Collaborative Learning as Educational Strategy for Deaf Children: A Systematic Literature Review

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ABSTRACT

The education of people with disabilities requires special attention and the use of teaching and learning strategies that can be adapted to every particular disability. This study focuses on the education of deaf children as part of a larger project that aims to mix teaching strategies like Logogenia and Fitzgerald Key with interactive storytelling and collaborative learning to support literacy teaching to these children. Since deaf people learn using the visual channel as main input, we believe that technology could play a key role in the development of such environments where user interfaces should be specifically designed to attract children's attention. We conducted a systematic literature review in order to find what researchers have done to apply Collaborative or Cooperative Learning in the education of deaf children and also what kind of emerging technologies are used to enhance collaborative environments. A total of 229 studies were found in 7 different databases. The results of this study show that Collaborative Learning has been used along with different kinds of technology in the education of deaf people with positive outcomes like improving skills in sign language, literacy and communication.

Interacción '17, September 25–27, 2017, Cancun, Mexico

ACM ISBN 978-1-4503-5229-1/17/09…$15.00
https://doi.org/10.1145/3123818.3123830

CCS CONCEPTS

• **Applied computing~Collaborative learning** • Human-centered computing~Collaborative interaction

KEYWORDS

Cooperative Learning; Deaf Children; Education; Systematic Review

1 INTRODUCTION

According to the World Health Organization, about 15% of the world's population are estimated to live with some form of disability which affects disproportionally vulnerable populations, mainly in lower-income countries [1]. People with deafness must use visual ways to communicate, that's why they have a special language for interaction based on signs which makes use of the body language and lip patterns [2]. These specific ways of communication, make deaf people learn at different paces compared to their hearing peers [3] (especially when sharing the same classroom) and that's why teaching/learning strategies, as well as educational tools, should be inclusive and accessible, where no matter what their abilities are, everyone in the same classroom should be able to use them. In this study, we want to know how Collaborative Learning (CL) has been applied in the education of deaf children and what emerging software-based tools have been used to support CL in order to identify how deaf children could benefit from working and learning in collaborative environments with other deaf/hearing peers.

This paper is structured as follows: section 2 presents an overview of the education of deaf children and collaborative learning as well. Section 3 presents the methodology used to conduct the systematic review. The results obtained after data extraction and analysis are described in section 4. Finally, section 5 include a set of conclusions and future work.

2 BACKGROUND

2.1 Education of Deaf Children

Prelingually deaf children face communication challenges due to the late acquisition of a first language at home, as 90% of these children have hearing parents [4][5] who do not know Sign Language (SL). SL is seen as the mother tongue of deaf community [6][7] and many countries legally recognize it as such [7][8]. Learning a first language (SL for deaf people) during the first five years of age [6] is necessary to acquire other skills such as a second language in a written form or knowledge in other areas like math and sciences [9]. According to this, a bilingual education should be adopted [10] in order to prepare deaf children for a more inclusive environment where they should not be in disadvantage with their hearing classmates.

There are different methods to teach literacy to deaf children, two of them are: Logogenia [11] which is a method that is based on Noam Chomsky's generative grammar theory and states that deaf children can learn a written language just by being exposed to it through the visual channel. The other method is called the Fitzgerald Key [12] which helps to understand the structure of grammar by assigning colors to different kinds of words, for instance, verbs, nouns, adjectives or places are differentiated by colors and that way children can learn how a phrase can be structured.

Teaching and learning strategies should be inclusive, as stated in [13] "any good teaching strategy is good not only for deaf students but also their hearing peers" and this is something that should also apply to educational tools based on technology, as designers and developers of such tools hardly ever consider the possibility of having a user with some type of disability, for instance, deafness. This is why, the design and development of educational tools and technologies should consider involving users in this process regardless of their diversity [14].

2.2 Collaborative Learning + ICT

Collaborative Learning (CL) is a learning strategy in which two or more people learn or attempt to learn something together by interacting with each other and taking advantage of one another's knowledge or skills [15][16]. CL has been shown to benefit students at social, academic and psychological levels [17]. This approach showed to be very effective as seen in [16][18][19] where students have perceived they have more control over their learning processes and the effects of this teaching strategy have a lasting effect on them. To achieve positive outcomes from CL, it must be applied in carefully crafted environments, not just technical but also social [15].

CL could be even more effective through the inclusion of ICT, since ICT facilitates student work, gives them independence and grabs their attention which in the end generates motivation according to the results found in [17]. ICT also allows the communication between peers regardless of time or location and this is a clear advantage for virtual education. New technologies like Augmented Reality (AR) have been used to promote CL [20][21][22][23] by engaging students with applications and games that superimpose virtual objects in a real world environment through computers and recent studies have shown how this technology can also be used with deaf children [24][25]. Cadeñanes and González [25] highlight how ICT such as AR avatars increased deaf children's interest in communication and improved in skills such as reading and writing.

3 RESEARCH METHOD

This study presented in this paper was carried out by following the guidelines to perform a systematic literature review in software engineering proposed by Kitchenham and Charters [26]. These guidelines define the procedures to be followed in order to identify and summarize existing data about a particular subject. In subsequent sections, the steps followed to perform this review are presented.

3.1 Research Questions

The main objective of this study was to answer the following research questions:

RQ1: How is Collaborative Learning being applied in the education of deaf children?

RQ2: What kind of technologies have been used in Collaborative Learning environments for deaf children?

3.2 Data Sources and Search Strategies

We searched for papers that are written in English and Spanish from the last five years (2012-2017) since we are interested in knowing what emerging technologies are being used in CL. The search was made in electronic databases with very specific keywords and filtering criteria. The following electronic databases were used.

English search
- IEEE Xplore (http://ieeexplore.ieee.org)
- ACM Digital library (http://dl.acm.org)
- SCOPUS (https://www.scopus.com/home.uri)
- Springer (http://link.springer.com)
- ProQuest (http://search.proquest.com)
- ERIC (https://eric.ed.gov)

Spanish search
- ProQuest (http://search.proquest.com)
- Dialnet (https://dialnet.unirioja.es)
- Redalyc (http://www.redalyc.org)

A first search in the databases included the words: Collaborative learning, Cooperative learning, deaf, children and education, but the number of papers found was really low and in some databases there where not one single paper with these terms. The keywords to address the search were reduced in order to widen the span of the search and increase the number of relevant papers found in English/Spanish, for instance, the word "children" was not included from the search because there could be studies where the focus groups are deaf adults with educational strategies that could also be replicated with deaf children. In addition,

according to the National Association of the Deaf, over the years, the most commonly accepted terms have come to be “deaf” and “hard of hearing”, so it was decided to use both of them in the search. The keywords in English were: Collaborative learning OR Cooperative learning, deaf, hard of hearing. The same words were used in Spanish without making any translation to “hard of hearing” since its translation does not represent the Deaf community but people with difficulties to hear: Aprendizaje colaborativo OR Aprendizaje cooperativo, sordos. Some of the results are depicted below:

IEEE Xplore. It has an advanced search that allows to find articles where the keywords are found in Metadata and Full Text, we decided to perform a general search to obtain as many papers as possible. After performing the following search clause, 21 papers were found.

(((“collaborative learning”) OR “cooperative learning”) AND (deaf OR “hard of hearing”))

ACM Digital library. It also has an advanced search where keywords can be found only in the title and abstract but due to the low amount of papers found we decided to use the general search and 2 papers were found.

+(“collaborative learning” “cooperative learning”) +(deaf “hard of hearing”)

SCOPUS. It allows to perform a search where the words can be found not just in the title and abstract but also in the keywords of the document. In this database, 7 papers were found.

(TITLE-ABS-KEY(“collaborative learning” AND deaf)OR TITLE-ABS-KEY(“cooperative learning” AND deaf)OR TITLE-ABS-KEY(“collaborative learning” AND “hard of hearing”)OR TITLE-ABS-KEY(“cooperative learning” AND “hard of hearing”))

Springer. This database does not allow to perform searches only in the title and abstract, instead, it performs the search finding the words in the whole document. Results from chapters of books were also included since these could be relevant for the research. 82 papers were retrieved from this database.

(“collaborative learning” OR “cooperative learning”) AND (deaf OR “hard of hearing”)

ERIC. This is probably the world's largest source of educational information and is supported by the U.S. Department of Education. With the following search clause, 9 papers were found.

(“collaborative learning” OR “cooperative learning”) AND (deaf OR “hard of hearing”)

ProQuest (English and Spanish). ProQuest was used to find papers in English and Spanish. The same structure of the command used in the previous databases was used for both searches. 80 papers were found in English and just 2 in Spanish.

(“collaborative learning” OR “cooperative learning”) AND (deaf OR “hard of hearing”)

(“aprendizaje colaborativo” “aprendizaje colectivo”) AND sordos

Dialnet. It does not have an advanced search and operators like AND/OR can’t be used. Two searches had to be performed in order to include all the words. Only 5 papers were found in Dialnet.

Aprendizaje colaborativo sordos
Aprendizaje colectivo sordos

Redalyc. Its engine does not allow to perform searches with filter or make use of operators like AND/OR, even though it is one of the most relevant databases for literature in Spanish, so we decided to perform the search using Google where we can filter a search by site and file type. In this database, 21 papers were found.

“aprendizaje colaborativo” OR "aprendizaje colectivo" sordos site:redalyc.org filetype:pdf

3.3 Management of Studies and Inclusion/Exclusion Criteria

The exclusion criteria (EC) are all the reasons why some studies found are not included into the systematic review.

- EC 1: Document not available to download
- EC 2: Document not in English or Spanish
- EC 3: Document not related to collaborative or cooperative learning and deaf people

Studies were selected for the systematic review if they met the following inclusion criteria:

- IC 1: The study was published between 2012 and 2017
- IC 2: The study focused on collaborative or cooperative learning with deaf people

3.4 Data Extraction

All the results of each database were registered in a template where we recorded all the relevant information of each paper: (a) Name of database, (b) Search terms, (c) Inclusion or exclusion criteria, (d) ID of paper, (e) Authors, (f) Paper Title, (g) Keywords, (h) DOI, (i) Year of publication, (j) Name of conference proceedings or journal in which the study was published, (k) Type of publication like chapters of books, article for a journal or conference papers.

The search of this systematic review was performed in March 2017. We obtained 229 studies from all databases. Once the inclusion and exclusion criteria were applied, only 14 papers were selected for the review process. The remainder papers were excluded since they were not focused on deaf community or

collaborative learning, for instance, the words deaf or collaborative/cooperative learning appeared in some papers only in the reference sections. Once these papers were reviewed, we noticed that 3 of them [S5, S6, S7] were based on the same study (not the same content); something similar happened with papers [S1, S9] which were also results of a same study, in other words, the 14 different papers did not represent 14 separate studies but just 11 studies that involved Collaborative/Cooperative Learning with Deaf people. Table 1 shows detailed data about the number of papers found on each database and relevant studies selected from them.

Table 1. **Summary of Search Result**

Database name	Search Results	Duplicated Papers	Relevant Papers
IEEE Xplore	21	-	3
ACM	2	-	1
SCOPUS	7	3	4
Springer	82	5	2
ERIC	9	3	1
ProQuest (Eng)	80	11	3
ProQuest (Spa)	2	-	-
Dialnet	5	-	-
Redalyc	21	-	-
Total	**229**	**22**	**14**

4 DATA ANALYSIS AND RESULTS

After reviewing the papers, we decided to consider [S5, S6, S7] as one publication since they were part of the same study, and we did the same with [S1, S9], so in total there were only 11 relevant results for this review.

The different strategies and technologies used in all the studies show the following results:

In [S1, S9] a game was built using a computer and external hardware; allowing students to work collaboratively by making decisions using body movements (jumping) and improved their motivation to learn grammar because it was enjoyable. The game also has a 'fill in the blanks' function that obtained good responses from students where most of them agreed that it helped their own learning. The conclusions of the study suggest that both functions of the system support the construction of CL environments for deaf children.

[S2] was the only study where an architecture was developed. It was made to support wireless infrastructures and mobile learning for Deaf and Hard of hearing (DHH) students. The conclusion in this study is that wireless networks and mobile devices form an attractive and helpful framework for supporting DHH students and foster collaboration in remote environments.

In [S3] the use of video streaming, whiteboards, file and application sharing in combination with sign language to support a bilingual work seems to improve the usability and interactivity between instructors and students according to the conclusions of the researchers.

The results of the study [S4] show that students had an improvement in the understanding of lip movement language after one month of using a system that presents visual animations of a face moving the lips according to the words spoken by the tutor of the class through a microphone. Unfortunately, this study does not present any collaborative strategies used to achieve these results, so it was not possible to identify how children worked in group activities.

In [S5-S7] a model and a tool was developed to support sign language understanding. In this study an AR avatar makes signs on a computer and children learn from it in a logical and sequential way to make signs, read and write, and the results reveal an improvement in all these communication skills. This study showed that by using AR avatars, child interest on learning is increased. This is something that has to be taken into account since this kind of technology is now possible through mobile devices and could be a great opportunity to promote learning of children.

The work done in [S8] is the most inclusive of all because a system was built taking into account different disabilities (visual and auditory), so it is an approach that can be used by deaf and blind people, people with low vision and people with no disabilities. The project was not tested with users since it was still in a construction phase and even though it is presented as interactive and collaborative, the strategies to achieve this are not mentioned.

In [S10] a virtual space for group learning activities was created so every student could interact through Moodle, blogs, wikis, a tool for social networking, hypermedia, video-sign language and lip-reading. The results show that the use of blogs, wikis and hypermedia was not helpful, on the contrary the use of video-sign language and lip reading was an effective strategy. It is important to bear in mind that the target group in this study was not deaf children but deaf adults, so we cannot assume the results would be the same if the strategies are applied with children.

An application for iPads was developed in [S11] which allow students to collaborate by peer-reviewing the art work of their classmates. According to the authors, after using the app, students thought they acquired knowledge and art skills easier than normal classroom lectures. They also report to enjoy collaborative learning using the application. Peer-reviewing could be a great idea to improve communication skills for deaf students through written text. This study was not focused on children, but the strategy could be easily replicated with them.

In [S12] the Google Hangouts platform was chosen for remote tutoring as a one-on-one approach between the tutor and every student. On one hand, results were positive when the student had an active participation during the remote session with the tutor

and when educational material were embedded into the session and accessible for both parties (document sharing, online homework programs and whiteboards applications). This allowed students to work directly in course materials without depending entirely on the visual communication with the tutor. On the other hand, a passive role was assumed by the students due to the lack of opportunities to collaborate when peripheral material was used in the remote tutoring (Projecting printed lecture notes, office whiteboards). This passive role forced students to depend on the visual communication channel to acquire the knowledge. So, synchronous remote tutoring holds great potential when it is used to promote active learning. This was another study that did not involve children but the strategies are suitable to be worked with them.

Another study that made use of Google platforms was [S13] where a mix of deaf, hard-of-hearing and hearing students used Google Chat and Google Documents to interact and collaborate during a series of lab sessions. Both tools were effective in fostering collaboration and allowed students to complete their work with the assigned requirements. As with previous studies, this one was not focused on children, but the tools and features that these platforms offer could be easily integrated in the education of deaf children.

An approach to facilitate the communication between DHH students and hearing students in an algebra-based statistics course can be found in [S14]. In this study, students worked in mixed groups by using a whiteboard ("low-tech" strategy) and tablets ("high tech strategy"). The former was easy to implement with no training required and was favored by the hearing and hard of hearing students. It also allowed students of the group to see others work and thus understand how they solved some problems. The latter showed that students liked the novelty of the tablet PC's and communication provided by these devices. The use of the tablets also helped students understand more clearly the work being done and they felt that the group worked more as a team. The cons of this second approach are that they were difficult to implement, due to access to the proper equipment and software, out-of-class training, and technical support. This study is from 2012 but the activities carried out were performed between 2007 and 2009, which could be the reason of the training required before working with tablets and the technical support, since it was a pretty new technology back then, but nowadays these devices are less expensive and children are more familiar with these devices and their interfaces, so this is something that could support even more the use of mobile devices for learning. In this study, the age of the participants was not mentioned, but due to it was an algebra-based statistics course, we assume that students were not children.

As this study focuses on the use of CL in the education of deaf children, we defined different categories in order to know: a) The educational objective of the study, b) what was developed or used (model, tool, platform) or used in order to achieve the educational objective, c) how researchers collected data and how they evaluated the results, d) what kinds of technologies were used during the study and e) what type of activities or strategies were applied to promote collaborative work.

Educational Objectives

2 out of 10 studies aimed to support literacy skills [S1, S5, S6, S7, S9] and 1 of these [S5, S6, S7] also focused on the acquisition of sign language. 6 studies had a different educational purpose: [S4] on developing lip movement learning, [S8] on spatial graphic representation, [S10] on e-commerce, dyscalculia and international accounting standards, [S11] on art and peer-review learning, [S12] on chemistry, [S13] on teaching and [S14] in communication among peers. The remainder studies [S3] and [S2] did not focus on any particular skill or field of knowledge.

What was developed or used?

This category involves the elements developed and/or used in order to achieve the objectives of each study: Tools which are developed as part of the study and used to support the activities carried out, Platforms or Frameworks developed also as part of the study and used to support different services and technologies, Teaching Models developed or proposed as educational support and Existing technologies used (but not developed) to support also the activities carried out.

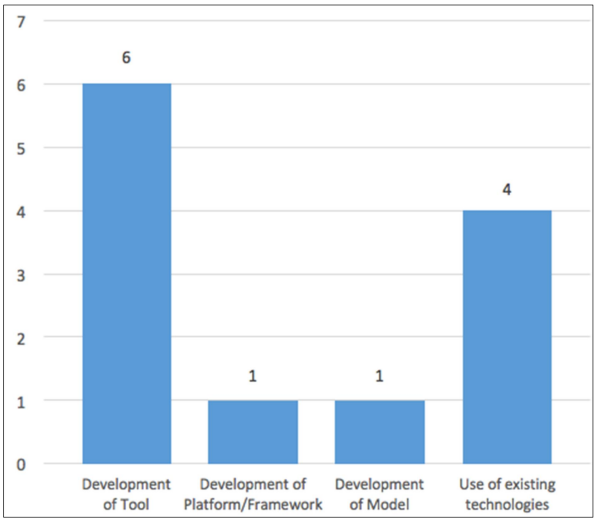

Figure 1: Elements developed or used to achieve the objectives of the study

Fig. 1 shows that 6 studies concerned the development of a tool. In [S1, S9] a Puppet Show System was designed for hearing-impaired children. [S3] shows the development of a system to create a virtual classroom for deaf people. In [S4] a system to learn lip movement language was proposed, while [S5, S6, S7] (papers that report data from the same study), show the development of a desktop Augmented Reality (AR) application and is also the only study where a teaching model was proposed. In [S8] an interface for a Virtual Environment of Education-Learning was developed for deaf and blind people but also for users without disabilities and in [S11] a system was built to allow peer-review for art education using an app developed for iPads and a server. Only 1 study [S2] focused on developing a platform

or framework, where an architecture was proposed to support Deaf and Hard of hearing (DHH) students through wireless networks and mobile learning (M-Learning). The remainder 4 studies used the integration of already developed tools like Moodle, Wikis, Blogs, social networks and hypermedia in [S10], while [S12] used Google Hangouts for remote tutoring, [S13] made use of Google Documents and Google chat for group work and [S14] compared the use of whiteboards and tablets in collaborative work.

Assessment and Data Collection Techniques

This is an important resource for researchers in order to gather information that can be evaluated and thus determine the results of the study or how effective the use of technology is [27]. Just 5 studies mention the assessment or data collection techniques used, and questionnaires or surveys were used in all of them to get data from users through using Likert scale answers [S1, S5-S7, S9, S10, S11, S14]. Two studies mention how the questions of the surveys were created: In [S5-S7] researchers designed the questions of the survey using the most relevant elements of the Principles of learning and Teaching P-12 [28] which is a set of 6 principles that can be used by schools, teams of teachers and individuals to reflect on practice and support professional dialogue to strengthen pedagogical practices. The Danielson's Group Framework for Teaching [29] was also used in [S5-S7] to design the questions; the framework identifies those aspects of a teacher's responsibilities that have been documented through empirical studies and theoretical research as promoting improved student learning. In [S1, S9] the physical/emotional/narrative presence (PENS) scale [30] was used to create the items. Studies [S2, S3, S4, S8, S12, S13] did not show how this kind of information.

Used Technologies

Technology is something that was involved in all the studies, which demonstrates that nowadays CL relies on ICT as an educational resource for deaf people since it has shown to help create more interactive and engaging learning environments [31][32]. The type of technologies used in the studies were divided in: a) The use of sensors and external hardware, b) DVD, TVs and Projectors, c) Desktop Computers d) Mobile Devices.

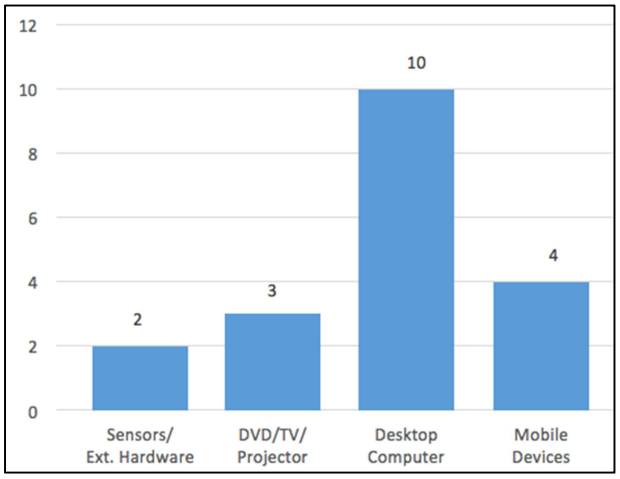

Figure 2: Used Technologies

As can be seen in Fig. 2, 10 out of 11 studies [S1-S13] made use of desktop computers to enrich teaching/learning processes. 2 studies made use of sensors and/or another kind of external hardware besides computers [S1, S2, S9]. 3 studies show the use of DVDs, TVs or Projectors [S1, S5-S7, S9, S14]. Finally, 4 studies made use of tablets or smartphones [S2, S5-S7, S11, S14]. One of these studies [S5-S7] made use of AR, which is a relatively new technology.

Activities or Strategies Applied to Promote CL

In [S1, S9] the system allows children to make decisions in group and answer questions by jumping up and down with their bodies. Filling in the blanks was another way to make collaborative decisions among children. In [S2] the idea is to have parallel classes where students can collaborate through mobile devices remotely. The virtual classroom proposed in [S3] allows people to collaborate through video streaming, application sharing, whiteboards, and file sharing. In [S5, S6, S7] students watch a series of videos in a collaborative learning environment with mixed-reality. In [S10] researchers propose the use of blogs, wikis and social networking to promote collaboration among students. The strategy used in [S11] is peer-reviewing the art work made by students. In this study students upload their work to a server using their mobile phones and the server application assigns the work to another student which will have to review it and annotate their comments using an app developed for iPads. In [S12] they used Google Hangouts as a platform for remote tutoring in chemistry and biochemistry courses. The collaborative work in this study was not an active approach among students but between the tutor and one student at a time. Other Google services were used in [S13], in this case it was Google Chat and Google Documents. Three lab sessions were carried out and students could collaborate through chat and co-construct a document according to the assignments of every lab session. Finally, in [S14] two different approaches to improve communication in groups where DHH students are mixed with hearing peers. One of

the approaches was the use of a whiteboard for 2 groups of 4 students in order to allow all members of each group to see the work-in-progress. The second approach was the use of tablet PC's for working on the problems where students could collaborate, share and contribute through these devices on a wireless network.

Findings about Research Questions

RQ1: How is Collaborative Learning being applied in the education of deaf children?

Unfortunately, collaborative learning (CL) for deaf people is something that has not been documented by the research community in the last five years, but in the reviewed papers we found some useful activities and strategies that can actually enhance the education of deaf children. Through the reviewed papers, we found that CL can be used in different ways and with different kind of tools (low-tech and high-tech). CL proved to be effective in all the studies and even more when ICT is part of this learning strategy. Finally, to answer this question, CL is being used in peer-reviewing, remote tutoring and video streaming, games (digital and non-digital), through platforms like Google Hangouts, Google Documents and Chat.

RQ2: What kind of technologies have been used in Collaborative Learning environments for deaf children?

It was clear that nowadays the use of technology helps to engage not only deaf children but also deaf adults into learning, since all the studies reviewed show that the use of computers and some other kind of technology like sensors, screens, mobile devices or AR encouraged students to learn and collaborate due to the facilities offered and for the game, it was also enjoyable. In the case of mobile devices, it is intriguing that with the actual use and opportunities that these devices offer, only 4 studies [S2, S5-S7, S11, S14] include this technology. Technology also proved to be useful for remote learning, which is crucial to allow deaf community to enroll in virtual education and with free platforms like Google Hangouts and Google Documents, there are no barriers of time or space to learn and collaborate with peers either from a smartphone, tablet or desktop computer. Nowadays, technology is not that expensive as it used to be, developers can build systems with open-source software and hardware, which makes them affordable.

5 CONCLUSIONS AND FUTURE WORK

A systematic Literature review was conducted where 14 out of 229 papers were selected as relevant to answer the research questions. These 14 papers were the result of 11 different studies where deaf people was involved in collaborative learning approaches. The fact that only 11 studies were found in 5 years illustrates the lack of research regarding the implementation of Collaborative Learning to support the education of deaf children, since only 6 out of the 11 studies were focused on them. After data extraction and analysis, we found that skills related to communication (literacy, sign language or lip movement) are one of the main objectives for researches that work with deaf community.

We think that there should be more research aiming to promote the use of CL and ICT in educational environments for deaf children because these could be used as a resource to promote learning inside and outside the classroom as well as improve communication skills with other deaf and hearing children.

The use of ICT is also crucial for allowing people with disabilities to be part of virtual education, but the design of virtual environments should be conceived taking into account the differences of each disability in order to make these spaces inclusive, for instance, the use of sign language or lip-reading is important for deaf community to have access to information.

We noticed that none of the studies included well-know and effective educational strategies like storytelling [33], especially in those studies where literacy was the educational objective, in fact, they don't mention any educational strategy for literacy teaching to deaf children like Logogenia [11] or Fitzgerald Key [12], which are the pedagogical base of the major research this study is part of.

Based on the results of this systematic review, we find an opportunity to promote the development of interactive collaborative tools by proposing a framework for the design of such tools to support literacy teaching to deaf children.

APPENDIX: PAPERS INCLUDED IN THE REVIEW

[S1] R. Egusa, T. Sakai, H. Tamaki, F. Kusunoki, M. Namatame, H. Mizoguchi, and S. Inagaki. 2016. Preparatory development of a collaborative / interactive learning game using bodily movements for deaf children. *IDC '16*: 649–653.

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