Designing a Mobile Application using Augmented Reality: The Case of Children with Learning Disabilities

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***Abstract*—The learning disorder has several difficulties to learn correctly; in many cases they have more stress because they do not understand the subjects proposed by the teacher. The aim of the research is to propose an innovative plan to design a mobile application for the treatment of learning disabilities using augmented reality in primary education. In this way, we used a methodology called Design Thinking that has five phases, empathize, define, devise, prototype and testing, which facilitates us in identifying the problems for itself to have solutions to these problems. For the prototype we used tools such as Marvel App, which is responsible for the layout of the mobile application. TinkerCad allows us to design the 3D model of the educational games and finally App Augmented Class to create the augmented reality model. The results obtained were through a survey about the prototype; identifying the acceptance about the prototype by parents for the usefulness of this idea for their children with learning disabilities, with 76% that the prototype is ideal for children. In addition, the prototype was validated by five experts, resulting in 85.4% acceptance. As a conclusion of the research is the achievement of a good design for a solution to the problems of children with learning disabilities to have a better understanding and to be free from stress.**

***Keywords*—App augmented class; design thinking; marvel App; learning disorder; TinkerCad**

I. Introduction

The learning disorder makes it difficult for the child to learn these causes correctly. These are presented worldwide, as there are various problems of language, comprehension or dyscalculia. In Jordan, it indicates that their primary school students have a lack of attention to classes, as they have a bad use of the internet, causing them to be completely distracted and prevent them from developing in their student process [1]. COVID-19 also had an impact on primary education, students were studying from home, avoiding the physical approach; they had no control over their virtual classes and were easily distracted by video games [2]. In the United States, multilingual children in most American schools are found to have language and learning disabilities [3].

In rural areas of Latin America there are difficulties in children's learning. In this way they obtain a low level in their subjects, as they do not have any learning method [4].By the end of 2021, students in Latin America will be affected by the COVID-19 pandemic, making a rapid shift from face-to-face to digital learning [5]. Brazil has 55 million people living in extreme poverty and has pre-school boys with illiteracy problems [6]. This developing, resource-poor country also analyses that 21 families believe that difficulties in learning development stem from poor social interactions, peer relationships, stress levels and communication [7].

In Peru, there were educational problems in the teaching of children during the COVID-19 pandemic [8]. They had student delays because virtual classes were not proposed. When these methods were declared, in Ayacucho and indigenous populations, they did not have these materials to carry out their classes at a distance, and also because of poor learning, the children had various problems of learning disorders [9] [10]. In this way, many children, especially in rural areas of Peru, have problems learning mathematics [11]. This also increases the level of stress, as they do not have the strategic methods for the child to be able to understand these subjects in an easy and simple way [12]. Also, dyscalculia which is a learning disorder can cause many problems at primary level and many mistakes in performing logical operations, lack of attention and concentration makes children unable to perform these functions [13] .

According to these problems at international and national level, we can see the importance of having new innovative and strategic models for students at primary level to have ease in their understanding so that they can improve these learning disorders and prepare themselves to not have any difficulties in their future life. With the proposed design for the solution of the problems of children with learning problems is helping parents where their children have these difficulties. So also with the teachers since in this way the learning of the students will be much better.

The objective proposed in this project is to develop a strategic and innovative model to solve these problems, designing a mobile application for the treatment of learning disorders, using augmented reality in primary education. Cognitive games were used to improve student learning. The structure of the paper is as follows: in Section II the literature review is explained, in Section III the methodology to be developed, in Section IV the results of our work, in Section V the discussions, in Section VI the conclusions and finally in Section VII the future work.

II. Literature Review

Augmented reality in education allows us to do didactic work as well as help us to discover new skills in children. It also implements an analysis of the impact of augmented reality in education, which indicates that teachers enable children to learn quickly and relieve their stress with the help of

augmented reality [14]. Similarly, this research analyses by Likert scale that students have more problems in the subject of geometry, and also evaluates a development of augmented reality to improve learning, indicating that 92.50% are satisfied with the use of technology and it is suitable for use in Indonesian schools [15].

In the same way, it indicates that augmented reality is used to enjoy and live a better educational experience. Therefore, the use of augmented reality was developed for the teaching of mathematics, helping to obtain a better visualisation and understanding in secondary school students. This was developed with Unity and was accompanied by the Vuforia software development kit in order to develop the augmented reality application. At the end they obtained as a result, a mobile application with augmented reality accessible to all devices that are installed in each classroom to improve the understanding of students in an easy and simple way [16].

At Sebelas Maret University, form-based tests were used with students and teachers to indicate problems in their programming education. A multimedia with augmented reality was also developed to improve critical thinking, resulting in a better understanding of basic and advanced programming [17].Something similar happens in this case, on the subject of biological education that develops an augmented reality application with Unity 3D for the training of its medical and veterinary students. Students indicate that augmented reality technology enhances their learning by demonstrating that virtual technology is a great support in their practices in human and animal anatomy [18].

On the other hand, he designed a mobile application with augmented reality, indicated that it will be the future of education. With the use of the Assembly application, he proposes that primary education can improve their learning in their computer, tablet and mobile assembly laboratories. This is done virtually, as during this pandemic, health restrictions prevented students from having contact with other people, which affected their face-to-face teaching. As a result, a survey of students showed that augmented reality design would be of great help in their laboratories [19].Similarly, in this research, it helps students to develop their knowledge in chemistry with intuitive games to learn science-related topics. This is done by combining three-dimensional objects from the virtual world to a real one, 87.90% of Indonesian students validate their improvement in their understanding of chemistry [20].

In the same way, in the business field, a mobile application is designed with the use of augmented reality to provide a multimedia marketing method with augmented reality. As a result, it was possible to improve advertising and impact users with the use of these technologies [21].This research also used Unity with the c# programming language, Blender 3D to develop a catalogue list application for the purchase of food and beverages with augmented reality. As a result, it improved the visualisation of customers observing in detail the quality of the product, gaining confidence in their purchase [22]. Finally, this article proposes to improve communications in companies, implementing an augmented reality design in animated infographics to improve their presentations, using Unity 3D to optimise communications processes resulting in the interest of new clients for their future projects [23].

The augmented reality identified by different authors in the fields of education, medicine, security, business among others, indicate the improvements that people can have when interacting with technologies. In this way, it provides ease of understanding, thus releasing stress, containing best practices in its development, so that its usefulness should be considered in problem solving. These aspects facilitate augmented reality solutions for children with learning disabilities. In this way, we will make a model for children, aiming to improve concentration in an efficient way in their cognitive development.

III. Methodology

For the development of the methodology we will use Design Thinking which will be divided into five phases (Empathise, Define, Ideate, Prototype and Test), as well as explaining the survey tools and the design of the prototype that was used.

A. Design Thinking

This methodology is focused on presenting creative solutions, generating ideas to improve society, and the methodology is of great interest to professionals because of their ability to adapt their innovative ideas [24]. The processes of Design Thinking are shown in Fig. 1. They are used to improve business environments by complementing the help of users in identifying their problems and thus solving them [25] .

1) Parent survey: A survey of parents about learning difficulties was formulated at the beginning.
2) Do children have learning difficulties ? In this first conditional we asked if they found the problems, if it was confirmed we took it into account and proceeded to the next step, if not we went back to the survey.
3) Identification of learning difficulties: In this process the children's learning problems were identified.
4) Solutions for learning disorders: In this process the identified problems are proposed to be solved.
5) Definition of the ideas of the prototype: Based on the proposed ideas, the final prototype is defined.
6) Surveys about the prototype: A survey about the prototype was formulated to parents for acceptance and development.
7) Is it an ideal prototype for children? In this second conditional it was asked if it is the ideal prototype, if it is ideal it is taken into account and if it is not, the new prototype is implemented again.
8) Innovation accepted: Finally, the prototype defined by the parents was accepted.

1) Empathise: In this first stage, it is focused on observing the needs of the users continuously through the use of interviews and surveys giving the facility to gain a better understanding of their needs [26] .

2) Define: In this second stage, the focus is on defining the user problems that are in the empathise phase so that the innovation team must consider the biggest problem impacted by the users [27].

3) Ideate: This is the third stage, which is responsible for generating innovative ideas for the problems of the defined stage, allowing the team to name the best solution [28].

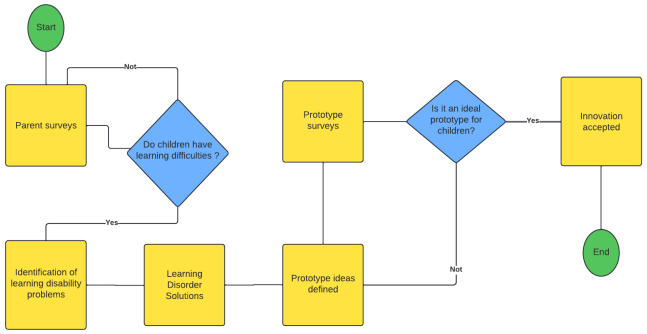

Fig. 1. Process Design Thinking.

4) Prototype: The fourth stage, prototyping, is responsible for designing the innovative solutions chosen by the working team in such a way that it uses prototyping tools [29]. Fig. 2 will show the procedure for the development of the mobile prototype with Marvel App, accompanied by a 3D modelling with TinkerCad and finally show the augmented reality with App Augmented Class.

a) Tinkercad: Tinkercad is a free tool that is used in education to design 3D objects online, its designs are made in an intuitive and easy to use way [30].

b) MarvelAPP: MarvelApp is a tool for the design of prototypes, with simple steps for its use, as well as limited templates for the user [31].

c) App Augmented Class: This application is used to design augmented reality models, it is free to use and can be downloaded from the Play Store [32].

1) Mobile prototyping with Marvel Apps: The start of this process is to make the mobile prototype to get the idea of the app's functions.
2) Make the 3D modelling with TinkerCAD: The second process was done using 3D models in TinkerCad in order to design the dynamic games for augmented reality.
3) Export the 3D model as an .OBJ file: The third process is to export the 3D models in a file called .OBJ.
4) Open the Augmented Class App : The fourth process will open the mobile application called the Augmented Class App to make the augmented reality model.
5) Import the 3D model from an .OBJ file : In the fifth process, the 3D modelling in the OBJ file was imported into the Augmented Class App application.
6) Realisation of the augmented reality: In the last process the augmented reality was realised by displaying the 3D model in the Augmented Class App.

5) Test: This is the last stage which involves surveying users about the solution and prototyping so that they give the go-ahead for development [33].

IV. Results

This section shows the results of the proposed methodology and the validation of the prototype by the experts. We will also tell the advantages, disadvantages and comparison of Design Thinking.

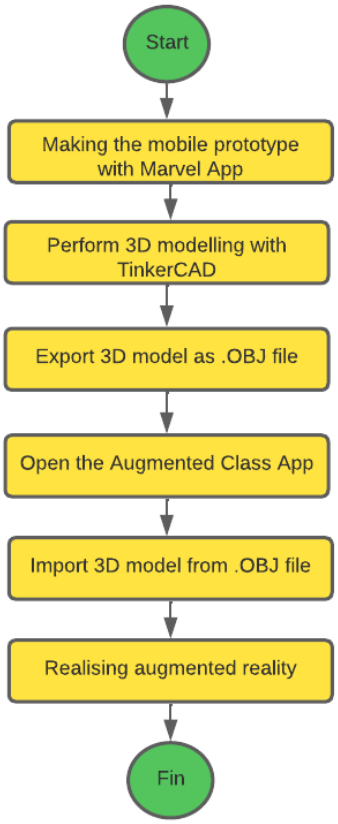

Fig. 2. The Process of Making an Augmented Reality Model.

A. Result of the Empathise Stage

Table I contains the questions (Q1 to Q6) for the survey of primary school children, asking about grade, gender, district, learning difficulty, learning stress and type of learning disability.

TABLE I. Primary Children Survey

Questions	
ID	**Questions**
Q1	Primary Child's Grade
Q2	Sex ?
Q3	In which district of Lima are you located?
Q4	Learning Difficulty?
Q5	Stress when studying?
Q6	What type of learning disability does the child have?

B. Result of the Define Stage

Table II indicates the 70 questionnaire responses (R1 to R6) from the first stage of Table I for parents. They are also responsible for identifying their children's learning problems at school.

TABLE II. PARENTS' RESPONSE TO THEIR CHILDREN

Answers	
ID	Answers
R1	First Grade 8.6%, Second Grade 24.3%, Third Grade 38.6%, Fourth Grade 14.3%, Fifth Grade 5.7%, Sixth Grade 8.6%.
R2	Female 40% Male 60%
R3	Puente Piedra 8.6%,Los Olivos 27.1%,Carabayllo 28.6%,San Martín de Porres 15.7%,Comas 17.1%,Rimac 2.9%
R4	Yes 85.7% , No 14.3%
R5	Yes 81.4% , No 18.6%
R6	Dyslexia 15.7%,Dyscalculia 54.3%,Dysgraphia 21.4%,Dysphasia 8.6%.

a) R1: According to the 70 responses, this indicates the number of pupils surveyed in primary school, Grade 1 has 8.6%, Grade 2 has 24.3%, Grade 3 has 38.6%, Grade 4 has 14.3%, Grade 5 has 5.7% and Grade 6 has 8.6%.

b) R2: It indicates that in the survey 60% are male students and 40% are female students.

c) R3: The students from Lima-Peru with the highest percentage are from the district of Carabayllo with 28.6%, Los Olivos 27.1%, Comas 17.1%, San Martín de Porres 15.7%, Puente Piedra 8.6%, Rímac 2.9%.

d) R4: 85.7% of students in primary education have learning difficulties and the other 14.3% have no learning difficulties.

e) R5: 81.4% of students in primary education have increased stress in their studies and the other 18.6% have no stress.

f) R6: This indicates that the students surveyed have different learning disorders and that the greatest impact of the students is Dyscalculia with 54.3%, Dysgraphia 21.4%, Dyslexia 15.7% and Dysphasia 8.6%.

C. Result of the Ideate Stage

Table III indicates the solutions (S1 to S3) proposed by the innovation team. Giving an estimated score for the choice of the best idea and completing its development in the next phase.

TABLE III. SCORING IDEAS

Punctuation of the Ideas		
Solutions	Innovation Team	Total
S1	Making a mobile application with augmented reality	58 points .
S2	To realise a website for your learning development	34 points .
S3	Implementing new learning methods in classrooms	20 points.

a) S1: The first solution will be the chosen one, as it has a high score of 58 points scored by the innovation team. This solution proposes the creation of a mobile application with augmented reality.

b) S2: The second solution that was not chosen but can be taken into account in future projects; it has a score of 34 points scored by the innovation team. Proposing to create a website for the development of their learning.

c) S3: The third solution that was not chosen but can be taken into account in future projects has a score of 20 points scored by the innovation team. Proposing to implement new learning methods in the classroom.

D. Result of the Prototyping Stage

Fig. 3 shows the model of the mobile application so that users who have a registered account can log in. If they do not have an account, they can register correctly, and if the user forgets their password, they will have the opportunity to recover it by sending an email to change their password.

Fig. 3. Mobile System Login

Fig. 4 shows the model of the mobile prototype so that the user can request a change of password by sending an e-mail for modification. Once the user has accepted the request, a new password can be set.

Fig. 4. Password Recovery

Once logged in to the mobile application the user can choose the learning disorder problem that counts, Dyslexia, Dysgraphia, Dyscalculia and Dysphasia as shown in Fig. 5.

Fig. 6 shows the level of the game so that the child can carry out his or her treatments by showing his or her name and age. The word-forming game consists of the child with dyslexia problems observing the letters and being able to form the word.

Fig. 7 shows the level of the game for the child with his name and age with his respective Dysgraphia problem. It consists of drawing the line of the picture using a pencil; the child can also count on a stable treatment.

Fig. 8 shows the level of the game so that the child with his name and age with his respective problem Dyscalculia. It consists of performing operations, in this case subtraction, so that the child can strengthen his knowledge dynamically and select the correct option.

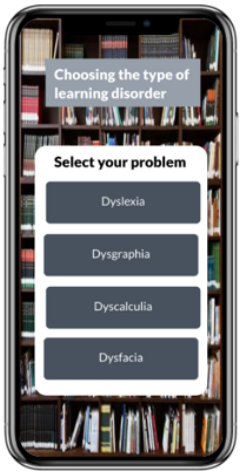

Fig. 5. Selection of Learning Disability

Fig. 6. Educational Game for Dyslexia

In Fig. 9 shows the level of the game for the child with his name and age with his respective problem Dysphasia, which consists of the child speaking slowly, pronouncing each letter, with the aim of improving the form of communication .

E. Responses from the Testing Phase

Table IV show the questions for the parents about the final prototype that was used for the input and improvement of their children with learning disabilities. Also, this interaction will serve to know the opinion, as well as the importance of the application on their stress treatment and cognitive improvement.

Fig. 10 shows the answers to the questions in the testing phase. In Q1, 76% responded that it is the ideal prototype for the children, 76% of the respondents found it very interesting and 24% did not, in Q2 they responded that the application will help in the treatment of learning disabilities, 76% agreed and 24% disagreed, in Q3 it indicates the improvement of stress, and in Q4 it indicates that 74% of the parents are confident that it does improve stress and 30% do not, in Q4

Fig. 7. Educational Game for Dysgraphia

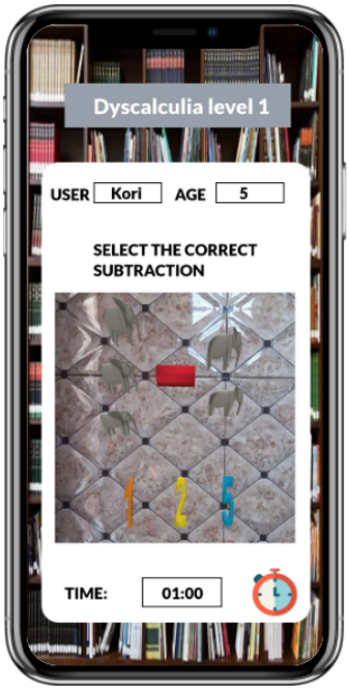

Fig. 8. Educational Game for Dyscalculia

Fig. 9. Educational Game for Dysphasia

TABLE IV. QUESTIONS FOR PARENTS ABOUT THE PROTOTYPE

Question about the prototype with augmented reality	
ID	Questions
Q1	Is the prototype ideal for your children?
Q2	Do you think it will help in their treatment of children?
Q3	Will this application improve children's stress?
Q4	Do you recommend a family member to use this application to improve the treatment of the learning disability?
Q5	Do you recommend private and public schools to implement this mobile application with augmented reality?

it indicates that 74% of the parents are confident that it does improve stress and 30% do not, in Q4 it indicates that the application will help in the treatment of learning disabilities. Likewise, 70 per cent are confident that it does improve stress and 30 per cent are not, in Q4 it indicates that 74 per cent of parents recommend that family members or close friends use the application for the treatment of learning disorders and 26 per cent do not, and finally in Q5 they responded that 78 per cent would recommend public and public schools in Peru to implement the mobile application with augmented reality and 22 per cent responded that they would not.

F. Expert Validation of the Prototype

This validation was carried out with 5 experts who will be in charge of scoring the four criteria (Functionality, Usability, Consistency and Integration). These validations were carried out on the final prototype, ensuring that it will be acceptable by the experts.

In Table V the scales Low, Moderate and High were considered. Low will have a range of 0% to 49% indicating that it would not be accepted, Moderate will have a range of 50% to 79% indicating that the prototype can be improved and High will have a range of 80% to 100% indicating that it would be an acceptable prototype.

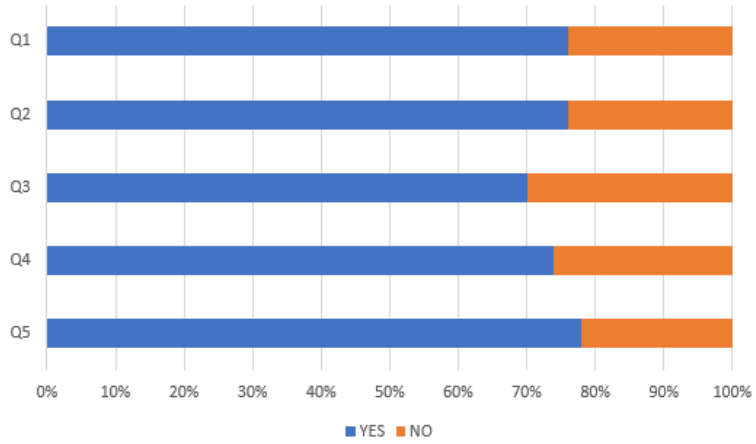

Fig. 10. Response from the Testing Phase

TABLE V. LEVEL OF ACCEPTANCE

Level		
Under	**Moderate**	**High**
0% - 49%	50% - 79%	80%- 100%

Likewise, to find the total percentage, it was calculated as the average of the four criteria, in percentages.

Table VI shows the scores of the five selected experts, so each expert will have to score each validation from 1 to 100, and finally the result shows the level of acceptance of the prototype.

TABLE VI. QUESTIONS TO EXPERTS

Question about the prototype with augmented reality						
Experts	Functionality	Usability	Consistency	Integration	Total	Level
Expert 1	80%	85%	83%	90%	85%	High
Expert 2	90%	85%	95%	80%	88%	High
Expert 3	73%	89%	85%	90%	82%	High
Expert 4	89%	92%	90%	97%	92%	High
Expert 5	75%	76%	86%	84%	80%	High

Finally, Fig. 11 shows the 5 validating experts with a high level, i.e. the prototype has a level of acceptance by each expert. Expert 1 indicates a high level with 85%, expert 2 indicates a high level with 88%, expert 3 indicates a high level with 82%, expert 4 indicates a high level with 92% and expert 5 indicates a high level with 80%. The overall average is 85.4% acceptance.

G. About the Methodology

1) Advantages: The Design Thinking methodology was used to bring innovative ideas to meet user needs. This allowed us to have a dynamic teamwork to be able to bring new ideas to society and to improve the decision making process. This also allows us to see the creativity of the team and also the analysis that leads to the understanding of the problems towards the users.

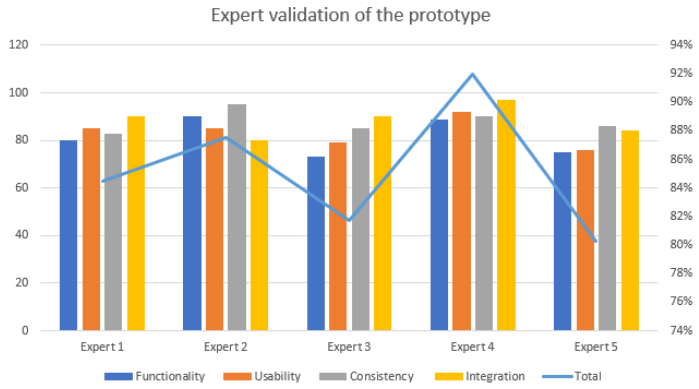

Fig. 11. Expert Validation of the Prototype

2) Disadvantages: The disadvantages of the Design Thinking methodology is that it is more dedicated to the prototyping of innovative ideas and not to the development of the application. In this sense, it should be considered that this methodology can go hand in hand with another methodology for the development of the proposal.

3) Comparison: The 5-phase methodology helped us to speed up the process of analysis and creative ideas for prototyping. Compared to other methodologies that focus on the development of the application, these include proposing innovative plans for the contribution to society.

V. Discussion

It is analysed that our proposal as a solution with the use of augmented reality is a good strategy, it is also integrated that the survey method that was effective for stakeholders to analyse their problems is valid for the search for solutions, this coincides with the author [15], who evaluated the problems based on surveys, proposing the use of technology to improve student learning. Similarly in the author [19], who conducted an analysis of the respondents, finding serious problems in students with learning disabilities so he proposes the use of augmented reality for computer, tablet and mobile assembly labs. In addition, the proposed design of a mobile application with augmented reality is a perfect combination as nowadays people handle their mobile devices anywhere, which results in user satisfaction. These results agree with the author [21], as he proposes a variety of mobile designs with augmented reality for advertisements in order to impact your customers with the use of technologies. In the same way, he indicates that the intuitive games with augmented reality in the [20] leads to a good result, validating an increase in learning and comprehension in his students.

VI. Conclusion

This model of an augmented reality application is developed to improve learning disabilities. In the prototype educational games were made to have a better understanding, since the survey identified that children have problems with Dyslexia, Dyscalculia, Dysgraphia and Dysphasia. Design Thinking allows us to have a greater analysis of the problems in search of the needs of users, helping us to have a variety of creative and innovative solutions. This contribution of the design of a mobile application for the treatment of learning disorders using augmented reality in primary education would be of great help to have an adequate treatment in children with the use of technologies, allowing to improve their stress level and to have a greater understanding in their subjects. A limitation of the research that was identified was the development of mobile application and augmented reality, since the methodology used only focuses on the design of innovative prototypes for problem solving.

VII. Future Work

It is suggested that the proposed research be considered for future work and that a virtual reality application be developed. In this way, children with learning disabilities can have a maximum technological experience. In addition, the research should be carried out in an interdisciplinary and multidisciplinary way, i.e. it is suggested that specialists in learning disabilities such as a psychologist, among others, be incorporated.

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