]. Nevertheless, as Chess and Booth [54] (p. 1004) point out, 'This game space is not so much a physical space provided by the game creators, but rather a conceptual space that supersedes into the real lives of the game players.' Therefore, an ARG's main elements are 'collaborative problem solving' and 'participatory storytelling' [25] as well as the blend of different media and means such as 'blogs, chat, and online community forums' (ibid, p. 1).

Especially collaboration among players for solving puzzles as the story progresses constitutes a fundamental element of ARG, underlining ARGs' connection with the collaborative character of social networking [24]. In educational settings, well-designed ARGs can offer opportunities for deep learning [55]; they involve characteristics contributing to this particular type of learning such as exciting and engaging narratives in the form of a puzzle-mystery story and interactive gameplay, requiring teamwork to reach to the solution of the game [25]. At the same time, they offer players the opportunity to get into different important roles [21]. It could be argued that the strength of ARGs lies in the fact that they blur the lines between what is real and what is not, what a game is, and what it is not [25]. As the same researchers [25] (p. 2) point out:

> "ARGs invite players to imagine and inhabit a past, present, or future alternate world, requiring that they look critically at the information they find, constantly asking "what if" questions. By embedding gameplay and story seamlessly into existing, everyday technologies, ARGs neither acknowledge nor promote the fact that they are games. The lines between "what's real" and "what's not" are unclear, fostering "what-if" interrogation."

Taking into account the aforementioned discussion, it emerges that AR and ARG have a wide range of unique affordances. As Dunleavy et al. [52] have argued, AR allows for greater fidelity of real-world environments, enables face-to-face communication among team members while bridging multiple user interface dimensions, and provides rich sensory spatial contexts which promote kinesthetic learning through physical movement. Concerning the main affordances within ARG, these incude the collaborative puzzle-solving element, the gaming element, and the constant interaction between 'digital' and 'real', which make ARG 'an ideal space to structure educational challenges and urge students to be creative and collaborative in the classroom' [54] (p. 1004). Therefore, AR and ARG have different multiple and different affordances, but at the same time, they also have a common one which refers to the blending of the online and offline environment. Considering the affordances provided by ARG and AR we designed an ARG enhanced with AR for formative assessment in primary school settings. In particular, this study aimed to explore the impact of a teaching intervention involving augmented reality in an alternate reality game on students' engagement and the ways that students perceived their

participation in the learning process. The activities were designed for students' formative assessment. The research questions that guided this study were:

(1) What is the impact of an alternate reality game enhanced with AR on students' engagement in learning?
(2) In what ways do the students perceive their participation in the learning process in the context of an alternate reality game enhanced with AR?
(3) In what ways do the affordances provided by the combination of ARG–AR in the context of UDL respond to students' variability?

3. Methodology

3.1. Context and Participants

3.1.1. Research Design

The study was designed by a multidisciplinary team involving educational practitioners and educational researchers from different fields (inclusive education, educational technology, science education, educational leadership and teachers' autonomy). A case study methodology was used in combination with an action research approach. The study design was situated within the qualitative research paradigm [56]. The specific design was adopted since it was well-suited to exploring and gaining insights into students' perceptions and experiences with the ARG–AR. At the same time, one of the authors is the teacher of the primary class where the teaching intervention took place. The teacher's participation and input in all the stages of the research were crucial, given that she was responsible for implementing the ARG–AR in her classroom. The study was exploratory in nature since to date, little is known concerning the utilization of ARG–AR for formative assessment in primary school settings, especially in the early years of schooling. The purpose was not to provide generalisations or concrete conclusions, but to attempt to gain an understanding and engage in reflections regarding the ways in which the affordances arising from the combination of ARG and AR might facilitate students' learning amongst the aspects of engagement, participation, and response to students' variability. Transferability constitutes one of the main elements of a qualitative research design [57], therefore these reflections might be used for comprehending similar educational approaches and for contributing to future studies focusing on similar topics [58].

3.1.2. Participants

The study adopted a purposeful sampling technique. It took place in a public primary school located in a rural area of Cyprus. The majority of the students were bilingual with or without a migrant background. The authors selected this context purposefully to implement the teaching intervention. Among the school community, a second-grade class consisting of 24 students (13 boys, 11 girls), aged 7–8 years old, was selected to comprise the sample. The specific classroom was chosen because the third author was the class teacher. Ten of the participants were bilingual, and four of them were students with learning disabilities, based on the Education Act for Children with Special Needs (N. 113(I)/1999).

3.2. Ethical Issues

The case study was part of a larger EU-funded project called 'Living Book: Augmenting Reading for Life' (Erasmus+/KA2, September 2016–August 2019), therefore permission for conducting research at the school and collecting data through observation and focus groups was obtained in the context of the project. However, before conducting the study, the classroom's teacher informed the parents about their children's involvement in the research. In addition, information sheets and consent forms explaining the scope of the study as well as issues of confidentiality and anonymity were given to parents and to students. Students' information sheets and consent forms were written in a child-friendly way. Discussing the parameters of confidentiality in research with students is vital [59]. Therefore,

prior to the study, the teacher had informal discussions with the students to explain to them about their involvement and terms related to the ethical issues of research, including data collection, voluntary participation, anonymity and confidentiality. Furthermore, special care was taken in every stage of the study to remind students about their voluntary participation and the right to withdraw from the study.

3.3. Preparation and Design Considerations

Before the conduct of the study, the authors met regularly to discuss and design the activities. These meetings created a 'space' for argumentative creative reflection on how to ensure that all children could actively participate in the educational process. Through a collaborative, reflective approach, the authors reached a common understanding of the notions of engagement and participation within UDL and the ways that its principles could translate into practice within the teaching intervention. Therefore, regarding *Principle 1 – providing multiple means of engagement*, it was decided to do the following: choose a central topic/theme of the ARG familiar to the students, use the name of a character appealing to children, and design the ARG in such a way that students have a clear purpose while playing the game (e.g., feeling that they are going to help someone solve a problem). Regarding *Principle 2 – provide multiple means of representation,* it was discussed that during the design of the ARG oral, written and video instructions should be used as well as different types of images and animations. Regarding *Principle 3 – Provide multiple means of action and expression* it was decided that, in addition to designing the ARG so as to provide formative assessment of student learning, it was also important to engage students in the creation of their own ARG. To this end, it was concluded that the use of digital tools and web-applications that allow students to design and compose their own ARG had an important role to play.

Another important aspect during the preparation phase was that the design of the ARG was based on interdisciplinarity. The purpose of the ARG was to integrate puzzle-solving aligned with the objectives of the Cypriot curriculum for second grade (ages 7–8) regarding Greek language, Mathematics, and Art so that the teacher could assess students' knowledge through formative assessment. The learning objectives are described below:

Greek language Cognitive Objectives:

The students must:

- Be able to read and understand instructions.
- Identify key information that is stated directly or indirectly in the text.
- Develop strategies for drawing conclusions about how a topic is presented.
- Understand the function of linguistic elements in rendering representation in descriptions with real or imaginary elements.

Mathematics Cognitive Objectives:

The students must:

- Know the patterns of 3, 4, and 6.
- Be able to add up to 100 (without or exceeding tens).
- Know the use of the calendar (days, weeks, months, time).

Art Cognitive Objectives:

The students must:

- Easily generate ideas by linking them to their real life experiences and imagination.
- Give images a variety of meanings.
- Link social concerns with artistic practices in their daily and school life.

The augmented reality platform used in the study was 'Zapworks'. The videos used in the game were created in 'Windows Movie Maker'. Both software are user-friendly for students and so is the movie maker program for the teachers.

3.3.1. Helping Nemo: Designing the ARG–AR

Drawing on contemporary multimodal learning approaches, we designed a Serious ARG enhanced with AR named 'Helping Nemo'. A very important element of an ARG is its storyline plot. Thus, we began by explaining the storyline. The storyline was developed by having in mind the objectives mentioned in the previous section. Nemo (Nemos is a traditional Cypriot name which comes from the name Neoptolemus) is a boy that has a similar age to that of the students participating in the activity. He and his family have a trip to the Cyprus countryside, and specifically to the village where the case study school is located. In the village, there is a Tower which is associated with a legend about a Queen that is well known to the students. Nemo is playing close to this Tower and suddenly falls into a hole. He finds himself trapped behind closed doors, and he cannot escape without solving a puzzle written on each door first. The boy asks the students to collaborate in order to help him solve the puzzle and open the door. The story begins with a picture of the Tower. Each team has a different puzzle to solve and a set of cards with numbers and words. Students are asked to see the picture through their tablets, and a video will begin. There is a puzzle at the end of each video. The right answer is the trigger image for the next video to play (Figure 1).

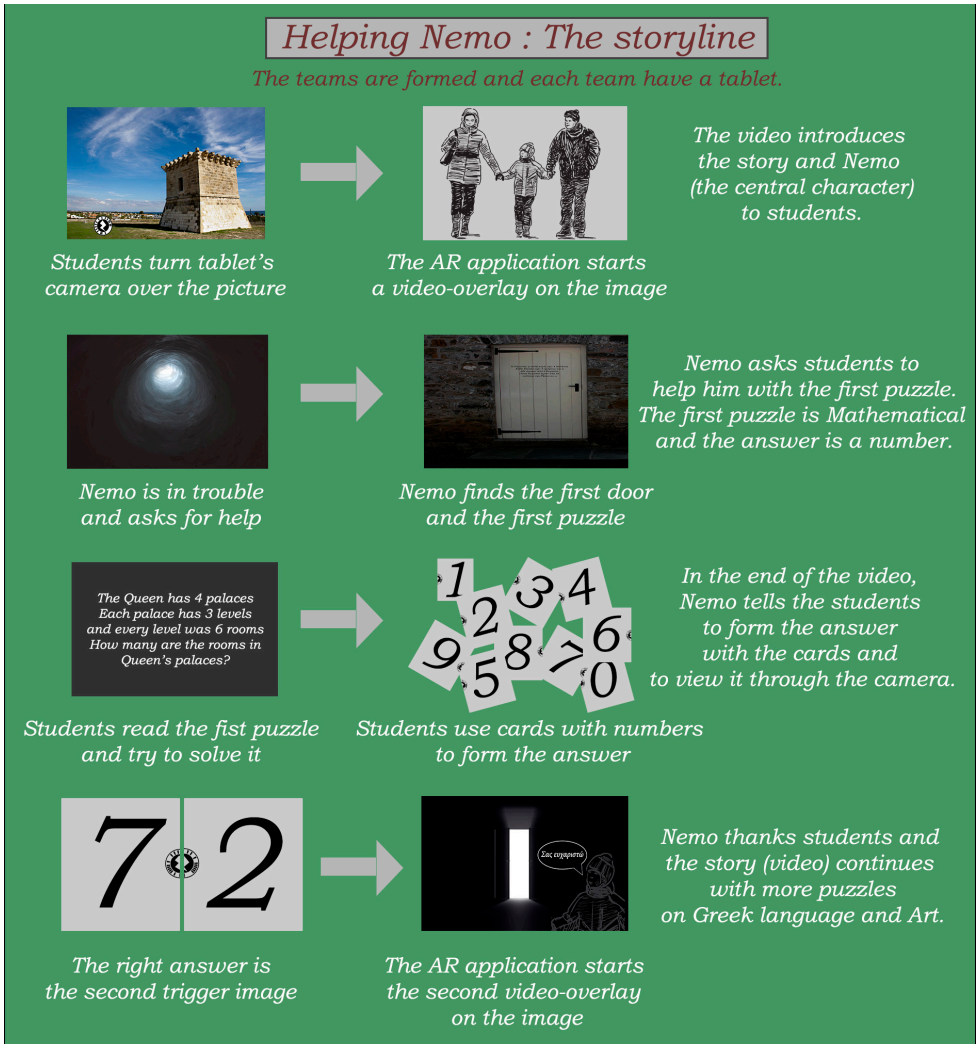

Figure 1. An illustration of how students participated in activity one ('Helping Nemo').

When the students and Nemo 'arrive' at the last door of the game, each separate team of students have to solve the puzzle. The door will open only if all the teams find the correct answer, as each team have to place the answers of the last puzzle alphabetically (as a trigger image) in order for the door to open.

3.3.2. Teaching Intervention

The teaching intervention consisted of two activities taking place on different days in the same month (80 min teaching session on each day). As already noted, the third author was the class teacher. She organized the class into four teams of six students. Each team of students had access to one tablet.

First activity: The ARG 'Helping Nemo' for formative assessment. This phase refers to the use of the ARG–AR 'Helping Nemo' for formative assessment. Each group played the game and solved the puzzles as the story-game progressed. This process lasted for 80 mins (two 40 min teaching sessions). The story developed through trigger images and videos included in an augmented reality environment.

Second activity: Students creating their own ARGs. The second activity was also a form of formative assessment since it was required of children to produce their own ARG and create puzzles based on their knowledge. The second activity consisted of two parts. Its duration was the same as that of the first activity (two 40 min teaching sessions). In the first part of the second activity, students were asked to work in the same teams and create their own short ARG, meaning to write a story which included puzzle-solving like the one in the Nemo story and write it on a paper sheet. In the second part of the activity, students were asked to use laptops, PCs, and tablets to write their stories in StoryJumper and enrich it with proper images and audio. StoryJumber constitutes a website that offers students a variety of tools to help them write and create their own stories by combining words, audio, pictures, and photos. Students can also publish their stories and view other students' stories. During this process, students collaborated to jointly decide how to write their story, which images and audio to use (whether they wished to record their own voice, to find a song to insert in the story, etc.), and what to writeon each page of their story. When all the teams completed their short ARG stories, the whole class played each team's ARG in turns (Figure 2).

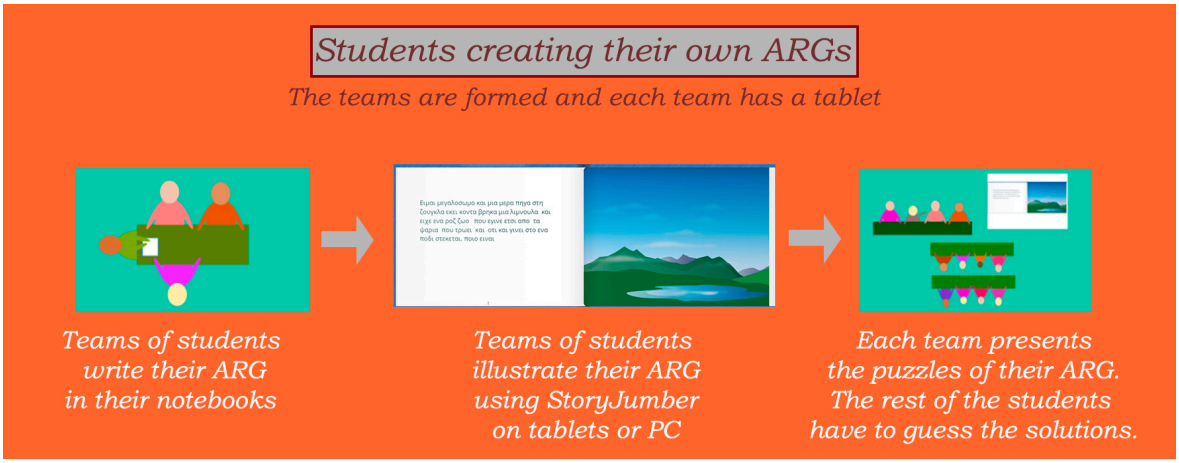

Figure 2. An illustration of how students participated in the second activity.

3.4. Data Collection

The study adopted a combination of quantitative and qualitative methods which included classroom observations (Leuven Scale), short reflective statements, student focus groups, and the teacher's reflective diary. The data collection methods are discussed in detail below with regards to which data collection methods were utilised for each activity.

3.4.1. Activity 1: Students' Short Reflection Statements

After completing the first activity, students were asked to reflect on the activity and to provide a short statement with their reflection.

3.4.2. Activities 1 and 2: Leuven Scale

The Leuven scale was used for both of the activities. Two observers (the teacher and one of the other authors) observed and recorded the reaction of the children during the activities in a systematic manner based on an observation tool for a total of four 40 min teaching sessions (80 min for the first activity, 80 min for the second activity). The observers recorded the students' actions on the observation sheet and their level of engagement based on a Leuven Scale. The Leuven scale is a descriptive scale that portrays five scales of engagement based on students' actions and attitudes during a learning activity (see Figure 3). The observers rated the engagement of each student based on a Leuven Scale and recorded the indications that justified their rates and decisions. The role of the observers was that of a spectator [60]. After the completion of each activity, the observers discussed their records and, in cases of different ratings for the same student, they compared the indications recorded to reach a consensus regarding the particular student's level of engagement.

Level	1	2	3	4	5
Engagement	**Extremely Low** *the child shows hardly any activity*	**Low** *the child shows some degree of activity which is often interrupted*	**Moderate** *the child is busy the whole time, but without real concentration*	**High** *there are clear signs of involvement, but these are not always present to their full extent*	**Extremely High** *during the observation of learning the child is continually engaged in the activity and completely absorbed in it*
Examples	No concentration: staring, daydreaming; An absent, passive attitude; No goal-oriented activity, aimless actions, not producing anything; No signs of exploration and interest; Not taking anything in, no mental activity	Limited concentration; looks away during the activity, fiddles, dreams; Is easily distracted; Action only leads to limited results.	Routine actions, attention is superficial; Is not absorbed in the activity, activities are short lived; Limited motivation, no real dedication, does not feel challenged; The child does not gain deep-level experiences; Does not use his/her capabilities to full extent; The activity does not address the child's imagination.	The child is engaged in the activity without interruption; Most of the time there is real concentration, but during some brief moments the attention is more superficial; The child feels challenged, there is a certain degree of motivation; The child's capabilities and its imagination to a certain extent are addressed in the activity.	Is absolutely focussed, concentrated without interruption; Is highly motivated, feels strongly appealed by the activity; Even strong stimuli cannot distract him/her; Is alert, has attention for details, shows precision; Its mental activity and experience are intense; The child constantly addresses all its capabilities: imagination and mental capacity are in top gear; Obviously enjoys being engrossed in the activity

Figure 3. Description and examples of the Leuven Scale that observers used to rate students' level of engagement.

The use of the Leuven scale as the observation tool allowed us to quantify the data for statistical analysis purposes.

3.4.3. Activity 1 and 2: Focus Groups and Teacher's Reflective Diary

Upon completion of all the activities, one of the authors conducted the student focus group. The students were divided into four groups. Each focus group discussion was guided by a semi-structured interview protocol that had been developed based on the study objectives. During the focus groups, students' ARGs on StoryJumper were also made available, acting as a trigger for further discussion with the students. To avoid the mirroring of a test-taking atmosphere [61] and the perceiving of the researcher as an authoritative figure [62], students were transferred to another room in the school which looked like a playroom and did not have the typical setting of a classroom. With regards to the reflective diary, the class teacher wrote extensive field notes immediately after each

activity. In addition, during the breaks she had informal conversations with the students and kept field notes of these conversations.

3.5. Analysis

The data collected through observation using the Leuven Scale for engagement were statistically analyzed. The analysis aimed at describing the extent to which students were engaged in the activities. First, a descriptive analysis (percentage of students at each level of engagement) was performed, focusing on the level of engagement of the class as a whole. Secondly, the percentage of the students was divided into three groups based on the following classification: bilingual, with learning disabilities, others (meaning not bilingual, not with learning disabilities). Though it is recognised that a student can be both a bilingual and with learning disabilities, this was not the case with the selected sample. For each group of students, the percentage of students in each level of engagement was calculated to highlight similarities and differences among the groups.

The data collected from students' short reflective statements, focus groups and the teacher's reflective diary were analyzed using thematic analysis [63,64], seeking to identify themes, categories, and sub-categories. According to Braun and Clarke [64] (p. 57), thematic analysis constitutes a method 'for systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a data set'. To identify relevant themes, the authors read the focus groups transcripts several times and collaborated to identify units of meaning. This process was first conducted by two of the authors and then with the other two authors to ensure the commonality among the themes. Atlas.ti facilitated the analysis of the qualitative data. Specifically, 25 codes were generated for the purposes of the analysis. Four major themes emerged from these codes: (1) students' stances towards learning with ARG; (2) students' stances towards technology including AR; (3) students' emotional reactions; (4) removing barriers to learning.

4. Results

The results of the current study are both quantitative and qualitative. Although the research is qualitative in nature, quantitative data were also included in order to answer the research questions (especially RQ1 which refers to students' engagement) more validly and reliably. The quantitative results describe the percentages of the students in each level of engagement in activities in total, and how the students are divided on each level based on the adopted classification: bilingual, with learning disabilities, and others. Statistical analysis of the data showed that all students in both activities were classified into the three highest levels of engagement. It is essential to highlight that three to four students were classified to the two highest levels in both activities. The qualitative results underline students' responses to the activities. More specifically, from the qualitative analysis the positive and the negative characteristics of the activities and what triggered students to engage and participate in these activities were highlighted. For clarity purposes, the results of the analysis are presented separately for each activity (though the thematic analysis was conducted by taking into account all the data). Findings referring to both activities are presented in a subsequent separate section. Then, in the discussion section all the results are discussed together with regards to the research questions of this study.

4.1. Results of Activity One: Helping Nemo!

4.1.1. Quantitative Results

The descriptive statistics for the first activity are presented. A pie chart shows the percentage of the students classified into each level of engagement. In the same figure, a diagram illustrates how students are ranked based on three groups: bilingual, students with disabilities, and others. Based on the statistical analysis of the data, all students were highly engaged (classified in Levels 3, 4 & 5, see Figure 4).

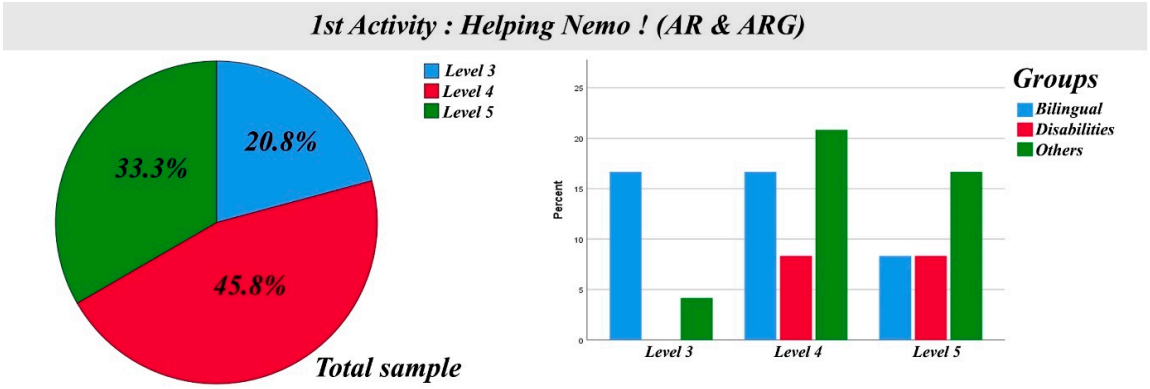

Figure 4. A pie chart with percentages of students at each level and a diagram with the classification of students by groups for the first activity.

In the first activity, 33.3% of the students were classified in Level 5, 45% in Level 4 and 20.8% in Level 3. As we can see in the diagram in Figure 4, students of all groups were motivated to be involved in the activity. It is important to highlight that although all the students seem to be highly engaged, less engaged among the three groups was the group of bilingual students.

4.1.2. Qualitative Results

A. Students' stances towards learning with ARG

(a) Learning through collaborative puzzle-solving

This category refers to the ways in which students perceived the ARG as well as the different aspects that students liked regarding the first activity. Findings from students' statements during the activity, the follow-up focus groups discussions, and the teacher's reflective diary indicate that learners truly enjoyed the process, but at the same time they believed that they had learned through ARG. The element of 'learning' was emphasized by the majority of students during the focus group in conjunction with the puzzle-solving element of the ARG. Furthermore, what also emerged in students' responses as an engaging factor was the aspect of collaboration:

R: What did you like more from what we did today? From what you did last time with your teacher? What was more wow?

S12: I had a great time with my team, we solved puzzles, and we learned more things about the myth of the Queen.

S3: I liked that we worked together and solved the puzzles and learned about the Queen's legend.

S1: I liked that we solved the puzzles as a group. I liked my team.

S15: I liked it because we solved puzzles and learned more.

S19: I liked the way we collaborated and we have to say thank you to our teacher for this gift.

(b) The element of collaboration was also noted in the teacher's reflective diary:

«*Almost all children participated in the lesson more than usual. They interacted widely with each other throughout the activity. The children seemed to find a way to work together to solve the puzzles. Without any intervention or prompting from me, they would take the tablet in turns and work together when they needed to find the correct answer to a puzzle.*»

In the above quotes, students bring forward what they have learned through playing the ARG. Through the data analysis it emerged that despite the fact that the ARG 'Helping Nemo' did not introduce any new concepts or ideas, students felt that they learned something new through this

process. In addition, students' emphasis on liking the element of puzzle-solving and collaborating with their classmates aligns with the benefits of ARG discussed in the theoretical background of this paper.

B. Students' stances towards the use of technology/towards the use of AR

(a) Students' enjoyment concerning their interactions with AR

Data analysis regarding this sub-category involves the ways that students interacted with technology, and particularly with utilising the AR application employed in the first activity. The findings from the students' statements and focus groups indicate that most students enjoyed using the technology, particularly the tablet and AR application. Students made specific references to the use of AR during the activity:

R: What did you like during this activity?

S5: I liked that we had to place the tablet over the image and watch a video.

S8: I liked that we used the tablet to open the doors.

Students' responses demonstrate that participants considered the process of using the trigger images during the first activity as interesting. In addition, S8's quote seems to imply that s/he felt like s/he was a part of the story. This aligns with the literature around mobile game-based learning which supports that this kind of learning facilitates immersion and stimulates students' motivation [65].

(b) Students' stances towards the friendliness and easiness of the game's interface

This sub-category refers to data showing that students considered the design of the ARG–AR friendly and easy to use. Still, it should be noted that, as discussed in the 'Preparation-Design Considerations' section, attempts were made by the research team to use technology in line with students' age as well as not using applications that required complex digital skills from the students. Data analysis from the teacher's reflective diary indicated that students perceived the immersive environment created by the utilisation of ARG–AR as easy and understandable to engage with, despite being the first time that students engaged with technology to such an extent:

«I had a concern about using technology to such an extent in the classroom. I did not know how the students would respond, if they were going to encounter any difficulties. In the end, the only thing they asked from me was the tablet's password, and the rest of the activity took place faster and easier than I had expected».

Furthermore, according to students' statements, engaging with technology was fun. The students pointed out that they 'liked playing with tablets' (S14), 'I enjoyed using the tablet and playing this game' (S8), 'It was easy to use the tablet and watch the videos' (S20). Students did not report any difficulties regarding the use of the tablets. In addition, according to the teacher's diary, because students did not face any challenges in interacting with technology, they were able to engage in independent learning and feel satisfied with the fact that they were learning on their own:

«By using the tablets and feeling that they were part of the game they felt that they had learned 'on their own' after solving the puzzles and had almost come to the end of the story with no help from their teacher but working in groups together.» (teacher's diary)

The above seems to suggest that the immersive environment created by ARG–AR was easy for students to navigate through, leading to a student-centred activity where the teacher's role was that of a facilitator. As the literature suggests in learning environments supported by technology, it is a challenge for teachers to find the right balance between teacher's control and students' autonomy for enabling self-regulating learning [66].

C. Students' emotional reactions to the first activity

This category emerged based on data from the focus group as well as from the teacher's reflective diary which indicated that students experienced positive emotional reactions during the activities. These are presented below in sub-categories.

(a) Wanting to share their experience and results of their work with family and friends (feeling proud)

Students expressed feeling proud by stating that they would be in a position to explain to their peers how to engage with the activities:

R: Would you recommend it to some of your other classmates who haven't done it before?

S8: Yes.

R: Why?

S8: Because they may not know what to do and I would be able to tell them what to do.

«The kids perceived what we did as something very creative and important. In the breaks that followed I heard them discuss and brag about it to their friends from other classes» (teacher's diary)

Students' responses suggest that they considered themselves competent to explain to others what they did in their classroom, how they solved the puzzles, and what they learned through puzzle-solving. This finding is aligned with literature revolving around self-regulated learning as well as literature referring to motivational beliefs and students' emotions [67,68]. In line with our finding, in Wilson's study [69] students expressed feelings related to proudness and satisfaction when they acquired new knowledge and skills and also when they shared this knowledge with other people. In this context, competency could be connected with feeling proud to show it to someone else without the teacher's help. Other students believed that what they had learned through the puzzles would excite their parents:

R: What do you think that you learned with all the things that we did today and last time?

S11: Things about our mum and our dad, for them to be excited.

R: What kind of things?

S11: The puzzles and that sort of things.

(b) Having fun and being excited

During the focus group, the author conducting the focus group asked the students if they would like to do similar activities (meaning combining AR and ARG) in other subjects. All of the students stated that they would like to do it again by emphasizing that they had fun, which was also corroborated by the teacher's diary:

R: Would you like to do similar activities in other subjects?

S19: Yes.

R: Why?

S19: Because it was amazing.

S5: Because I had fun.

S7: Because it was fun!

S20: Today we learned that the lesson . . . looks . . . like . . . a game!

«all the children had fun and treated the activity as a game» (teacher's diary)

Particularly, by taking into account that the first activity was designed as a form of formative assessment, it was interesting to observe that students did not feel that they were being assessed, but that they were having fun and playing. The value of learning through playing has been widely discussed in the literature. Dyson has supported that play constitutes an important learning process for children, leading them to the discovery of ideas, experiences and concepts while urging them to consider these discoveries as well as the effects of those discoveries. [70]. Furthermore, according to Lillemyr et al [71], playing is related to childrens' social interaction, helping them to develop social competencies and providing children with opportunities to experiment, expore their creativity, and learning strategies.

4.2. Results of Activity 2: Students Creating Their Own ARGs

4.2.1. Quantitative Results

In the second activity, half of the students were classified in Level 5 and 37.5% in Level 4. Only 12.5% of the students ranked in Level 3. As we can see in the diagram (Figure 5), students from all three groups (bilingual, students with disabilities, others) were highly involved. All students with disabilities were classified in the two highest levels while all bilingual students were ranked in Level 3, 4 and 5. These results indicate that all students, irrespective of their diverse needs, were highly engaged in the activities.

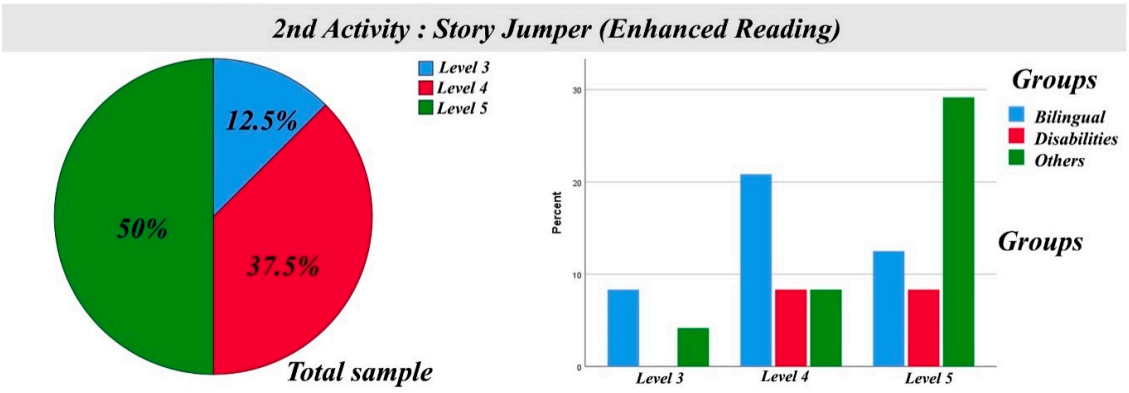

Figure 5. A pie chart with percentages of students at each level and a diagram with the classification of students by groups for the second activity.

4.2.2. Qualitative Results

Students' emotional reactions to the second activity

(a) Perceiving their own ARG as an important memento

Most of the students placed emphasis on the fact that they would like to continue their ARG (puzzle-story) and particularly to 'have it as a memento' (S20) or 'remember that they were in second grade with their teacher' (S22):

R: Do you have any ideas so that these activities can become better?

S20: I would like to continue our puzzle-story, finish all the pages and have it as a memento.

R: What did you like most from all we did today?

S22: I liked that we all did the puzzle-story because we would have it and remember that we were in second grade with our teacher.

Wanting to continue, finish, and keep their creation (their ARG) suggests that students were proud concerning the result of their work. Specifically the words 'memento' and 'remember' communicate that students considered that they created something worth keeping.

(b) Autonomy

Another sub-category that emerged from data analysis was 'autonomy'. This category refers to data indicating that students enjoyed being in a position to engage in the activity by themselves. A lot of the students combined inserting or uploading pictures and photos on StoryJumper with being able to do things on their own:

R: What did you like most about everything we did?

S3: That we inserted the photos.

S9: I liked that we were inserting the pictures.

S25: I liked that we created a puzzle-story, and we uploaded the pictures and we wrote the puzzle-story by ourselves.

S17: I liked the computer.

R: Why did you like that?

S17: Because we could insert the pictures and do things by ourselves and it was very nice.

4.3. Results Referring to Activity 1 & Activity 2

This section refers to findings that emerged from the analysis of the focus groups and teacher's reflection diary that were related to both activities. The presentation of the findings draws on two main axes: on students' desire to incorporate ARG in more subjects and on data that indicate removal of barriers to learning.

A. Wanting more puzzles to have more fun and learn more

During the focus group, the author conducting the focus group asked students to share with her some ideas regarding the improvement of the activities. Most of the students' ideas revolved around having more puzzles as 'it would be nicer', 'we would have more fun'. Using puzzle-solving to learn more arose as an important element in students' responses and in the teacher's diary:

R: Would you like to do similar activities in other subjects?

S2: Yes.

R: Why?

S3: I would like to do it in other subjects because I liked puzzle-solving a lot.

S16: I would like to do it again because I had fun with my team and the puzzles.

S12: I would like to do this next year too, writing a puzzle-story also do the activity with the Queen's tower.

What seems to emerge from the quotes above is that students would like to do similar activities in the future by stressing that they liked puzzle-solving (both the ARG prepared by the research team and the ARG they created themselves). Students' responses suggest that puzzle-solving in the form of an ARG constitutes an element of engagement for the majority of students. This finding emerged during all the focus groups:

R: I want you to think a little bit and tell me some ideas about how we can do these activities better.

S2: We might have used more tablets and have more puzzles it would be nicer.

R: Why?

S2: Because we had only three puzzles and they were very few if we had more puzzles we were going to have more fun. It will have more action if we have more!

S4: We could change the topic with the tablets a little bit and learn more things.

R: Do you mean instead of the Queen's tower that you did last time to do something else?

S4: Yes, to learn more things.

S8: I would like to do all 40 class periods in this way!

«The kids got excited about the puzzles, and they kept asking me to do something similar in other lessons with even more puzzles. They liked using the tablets and they told me that they would love it even more if they had more. Most kids would like to take some time to use the tablet and continue the activity». (teacher's diary)

B. Removing barriers to students' participation in learning

This sub-section refers to data from the teacher's diary that seems to indicate that combining the affordances of ARG–AR in the context of UDL contributed in removing barriers to learning for students. As the teacher recorded in her reflective diary:

«I was very impressed with the case of a student with selective mutism who was talking with his/her classmates and participating in the lesson like never before. In addition, the bilingual children participated in the activity more than they usually do. If I compare each student with his/her own level of engagement in conventional lessons, the level of engagement during these activities was higher for each individual».

«The students understood what was requested from them from the first minutes and worked as a team to solve the puzzles. All children were working on equal terms, and someone who doesn't know them would not be able to identify academically strong and weak students».

Furthermore, as two students commented: 'It was nice that everyone was busy, all of us had something to do' (S10); 'I liked that we all collaborated and wrote a book together' (S18). The phrase 'all of us' was repeated by a lot of students. Though this phrase must be interpreted with extreme caution concerning its meaning, at the same time it could be suggested that amongst its possible interpretations is that students perceived that they were a part of a community where everyone contributed to completing the different tasks without any discriminations. This finding might also be related to the overall design of the activities, since as discussed in the Preparation-Design Considerations section, the research team made attempts to consider ways in which the activities would ensure that all students could equally participate in the activities.

5. Discussion

This research was instigated to explore the impact of a teaching intervention involving augmented reality in an alternate reality game on students' engagement, the ways that students perceived their participation in the learning process, and the ways in which the affordances provided by the combination of ARG–AR in the context of UDL responded to students' variability. Due to the exploratory nature of the study, the results are not considered by any means as conclusive or generalizable, but they can be perceived in the light of reflections and suggestions for conducting more studies on the topic. Despite the suggestive and reflective nature of the results, the conducted study contributes to the literature revolving around the utilisation of AR and around the utilisation of ARG in learning by providing some useful insights regarding each of our research questions.

5.1. What is the Impact of an Alternate Reality Game Enhanced with AR on Students' Engagement in Learning?

The findings of our study indicated that students were actively engaged in the activities since they perceived learning in the context of the ARG–AR as fun and exciting. Based on the quantitative data, a vast majority of the students (three-quarters) exhibited a high level of engagement in both activities. Similar levels of engagement were observed among learners with diverse characteristics. At the same time, the learning objectives set for assessing students' knowledge through formative assessment were also achieved. As Watson and Salter [72] (p. 101) point out about work related to serious games

communities: 'it is particularly helpful in addressing an apparent contradiction between games and educational objectives, as traditionally the idea of "fun" has fallen into a separate space from that of learning'. The findings of our study suggest that this contradiction was not evident in the participating students. Despite the fact that 'Helping Nemo' was designed for formative assessment purposes, children did not perceive that the aspect of 'fun' was distinct from the aspect of learning. On the contrary, all the students stated that they would like to play again, to learn more via puzzle-solving, and have more fun. In line with other studies that explored students' engagement through ARG [23], 'Helping Nemo' can be characterised as flexible in the achievement of learning objectives by facilitating the inclusion of playful and interdisciplinary practices. In the same spirit, Jagoda et al. [73] (p. 95) argue that 'play is crucial to the process of learning to be flexible, adaptable, and collaborative in ways that can help learners engage in critical practice enabling them to belong to and resist the historical present'.

Furthermore, what seemed to facilitate students' perception of learning and play as a continuum might also be related to the immersive environment created by combining the affordances of AR technologies with those of ARG. According to the results of the first activity ('Helping Nemo'), students enjoyed using the tablet and placing it over the images to watch the videos. Other students put it in a different way by stating that they 'used the tablet to open the doors'. This finding is in accord with other studies in the field of augmented reality in education which have demonstrated that immersive environments enabled by the utilisation of AR can be highly engaging for students [52,74,75]. Likewise, Georgiou and Kyza [76] in the findings of their study suggest that designing learning environments supported by AR should contribute to providing the students with immersive learning experiences as there is a positive relation between immersion and students' learning gains.

In line with the aforementioned, another important finding that aligns with the ARG literature is that our data suggest that collaborative puzzle-solving constitutes an important factor of engagement for students [23,25,77]. The children in our study stressed the fact that they enjoyed working collaboratively to solve the puzzles, as well as to create their own puzzles. Klopfer [77] (p. 19) has pointed out that 'through game playing students learn how to collaborate'. Based on our results, it was evident that students considered collaboration and teamwork of high value during their involvement in the activities. Similarly to Bressler and Bodzin [74] (p. 514), we also found that learning through collaboration was a 'source of enjoyment for students'. Moreover, our results indicated that collaborative puzzle-solving and collaborative puzzle-creating helped students to engage in deep learning and simultaneously to learn about teamwork. This is an important finding, as 21st century skills do not include only cognitive skills (such as critical thinking) but also non-cognitive (such as teamwork) as the ground for new assessments supporting learning [78].

5.2. In What Ways do the Students Perceive Their Participation in the Learning Process in the Context of an Alternate Reality Game Enhanced with AR?

Concerning students' perceptions regarding their participation in the learning process in the context of the ARG–AR, our results indicated that students perceived that they were learning on their own, without their teachers' help. Autonomy is considered as an important element of ARG [79]. With regards to our study, this finding is aligned with literature on the utilisation of technology in learning through pedagogical student-centred approaches that facilitate students' participation in learning; in other words, by considering technology—in our case the AR technology—'to realise innovative constructivist pedagogies . . . promoting a student-centred, peer-learning approach, in which knowledge is created rather than transmitted' [80] (p. 908). As research indicates, the shift towards the utilisation of the multimodal affordances of technology, including augmented reality applications, for enhancing the learning process does not arise merely from the utilisation of technology for technology's sake. On the contrary, it seems that it emerges mostly from the necessity to enable students to construct and deconstruct their own meanings based on their own experiences, which at the same time are socially located within a wider context [2,38].

Based on our findings, the meaning(s) that students gave to their participation in the ARG–AR context revolved around the involvement of all students in the activities: by wanting to share their work with family and friends and by perceiving their own ARG–AR as an important memento. It could be argued that students' perceptions about their participation in the activities is interlinked to emotive dimensions of learning and that these dimensions are critical in the design and application of ARG–AR. In line with our argument, Boekarts [67] (p. 95) eloquently explains that:

> "Emotions have diagnostic value for the teacher because they reveal underlying cognitions, commitments and concerns. Teachers need to be aware of their students' motivational beliefs and be sensitive to their emotions as this information can inform the design of the learning process. Their own behaviour and their teaching and evaluation practices trigger specific emotions and motivational beliefs in the students, which in turn affect the quality of the learning which takes place."

Especially the last sentence of the above quote is of utmost relevance to our study as the results indicated that the emotional reactions of students (i.e., feeling proud; feeling that they learned on their own; feeling competent to engage with puzzle-solving and puzzle-creation; feeling that they created something important; wanting to share their knowledge) contributed to the quality of learning concerning both activities.

5.3. In What Ways do the Affordances Provided by the Combination of ARG–AR, in the Context of UDL, Respond to Students' Variability?

With regards to the third research question of this study, the results of the study indicated that the creation of a multimodal environment, which draws on the principles of UDL and combines the affordances of ARG–AR, can respond to the wide range of students' diverse needs. As other researchers have supported, AR technologies should be considered as contemporary resources that can be used in the context of the UDL framework and as powerful tools that teachers can exploit to build on the work they already do in the classroom [81]. The results indicated that all students participated in the activities and the degree of their engagement was higher in comparison to more conventional classroom activities. In particular, the results of our study suggested that valorising the affordances of the different modes emerging from mixing AR with ARG and taking into account the UDL principles can contribute towards removing barriers to students' participation in learning. This finding comes in line with Tesolin and Tsinakos' study [82] where the researchers concluded that the provision of multimodal learning opportunities is related to equipping the students with 'alternatives and assistance to activities that contain physical and structural barriers' and therefore, 'these students are no longer limited' (p. 65). For instance, in our study the case of the student with selective mutism was a characteristic example of the ways that a student can be no longer restricted to the shackles of conventional activities used for formative assessment.

Furthermore, it is documented in the literature that students learn better when they are actively involved in the learning process [81]. Our results indicate that AR technologies can contribute towards this direction since they provide students with new ways of accessing and interacting with information (ibid). However, as the results of our study demonstrate, AR technologies by themselves or ARGs by themselves are not sufficient for removing barriers to learning. Utilizing AR technologies in the context of ARG for formative assessment, or for any other type of learning activities, necessitates teachers and educational researchers to consider and reflect on important questions: in what ways can the combination of AR-ARG be accessible to all students? In what ways can the combination of AR-ARG involve all students? Which kind of AR applications should be used in the context of ARG? What kind of story plots concerning the ARG are engaging and challenging for all learners, taking into account students' diversity? How can we avoid stereotypical representations in story plots within the context of ARGs? These questions are critical in terms of engaging students into inclusive, multimodal, contemporary learning experiences.

6. Limitations of the Study

The study had several limitations. First, participants came from a sole primary school; thus, care must be taken when generalizing to other settings. Secondly, the duration of the study was short (four 40 min teaching sessions), therefore our findings are confined to this time limit. Third, the students' excitement and engagement towards learning might, in part, be attributed to the fact that it was the first time that the students used AR technology and engaged in ARG in the classroom. Finally, another important limitation is the exploratory character of the current study and the lack of additional sources of data (e.g., from students' parents) as well as more systematic ways of collecting data that would have allowed for a deeper understanding of the impact of ARG–AR on students' engagement, of their perceptions about their participation in the activities, and of the ways in which the affordances provided by the combination of ARG–AR in the context of UDL responded to students' variability. Therefore, the results of the study must be interpreted with caution and in light of these limitations.

7. Conclusions

Our personal belief is that combining the multimodal affordances of alternate reality games and augmented reality in a learning environment that builds and enacts on the principles of inclusive education has the potential to provide all students with accessible, participatory, and transformative learning experiences. However, the evidence to support inclusive approaches in the context of alternate reality games enhanced with augmented reality technologies is limited. The findings of our study concur with the research literature in the areas of AR in education and in educational ARG and provide useful insights indicating that using alternative forms of formative assessment contributes towards higher levels of engagement and participation in the learning of all students, including bilingual students, students with learning disabilities, and students who are currently disengaged. More specifically, this study contributes in providing educators with (a) a potential way of using AR technologies in the context of ARG in an inclusive manner and (b) underlines the potential pedagogical added value of combining the affordances of ARG–AR within the UDL framework.

Further studies are required to explore the potential provided by the multimodal affordances arising from the combination of ARG–AR in the context of learning approaches and frameworks that promote inclusive education, such as Universal Design for Learning. Moreover, studies with longer duration and with more representative samples in the context of Cyprus and abroad would help educational researchers and teachers to gain more in-depth understanding of the possibilities and the limitations of the proposed combination. In addition, further research could take into account the questions presented in the previous section of the paper, build on these questions, and elaborate on these questions to implement ARG–AR learning activities. Contemporary multimodal learning approaches can specifically address 'those areas where traditional methods are weakest' [83] (p. 3). To conclude, much remains to be discovered in combining multimodal learning, AR technologies, ARG and approaches that enable inclusive education.

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