

DESIGN THINKING AS A RESEARCH-METHOD TO DELIMIT THE REQUIREMENTS OF AN INTERACTIVE ENVIRONMENT FOR LEARNING ENGLISH IN EARLY CHILDHOOD THROUGH AUGMENTED REALITY

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Abstract

Language in teaching and learning environments have been using Information and Communication Technologies (ICTs) due to their potential as a powerful pedagogical tool. This research work aims at assessing some factors that facilitate and hinder the sound pedagogical use of ICTs within the context of English as a Second Language (ESL) at the early childhood education level, using Design Thinking (DT) as a method to define the requirements of a great use of emerging technologies in education. The goal of such analysis is to enable an interactive design which not only promotes the efficient use of emerging technologies, such as Augmented Reality, but also combines the benefits of incorporating multisensory components and the game-based learning, so that design becomes more inclusive, thus bridging the gap of the current digital divide. In order to understand the needs of an environment ideal for an adequate exploitation of technological resources in the learning process, this Design (DT) methodology leads us to empathize with the direct and indirect users (Students/teachers) and also the socio-economic dimension of the educational institutions willing to invest on the use of ICT-based tools for meaningful and innovative language teaching. Therefore, to meet this aim, two ad hoc questionnaires were handed out to school executives and teachers, respectively, in the specific educational context of Barranquilla, Colombia. The surveys were applied to n=25 preschools. The qualitative data analysis made with SPSS, showed the importance and the need to integrate in the school curriculum technological tools that both improve knowledge and skills, allow for the pedagogical assessment and monitoring of pupils. In the other hand, showed the importance of a design that does not generate frustration due to the fact that some teachers might have low levels of technology training or some difficulties with self-generation contents. Certainly, schools where the socioeconomic aspects are low indicate a scarce tendency towards the use of ICT in the classrooms, as well as poor investment on educational tools from the main directors to facilitate the learning process. In the analysis of the emerging technologies, contrasted with these results (user's characterization), Augmented reality seems to be the appropriated technological tool to insert ICT in classroom. This first methodological step leads us know the characteristic of the prototypes in design terms and will define the needs in this specific context (Barranquilla), in order to develop an interactive environment of English language learning addressed to early childhood education.

Keywords: Early Childhood Education, Information and Communication Technologies, Augmented Reality, Design Thinking.

1 INTRODUCTION

In recent years, Information and Communication Technology (ICT) has been present in different fields of human life. Education has been one of those areas where the positive effect of technological advances has produced important changes [1]. Most of all, there is evidence of advantages in teaching and learning methods at the educational level [2]. These advantages demand constant pedagogical innovation, in which teachers and educational centers are immersed [3]. For this reason, the emerging changes propelled by technology have made support frameworks necessary to guarantee a digital pedagogy that is responsible and coherent [4] with the training structures where, in addition, it is possible to draw a results curve that demonstrates the efficiency of the incorporation of ICT in education.

ICT offers different novel possibilities to be integrated into the area of education [5]. Emerging technologies such as Virtual Reality (VR), interactive applications or Augmented Reality (AR) [6] are increasingly becoming more frequent in pedagogical solutions and new learning strategies [7]. It is estimated that, according to the NMC Horizon Report, this type of technology will be in a state of development in the next 3 years.

Confronted with this trend, it is important to consider the design of interfaces developed under the lens of a methodology that allows for more relevant digital interactions focused on real contexts. There are several methodologies for the design of ICT tools that favor teaching processes [8], many of them are focused on the end user. As part of a research project under development, and throughout this article (paper), the characterization of a specific educational context and a model to establish the design requirements of an ICT environment for the teaching of a second language (L2) in early childhood through Augmented Reality (AR) will be analyzed, through the methodology of Design Thinking. This method seeks not only to know the needs of the end user, which in many cases are the students, but the needs of all the users involved, such as teachers and the directors of the institutions who, usually, are the ones who invest in these products depending on the value they generate compared to the tangible academic results that are evident after their use.

2 BACKGROUND: CONCEPTS AND FUNDAMENTALS

2.1 ICT in teaching

In most cases, the use of ICT is directly related to a series of variables that make it possible to integrate ICT into the classroom, such as: the development of technology, the training of users in relation to their use, didactic and pedagogical debates, in addition to the educational policies that are developed around the technological resources [9]. In this sense, the integration of ICT to education questions the strategies and policies used by some governments and institutions [10] by focusing their technological appropriation on insignificant experiences or on resources that do not make it possible to measure technological efficiency [11] associated to the inherent needs of the teaching environments in which these resources will be applied. On the contrary, integration of ICT often corresponds to imported technologies without taking into account that they were created for other purposes, or in different contexts.

In Colombia's case, the government's actions, from its Ministry of ICT, favor the use and technological access in education from two major aspects: connectivity and the number of computers per student (technological resource), the latter being the one that represents a greater impact at an educational level, and by which the advances are measured in terms of ICT incorporation in education. An indicator suggests that Colombia went from having 24 children per computer in 2010 to 4 children per computer in 2018, [12] and since 2015 the delivery of tablets has been added to this government strategy with the goal of minimizing the country's digital divide. However, what happens with these technological resources and how they are used, is another discussion that opens the doors to this research.

In this report, the teachers and directors of the school institutions created a list of the resources they had, since this is the key to determining their contact with technology and, in some way, measuring its effective use; two variables necessary to incorporate emerging technologies into this particular environment and to be efficient at work.

2.2 The second language and the sample's context

In recent years there has been growing concern about the levels of English achieved by students in Latin America. According to the Educational Program of the Inter-American Dialogue and Pearson, the causes that impede the significant advance in the aspects that concern the second language (for Latin American effects: English), revolve around the scarce preparation of teachers and the public policies deficiency to adequately promote learning [13].

Other sources of information, such as EF EPI of Education First report, position Colombia, after a thorough evaluation, in 12th place among 18 Latin American countries, with a "very low" level of proficiency.

These results have made the government officials commit themselves much more with the learning of the second language, giving priority to this aspect in the education of official schools and encouraging the learning of the English language in the early school years, as mentioned by Rosa María Cely [14], manager of "Colombia Bilingüe" of the Ministry of Education. Her bet reinforces the intentions of changing the worrying figure that makes up the percentage of students from schools who barely reach the Pre-intermediate or B1 level, which only corresponds to 5.6% of the graduate student population [15].

For this reason, the purpose of this study will be based on the learning characteristic of the second language and the impact that the use of ICT has on it, in a context where progress has been slow, but the government's intentions regarding this issue have opened the door to implementing pedagogical and technological improvements in education.

2.3 Augmented reality (AR)

AR is considered one of the emerging technologies of these days. It allows virtual objects in 3D and 2D, previously generated by a computer, to appear mixed within the environment that the camera is seeing on the device that it is being used (e.g. tablets or cell phones). It is possible to implement this technology thanks to two elements: the first corresponds to the markers, also known as QR codes, to produce virtual objects. The second element does not require any marker and is based on location sensors of mobile devices thanks to GPS location technology. [16]

AR became popular among educational researchers, due to the growing demand from teachers who use digital pedagogy to teach in an innovative way. Such interest has made the educational community recognize the pedagogical possibilities offered by AR and other emerging technologies [17].

AR became an excellent tool whose dynamism has allowed it to be applied often in didactic teaching purposes, thanks to the fact that it combines imagination through virtual content, making children feel immersed in a parallel reality that is not alien to them, [18] and allows them to better understand the contents while their motivational levels increase, as well as their interest in learning [19].

2.3.1 Works related to the learning of a second language L2.

There is a variety of teaching tools that use AR to learn a second language. One of the traditional methods used with this technology is based on "flashcards", where the student can learn vocabulary in a different way by using picture cards and a technological device with an integrated camera. This model makes it possible to see objects in the third dimension and from multiple optics while discovering the meaning of words through a visual resource.

An experiment conducted by Santos et.al. (2016) [20] reported that learning using AR significantly reduces cognitive load and improves attention by increasing levels of user satisfaction. This could be evidenced by using a traditional teaching method with one group, while the other group was given flashcards with the AR application.

Similar to this, we can find many new developments around AR in the teaching of the second language. The University of Oregon in the United States is one of the most influential universities in the creation of AR-based games through the Center for Applied Second Language Studies [21]. Their design was taken into account to create the requirements matrix of this research.

2.4 Research objective

The objective of this document is to show, through the Design Thinking method, a route that allows to establish the necessary requirements to develop an interactive design for learning English, taking into account the advantages of emerging technologies such as AR and studying the particular context of the preschools in the city of Barranquilla, Colombia. With this methodological resource, we will involve all the users benefited by this development (Managers, teachers, and students) into the creative process that will solve the problems encountered by the effective use of ICT in the teaching process.

3 METHODOLOGY

The methodology used for the present study is based on a human-centered strategy and its focus is on innovation. It is about looking at new options to solve problems through empathy and user collaboration.

3.1 Design Thinking

The term Design Thinking was popularized by the design consultancy agency IDEO and especially by its CEO Tim Brown. According to IDEO, design thinking provides a middle ground between a problem-solving approach based on intuition and an analytical and rational thinking approach. The interesting thing about this methodology is that it proposes a combination with the principles of human-centered

Design (HCD) which involves people within the Design process as a main analysis factor, which will lead us to the discovery of the problem and, at the same time, to the discovery of the solution.

Design Thinking is divided into 5 important steps. The analysis of this research is focused on the first two steps that correspond to the understanding phase indicated in Figure 1 below.

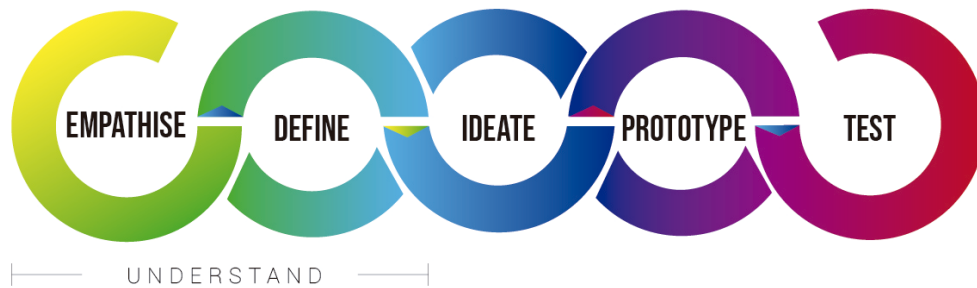


Figure 1 Design Thinking

3.2 Empathize

Empathy is the first step that involves an approach from the researcher to the users. In this research, empathy will allow us to determine the user's most underlying needs, the aspects that make them feel frustrated with the use of ICTs in the classroom, as well as their motivations and expectations. All of this will generate a new perspective through which it will be possible to intervene later.

3.2.1 Sample

The instrument was applied to $n=25$ teachers and $n=10$ managers of pre-school educational institutions. The first items of this instrument corresponded to exogenous identification variables, in order to characterize the sample.

The distribution of the nominal categorical variable regarding the sex of the teachers is distributed as 8.7% men and 91.3% women, with an average age of $M=36$ years and a standard deviation of $SD=6.95$. Their level of training indicates that 61% have training at the undergraduate level, and 39% at the undergraduate level. The sample, on average, has around 11.2 years of experience at the preschool level, with a minimum of 5 years and a maximum of 24 years of experience. The level of English of the teachers is 17.4% for A1, 13% for A2, 17.4% for B1, 26.1% for B2, 8.7% for C1, 4.3% C2. 13.1% mentioned not knowing at what level they were. 28% of the teachers belonged to official state schools and 72% to private schools. On the other hand, the sample of the Directors of the educational institutions corresponded with 50% to official state schools, and the other 50% to private schools.

3.2.2 Method

The approach to ICT users in teaching L2 begins with a questionnaire as a data collection strategy. The obtained information is of a mixed nature: quantitative and qualitative, under a descriptive structure. The instrument consisted of a questionnaire designed ad hoc to complete the first methodological phase.

3.2.3 Instrument

The instrument was composed of identification variables (sex, age, educational institution, years of validity, technological resources available, level of English of the teaching staff, typology of the school, socioeconomic strata, among others), with a total of 17 items. In turn, 17 other items were created, which corresponded to independent variables that sought to shine a light on the needs related to learning environments that incorporate ICT, the importance they give to their use in the teaching of L2, and the available technology in the institutions, through a Likert rating scale (Always = 4, Frequently = 3, Sometimes = 2, Never = 1).

These items of independent character were put to the Cronbach's Alpha test, where a score of 0.851 was obtained. This score, according to the psychometric analysis, is considered as a high degree of reliability (Cronbach, 1951).

Table 1 Ad Hoc Questionnaire

Common questions	Q1	You consider it vital to use didactic materials within the teaching process.
	Q2	You have technological resources for teaching the second language.
	Q3	Students have better results when they use additional learning resources (didactic materials or digital resources – ICT)
	Q4	The curricular structure of the second language teaching programs uses new information technologies as a mean to favor the significant learning of the second language.
	Q5	You have resources that allow you to evaluate your students when they use didactic and/or support materials in the teaching process.
	Q6	The contents of the second language teaching program are aligned with the National Plan of Bilingualism of Colombia (PNB).
	Q7	The contents of the second language teaching programs are updated annually.
	Q8	You have mechanisms to prevent the possible learning difficulties of your students.
	Q9	The technological platforms that require you to generate your own learning content seem frustrating.
	Q10	The classrooms have all the necessary resources for quality teaching.
Independent questions	Q11	The contents of the second language teaching program include graphic representations that facilitate the understanding and application of the new language.
	Q12	The children's work centers facilitate their integration in the development of learning activities.
	Q13	You consider it useful that the didactic materials that you use in the learning process be inclusive, whether physical or digital.
	Q14	You invest in teaching materials to support lesson development.
	Q15	You invest in digital and/or multimedia resources to facilitate teaching.
	Q16	You invest in the training of teachers to keep them up-to-date with the New ICT and new contents.
	Q17	The academic courses have up-to-date educational software or licenses.

3.3 Defining

Once we understand what the underlying needs are, and the resources available to the educational institutions are identified, the second phase of this methodology suggests clearly defining the problem that will give way to the creative process to find the solution to it. A bibliographic review was conducted, which allowed combining different theories which established the categories that the final design should have, and they were indicated in a matrix of requirements in order to later understand the questionnaire carried out in the first phase, in light of the discovered needs.

In turn, the defined matrix determines the characteristics that ICT must have according to the considerations identified by the digital divide. This gap implies three facets according to Mancinelli (2008) [22]: the access gap, which implies having access to primary technological resources; the use gap, which refers to those who have access, but are not users; and the quality of use gap, which evaluates the differences between the participation of those who have access and those who are users. This research will take into account the second gap, considering that connectivity is already a resource insured by the country's coverage.

The models and theories that were taken into account were based on authors such as Almuwil, Weerakkody, and El-Haddadeh (2011) [23]; Bradbrook, Gail and Fisher (2005) [24].

4 RESULTS

The results that evaluated the experience of the first phase of the methodology are structured in two blocks: Table 2 shows a comparison of the descriptive statistics obtained from the questionnaire items that correspond to the directors, and then to the teachers. The first 10 questions (Q1 - Q10) correspond to an approach that was made to both directors and teachers because they are "common

questions". The following 7 (Q11 - Q17) correspond to relevant questions that could only be answered by a particular group of respondents.

In Table 2, it is possible to see the average scores with their corresponding standard deviations and percentages based on the answers given by the respondents.

Table 2 Descriptive Statistics: Directors and Teachers

	SCHOOL DIRECTORS (D)						TEACHERS (T)						
	\bar{x}	σ	S	F	A	N	\bar{x}	σ	S	F	A	N	
COMMON QUESTIONS	Q1	4	0	100%	0%	0%	0%	3,92	0,28	92%	8%	-	-
	Q2	3	1,24	50%	20%	10%	20%	3	1,04	40%	44%	-	16%
	Q3	3,6	0,51	60%	40%	-	-	3,64	0,49	64%	36%	-	-
	Q4	3,1	0,99	40%	40%	10%	10%	3,4	0,87	56%	36%	-	8%
	Q5	3,1	0,99	50%	10%	40%	-	3,32	0,69	40%	12%	44%	4%
	Q6	3,7	0,48	70%	30%	-	-	3,24	0,97	48%	40%	-	12%
	Q7	3,6	0,69	70%	20%	10%	-	3,28	0,98	52%	36%	-	12%
	Q8	3,3	0,48	30%	70%	-	-	3,16	0,37	16%	84%	-	-
	Q9	2	0,81	10%	-	70%	20%	3	0,57	80%	16%	-	4%
	Q10	3,7	0,48	70%	30%	-	-	3,16	0,80	32%	60%	-	8%
INDEPENDENT QUESTIONS	Q11	-	-	-	-	-	-	3,16	0,62	24%	-	72%	4%
	Q12	3,6	0,70	70%	20%	-	-	-	-	-	-	-	-
	Q13	3,6	0,52	60%	40%	-	-	-	-	-	-	-	-
	Q14	3,6	0,52	60%	40%	-	-	-	-	-	-	-	-
	Q15	3,6	0,70	70%	20%	10%	-	-	-	-	-	-	-
	Q16	3,2	0,79	40%	40%	20%	-	-	-	-	-	-	-
	Q17	3,3	1,25	70%	10%	-	20%	-	-	-	-	-	-

Some of the important findings that we can highlight from these results are that, although the didactic materials (Q1) are considered indispensable for the teaching process (D = 100%, T = 92%) when contrasted with the investment that institutions make to facilitate these resources in order to improve teaching, we find that only 60% give priority to it (Q14). On the other hand, when the use of technological resources for particular teaching of the second language is questioned (Q2; Q4) the levels of importance are considerably reduced with indicators that are ≤ 50 [Q2 (D=50%; T=40%)] and [Q4 (D=40%, T=56%)]. Another deficit that can be observed is the lack of ICT resources that make it possible to evaluate the students' results when they use them (Q5), where, on average, 45% have access to this type of resources (D=50%, T=40%), which are key to really measure performance. With regard to updating teaching resources of the second language (Q7) we find an average of 61% that is rigorously concerned with renewing the content annually; an important percentage, but still not enough. This is consistent with the scarce investment of only 40% made by educational institutions to train their teachers in updating content and ICT (Q16). This series of incentives promotes new training and guarantees the effective use of ICT resources for teaching-learning processes. On the other hand, there is a large deficit in the mechanisms to prevent learning difficulties [Q8 (D=30%, T=16%)]; Nowadays, technologies must guarantee that education is universal and inclusive [25]. Another consideration worth highlighting is the use of graphic representations to facilitate the understanding of L2 (Q11) which obtained only a small percentage of importance of 24%. This characteristic is highly important to help the child understand his immediate environment, especially when he approaches an unknown language (L2 learning) [26]. Finally, if we analyze the preference for the use of ICT, we can see that there is a significant frustration in teachers who are faced with generating their own resources (ICT) (Q9), as it is required by many developments or applications for teaching, indicating agreement levels of 80% with this item.

4.1 Technological resources

To get to know the use of ICT in teaching processes, teachers and managers were asked to identify what types of technological resources their school institutions had and to which of those resources they had access. With regard to this analysis, we found that 85.7% of these preschools have computers. 62.9% have a website, as well as screen projectors. 51.4% say they have and use multimedia material, and this percentage is equally shared with the possession of a sound system in the classroom. Likewise, 42.9% of the surveyed schools claim to have a microphone. The following resources begin to be scarcer: 25.7% said they have Digital Boards and cameras, tablets reach only 22.9%, and access to specialized software is only 20%.

4.2 Requirements Matrix

Once the underlying needs of the sample were identified, we went on to connect each evaluated item within a matrix that identifies various theories. The first theory quotes Bradbrook and Fisher (2005), connecting characteristics that make use of ICT for inclusive education [24]. The second theory, developed by Jan Van Dijk (2006) structures an analysis on the characteristics of the digital divide when there is novelty (ICT) or what we call emerging technologies, inequalities in the information society, and the use of digital resources [27]. Finally, some characteristics of the evaluation rubrics of technological projects of education from the Learning Impact Institute were taken as reference (to complement the previous two theories), which use criteria based on conveying, access, affordability, quality, and adoption, among others [28].

Accordingly, AR was taken as the emerging technology to be evaluated according to the criteria described in each of the aforementioned theories. After this, the expected degree of importance of each item that was developed in the first methodological phase was placed. Based on this, the underlying needs were observed, which are marked in red, based on the expected position and the results obtained by the questionnaire (see Table 3). In this way, the design will solve these incidences or present improvement opportunities to guarantee an ICT resource for teaching the L2 within a context that is more adjusted to the reality of the evaluated educational institutions.

Table 3 Requirements matrix for AR in education

Theories	Criteria for the use of AR	Basic/ scarce 0-25%	Flexible/ Moderate 25-50%	Complex/ Important 50-75%	Essential 75-100%	Demands sources
Bradbrook and Fisher 2005	Connectivity (access)				Q17	Q17
	Capacity (skills)		Q10			
	Content continuity	Q6	Q11			
Dijk 2006	Motivational access (interest in the use of ICT)			Q3		
	Material access (resource availability)			Q1, Q2	Q1, Q2	Q12, Q14
	Use access (opportunities of use)		Q7			
Learning Impact Report 2014	Improves the results in the domain of the subject, measured by the evaluations			Q3, Q5		
	Improves self-directed learning		Q9	Q4		
	Inclusive access to the population		Q8	Q13		

5 CONCLUSIONS

The data observed in the previous sections describes aspects that should be considered in the future design that will be developed for this context with the use of augmented reality. According to the results, in the first phase of the analysis, we can highlight the following requirements:

- The ICT resource must prove the benefits of its use in the context of teaching the second language to encourage investment by entities willing to provide better pedagogical support tools, as evidenced by the directors of educational institutions and the government proposals.
- ICT resources that use Augmented Reality must have systems that make it possible to evaluate the results of students to demonstrate pedagogical effectiveness and provide teachers with evaluation systems.
- An opportunity that represents a great value as a technological product will be the incorporation of a mechanism that makes it possible to identify if the student, who uses the technological resource, has a learning difficulty.
- Employ elements that facilitate the use of different senses to promote inclusion and universal design.
- The final product should facilitate the generation of content, so as to minimize teachers' level of frustration.
- In the first instance, the basic training of teachers who implement the pedagogical tool in the classroom must be guaranteed to ensure that digital educational products are used. The advantage of AR is that learning is very fast (teacher role) but the internal development of the application in order to operate requires a high investment cost and its complexity falls on the engineer or designer, which causes content's self-generation level to be reduced.

On the other hand, another of the aspects that could be observed in this study refers to the technological resources available to preschoolers in the studied context. It was evidenced that, although computers are the most popular resource, the deficit found in access to specialized software and teaching materials for English teaching shows a very large gap that reveals the existence of a difference between the availability of a resource and its effective use.

To sum up, through its method, this research has contributed to shine a light on a method that, although it is used in the field of business and design, it can be used to build a path that makes it possible to characterize and empathize with the users of ICT in the education of a specific environment. Additionally, this research has established some criteria (taken from several theories) to identify where the most immediate needs are.

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