Augmented Reality as a Sustainable Technology to Improve Academic Achievement in Students with and without Special Educational Needs

María Graciela Badilla-Quintana [1,*] **, Eileen Sepulveda-Valenzuela** [2]
and Margarita Salazar Arias [3]

1   Centro de Investigación en Educación y Desarrollo, CIEDE-UCSC, Universidad Católica de la Santísima Concepción, 4090541 Concepción, Chile
2   School of Education, University of Bristol, Bristol BS8 1JA, UK; eileen.sepulveda@bristol.ac.uk
3   Facultad de Educación, Universidad Católica de la Santísima Concepción, 4090541 Concepción, Chile; msalazar@ediferencial.ucsc.cl
*   Correspondence: mgbadilla@ucsc.cl

Abstract: Virtual reality has impacted education, where progressively more educational institutions consider its inclusion. The research problem derives from the need to study the educational possibilities provided by integrating augmented reality into the curriculum, and its effect on academic achievement in a diverse class, specifically in the chemistry subject. This study examines 60 school-age participants with and without special educational needs, and addresses three overarching questions: (a) Would integrating augmented reality (AR) technology result in better academic achievement? (b) Would knowledge be retained longer by using AR? (c) Is there any relationship between academic achievement, acceptance and motivation regarding the use of this technology? Embracing the socio-constructivist theory of learning and collaborative and immersive learning as a framework, this study was carried out using a quantitative approach and a pre-experimental design. The AR VR Molecules Editor application was used in chemistry lessons. Main results showed significant immediate academic achievement and content retention. Despite classroom diversity, immersive technologies enhance students' learning regardless of whether they have special educational needs (SEN) or not. They also acknowledge that AR is a suitable sustainable technology that may foster social and cognitive justice and inclusive education, and train students that are equally prepared for the dynamic future.

Keywords: inclusive education; academic achievement; augmented reality; sustainable technologies; knowledge retention; chemistry learning

1. Introduction

Currently, the Chilean Educational Reform, with its pillars of inclusion as well as comprehensive, quality and public education, has promoted a process of transformation in the educational system. Through public policy, it also has traced a route to transit, with a rights-based approach, towards quality education in which all students participate and progress in learning and comprehensive development [1]. The Educational Inclusive Law N°20.845 [2] in this country states that schools must guarantee the right to education to all people in the community by working on the elimination of discrimination and an approach to diversity. Therefore, they must guarantee the access, permanence, learning and participation of every student, recognizing their diversity and favoring a pedagogical work more pertinent to their identities, abilities, needs and real motivation [3].

Moreover, the Ministry of Education's 2015 formal resolution on special education, called Decree 83, approves guidelines and criteria for curricular adaptation. It also promotes the diversification of

teaching, not only for those students with special educational needs (SEN) but with the understanding that any child or young person in the classroom, by virtue of their individual characteristics or the circumstances of their context, could find barriers for learning, developing or participating in culture, curriculum and life at some point in their schooling. Additionally, it specifies more or less specialized or personalized support [4]. In this sense, it pursues promoting the ability of teachers and professionals in general, to innovate their pedagogical practices through a theoretical-practical approach called Universal Design of Learning (UDL). It is assumed that implementing UDL facilitates greater opportunities for participation and access to learning in a multicultural and diverse school. It also encourages all students to achieve the essential and fundamental learning objectives established in the school curriculum [1].

To provide an understanding of the concept of inclusive education, we agree with the UNESCO [5] approach, which considers it as the process of strengthening the capacity of the educational system to reach out to all learners. As learners, we understand all students in a classroom, with and without disabilities [6]. For us, this concept is broad and enhances all the diversity of students that can be presented in a classroom. However, in this study, we emphasize students with special educational needs.

Meanwhile, the incorporation of information and communication technologies in education has managed to become an educational resource that facilitates student learning in a didactic, creative and motivating way. Technologies have had an essential role in the development of Universal Learning Design (known as DUA in Chile) since its origin, and the use of digital materials in classrooms shows that students with disabilities obtain better results than with printed materials [7]. Learning is also enhanced for students without disabilities. ICT enables the students' ways of learning in science subjects (physics, biology and chemistry) where students have presented serious difficulties for decades. Research has shown that these difficulties are related to the traditional one-way, teacher-centered, expository and rote teaching, causing a lack of motivation and study techniques by the students [8].

Different studies show that the use of technology in general, and of immersive technology specifically, favors educational processes. Both virtual reality and augmented reality improve student achievements, as it is possible to have better results with technological means. It also improves and increases interest, motivation to learn and positive acceptance in the use of technologies in educational processes [7,9–13].

In Chile, studies on immersive technologies are mostly carried out at the tertiary levels [14–16], and findings in K-12 are rather scarce, especially using technology with students with special educational needs [17,18]. In this context, the research problem derives from the necessity to study educational possibilities provided by the curricular integration of immersive technology such as augmented reality and its effect on academic achievement in a diverse class of secondary students taking chemistry.

In this context, the research questions are: (Q1) Would integrating augmented reality technology in the learning process of chemistry result in a better academic achievement of students with and without special educational needs? (Q2) Would the knowledge be retained longer by using augmented reality? (Q3) Is there any relationship between the academic achievement, acceptance and motivation to use augmented reality technology of students with and without special educational needs after integrating this immersive technology in their learning processes?

We begin the article with a review of the main concepts embraced by this study, together with a review of the literature. Then, we present the methodology followed by the participants, the activity developed in the school as well as a detailed description of the data collection instruments to conclude with an explanation of the data analysis. Finally, we present the results that demonstrated that AR is a sustainable technology for reinforcing and improving the academic achievement of all students in a diverse classroom. This research addresses the concepts of academic achievement, knowledge retention, motivation and acceptance of the use of augmented reality technology in an attempt to describe and to pull apart the components that impact more. When we better understand these components, they can be folded into established classroom pedagogies from the learning sciences.

2. Literature Review

This research is contextualized in the concept of sustainable education and addresses the term of sustainable technology to frame the research. Then, we examine attention to diversity and technology followed by a description of augmented reality as an inclusive educational tool. Finally, we define the concepts of academic achievement and knowledge retention.

2.1. Sustainable Education

In this study, we embraced the concept of sustainable education as Education for Sustainable Development (ESD) which is defined by [19] as a process that enables people to develop the knowledge, skills, attitudes and values necessary to shape and live in a sustainable future. ESD is associated with lifelong learning as well as the idea that communities must know their rights to develop policies and practices that can change their lives [20]. We also considered that it is related to the educational inequalities that can restrict the learning ability of students, especially disadvantaged and underrepresented students.

Sustainable development (where ESD is grounded) seeks "to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" and "to reduce inequality within and among countries to make cities and human settlements inclusive, safe, resilient and sustainable" [20] (p. 5). We understand that the relationship between education and other areas of sustainable development is problematic. We agree with the author that education is not the panacea for development on its own. We acknowledge that technology, in this case AR, can complement sustainable development, especially when students (future citizens) acquire new knowledge and skills by combining both.

We therefore pay attention to how technology can open up or limit the possibilities for students with and without SEN, and how they reinforce academic achievement and content retention. These skills will help them to continue learning and adapting to new scenarios in the future.

2.2. Sustainable Technology

A focus on sustainable development contributes to defining what a sustainable technology is, since there is no agreement on the term. In this study, we understand the concept as the technologies that use fewer resources to obtain an objective. We consider that sustainable technology can be characterized as being flexible and adaptable and enables students to live a real experience or represent real context experience to practice their abilities. At the same time, it is essential that sustainable technology can be accessed by anyone anywhere to foster equity, and it must not provoke discrimination of any kind.

In this research context, we argued that sustainable education might exist together with sustainable technology since both require a sustainable development strategy whose final objective is to achieve both personally and socially sustainable policies and practices [21,22]. To sum up, what is essential in sustainable technology is its transformational power.

2.3. Attention to Diversity and Technology

Attention to diversity implies the design of new educational models that consider the different kinds of realities that make up the classroom. Moreover, we must consider the social and cultural aspects that direct us to develop new inclusive modalities for implementing classroom strategies and the human and material resources that will be used to address different contents, among others. To improve teaching quality, emphasizing the learning of all students, it is essential to know what we mean by students with special educational needs.

For this study, we follow the definition of Decree 170, which defines a student who presents special educational needs as one who needs additional help and resources, whether human, material or pedagogical, to lead their development and learning process, and contribute to achieving the educational goals.

In this sense, all teachers, regardless of the content they teach or the level they teach, must be prepared to provide supportive and inclusive responses according to each of the needs of students with or without special educational needs within the classroom context. Teachers should also be prepared to distinguish between the special support for those students who require it, while respecting their individualities as to whether they have been diagnosed as having permanent or transitory needs [23].

In Chile, the use of technologies in education has increased considerably, responding to changes in society, and technologies are used both for the learning and teaching processes [24,25]. Once information and communication technologies (ICT) are incorporated, schools are forced to consider changes at all levels and integrate a more efficient use of ICT by teacher educators, pre-service teachers and in-service teachers [26].

In this sense, technologies allow education to consider multiple social, ecological and cultural changes. For instance, it allows for greater personalization of processes leading to significant learning, and provides students with the technological and pedagogical resources that eventually allow them to be agents in the production and distribution of knowledge [27]. Incorporating technologies in educational processes acknowledges the use of a social constructivist theory of learning [28], where the social context is essential for the students' learning and students are considered exploratory agents, actively making sense of the external world by using technological artefacts that mediate the learning process. It also gives space to practice collaborative learning where students can develop other skills such as group work, critical thinking, reflection and participatory learning. All these skills are considered for sustainable education, whose main purpose to promote student autonomy in order to shape a sustainable and just future [29].

Immersive learning can be understood as the learning process that occurs in a simulated environment. Immersion is a cognitive state influenced by factors within and around a virtual learning environment [30]. Immersive learning enriches learner experiences because it is like experiencing a real environment. It is "composed of different psychological faculties such as attention, flow, engagement, planning and perception, and is qualified by a lack of awareness of time and the real world around an individual" [30] (p. 18).

Regarding students with special educational needs, it is crucial to paying attention to diversity as a broad concept which embraces all the students [31]. These aspects suggest that all students have their own specific educational needs for accessing the learning experiences necessary for their socialization, established in the school curriculum.

There are no known studies that measure learning directly. It is widely accepted that technology can improve the learning environment, help with student motivation [32], improve academic achievement and help the retention of knowledge. In this context, the main terms in which this study is framed are the concepts of academic achievement and knowledge retention.

2.4. Augmented Reality as an Inclusive Education Tool

Immersive technologies make up artificial environments created and inhabited by man, causing an educational disruption expressed in new ways of teaching–learning in mixed, face-to-face and virtual contexts [33,34]. Today, within many classrooms throughout the country, teachers and students of all ages use technological resources to make classes more dynamic, achieving more effective and participatory learning.

Augmented reality is one of the emerging technologies with great educational possibilities, and is being incorporated by various disciplines at different academic levels. It combines digital information with physical information in real time and with user participation. This combination is made through different technological supports such as smartphones or tablets, to create a new reality enriched with information from the real and the virtual world [35]. Most importantly, this kind of technology "covers a wide range of topics, target groups, academic levels and more" [36] (p. 447).

Augmented reality is defined as the technology that allows the real world to be combined with digital information through different augmented reality technological devices [37]. Thus, synthetic

elements such as 3D objects, multimedia content or text information are superimposed on real-world images. These elements increase the possibilities of interaction with the user. Augmented reality is also seen as an extension of virtual reality [38]. However, virtual reality acts as a bridge between reality and the virtual world [39].

In various studies, authors have emphasized that interactive technologies such as multimedia technologies and virtual 3D technologies affect learning outcomes [30,40]. However, it is highlighted that technologies are facilitators for student learning because they allow students to focus on the importance of information [9,41], enriching it to make it more understandable, promoting ubiquitous learning, observing an object from different points of view and creating safe artificial scenarios for students such as laboratories and simulators. They also enhance printed materials with additional content in various devices and turn students into pre-consumers of learning objects.

The educational field has permanently adopted AR among its technological resources. Using technology, learning may occur not only in the classroom but also at home, places of play and in the daily interactions established with others.

On the other hand, augmented reality is commonly used with in-class projects, as an educational complement or even as protagonists, with students and teachers being the creators of the information [42]. Its use has been promoted at different educational levels, as well as in different scientific disciplines, such as mathematics, geometry, natural sciences, physics, chemistry, medicine and educational sciences [43].

A recent study in Spain has shown that the evaluation of secondary students on the use of AR in a chemistry subject was satisfactory [44]. The students considered AR as an excellent educational resource and pointed out that this technology allows them to be the protagonists of learning. A total of 63% of the surveyed students considered the use of the chemistry class book and the use of AR to be suitable for learning the chemical elements. The results showed that the students conceive the use of an innovative method as a complement and reinforcement of the traditional method.

Another study on students' academic success and cognitive workload when learning anatomy with mobile augmented reality showed that the students using AR applications had more academic success and lower cognitive loads compared to the students in the control group [45].

In the US, research was conducted on the use of technologies such as immersive exergame and different levels of embodiments in lessons with college-age participants. The results showed that participants made significant immediate learning gains from pre-test to post-test. In addition, the level of embodiment interacted significantly from post-test to the one-week follow-up test [46].

There are also examples where AR applications targeted at students with special educational needs are used to help treat cognitive problems, learning disabilities and emotional trauma [17,47]. Other studies use a virtual world to help students with autism develop confidence, finding that technology facilitated interaction rather than creating a barrier [48].

Consequently, based on the theoretical elements and studies previously shared, it is possible to affirm that AR can contribute to the academic achievement of students, among other advantages, and that students can react positively to such practices. In other words, the effectiveness and efficiency of education, translated into academic achievement and school retention, may increase when the relationship of the content is similar to real life. In this scenario, abstract concepts, such as those in chemistry, become more concrete, accessible and manageable.

2.5. Academic Achievement and Knowledge Retention

It is understood that the human being is an active processor of experience, through the complex system in which the information is received, transformed, accumulated, recovered and used. In other words, to ensure learning, an interactive environment is needed, as is the subjective representation made by the individual through internal (cognitive) processes. There is coincidence in the need of subjective representation that students generate when learning [49]. Moreover, it is suggested that to generate knowledge using technologies, four processes must occur: (1) access to information,

(2) representation of this information, (3) creation of new knowledge and (4) knowledge transfer. It is in this last step when we can see the students' final achievement. After completing each step (with the use of technology), they manage to transfer their representation to others. This process is often assessed in most Chilean schools by assigning scores, and these results indicate to the students how well or poorly they did.

Undoubtedly, one of the most critical dimensions in the teaching–learning process is students' academic achievement. To assess academic achievement and how to improve it, we must take into consideration factors such as socioeconomic status, social skills, personal perceptions, family constitution and even genetic determinations [50], working memory skills [51], academic resourcefulness [52] and performance anxiety [53], among others.

According to the literature, students' academic achievement is defined as a net result of their cognitive and non-cognitive attributes [54], which also includes the sociocultural context in which the learning process takes place [55].

Some authors agree that it is very imprecise to identify the achievement of a student only by their scores [56]. Nonetheless, it is the indicator that gives the best approximation and objectivity. In this study, the concept is understood as the relationship between the learner strength (input) and what is achieved as a product (output) through the interaction among students and educational resources.

How students learn, and how they can perform academically also depends on another critical factor: retention of knowledge. This concept represents the mental process that enables storage, ensures the retrieval of information and is associated with skills [57]. At the memory level, the student internalizes and links knowledge, abilities and skills to build learning. In this sense, augmented reality is one of the new techniques that is revolutionizing teaching, since it enhances the retention capacity of students by allowing them to interact with visual objects in the real world through mobile devices [58], which are increasingly immersed in the lives of children and young people.

An interesting study from England pointed out that students who experienced practical education using augmented reality increased their retention rates by 18.1% in the area of mathematics, followed by 13.1% in mechanics and 2.9% in engineering [59]. These results, although placed in a tertiary education context, are an antecedent for this study as they address knowledge retention as a key element to demonstrate learning built on chemistry content, but in secondary education.

To support academic achievement, we also embrace the concept of collaborative learning to design some of the activities for the pedagogical intervention. This concept refers to a method in which students work together in small groups [60,61]. It involves the process of elaborating an object, idea, concept, phenomenon or application with more people. Another reason to embrace this concept is that teachers that use collaborative learning methods assume that knowledge is created through students' interaction and not from a teacher–student relationship [62].

The concept of special needs (transitory or permanent) is also developed in the framework of this study. There is a regulation that seeks "to provide equal opportunities and social inclusion of people with disabilities by having access to the regular educational schools" (article N°34) [63], among other rights. In this context, the Ministry of Education of Chile emphasizes that the special educational needs concept implies a transition in understanding learning difficulties, from a deficit-focused model towards a proper educational approach [4] (p. 4). It implies an integral development of the students' characteristics challenging educators to provide the necessary support so students with special needs can learn and participate in the regular school environment.

Dyslexia, dyscalculia and dyslalia, among others, are learning problems that any student may face at some point in their educational itinerary. Consequently, the system demands a proper and timely educational response, which will allow them to identify their causes and to promote offering relevant pedagogical support to enhance learning outcomes of students with SEN. A good example is a significant disparity reported by the Nation's Report Card in the US [64] national tests. A low mathematics and reading proficiency level in year 4 primary students with specific learning disabilities can be observed. Results place them right at the lower achievement level of the cut score.

Science results for year 12 students with SEN show that 70% of them are at the lower end of the basic achievement level. In comparison, 36% of students without special educational needs were placed at this level.

3. Hypotheses

Based on the insights gained from the literature review, and considering the research questions and existing theories, three hypotheses were tested in this research and our predictions and rationales are listed after each one.

(1) Using AR should be predictive of both improvements in academic achievement and knowledge retention. We predict that the immersive characteristics of AR such as the combination of digital and physical information in real time enable students to enter in a cognitive process, which is influenced by internal and external factors from the real and virtual world.

(2) The level of motivation regarding AR integration is related to the improvement in students' academic achievement. This is hypothesized because a high level of motivation regarding the technological advantages and benefits generate a positive predisposition to using them, which leads the creation of an appropriate scaffolding scenario for learning.

(3) The level of acceptance of AR integration is related to the improvement in students' academic achievement. This hypothesis is raised because a high level of acceptance of the technological advantages and benefits could generate a new and safe learning environment where interaction can enhance academic achievement and inclusive education.

In summary, this study addresses the concepts of academic achievement, knowledge retention, motivation and acceptance of the use of augmented reality technology in an attempt to describe and to pull apart the components that have a greater impact. When we better understand these components, they can be folded into established classroom pedagogies from the learning sciences.

4. Methodology

This study is based on a pre-experimental design with a pre-test and a post-test and a single group. It consisted of determining academic achievement before and after the integration of augmented reality into the classroom. Additionally, to determine knowledge retention, a follow-up test was applied one month later. The method used was quantitative with an explanatory approach, since its focus was to explain whether the incorporation of AR affects secondary school students' academic achievement in their chemistry knowledge. In educational experimentation, it is difficult to totally control the external features [65]. However, the within-subjects factor and the test time design, which had three levels: pre-test (the day before the intervention), post-test (the day after the intervention ended) and follow-up (an average of 1 month after instruction), permit measuring the effects on academic achievement. External control features were agreed on with participants. For instance, they pledged not to use AR outside of the classroom. Additionally, we verified that the chemistry content was not taught previously during the academic year.

4.1. Participants

The sample was chosen non-randomly, and it was composed of 60 secondary female students, who were studying the second semester of the 4th year of secondary school (12th level). There were no group selections since all the students participated in the experiment. From the total of students, 7 had been diagnosed as having SEN, of which 6 had transitory needs and 1 had permanent needs. Students' age ranged between 17 and 18 years old. They attended a private subsidized educational institution for women in Concepción, a city located in the Biobío Region, in Southern-Central Chile. The ethical committee of the university evaluated and approved the research project and its ethical guidelines and documents. This process enabled us to conduct the research with students under 18 years old in educational settings.

Then, to participate in the research, an information sheet and informed consent were delivered to the students' parents in order to obtain their permission, as most of the students were under 18 years old. Students also verbally manifested their intention to participate in the study. All the information was used confidentially, safeguarding the students' identities, as well as not causing any physical or psychological harm from the use of AR technology.

4.2. Description of the Activity

In its experimental stage, the study was carried out between August and October 2019. It consisted of building and manipulating 3D molecules of organic and inorganic compounds using the AR VR Molecules Editor application.

The intervention took place over three phases. Phase 1 consisted of the face-to-face administration of a chemistry test to determine the baseline. In Phase 2, the instructional intervention, hereafter lessons, was carried out by implementing three 45-min sessions in which students carried out didactic activities, integrating the use of augmented reality technology, collaborative group work, reflection and the use of specific printed support material. In the end, the acquisition of chemistry content was tested through version B of the test. In Phase 3, a delayed follow-up test was applied one month after the completion of the last lesson, in order to find the students' deepest remaining knowledge after working with AR.

The lessons were carried out in the chemistry laboratory of one private subsidized school. To carry out the proposed activities, participants manipulated the augmented reality technology. Students also organized themselves into teams of 3 to 5 members, and participated in different workstations on a rotating basis. This means that all the students followed the same experimental work scheme. Within each team, students assumed different roles for the development of the activities: for instance, to visualize components using AR lenses, to give instructions to those who visualized the components in augmented reality, to write the results of the visualizations in the practical guides and to generate questions to reflect on the contents and experience with the use of AR. Once the team completed assignments, all groups were rotated so they would have the opportunity to perform the activities at the next station.

During the first session, a review of the chemical elements, colors and symbols was generated. The objective was to enhance the ability to recognize organic and inorganic compounds according to their molecular composition

In this activity, the students used the AR lenses and the AR VR Molecules program. The students were asked to identify the molecular structure of the chemical compounds that were written in their work guides. Then, they had to write the chemical formula corresponding to each organic and inorganic component displayed, including the chemical elements that it is composed of, the shape and number of bonds.

During the second session, the ability to answer questions was promoted. The questions were about chemical compounds and functional groups to which these compounds belong. Using the AR cards, the students had to observe which functional group each card belonged to.

Finally, the students were asked to draw structures representing the order and number of bonds, and to build chemical compounds. In this activity, the students had to form chemical compounds written on their worksheets by using the AR VR Molecules program in the virtual laboratory, respecting the chemical elements, structure and bonds. Then, they were asked to draw and paint the product on their worksheets.

To sum up, all the activities described in this section were created under the socio-constructivist theory, considering collaborative and immersive learning. Students were able to access information and to represent the content through the action of drawing a sum of molecules that they had learned about during the AR experience. In order to transfer their new knowledge to the rest of their group, one student in the group instructed others to create what she had done. This process generated

an environment full of curiosity, social interactions and re-transference of knowledge that favors students' engagement.

4.3. Data Collection Instruments

For this study, three data collection instruments were used: (1) academic achievement test, (2) motivation scale of augmented reality (MSAR) and (3) scale of acceptance of the use of augmented reality for secondary students (SoASESS). They were temporarily administered at two moments. First, before the experience of using AR, because the academic achievement test was applied as a pre-test. Second, at the end of the experience of using AR, where the academic achievement test was applied as a post-test. Third, the post-test, the scale of acceptance of the use of augmented reality and the MSAR questionnaire were applied.

4.3.1. Academic Achievement Test

The academic achievement test is an evaluation created to measure the content addressed in the intervention. It aims to inform the analysis of academic achievement. Its contents are related to the chemical compounds, in this case: the identification of organic (hydrocarbon) and inorganic compounds, and functional groups. Both versions of the test were specially designed by the researchers, considering the contents addressed in the intervention, which are also part of the national curriculum for the 12th level.

To validate the instrument, it was submitted to a content validation process, which was carried out considering the relevance of the questions concerning the curricular bases of the 4th year of secondary school (12th level) in the training plan of chemistry [66]. Furthermore, the test was subsequently validated by the judgment of experts in the area of science. Three expert teachers from the chemistry area participated, who spoke about the relevance (content) of the questions, the educational level and the writing (clarity) of the questions.

This test consists of 30 multiple-choice questions from which each correct answer awards 2 points with the maximum possible score being 60 points. The scoring range used in the analysis goes from the score of 1.0, that is, those who obtain 0 points, which means 0% achievement, and which is considered as Very Poor, to a 7.0 score, for those who get 60 points, which means 100% achievement, considered Very Good. The required percentage to pass is 60%, which corresponds to 36 points, and which grants a passing score of 4.0.

This test was applied under the modality of a pre-test, post-test and follow-up test, with two versions to avoid prior knowledge of the questions. Both versions evaluate the same content, although the questions are different. Version A was applied as a pre-test, and version B was applied as a post-test and after one month as a follow-up test.

4.3.2. Motivation Scale of Augmented Reality (MSAR)

The creation of the motivation scale of augmented reality was based on the Instructional Material Motivational Survey (IMMS) [67], which measures middle and secondary school students' motivation regarding the use of augmented reality.

For this study, the validation of the MSAR was carried out in two stages. First, it was validated through expert judgment, regarding the wording and clarity of the indicators. Second, a psychometric validation was performed using exploratory and confirmatory factor analysis. The application of this test for its validation was applied to a sample of 252 secondary school students.

The instrument is made up of 33 items that are divided into 3 dimensions. The first one is the Attention, Trust and Satisfaction Dimension, defined as motivational constructs such as curiosity, personal control, enthusiasm for success and continuation for the pleasure of learning with augmented reality. The second one is the Complexity Dimension, referring to the difficulty that the use of augmented reality can generate. The third one is the Irrelevance Dimension, alluding to the little or no

importance of using augmented reality for learning. The response options are arranged in 7 levels of agreement ranging from 1 to 7, where 1 means Extremely Disagree, and 7 Extremely Agree.

The subscales Attention, Trust and Satisfaction; Complexity; and Irrelevance of the Motivation Scale of technology use all had adequate reliabilities, all Cronbach's α = 0.76. However, the Irrelevance subscale had relatively low reliability, with Cronbach's α = 0.61. A confirmatory factor analysis was conducted on the 33 items with orthogonal rotation (varimax). The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, with KMO = 0.93, and all KMO values for individual items were > 0.90, which is well above the acceptance limit of 0.5 [68]. Barlett's test of sphericity χ^2 (528) = 4772.2, $p < 0.001$, indicated that correlations between items were sufficiently large enough for the MSAR.

4.3.3. Scale of Acceptance of the Use of AR for Secondary Students (SoASESS)

The SoASESS was based on the scale of the acceptance of the use of technology (TAM) translated from the English version to a Spanish one [69], aiming to measure the degree of acceptance of the use of technology in Spanish university students. In the case of our scale, it was designed to measure the secondary students' level of acceptance regarding the incorporation of augmented reality.

For this study, the validation of the SoASESS was carried out in two stages. First, it was validated through expert judgment regarding the indicators' wording and clarity. Second, a psychometric validation was carried out by means of an exploratory and confirmatory factor analysis with a sample of 183 students who were in secondary education.

The instrument is made up of 14 items which are divided into two dimensions. The first one is the utility and facility of use observed, defined as the belief that a person has that using a particular technological system will improve their performance at work and the facilitation that they perceive when using the system. The second one is attitude and enjoyment towards the use and intention to use it, which refers to the predisposition and extrinsic motivation of the person when making use of a technological system. The response options are arranged in 7 levels of agreement ranging from 1 to 7, where 1 means Extremely Disagree, and 7 Extremely Agree.

The observed utility and facility of use, and attitude and enjoyment towards the use and intention to use the subscales of the scale of acceptance of the use of technology all had high reliabilities, all Cronbach's α = 0.90 (according to the criteria expressed by the author) [68]. A confirmatory factor analysis was conducted on the 14 items with orthogonal rotation (Varimax). The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, with KMO = 0.91, and all KMO values for individual items were > 0.90, which is well above the acceptance limit of 0.5. Barlett's test of sphericity χ^2 (105) = 2445.7, $p < 0.001$, indicated that correlations between items were sufficiently large enough for TAM.

4.4. Data Analysis Procedure

To analyze data, we conducted a descriptive statistical analysis of the central tendency and dispersion of the variable of study, academic achievement, knowledge retention, acceptance and motivation of the use of technology with augmented reality. It was carried out using the statistical program IBM SPSS Statistics 23 version software. We also tested the homogeneity of variances. Levene's test denoted that for academic achievement $F(1, 58) = 0.53$, ns, for motivation to use AR $F(1. 58) = 1.41$, ns, and for acceptance of the use of AR technology $F(1, 58) = 0.43$, ns, and the variances were equal. We used the Kolmogorov–Smirnov test to see if the test distribution of scores significantly differed from a normal distribution. It is reported that for the academic achievement in the pre-test $D(60) = 0.03$, $p < 0.05$, in the post-test $D(60) = 0.00$, $p < 0.05$, and in the follow-up test $D(60)=0.00$, $p < 0.05$, and they were all significantly non-normal. Results also showed that for the motivation of the use of augmented reality $D(60) = 0.16$, $p < 0.05$, and for the acceptance of the use of AR technology $D(60) = 0.19$, $p < 0.05$, which were both significantly non-normal.

In this sense, homoscedasticity is assumed as not normal, therefore, a non-parametric inferential analysis of the academic achievement variable was carried out using the non-parametric test ANOVA by Friedman and Wilcoxon, for testing differences in the mean rank in each condition (pre-test, post-test and follow-up test) considering that the same participants have taken part in all conditions. Moreover, Kendall's tau was used to determine a non-parametric correlation between the variables following recommendations considering that is a better estimate of the correlation when there is a small data set with a large number of tied ranks [68].

5. Results

The results that we introduce in this section are linked to the three research questions proposed at the beginning of this article. The data processing includes descriptive and inferential statistical analysis.

5.1. Academic Achievement and Knowledge Retention Results

Guided by the first research question, it can be said that the overall immediate academic achievement increases from pre-test ($M = 3.65$, $SD = 1.21$) to post-test ($M = 5.21$, $SD = 1.15$). The score increase is as high as 1.56 points more after the integration of the AR technology in the classroom. It is also possible to observe that the results of the pre-test are low, not exceeding a score of 3.7, which means that they do not reach the minimum passing score (4.0) under the Chilean system.

Guided by the second research question, it is also possible to observe that, overall, the mean scores on the follow-up test ($M = 5.34$, $SD = 1.29$) are higher than the results obtained on the post-test ($M = 5.21$, $SD = 1.15$). The increase in the score is 0.17 points more one month after the students ended the intervention (see Table A1 in the Appendix A Section).

In the post-test (see Figure 1), the students with and without special needs performed similarly on the three tests. Moreover, students did not retain as much of the content of the chemical compounds one month after the lessons ended. However, the decrease in knowledge retention is less in the students with special needs (0.17 points less than their main post-test score) than the other sub-group (0.21).
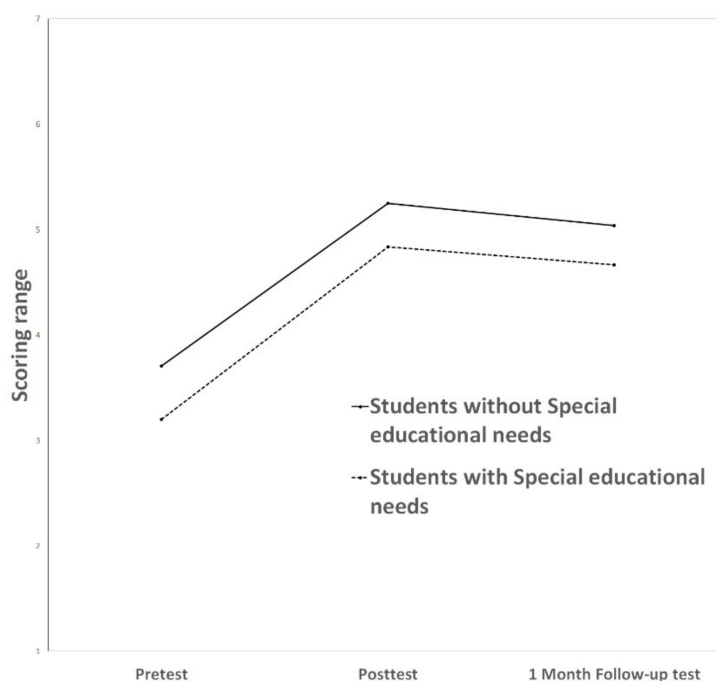

Figure 1. Students' trajectories of academic achievement from pre-test to follow-up test. (Source: prepared by the authors.)

Performing a global analysis, both the post-test and follow-up test show results above a score of 3.6, which means that all the students obtain passing averages in their score, regardless of being diagnosed with a special educational need or not.

Equally noteworthy is the fact that the group of students with special educational needs ($n = 7$) increased their score by 1.64 once the intervention was completed, compared to the post-test. If we consider the post-test with the follow-up test, this difference falls only 0.17 points. The relevant thing about the data is that in this group of students, one month after the end of the intervention, the result of the scores is still almost one and a half points (1.47 points) if we compare with the post-test.

To approach the inferential analyses, the distribution of the sample was also tested through the Kolmogorov–Smirnov test of homogeneity of variance. The results showed that there is a difference between the variations in the population (in academic achievement, the variances were for pre-test $D(60) = 0.14$, $p = 0.00$; for the post-test $D(60) = 0.16$, $p < 0.001$; and for the follow-up test $D(60) = 0.17$, $p < 0.001$).

In this sense, homoscedasticity is assumed to be non-normal, so a non-parametric inferential analysis of the academic achievement variable was carried out using the non-parametric test of Friedman's ANOVA, in order to observe the differences in the results of the achievement tests before and after the intervention, as well as in the follow-up test.

The results show that the students' scores changed significantly throughout the three measurements (within-subjects) in which the augmented reality intervention was carried out ($\chi^2(2) = 74.02$, $p < 0.01$). The Wilcoxon test was used to follow-up on these findings. A Bonferroni correction (to correct the error) was applied, so all effects are reported at a 0.167 level of significance. It is observed that academic achievement significantly changed from before carrying out the instructional intervention to after, $T = 26$, $r = -0.58$, as well as from the beginning to the measurement made a month later, $T = 18.50$, $r = -0.60$.

Finally, it is possible to affirm that there are no significant differences from the end of the intervention to the measurement after one month, since the difference in academic achievement of the participants' averages is 0.17 points in the score.

5.2. Acceptance and Motivation to Use Augmented Reality Technology Results

Guided by the third research question, we ran the non-parametric correlation. These analyses used Kendall's tau for two reasons. First, it should be used when dealing with a small data set with a large number of tied ranks. Second, it can draw more accurate generalizations from this statistic than others [68]. Kendall's tau, however, is not numerically similar to another non-parametric test, so the authors emphasized that the effect reported should not be squared. We analyzed those variables related to academic achievement separately in order to approach hypotheses 2 and 3.

As can be seen in Table 1, the level of acceptance of the use of technology by the students after having carried out the intervention with AR at a global level is high ($M = 6.71$, $SD = 0.55$) with a score close to the maximum (7 points). Regarding the dimensions, it can be seen that both the utility and observed use of AR ($M = 6.58$, $SD = 0.698$) and the attitude, enjoyment and intention of using AR ($M = 6.82$, $SD = 0.45$) present a high degree of acceptance by the students.

Table 1. Acceptance of the use of augmented reality (AR) results (SoASESS).

	Students with and without SEN	Students without SEN	Students with and without SEN
	M (SD)	*M (SD)*	*M (SD)*
SoASESS	6.71 (0.55)	6.70 (0.62)	6.80 (0.38)
Utility and ease of use observed	6.58 (0.69)	6.53 (0.76)	6.68 (0.52)
Attitude, enjoyment and intention to use it	6.82 (0.45)	6.82 (0.51)	6.89 (0.28)

These results allow us to affirm that when students perform their chemistry activities with AR, they consider that this type of technology helps improve their academic achievement, facilitates understanding of the content and is a more fun way to learn, and they enjoy the class.

Besides, we found that overall, the students' level of acceptance was significantly related to academic achievement, $\tau = 0.78$, $p = 0.01$, and with the level of students' motivation, $\tau = 0.47$, $p < 0.001$. Nonetheless, it cannot be assumed that the level of acceptance caused success in academic achievement or increased students' motivation.

The descriptive results of the subgroup with SEN and without SEN show that the medium is relatively similar. However, students with SEN have a better attitude toward the use of AR. In all phases, they surpass the average level of acceptance by between 0.07 and 0.15. Furthermore, focusing on SEN, we also found that the level of acceptance of students was significantly related to academic achievement, $\tau = 0.78$, $p = 0.01$.

Following the third research question, this total average result is why the motivation analysis instrument was made up of both positive factors such as attention, trust and satisfaction, as well as negative factors, which correspond to complexity and irrelevance.

This interpretation is evident in the mean obtained in the Attention, Trust and Satisfaction dimension, which corresponds to a score close to the maximum ($M = 6.35$, $SD = 0.53$). It was evident that the students were curious to learn through AR, and that they felt motivated to carry out the activities, which maintained and managed to capture their attention, and in turn complete the activities that generated a feeling of satisfaction with their results. On the other hand, regarding the Complexity dimension ($M = 1.75$, $SD = 0.78$) and the Irrelevance dimension ($M = 1.55$, $SD = 0.68$), low scores are evident as it can be seen in Table 2, failing to exceed 2 points, since the answers on the scale extremely disagree. In both dimensions, it could be shown that using AR was not a difficult task for the students, so they did not require much effort to use it, and the images and videos were attractive, therefore they were not boring and the participants managed to relate the images very well to the real world.

Table 2. Students' motivation to use AR technology.

	Students with and without SEN	Students without SEN	Students with SEN
	M (SD)	*M (SD)*	*M (SD)*
MSAR	4.94 (1.02)	4.93 (1.06)	5.04 (0.52)
Attention, trust and satisfaction	6.35 (0.53)	6.31 (0.98)	6.34 (0.53)
Complexity	1.75 (0.78	1.81 (1.36)	1.30 (0.52)
Irrelevance	1.55 (0.68)	1.55 (0.96)	1.57 (0.78)

Similarly, it can be seen that both the students presenting SEN ($M = 5.04$, $SD = 0.52$) and those without SEN ($M = 4.93$, $SD = 1.06$) were highly motivated to use AR in the lessons. Thus, it is evident that, whether there is any special educational need or not, the students show high attention, confidence and satisfaction when using AR. Further, in both cases, a low level is observed in the dimension of Complexity, and in the Irrelevance dimension.

In summary, both students with and without SEN consider it relevant to work with AR, being an entertaining audio-visual material, which is easy to understand and use in class. Our findings inform that the student's motivation is not related to academic achievement or to the retention of knowledge.

Focusing on SEN, we found that the student's motivation was significantly related to academic achievement, $\tau = 0.78$, $p = 0.01$. Nonetheless, it cannot be assumed that the students' motivation caused success or an increase in academic achievement.

6. Discussion

The research began with the following three predictions: (1) using AR should be predictive of both improvements in academic achievement and knowledge retention, (2) the level of motivation regarding AR integration is related to the improvement in students' academic achievement and (3) the level of acceptance of AR integration is related to the improvement in students' academic achievement.

The first prediction was supported: augmented reality technology did improve academic achievement in secondary students. This result was achieved thanks to the use of the socio-constructivist learning theory in the three-week educational intervention [28], where collaborative and immersive learning were central didactic ways to direct the use of immersive technology. It is important to mention that according to the positive outcomes, the research team highlights several issues that need to be addressed to get a better understanding of the result's rationale. The technology was just a medium to fulfil the curricular objectives. Prior training on how to use the AR lens and/or AR VR Molecules Editor was not needed. Once the app was chosen, all its benefits and advantages were evaluated to determine if it should be used or not. The main reasons were related to the free access, the different options to work on chemistry content and its friendly interface. These app characteristics help students feel secure, which is a characteristic that enhances AC. Teachers play a crucial role, as they act as facilitators who guide the activity and give not only support but feedback in case something would not have worked. In this case, students developed activities by themselves in a "learning by doing" process, which was fruitful for improving their academic achievement.

Following the first prediction, augmented reality did improve knowledge retention. Interestingly, students achieved retaining knowledge one month after the educational intervention had finished. Participants demonstrated knowledge retention since they were able to identify concepts, relate ideas and answer chemistry content questions. Researchers dismiss the idea that the positive outcome is due to previous knowledge since a different version of the test was applied in phase 3.

The positive outcome can be explained by the immersive characteristic of augmented reality as it combines the real with the virtual world. This is closely related to the reviewed literature, where [42] argues that AR allows the construction of knowledge by the student and grants greater access to information that broadens the possibility of accessing knowledge.

The findings of our research are similar to the results presented by various authors who have worked with the use of immersive technologies in related fields [10–13]. Thus, we agree with [9], who studied the impact of mobile augmented reality on the teaching–learning process of university medicine students. These authors concluded that the use of AR is a facilitating element for student academic achievement because its use in training allows students to focus on the importance of information. In this sense, it is possible to affirm that regardless of educational level, in both studies the positive impact on academic achievement is highlighted since it can be seen in both secondary school and university students.

Another critical finding regarding academic achievement is that results are also positive and coincide with those reported by [11], who mentioned that by using digital materials in classrooms, students with different abilities obtain better results with technological resources than with printed materials. In our case, the students diagnosed with special educational needs presented better academic achievement after having carried out the intervention with AR, compared with before using this technological resource in the specific chemistry content.

Based on the previously presented context, and in order to answer the research question, it is possible to affirm that the use of AR positively affects the academic achievement of students both with and without SEN, which complements our idea that AR poses an inclusive educational potential. Being exposed to this kind of technology and virtually working through the chemistry content, in a close and attractive manner, mainly by exploring objects related to the content in a more realistic way, made it possible for all students to increase their academic achievement.

This research provides pertinent information on the academic achievement of 60 fourth year secondary students (12th level) in chemistry, through the development of didactic and dynamic activities

with AR based on a socio-constructivist theory of learning [28]. However, future research must consider the design: individual work with the technology, increased exposure time to augmented reality technology and the inclusion of content from other areas of knowledge, as well as the incorporation of a control group to compare results.

The second prediction was supported: augmented reality improved secondary school students' level of motivation in an intervention on chemistry knowledge. The students showed a high level of motivation through the development of the pedagogical activity because by using immersive technologies, they can develop higher levels of engagement with their learning processes. In the same line, the authors agree that students using AR have a better learning environment since the combination of the real world with a virtual world is one of the most attractive characteristics for students [33]. Furthermore, AR is a wireless technology that triggers motivation and multiple activities in and out of the classroom, which helps the educator to manage multiple learning environments [70]. It is important to mention that students with SEN showed a greater level of motivation. However, the level of students without SEN is also high.

The third prediction was supported: the students' level of acceptance of the use of augmented reality was high. The students' attitude is positive, and they enjoy working with this kind of technology. This result also agrees with other studies that express that students develop high levels of motivation when they use augmented reality [32–37]. They also agree that immersive technology makes learning easier, since it helps to simplify content.

Both groups of students have a high level of motivation; however, the students with SEN have a higher level of acceptance (almost the total). The previous idea makes sense when considering the multi-affordances that AR covers such as audio, video, printed text and photos, among others, as well as the assistive function that enables supporting students with disabilities and SEN.

As final considerations, it is possible to suggest the curricular integration of augmented reality is a sustainable technological resource that contributes specific employability skills that students should develop for being citizens in the 21st century. Moreover, immersive technologies also enable students to navigate complex areas of knowledge, such as science, and particularly chemistry. It also gives outstanding support to students with diagnoses of special educational needs to develop scaffolding [71] and access information that is complex to understand due to its high level of abstraction, in a friendlier way.

What is now needed is to consider the incorporation of the Universal Design of Learning (known as DUA in Chile) using a more practical approach that can match the theory where all of the diverse types of students can achieve the fundamental learning objectives established in the Chilean curriculum. Using augmented reality technology may help connect the theoretical and practical basis of this approach.

An implication of this is the possibility that all of the diverse types of students presented in a classroom can develop the scientific skills and improve their academic achievement which makes this technology able to prepare students for a dynamic and sustainable future. Moreover, it helps students with special educational needs to learn in similar conditions as their classmates, which facilitates the creation of an inclusive environment and promotes cognitive justice for all students in the same way.

The integration of AR may have another implication, which is related to its contribution to significant learning and the development of social and cultural skills, especially those identified as 21st century skills. Through the exposure to immersive technology, students can override the experience of learning and relearning [72], which is a skill they need to embrace in order to live in future smart cities, which are characterized first by the growth of information and communication technologies (ICT) in most human activities and by the continuous reinvention and innovation in people's everyday activities [73]. Thus, it helps students to think and then act in new ways of being able to work collaboratively and critically to be prepared for a sustainable future. In this way, students with special needs could also develop abilities that allow them to study in a fairer educational institution and to be more engaged while learning to survive the dynamic technological future.

7. Conclusions and Further Research Work

This study will prove useful in expanding our understanding of how cognitive and social justice are possible, since the research shows that students with and without special educational needs could mix specific science content with social and cultural skills such as collaborative learning, reflection and critical thinking. Educators need to understand how to increase the effectiveness in action, to rethink education and find new ways of teaching and learning to improve not only their students' academic achievement, but also empower them by developing effective learning experiences. All these processes are based on the phenomena of innovation and management [23], mediated by technology, which embrace new demands and needs for the two-dimensional human being. The previous idea leads us to prepare ourselves to prefigure new paradigms by sharing the challenge of knowing, understanding and performing new roles, not yet sufficiently assumed in current educational systems.

Considering the research problem stated in this article, which shows the need for exploring the educational possibilities provided by the curricular integration of augmented reality and its effect on academic achievement in a diverse class, we reflected that our study sheds light that indicates that augmented reality is a sustainable technology, that can help students with special educational needs to study in the same way as students who do not have SEN. It also helps the teaching and learning of science in a more dynamic and active way. At this point, we strongly suggest choosing the AR technology carefully, keeping in mind the lessons' aim. Moreover, we propose that the incorporation of embodied content would be a fruitful area for further work, since the immersive and embodiment experience would create a new environment where students with SEN can improve their academic achievement and knowledge retention. In conclusion, it can even make their educational, social and cultural experience better as well as their sense of belonging to a group of students without feeling discriminated. It could be an opportunity for developing an inclusive educational experience, favoring social and cognitive justice that enables students to be agents for a sustainable future.

One of this study's limitations was the small number of participants, as it was a postgraduate study without funding for having a research assistant to cover a more considerable number of participants. Additionally, time was also limited to implement the intervention. Notwithstanding these limitations, the study interestingly suggests that the incorporation of augmented reality into the educational context (no matter the area) enables students to develop an ecological relationship in the space where they are learning that fosters sustainable education for their future.

It would be a fruitful area for further work to incorporate AR at other educational levels, as it would be interesting to address far too little-studied age groups in Chile, such as pre-school and elementary education students. Additionally, this study should also be replicated with other contents and subjects, especially in those where students present more significant difficulties in our country, such as language, mathematics and science. Equally, a further study could assess the long-term effects of using AR to reinforce academic achievement in students with SEN. Considerably more work will need to be done to determine the impact of this sustainable technology on improving the social and critical skills of students with and without special educational needs, as well as improving the knowledge and the values to shape a sustainable future.

Author Contributions: M.G.B.-Q. designed the project, oversaw the study, analyzed results and wrote most of the manuscript. M.S.A., acted as psych pedagogy and special education expert, created tests and lessons, wrote part of the manuscript and was the lead experimenter as a postgraduate student. E.S.-V. wrote part of the manuscript, translated the manuscript and contributed and supported the conceptual framework, discussion and conclusion sections. All authors have read and agreed to the published version of the manuscript.

Appendix A

Table A1. Descriptive statistics based on academic achievement results.

	Students with and without SEN		Students without SEN		Students with SEN	
	N	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*
Pre-test	60	3.65 (1.21)	53	3.71 (1.25)	7	3.20 (0.75)
Post-test	60	5.21 (1.15)	53	5.25 (1.16)	7	4.84 (1.04)
Follow-up test	60	5.34 (1.29	53	5.04 (1.29)	7	4.67 (1.18)

Source: prepared by the authors.

References

1. Ministerio de Educación de Chile. Decreto 83/2015. Orientaciones Sobre Estrategias Diversificadas de Enseñanza Para Educación Básica. 2017. Available online: https://especial.mineduc.cl/wpcontent/uploads/sites/31/2017/05/ORIENTACIONES_D83_Web_05-2017.pdf (accessed on 17 September 2020).
2. Biblioteca del Congreso Nacional de Chile. Ley 20845 de Inclusión Escolar que Regula la Admisión de los y las Estudiantes, Elimina el Financiamiento Compartido y Prohíbe el Lucro en Establecimientos Educacionales que Reciben Aportes del Estado. 2020. Available online: https://www.leychile.cl/Navegar?idNorma=1078172 (accessed on 17 September 2020).
3. Ministerio de Educación. Inclusión. 2020. Available online: https://escolar.mineduc.cl/inclusion/ (accessed on 17 September 2020).
4. Ministerio de Educación de Chile. Diversificación de la Enseñanza. 2015. Available online: http://especial.mineduc.cl/wp-content/uploads/sites/31/2016/08/Decreto-83-2015.pdf (accessed on 17 September 2020).
5. UNESCO. *A Guide for Ensuring Inclusion and Equity in Education*; UNESCO: Paris, France, 2017; Available online: https://unesdoc.unesco.org/ark:/48223/pf0000248254 (accessed on 17 September 2020).
6. Göransson, K.; Nilholm, C. Conceptual diversities and empirical shortcomings—A critical analysis of research on inclusive education. *Eur. J. Spéc. Needs Educ.* **2014**, *29*, 265–280.
7. Alba, C.; Sanchez, J.; Zubillaja, A. Tecnología y diseño universal para el aprendizaje (DUA). Experiencias en el contexto universitario e implicaciones en la formación del profesorado. *Rev. Latinoam. Tecnol. Educ.* **2015**, *14*, 89–100.
8. Busquets, T.; Silva, M.; Larrosa, P. Reflexiones sobre el aprendizaje de las ciencias naturales: Nuevas aproximaciones y desafíos. *Estud. Pedagógicos* **2016**, *42*, 117–135. [CrossRef]
9. Barba, R.; Yasaka, S.; Manosalvas, C. Impacto de la realidad aumentada móvil en el proceso enseñanza-aprendizaje de estudiantes universitarios del área de medicina. *AIDIPE* **2015**, *3*, 1421–1429.
10. Ghitis, T.; Alba, A. Percepciones de futuros docentes sobre el uso de tecnología en educación inicial. *Rev. Electrónica Investig. Educ.* **2019**, *21*, 1–12.
11. Hernández, C.; Gómez, D.; Balderas, M. Inclusión de las tecnologías para facilitar los procesos de enseñanza-aprendizaje en ciencias naturales. *Rev. Electrónica Actual. Investig. Educ.* **2014**, *14*, 1–19.
12. Olea, A.; Peña, S.; López, D. Lo que las investigaciones dicen sobre el uso de las TIC para la enseñanza y el aprendizaje de las ciencias naturales. In Proceedings of the XIV Congreso Nacional de Investigación Educativa, San Luis Potosí, Mexico, 20–24 November 2017.
13. Medina, H.; Lagunes, A.; Torres, C. Percepciones de Estudiantes de Nivel Secundaria sobre el uso de las TIC en su Clase de Ciencias. *Inf. Tecnol.* **2018**, *29*, 259–266. [CrossRef]
14. Gallego, Ó.; Barroso, J.; Marín, V. Análisis de la motivación de los estudiantes universitarios como productores de recursos educativos utilizando la Realidad Aumentada. *Rev. Espac.* **2018**, *39*, 8–21.

15. Badilla, M.G.; Vera, A.; Lytras, M. Pre-service teachers' skills and perceptions about the use of virtual learning environments to improve teaching and learning. *Behav. Inf. Technol.* **2017**, *36*, 575–588. [CrossRef]

16. Gavilanes, W. Percepción de los estudiantes en relación al uso de la realidad aumentada en los procesos pedagógicos. *Rev. Publicando* **2017**, *4*, 388–397.

17. Kellems, R.; Eichelberger, C.; Cacciatore, G.; Jensen, M.; Frazier, B.; Simons, K.; Zaru, M.; Zaru, M. Using video-based instruction via augmented reality to teach mathematics to middle school students with learning disabilities. *J. Learn. Disabil.* **2020**, 1–15. [CrossRef] [PubMed]

18. Contreras, D.; Brante, M.; Espinoza, S.; Zuñiga, I. The effect of the integration of students with special educational needs: Evidence from Chile. *Int. J. Educ. Dev.* **2020**, *74*, 102163. [CrossRef]

19. UNESCO. Shaping the Future, We Want: UN Decade of Education for Sustainable Development. Final Report. 2014. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000230171 (accessed on 17 September 2020).

20. Tikly, L. *Education for Sustainable Development in the Postcolonial World: Towards a Transformative Agenda for Africa*; Routledge: London, UK, 2019; pp. 4–33.

21. Chen, H.; Ling, L.; Ma, Y.; Wen, Y.; Gao, X.; Gu, X. Suggestions for Chinese university freshmen based on adaptability analysis and sustainable development education. *Sustainability* **2020**, *12*, 1371. [CrossRef]

22. Burbules, N.; Fan, G.; Repp, P. Five Trends of Education and Technology in a Sustainable Future. *Geogr. Sustain.* **2020**, *2*, 93–97. [CrossRef]

23. Ministerio de Educación de Chile. Decreto 170. Fija Normas para Determinar los Alumnos con Necesidades Educativas Especiales qué Serán Beneficiarios de las Subvenciones para Educación Especial. 2009. Available online: https://especial.mineduc.cl/wp-content/uploads/sites/31/2018/06/DTO-170_21-ABR-2010.pdf (accessed on 17 September 2020).

24. Chávez, J.; Jaramillo, C. *TIC y Educación en Chile: Una Revisión Sistemática de la Literatura: Nuevas Ideas en Informática Educativa*; TISE: Santiago, Chile, 2015; pp. 221–231.

25. Sepúlveda-Valenzuela, E.; Careaga, M.; Badilla-Quintana, M.G. Intercultural talent management model and its application as an active teaching and learning strategy. Preservice teachers in a new time and space dimension: Virtuality. In *Active Learning Strategies in Higher Education: Teaching for Leadership, Innovation, and Creativity*, 1st ed.; Misseyanni, A., Lytras, M., Papadopoulou, P., Marouli, C., Eds.; Emerald: Bingley, UK, 2018; pp. 247–272.

26. Carpenter, J.P.; Morrison, S.A.; Rosenberg, J.M.; Dousay, T.A.; Romero-Hall, E.; Trust, T.; Krutka, D.G. What should teacher educators know about technology? Perspectives and self-assessments. *Teach. Teach. Educ.* **2020**, *95*. [CrossRef]

27. Carrasco-Sáez, J.; Careaga-Butter, M.; Badilla-Quintana, M. The new Pyramid of Needs for the Digital Citizen: A transition towards Smart Human Cities. *Sustainability* **2017**, *9*, 2258. [CrossRef]

28. Crook, C.; Sutherland, R. Technology and Theories of Learning. In *Technology Enhanced Learning: Research Themes*; Sharples, M., Sutherland, R., Eds.; Springer: Cham, Switzerland, 2017; pp. 17–22.

29. UNESCO. *Issues and Trends in Education for Sustainable Development*; UNESCO Publishing: Paris, France, 2018; pp. 7–235.

30. Chu, G.; Humer, I.; Eckhardt, C. Special Relativity in Immersive Learning. In *Immersive Learning Research Network, 5th International Conference on Immersive Learning*; Beck, D., Ed.; Springer: London, UK, 2019; pp. 16–29.

31. Ruiz, P. La evolución de la atención a la diversidad del alumnado de educación primaria a lo largo de la historia. Temas para la Educación. *Rev. Digit. Prof. Enseñ.* **2010**, *8*, 1–15.

32. Kanh, T.; Johnston, K.; Ophoff, J. The impact of an augmented reality application on learning motivation of students. *Adv. Hum. Comput. Interact.* **2019**, 1–15. [CrossRef]

33. Duncan, K.J. Examining the effects of immersive game-based learning on student engagement and the development of collaboration, communication, creativity and critical thinking. *TechTrends* **2020**, *64*, 514–524. [CrossRef]

34. Sırakaya, M.; Sırakaya, D. Augmented reality in STEM education: A systematic review. *Interact. Learn. Environ.* **2020**, *28*, 1–14. [CrossRef]

35. Cabero, J.; Barroso, J.; Gallego, Ó. La producción de objetos de aprendizaje en realidad aumentada por los estudiantes. Los estudiantes como prosumidores de información. *Rev. Tecnol. Cienc. Educ.* **2018**, *11*, 15–46.

36. Garzón, J.; Pavón, J.; Baldiris, S. Systematic review and meta-analysis of augmented reality in educational settings. *Virtual Real.* **2019**, *23*, 447–459. [CrossRef]

37. Chen, C.; Huang, C.; Chou, Y. Effects of augmented reality-based multidimensional concept maps on students' learning achievement, motivation and acceptance. *Univers. Access Inf. Soc. Int. J.* **2019**, *18*, 257–268. [CrossRef]

38. Cakir, R.; Korkmaz, O. The effectiveness of augmented reality environments on individuals with special education needs. *Educ. Inf. Technol.* **2019**, *24*, 1631–1659. [CrossRef]

39. Cakır, R.; Solak, E. Attitude of Turkish EFL learners towards e-learning through tam model. *Procedia Soc. Behav. Sci.* **2015**, *176*, 596–601. [CrossRef]

40. Wook Ok, M.; Haggerty, N.; Whaley, A. Effects of video modelling using an augmented reality iPad application on phonics performance of students who struggle with reading. *Read. Writ. Q.* **2020**, *36*, 2–16.

41. Cabero, J.; Barroso, J. Ecosistema de aprendizaje con realidad aumentada: Posibilidades educativas. *Rev. Tecnol. Cienc. Educ.* **2016**, *5*, 141–154.

42. Blázquez, A.; Realidad Aumentada en Educación. (Universidad Politécnica de Madrid, Madrid, Spain, Gabinete de Tele-educación). Personal Communication, 2017.

43. Cabero, J.; García, F. *Realidad Aumentada*; Síntesis: Madrid, Spain, 2016.

44. Moreno, N.; Franco, R.; Franco, A. Realidad aumentada en química: Experiencia en educación secundaria a través de Elementos 4D. *J. Sci. Educ.* **2018**, *2*, 71–94.

45. Küçük, S.; Kapakin, S.; Göktaş, Y. Learning anatomy via mobile augmented reality: Effects on achievement and cognitive load. *Anat. Sci. Educ.* **2016**, *9*, 411–421. [CrossRef]

46. Johnson-Glenberg, M.; Megowan-Romano, C.; Birchfield, D.; Savio-Ramos, C. Effects of embodied learning and digital platform on the retention of physics content: Centripetal force. *Front. Psychol.* **2016**, *7*, 1–22. [CrossRef]

47. Baragash, R.S.; Al-Samarraie, H.; Moody, L.; Zaqout, F. Augmented reality and functional skills acquisition among individuals with special needs: A meta-analysis of group design studies. *J. Spec. Educ. Technol.* **2020**, 1–8. [CrossRef]

48. Howorth, S.; Rooks-Ellis, D.; Flanagan, S.; Woom Ok, M. Augmented reality supporting reading skills of students with autism spectrum disorder. *Interv. Sch. Clin.* **2019**, *55*, 71–77. [CrossRef]

49. Careaga, M.; Jiménez, L.; Badilla, M.G. School networks to promote ICT competences among teachers. Case study in intercultural schools. *Comput. Hum. Behav.* **2014**, *30*, 442–451.

50. López, P.; Barreto, A.; Mendoza, E.; Del Salto, M. Bajo rendimiento académico en estudiantes y disfuncionalidad familiar. Low academic result in students and dysfunctional families. *Medisan* **2015**, *19*, 1163–1166.

51. Kyttala, M.; Kanerva, K.; Munter, I.; Bjorn, P.M. Working memory resources in children: Stability and € relation to subsequent academic skills. *Educ. Psychol.* **2019**, *39*, 709–728. [CrossRef]

52. Quinn-Nilas, C.; Kennett, D.; Maki, K. Examining explanatory style for failure of direct entry and transfer students using structural equation modeling. *Educ. Psychol.* **2019**, *39*, 749–767. [CrossRef]

53. Núñez-Peña, M.; Bono, R. Academic anxieties: Which type contributes the most to low achievement in methodological courses? *Educ. Psychol.* **2019**, *39*, 797–814. [CrossRef]

54. Stankov, L.; Lee, J. Quest for the best non-cognitive predictor of academic achievement. *Educ. Psychol.* **2014**, *34*, 1–8. [CrossRef]

55. Liem, G.A.; Tan, S.H. (Eds.) *Asian Education Miracles: In Search of Sociocultural and Psychological Explanations*; Routledge: New York, NY, USA, 2019.

56. Serna, E.; Duran, V.; Pedraza, A. Learning Styles and Academic Achievement. *Rev. Horiz. Pedagógicos* **2014**, *16*, 42–54.

57. Jones, H.; Black, B.; Green, J.; Langton, P.; Rutherford, S.; Scott, J.; Brown, S. Indications of knowledge retention in the transition to higher education. *J. Biol. Educ.* **2015**, *49*, 261–273. [CrossRef]

58. Innovavión.cl. Llega la Realidad Aumentada a las Salas de Clase en Chile. 2018. Available online: http://www.innovacion.cl/2018/12/llega-la-realidad-aumentada-a-las-salas-de-clase-en-chile (accessed on 30 September 2020).

59. Bloxham, J.; Wileman, S. Evidence of pedagogical and learner outcome improvements through the use of augmented reality. *J. Virtual Stud.* **2016**, *7*, 26–33.

60. Rosas, R.; Peréz-Salas, C.; Olguín, P. Pizarras Interactivas para un Aprendizaje Motivado en Niños con Paralisis Cerebral. *Estud. Pedagógicos.* **2018**, *36*, 191–209. [CrossRef]

61. Weber, P.; Lehr, C.; Gersch, M. Improving virtual collaborative learning through canonical action research. *Electron. J. ELearn.* **2014**, *12*, 313–338.

62. Careaga, M.; Sepúlveda-Valenzuela, E.; Badilla-Quintana, M. Intercultural talent management model: Virtual communities to promote collaborative learning in indigenous contexts. Teachers' and students' perceptions. *Comput. Hum. Behav.* **2015**, *51*, 1191–1197. [CrossRef]

63. Ministerio de Planificación de Chile. Ley no. 20.422. Establece Normas Sobre Igualdad de Oportunidades e Inclusión Social de Personas con Discapacidad. 2011. Available online: https://www.leychile.cl/Navegar?id Ley=20422 (accessed on 17 September 2020).

64. The Nation's Report Card. How Did U.S. Students Perform on the Most Recent Assessments? 2019. Available online: https://www.nationsreportcard.gov/ (accessed on 17 September 2020).

65. Cohen, L.; Manion, L.; Morrison, K. *Research Methods in Education*; Routledge: Oxon, UK, 2013.

66. Ministerio de Educación de Chile. Bases Curriculares 3º y 4º Medio Ministerio de Educación. 2019. Available online: https://curriculumnacional.mineduc.cl/614/articles-91414_bases.pdf (accessed on 17 September 2020).

67. Keller, J.M. Challenges in learner motivation: A holistic, integrative model for research and design on learner motivation. In Proceedings of the 11th International Conference on Education Research (ICER): New Educational Paradigm for Learning and Instruction, Seoul National University, Seoul, Korea, 30 September–1 October 2010.

68. Field, A. *Discovering Statistics Using SPSS*, 3rd ed.; Sage: London, UK, 2009; pp. 627–685.

69. Fernández, B. Aplicación del Modelo de Aceptación Tecnológica (TAM) al Uso de la Realidad Aumentada en Estudios Universitarios. Ph.D. Thesis, Universidad de Córdoba, Córdoba, Argentina, 2017.

70. Kotkas, T.; Holbrook, J.; Rannikmae, M. A theory-based instrument to evaluate motivational triggers perceived by students in STEM career-related scenarios. *J. Balt. Sci. Educ.* **2017**, *16*, 836–854.

71. Adams, A.; Glenberg, A.; Restrepo, M. Moved by Reading in a Spanish-Speaking, Dual Language Learner Population. *Lang. Speech Hear. Serv. Sch.* **2018**, *49*, 1–13. [CrossRef] [PubMed]

72. Ohlsson, S. *Deep Learning: How the Mind Overrides Experience*; Cambridge University Press: Cambridge, MA, USA, 2011; pp. 3–23.

73. Appio, F.P.; Lima, M.; Paroutis, S. Understanding Smart Cities: Innovation ecosystems, technological advancements, and societal challenges. *Technol. Forecast. Soc. Chang.* **2019**, *142*, 1–14. [CrossRef]