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A single-display groupware collaborative language laboratory

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Language learning tools have evolved to take into consideration new teaching models of collaboration and communication. While second language acquisition tasks have been taken online, the traditional language laboratory has remained unchanged. By continuing to follow its original configuration based on individual work, the language laboratory fails to take advantage of the potential provided by collaborative learning. We propose the use of a language laboratory based on single-display groupware (SDG) for learning vocabulary, grammar, pronunciation, and listening comprehension. By adopting SDG, the language laboratory benefits from the advantages of small group collaborative learning. In this paper, we first describe the design and pedagogical merit of the SDG collaborative language laboratory. We then share the results of a quasi-experimental pre–post comparison study, and use an observation guideline to analyze whether the conditions for collaborative learning have been fulfilled. Based on the results of this study, we conclude that developing pronunciation skills can be more effective when using a collaborative language laboratory versus an individual language laboratory. In addition to this, it can also be concluded that collaborative learning is most effective when accompanied by adequate instructional design.

Keywords: computer-assisted language learning; computer-supported collaborative learning; single-display groupware; language laboratory; speech recognition; speech synthesis

1. Introduction

Second language acquisition (SLA) has become increasingly relevant on a global level. This is due not only to the increased need for learning a new language, but also to the introduction of new technologies. These technologies allow for new forms of communication and interaction between students, both face-to-face and remotely via the Internet (Rama, 2012). When SLA is supported by the use of computers in this way, it is known as Computer-Assisted Language Learning (CALL).

The history of CALL can be divided into three stages, with the technological developments of each stage currently in co-existence (Warschauer & Healey, 1998):

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- Behaviorist CALL: focuses on learning a second language by repetitively completing exercises on an individual basis. Here, the computer acts as a tutor by checking answers and giving the corresponding feedback (Lee, 2000).
- Communicative CALL: focuses on fostering communicative situations where students must be capable of producing texts and generating dialogs. Examples include systems that allow for the reconstruction of texts, role playing, and video games (Bax, 2003).
- Integrative CALL: focuses on integrating four basic skills needed for language learning (reading, writing, listening, and speaking) in a single activity. Here, the computer goes beyond the role of tutor by coordinating the entire learning process. In turn, these four skills should each be associated with other areas or concepts of language learning, such as grammar, vocabulary, pronunciation, and cultural awareness (Levy, 2009).

Although the teaching models applied to SLA have evolved, this evolution is not always reflected in the development of SLA applications. One such application is the language laboratory (Roby, 2004).

Language laboratories initially focused on listening comprehension and pronunciation activities without the support of a computer (Harvey, 1978; Morton, 1960; Vanderplank, 2009). Although students could receive feedback on their work from a teacher, this was often without direct interaction between the two. When language laboratories were first introduced, students used individual cabins equipped with headphones and a microphone, as well as recording and playback devices. With the development of computer technology, this new technology was incorporated into language laboratories in several different ways. Visual support was added to help organize the activities, as well as supplementary audiovisual materials (Barr, Leakey, & Ranchoux, 2005; Pranita, 2010). Automatic speech recognition (ASR) software was used to test pronunciation (Neri, Cucchiarini, & Strik, 2003; Xu & Seneff, 2009). Synthesized voice was used to reinforce pronunciation (Handley, 2009). The internet was used to access materials and activities (Hsu, 2005; Singhal, 1997), and audiovisual recordings were used to create narratives (Wagener, 2006), among others. However, the incorporation of new technology into the language laboratory has not affected its pedagogical design. The reported evidence suggests that the role of the language laboratory should be focused on constant drilling and practice combined with interaction. This interaction can be achieved through individual and collaborative tasks monitored by the teacher (Vanderplank, 2009).

Socio-cultural theories of learning suggest that SLA technologies should promote the development of a methodology to foster communicative skills, in line with the following hypotheses (Nguyen, 2010):

- Student learning must focus on processes of interaction and collaboration that are relevant to the learner.
- SLA activities should encourage group work, role play, and projects that take the students beyond the confines of the classroom.
- The teacher is a facilitator and should monitor student learning in both cooperative and/or collaborative work.

Given the importance of communication and integrated language learning in the design of such systems, these hypotheses can be related to the "Communicative" and "Integrative" stages of CALL development. This is also evidenced by the fact that the computers, and not

just the teachers, mediate communication between students. Applications designed with these hypotheses in mind have been shown to be effective when learning a second language and developing communication skills. However, they often fail to integrate the four main language learning skills, focusing instead mainly on oral communication (Yang, Gamble, & Tang, 2011). Furthermore, an analysis of the contribution made by collaborative laboratories versus individual laboratories is also missing. This therefore gives rise to our first research question: when learning a language through integrated practice of the four skills, what advantages does a collaborative laboratory hold over an individual laboratory?

Collaborative learning (Dillenbourg, 1999) allows for skills such as negotiation and individual responsibility to be developed, as well as building group knowledge. These have all been defined as *twenty-first century skills* (ATC21S, 2012). (Assessment and Teaching of 21st Century Skills, 2012) Collaboration in SLA has been shown to allow peers to discuss comprehension, improve the quality of discourse and develop responsibility and independence in learners.

When collaborative learning is aided by technology, it is referred to as Computer Supported Collaborative Learning (CSCL). In this case, the technology allows the interaction between participants to be mediated. This is achieved by sharing information, administering homework assignments, establishing rules and roles, and facilitating the acquisition of new knowledge (Zurita & Nussbaum, 2004a). CSCL shares certain aspects from the categories proposed in the taxonomy by Warschauer and Healey (1998), especially the incorporation of technology to encourage communication and interaction among peers. In language learning, this concept is defined as Computer Mediated Collaborative Learning (Warschauer, 1997; Yamada, 2009). This concept has also been adopted by Levy (2009) in developing language learning skills by reviewing Sykes' analysis (2005) of three types of synchronous group discussion: written chat, oral chat, and face-to-face discussion.

In order for collaborative learning to be successful, certain conditions must be fulfilled regardless of whether or not they are mastered (Szewkis et al., 2011). These conditions include the existence of a common goal (Dillenbourg, 1999), positive interdependence between peers (Johnson & Johnson, 1999), coordination and communication between peers (Gutwin & Greenberg, 2004), individual accountability (Slavin, 1996), awareness of peer work (Janssen, Erkens, Kanselaar, & Jaspers, 2007), and joint rewards (Axelrod & Hamilton, 1981).

In the field of language learning, some of these conditions have already been analyzed within the specific context of developing cooperative work among peers. In particular, this analysis refers to the incorporation of positive interdependence or personal accountability in activity design (AbuSeileek, 2012). In general terms, it is noted that this is achieved when there is less interference by peers. This shows that when developing communication and speaking skills, the contribution made by each individual should be accepted by their peers (AbuSeileek & AbuAlshar, 2012). Further conditions or aspects have also been shown to develop within collaborative work. These include the emergence of an *expert* among peers, discussions about how a task should be performed, how students work when faced with challenges, and how they develop interpersonal relationships (Leahy, 2008). The presence of these additional conditions or aspects allow learner behavior to be analyzed within the context of CALL. This therefore gives rise to our second research question: when learning a language in a collaborative, face-to-face activity, which are the most relevant conditions of collaboration to be fulfilled?

Incorporating collaboration into CALL tools requires an understanding of the processes in which the students are engaged during these activities (Hampel, 2009). An important aspect to review is the influence of technology on student behavior regarding collaborative

activities (Leahy, 2012). One such case is the use of mobile platforms and sensors. In this case, technology helps to organize and mediate social interactions, regardless of the place and time in which the activities are performed (Ogata, 2008). In language learning, advantage can be taken of the ubiquity of these devices to encourage collaboration when completing activities with common goals, using personalized context-aware techniques in order to enhance learner learning interest and efficiency (Chen & Li, 2010). This should be accomplished by using the devices' multimedia capabilities to record videos and images as a group (Ogata & Yano, 2003). Another example of that is virtual worlds, where real-life environments are generated in 3D (Shih & Yang, 2008) and simulated by the computer systems. In these virtual worlds, the participants are represented by avatars or representations of the users' identities (Li & Wong, 2010). It has been demonstrated that a virtual space for face-to-face interaction favors collaboration (Wang & Chen, 2010) and in particular the development of communication and peer support through voice and image interaction (Yamada, 2009). For example, Second Life provides a stimulating environment for learners to engage in a range of social interactions involving collaborative dialog (Peterson, 2012). The use of virtual worlds has also been shown to be effective in SLA at both utterance and discourse levels (Zheng, Young, Wagner, & Brewer, 2009), as well as the acquisition of communication skills (Berns, Palomo-Duarte, Dodero, & Valero-Franco, 2013), and the construction of meaning (Blake, 2011; Deutschmann, Panichi, & Molka-Danielsen, 2009). However, these models also have some disadvantages. One of the disadvantages is the high cost of implementation, given that they require one or more device per student. Furthermore, the computers are not shared, making it difficult for peers to be aware of each other's work. This is because each student's answers are only shown on their respective devices, both for the ubiquitous in-person activities as well as those in the virtual world. In the latter case, coordination and communication among peers can be compromised by connectivity and latency issues on the various different devices (Garrido-Iñigo & Rodriguez-Moreno, 2013). This situation is critical because the students require permanent connectivity in order to provide relevant and timely feedback and/or the possibility of mutual reinforcement between peers. Another concern is that the absence of face-to-face contact could result in less engagement by students. As students can only see the avatars and do not receive verbal or non-verbal cues from their fellow learners, this could result in problems with the interaction among peers (Macías-Díaz, 2008b) in Duncan, Miller, & Jiang (2012).

The single-display groupware (SDG) model has been used to develop collaborative learning (Stewart, Bederson, & Druin, 1998), which allows several students to learn collectively in front of a single screen (Infante, Hidalgo, Nussbaum, Alarcón, & Gottlieb, 2009). The information shown to users is shared on a single-display device, with multiple input devices for shared control allowing the students to act simultaneously and in the same place (Kaplan, et al., 2009). One important aspect that promotes interaction between students is the fact that each student must work with their own objects on the screen using their own input device. This forces them to participate and play a central role in their own learning process (Infante et al., 2009). This interaction allows for the emergence of a shared interaction pattern, leading to the development of better quality discussions in environments where face-to-face interactions do not take place (Chung, Lee, & Liu, 2012).

In this study we propose the implementation of a language laboratory that uses small group collaborative learning as a teaching method. The laboratory is based on SDG, with the aim of studying the contribution of collaboration in the language laboratory and determining how the conditions of collaboration are fulfilled. First, we describe the design of the pedagogical activity, detailing the skills to be developed by the students. Next, we

describe the experimental design and detail the result of the experiment, along with the corresponding statistical analysis. This is followed by a discussion of the analysis, where the conditions for collaborative learning are reviewed. Finally, we present the conclusions.

2. Collaborative language laboratory

Kessler and Bikowski (2010) highlight that it is possible to observe the following forms of collaboration in SLA activities:

- Joint collaboration: individuals should have equal responsibilities.
- Parallel collaboration: individuals should have different responsibilities, but work towards the same objective.
- Incidental collaboration: individuals collaborate based on the requirements that come up as they are carrying out the task.

This section presents the collaborative language laboratory design, which uses collaboration as its guiding principle. This was chosen as the guiding principle as it aims to give all students the same level of responsibility while working towards a common goal.

The design of the laboratory should take into consideration not only the students who will use the laboratory, but also the teachers. The teacher's role in this case is defined by orchestrations (Nussbaum, Dillenbourg, Dimitriadis, & Roschelle, 2013). These consist of previously-prepared lesson plans that integrate conventional and digital resources as well as combining the teacher's work with the students' laboratory work. In the practical laboratory work, the teacher's role includes explaining how to use the technological platform and offering instruction based on any difficulties faced by the students.

This project teaches the following skills: grammar, vocabulary, listening comprehension, and pronunciation (Table 1). These skills were taken from the curriculum defined by the Ministry of Education (Mineduc, 2010). The aim of this subject is for students to learn English and be able to use it as a tool to communicate on a basic level in a range of situations. In order to achieve this, these skills are combined in such a way so as to allow the students to acquire the knowledge that they need in order to obtain information and develop communicative functions. So as to incorporate these skills, and by following the aims of the ministry, orchestrations were developed and defined by a script that combines collaborative learning with the rest of the students' and teacher's activities.

The groups comprise three students as this has been shown to be the optimum number for collaborative learning in SLA (Hsu, Hsu, He, & Chang, 2009). Each student has their own headset, which they can use to communicate with the system and listen to the system's instructions (Figure 1). The collaborative learning is based on ordering a series of elements (Zurita & Nussbaum, 2004a), where the students must work together to build an ordered sequence using the elements belonging to each individual. Each member of the group

Table 1. Skills taught and material created for the collaborative language laboratory.

Skill	Number of sessions	Number of activities per skill
Grammar	4	40
Vocabulary	4	42
Listening	4	27
Pronunciation	Integrated into the previous skills	Integrated into the previous skills

Figure 1. In the foreground, students are using the collaborative language laboratory. In the background, students are using the individual language laboratory.

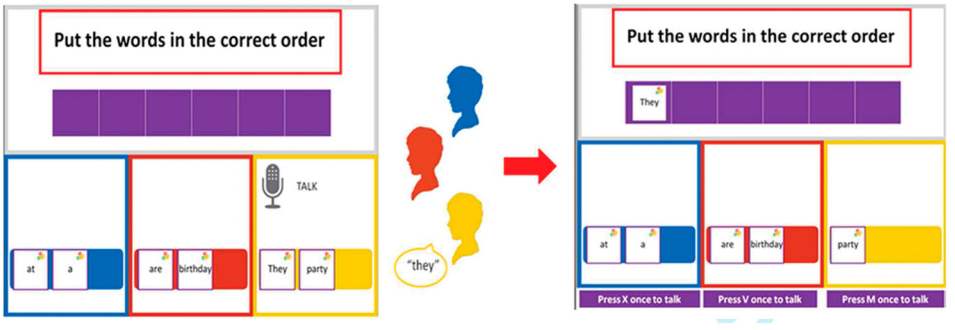

Figure 2. Example of exercises from a grammar activity. When a student pronounces a word correctly, it is moved to the shared space where the sequence is constructed. At the end of the exercise, the system confirms that the sequence is in the correct order.

can see the sequence and everyone else's personal elements using the shared screen. The sequence to be put in order will depend on the skills being developed:

- Grammar: a sentence must be constructed based on the words belonging to each student (Figure 2).
- Vocabulary: three photographs are presented, one per student, which must be matched with a word belonging to each of the students (Figure 3).
- Listening: a sequence of words must be built based on the order in which they appear in a text, which is listened to by the three members of the group simultaneously (Figure 4).

So that students will learn to accurately pronounce the words, they must select the words for each of the exercises by enunciating them. In order to build each sequence of

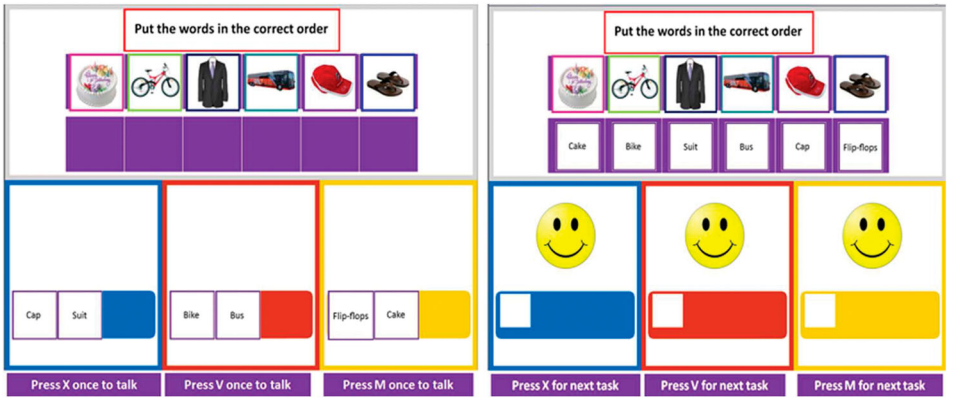

Figure 3. (Left) Screenshot of an exercise from a vocabulary activity. Students must match the pictures with words by pronouncing them. (Right) The system provides feedback; in this case the sequence is correct.

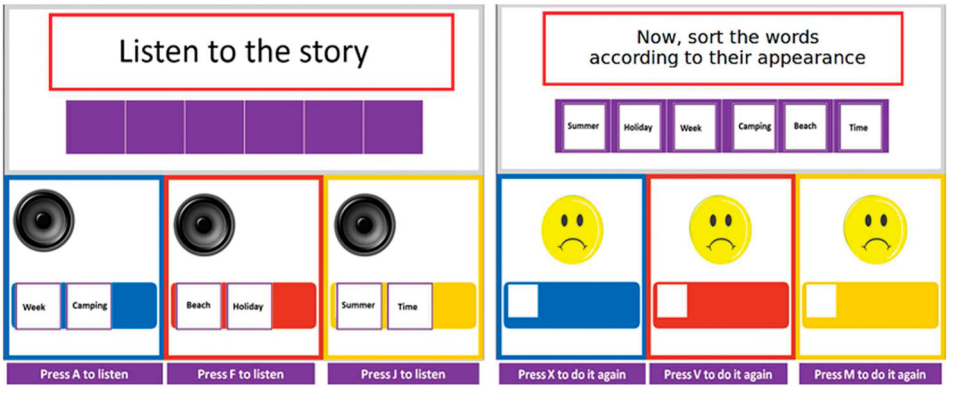

Figure 4. (Left) Screenshot of an exercise from a listening activity. Students must put the words in order according to their appearance in the text they are listening to. (Right) The system provides feedback; in this case the sequence is incorrect.

words, each student must correctly pronounce the words that belong to them so that they are included in the sequence. For example, for the grammar exercise in Figure 2, an example is shown where the student correctly pronounces the first word of the displayed sentence. When this happens, the word disappears from the student's workspace and appears in the shared space. If the students build a sequence incorrectly, the system will indicate that there is an error and make them repeat the whole exercise by reassigning the words.

The model used to develop student feedback must be simple, clear, and in line with the design of the activity in order for it to be effective (Hemard, 1997). Thus, when a student makes a mistake in their pronunciation, the feedback given by the system is based on the model proposed by Mackey (2006) for interaction feedback. In this model, an expert repeats the concept or phrase attempted by the student so that the student may repeat it correctly. Alternatively, the student can indicate that they do not understand, and the phrase will be repeated again.

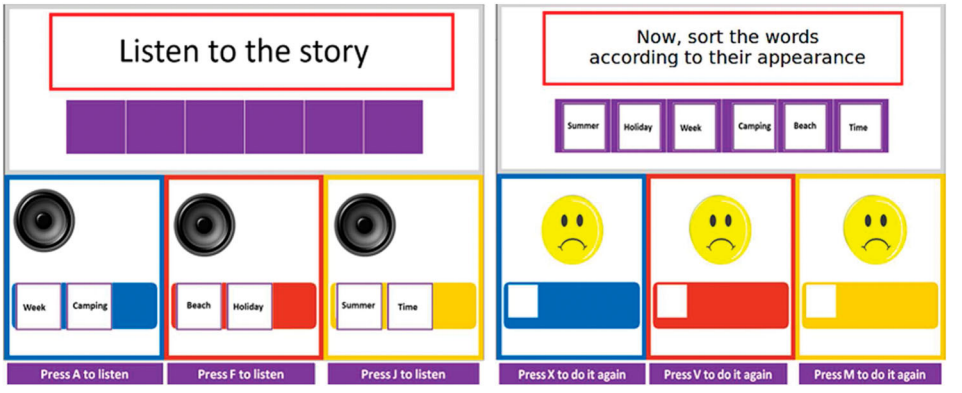

Figure 5. Sample screen of a word pronounced incorrectly, and the corresponding feedback given during a grammar activity.

In our case, the system acts as an expert by reproducing a recording of the word spoken by the student to the whole group. It then proceeds to give feedback to every member of the group through their headsets. When the student's pronunciation is similar enough for the word to be recognized but is still incorrect, the system offers feedback by repeating the correct pronunciation of the word (Figure 5). If the pronunciation is too dissimilar for the word to be recognized, the system will indicate that the word is incorrect. When the other students in the group receive this feedback, they can help their classmate to correct their pronunciation in a next opportunity. This feedback design therefore resembles incidental collaboration as it relates to an emerging situation which can be addressed by the students using collaboration.

The ASR system is used to evaluate pronunciation, with a voice synthesizer used for feedback. Both of these are provided by the Speech API (SAPI) version 5.4 Recognition and Synthesis libraries, which work on a Microsoft Windows operating system. Chen (2011) suggests that this library, with the corresponding modifications, is a free yet powerful tool that can be used to train oral skills in second language students.

Once the exercise is completed by the students, the system verifies that the sequence is correct. In this case, positive feedback is given and the students continue on to the next exercise (Figure 3, right). If the exercise was completed incorrectly, negative feedback is given and the same exercise is repeated (Figure 4, right). Students can only continue on to the next exercise if the sequence is correct, regardless of how many attempts they make.

3. Experimental design

3.1. *Tools used*

One of the questions that this study looks to answer is: when learning a language through integrated practice of the four skills, what advantages does a collaborative laboratory hold over an individual laboratory? Therefore, to carry out this study, a second version of the collaborative language laboratory described in Section 2 was built, with the same activities and technological resources, but adapted for individual work. The main difference is that there is only one set of elements, all of which belong to the student seated in front of the screen (Figure 6). With this, the student must build the sequence on their own without collaboration.

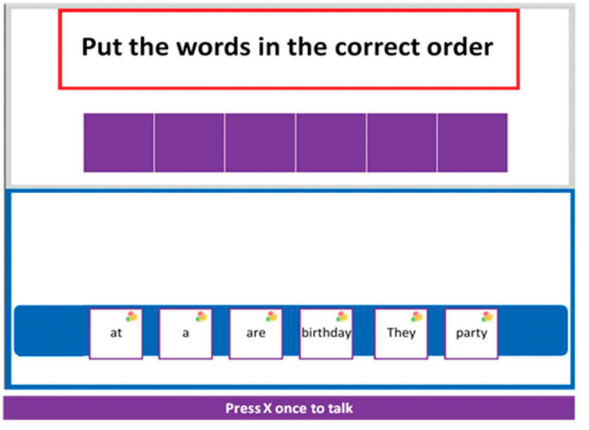

Figure 6. Sample screen of a grammar exercise in an individual language laboratory.

3.2. *Study participants and procedure*

For this study, an investigation was carried out with a quasi-experimental, pre–post type design. This was because the various groups that were to be analyzed were not necessarily even. The sample was composed of sixth grade students from a state-subsidized elementary school, whose ages range from 11 to 13. Three groups were defined and selected at random:

- Group working without the use of technology (control) ($N = 20$: 8 boys and 12 girls)
- Group working in a collaborative language laboratory ($N = 24$: 11 boys and 13 girls)
- Group working in an individual language laboratory ($N = 15$: 8 boys and 7 girls)

Samples with small groups have already been used in other studies of this kind, where learning results are measured using quantitative variables and learner behavior observed using qualitative variables (Lee, 2011). The three groups were taught by the same teacher, who worked by following the orchestrations provided for this study (see Appendix 1). On the one hand, these orchestrations were designed to ensure that the teacher followed the curricular objectives set out by the Ministry of Education. On the other hand, they guaranteed that the teacher had the necessary resources to carry out the activity, ensuring that their use followed the scope and sequence proposed by the Ministry. The teacher plays a central role during the three phases of the orchestration. Each phase and the respective activities are assigned an initial quantity of time *a priori*. In the first phase, the professor introduces the activities to be carried out by the students using an activity that is familiar to everyone. The aim of doing so is to activate prior knowledge and include any additional necessary explanations. The activity in the second phase incorporates the use of language laboratories, where the teacher moves between groups to supervise the students' work and answer any questions that come up during the task. Finally, in the third phase, the teacher does an end-of-class activity where student learning outcomes are reviewed. The teacher also answers questions while the students work and is able to make certain decisions according to what comes up during class. The teacher may also change certain aspects of the orchestrations in order to adapt them to the specific needs observed during the class.

The role of the technological platform is to evaluate the development of language skills and it is designed to encourage collaboration. This is complementary to the role of the teacher since it relies on the development of an activity that involves many students,

allowing them to work in a coordinated manner through a system of hardware and software. Furthermore, the use of multimedia resources serves as a learning aid for all students, specifically in this case through the visual display of material and the use of a speech recognition/speech synthesis engine. As mentioned previously, the use of technology does not necessarily lead to an improvement in learning if it is not accompanied by an adequate design where both the teacher and students are well coordinated.

The students that worked without technology followed the same contents as the other two groups and worked on tasks that aimed to meet the same objectives. In this case, the teacher played a leading role by coordinating the interaction among students by following the same orchestrations as those for the groups using technology (Appendix 1). However, the orchestrations were adapted so that they could be followed without the use of language laboratories. In order to do this, sequencing activities were incorporated that students solved individually on paper, while pronunciation practice was carried out with the whole class.

3.3. *Pre- and post-tests*

The pre–post instrument consisted of a test developed by an expert, which students had to answer by using a computer platform. The test was multiple choice and included questions that independently evaluated the following four skills: vocabulary, grammar, listening, and pronunciation.

To evaluate vocabulary, grammar, and listening, the items on the test followed a similar design to that used in the activities included in the orchestrations (see Appendix 2). In order to measure the level of pronunciation, the same ASR engine from the language laboratory was used on the test. The items on the test evaluated the same skills and contents that the students developed in the activities. Table 2 details the number of items associated with each unit and skill.

The pre- and post-test items were selected using an item response analysis (Wright & Stone, 1979). The items selected in this analysis allowed for them to be effectively discriminated (value between 0.3 and 0.99, in a range between 0 and 0.99, where a higher value means a higher degree of item discrimination).

There were more items for pronunciation and fewer for listening because of the time it took to evaluate each one. In the case of pronunciation, each item corresponded to the evaluation of one word. The listening items also included a recording of a spoken text that students had to listen to (see Appendix 2).

Analysis of the reliability of the pre–post instrument was conducted using Cronbach's Alpha, calculated for each of the tests that measure the various language skills (Table 3).

Fourteen sessions were held over a period of three months, in a computer room where both collaborative and individual laboratories were set up simultaneously (Figure 1).

Table 2. Skills, units covered, and number of items associated in the pre–post-test.

Units	Vocabulary	Grammar	Listening	Pronunciation
Family and friends	5	6	2	7
Socializing	5	5	4	6
Celebrations	5	4	5	7
Holidays	5	5	3	7
Total	20	20	14	27

Table 3. Cronbach's Alpha for the instrument used.

Skill	Cronbach's alpha
Vocabulary	0.77
Grammar	0.71
Listening	0.89
Pronunciation	0.76

3.4. *Collaborative learning evaluation*

The second objective of this study is to analyze how collaborative learning conditions are fulfilled by the students. In order to do so, classroom and video observations were carried out during 5 of the 14 sessions. These corresponded to the 1st, 4th, 7th, 10th, and 14th sessions, with the aim of observing how the variables that were analyzed evolved over time. In the field of CALL technology, various aspects have been analyzed regarding the interaction between learners, student attitudes towards the activity, motivation (Merisuo-Storm, 2007; Saggara & Zapata, 2008), development of communication in a face-to-face environment (AbuSeileek, 2012), and the quality of brainstorming when solving exercises (Leahy, 2008). To evaluate these aspects, an observation guideline was defined based on one that had been previously used in a study of collaborative SDG tools (Infante et al., 2009). The purpose of this guideline was to analyze the extent to which conditions for collaboration are fulfilled by incorporating the specific aspects of language learning described here. The aspects to be analyzed were the following:

- Communication: measuring the level of communication in a face-to-face setting (AbuSeileek, 2012). This is measured using the number of person-to-person dialogs, person-to-group dialogs, and the number of times that students ask for and receive help from the group regarding the solution to an exercise. This also quantifies the number of times that solutions were imposed by a group member and not taken on board, but acknowledged by the rest of the group without further discussion.
- Interaction: observing aspects of the students' interaction, attitudes, and motivation (Merisuo-Storm, 2007; Saggara & Zapata, 2008). This is measured on a scale of 1–3, and sub-categorized as follows:
  - Positive interdependence: students feel that they are responsible for their own learning and that of their classmates.
  - Mutual trust: students trust each other; they do not question other group members' opinions, and they feel comfortable expressing their own.
  - Acceptance and tolerance: students are capable of accepting the opinions of other group members with whom they do not agree.
  - Motivation and interest: there is interest and motivation to work as a group to solve the problems in the activity.
- Coordination: observing aspects related to the students' attitudes towards the activity (Merisuo-Storm, 2007; Saggara & Zapata, 2008), and the quality of brainstorming when solving exercises (Leahy, 2008). This is measured on a scale of 1–3, and sub-categorized as follows:
  - Disciplined work: the established set of rules and roles are followed, with students working together as a group.
  - Requested support: support for performing individual or group activities is requested from people outside the group. A high score indicates that little

support was requested from people outside the group; a low score indicates that a lot of support was requested.
  - Quality of brainstorming: students organize themselves to answer each exercise, with responses based not just on intuition but rather as the result of group planning.
- Appropriation: observing the students' attitudes towards the activity (Merisuo-Storm, 2007; Saggara & Zapata, 2008). This is measured on a scale of 1–3, and sub-categorized as follows:
  - Suitable handling of material: students master the use of the system (hardware and software).
  - Behavior towards the system: students develop adequate behavior towards the activity and its technological elements, without any discipline issues.

In order to apply this instrument, five observers were present (one per group) who had received previous training in how to apply the observation guidelines to a laboratory situation. Furthermore, videos were recorded for subsequent group analysis by the observers. This allowed the observations to be validated and for aspects that had not been considered by all the observers to be completed. The videos made it possible to agree on a set of criteria when applying the respective observation guidelines (see Appendix 3).

4. Results

4.1. *Pre–post-test results*

To analyze the results from the application of the pre–post-test, a two-tailed, unequal variance *T*-test was used to measure the significant differences between the different groups. An analysis of covariance (ANCOVA) was also conducted with the goal of adjusting the sample results based on a pre-test. The post-test was used as a way of discerning the differences among the samples. Cohen's d was used to measure the impact or effect size of a given group.

Table 4 shows the application of the *T*-test on the samples, and Table 5 shows the significant differences post-ANCOVA between groups (p-value < 0.05), along with the effect size using Cohen's d.

Significant differences (p-value <0.05) can be observed for each skill and in every group between the pre- and post-tests (Table 4). The only exception is for pronunciation in the group using the individual language laboratory.

The significance of the results when comparing groups are indicated by the p-values and Cohen's d (Table 5). The three significant differences between the groups ($p < 0.05$) are highlighted in gray. The collaborative learning group stands out as improving pronunciation when compared to the other two, and for listening when compared to the control group. The negative values of Cohen's d for the technological groups in terms of vocabulary indicate that the technological groups performed worse than the control group. However, this difference is not significant.

4.2. *Collaborative learning results*

Table 6 shows the results from the analysis of the conditions required for collaborative learning in the collaborative group.

From the quantitative data in Table 6, it is evident that person-to-person and person-to-group dialogs are consistently present throughout the sessions, with a standard deviation of 5.61 and 2.98, respectively. This indicates that there is a greater dispersion

Table 4. *T*-test of the samples.

		Pre-test				Post-test			
		Vocabulary	Grammar	Listening	Pronunciation	Vocabulary	Grammar	Listening	Pronunciation
Control	Min. value	3	0	3	1	5	0	3	1
$N = 24$	Max. value	19	9	11	16	19	9	12	15
	Average	8.45	2.45	6.65	9.2	11.15	3.45	7.35	10.05
	Std. Dev.	3.71	2.52	2.25	3.71	2.70	2.54	2.64	4.02
	p-Value	–	–	–	–	<0.01	0.02	0.03	0.04
Collaborative	Min. value	2	0	1	2	4	1	2	6
$N = 20$	Max. value	13	15	14	15	17	18	14	17
	Average	7.21	2.58	6.67	9.71	9.58	4.83	9.33	12.67
	Std. Dev.	2.98	3.57	3.25	3.80	3.55	3.93	2.88	2.97
	p-value	–	–	–	–	<0.01	<0.01	<0.01	<0.01
Individual	Min. value	3	0	4	4	6	0	4	5
$N = 15$	Max. value	14	12	11	15	17	12	14	17
	Average	8.47	3.40	6.73	9.13	10.80	4.47	9.20	10.13
	Std. Dev.	2.88	3.16	2.52	3.20	3.00	3.16	3.36	3.89
	p-Value	–	–	–	–	<0.01	0.01	<0.01	0.14

Table 5. Significant differences between samples (post-ANCOVA), and effect size using Cohen's d.

	Vocabulary *p*-Value	*d*	Grammar *p*-Value	*d*	Listening *p*-Value	*d*	Pronunciation *p*-Value	*d*
Collaborative vs. control	0.11	−0.23	0.18	0.38	0.02	0.70	0.02	0.92
Collaborative v/s Individual	0.28	−0.11	0.76	0.31	0.90	0.06	0.03	0.62
Individual v/s control	0.72	−0.13	0.30	0.05	0.08	0.76	0.95	0.07

in person-to-person dialogs. We can also see that the number of person-to-person dialogs always exceeds the number of person-to-group dialogs, something which is statistically significant (p-value of < 0.0003). This shows that the platform favors interactions that include the whole group over person-to-person interactions. It can also be noted that in all of the sessions, students were observed receiving more support than they requested; although this is not statistically significant (p-value > 0.05). Based on this, we can conclude that while students do not always necessarily receive more support than they ask for, it can be seen as a general trend. This could be attributed to the fact that the students are willing to support the rest of their peers proactively, without waiting for a specific request for help. On the other hand, the number of peer-imposed solutions from one peer to another decreased across the sessions, with the exception of the fourth session. Although this decrease was not significant (p-value > 0.05), the trend would suggest an improvement in communication among students.

With regards to the qualitative data, the results for the majority of the categories that were analyzed are consistently closer to the maximum value than to the minimum (avg. = 2.36, s.d. = 0.21). In general terms, the variables indicate that these attributes are developed among the students. There is also a session where we can begin to observe a trend in each of these behaviors, whether this trend be an increase, decrease or constant. As this changes from variable to variable, the students' behavior over the observed sessions is not necessarily consistent, as discussed below.

Of the variables that were observed, mutual trust had the highest, significant value that was constant across the sessions, (p-value = 0.027), with the exception of the fourth session. This indicates that mutual trust is a characteristic which is constantly favored and that generally does not vary over time. The fourth session corresponded to a grammar activity where there was a notably higher number of peer-imposed solutions (Table 6). This can be aligned with a lower level of mutual trust given that the students tried harder to impose their opinions than in the other sessions and failed to acknowledge input from other group members.

Acceptance and tolerance and positive interdependence do not become constant until the 10th session. This shows that in general although these aspects are achieved across the sessions, they were slow to become constant. This is related to the decline in the number of peer-imposed solutions, which, while not significant, do start form a trend towards the end of the study. This implies greater development of acceptance and tolerance and positive interdependence, given that an environment favoring equal communication among peers is essential for these to exist.

Motivation and interest is another variable that increased over time, eventually becoming constant after the fourth session (s.d. = 0.17 until the fourth session, versus. s.d. = 0.07 after the fourth session, p-value < 0.023). This indicates that it did not decrease as the sessions advanced, but instead reached a plateau. This also means it would not be affected even

Table 6. Results from the collaborative learning observations.

	Session	1st		4th		7th		10th		14th	
	Type of activity	Vocabulary		Grammar		Listening		Vocabulary		Listening	
	Duration	24 min.		29 min.		30 min.		33 min.		28 min.	
	Number of questions	4		4		5		6		5	
	Total number of words	12		25		15		18		15	
Category	Variable	Avg.	Std.	Avg.	Std.	Avg.	Std.	Avg.	Std.	Avg.	Std.
Communication	Person to person	31.25	7.36	43.50	9.37	34.00	6.74	32.63	6.99	28.88	6.49
	Person to group	14.75	2.43	21.88	5.33	14.88	2.90	15.50	2.45	16.25	2.60
	Receive support	5.63	1.30	13.00	6.97	5.75	2.25	5.50	2.14	5.38	2.33
	Request for support	3.88	1.73	8.50	6.07	3.75	2.43	3.88	2.42	3.75	2.49
	Peer-imposed solutions	4.13	2.42	9.25	3.99	3.63	2.56	3.50	2.20	3.13	1.81
Interaction	Positive interdependence	2.25	0.46	2.38	0.52	2.50	0.53	2.63	0.52	2.63	0.52
	Mutual trust	2.63	0.74	2.13	0.35	2.63	0.52	2.75	0.46	2.75	0.46
	Acceptance and tolerance	2.25	0.46	2.13	0.35	2.50	0.53	2.75	0.46	2.75	0.46
	Motivation and interest	2.00	0.76	1.75	0.89	2.25	0.46	2.38	0.52	2.38	0.52
Coordination	Disciplined work	1.88	0.64	2.00	1.07	2.13	0.83	2.25	0.46	2.50	0.53
	Requested support	2.13	0.35	2.00	0.53	2.25	0.71	2.25	0.71	2.25	0.71
	Quality of brainstorming	1.75	0.46	2.13	0.83	2.25	0.71	2.25	0.71	2.25	0.46
Appropriation	Suitable handling of material	1.25	0.46	2.38	0.52	2.38	0.52	2.50	0.53	2.75	0.46
	Behavior towards the system	2.13	0.83	2.75	0.46	2.75	0.46	2.75	0.46	2.75	0.46

if the number of sessions were increased, suggesting that the students did not find the work to be tedious. In terms of the quality of brainstorming in solving each exercise, this clearly increases and becomes constant following the seventh session. Although this increase is not significant (p-value >0.05), it does imply that a greater number of sessions would not improve the quality of brainstorming achieved by the seventh session.

In terms of coordination, the students consistently required support from outside the group after the third session (p-value < 0.027). The level of disciplined work increased over time until the final session, although it never became constant. This could indicate that this particular aspect would continue to improve with further sessions. With regards to the students' appropriation of the platform, it is clear that their behavior towards the system became constant from the fourth session (p-value < 0.00002). This also indicates that the students' attitude towards the activity in general was positive and consistent. We can also observe that this is in direct relation to the achievements in motivation and interest, both of which remained constant from the fourth session onward. This also shows that working with the technological platform did not result in a loss of motivation towards the end of the study, despite the number of sessions. However, the suitable handling of material never became constant and instead increased continually until the end. As with the trend observed with disciplined work, this also suggests that the handling of materials could have improved with further sessions.

5. Discussion

Our first research question asked: when learning a language through integrated practice of the four skills, what advantages does a collaborative laboratory hold over an individual laboratory? As shown in the previous section of this paper, progress was made by all of the experimental groups (individual and collaborative language laboratory) in the four skills that were practiced: vocabulary, grammar, pronunciation, and listening. All of these results were significant, with the exception of the work on pronunciation in the individual laboratory. By comparing the results from the different groups (Table 5), we can see that pronunciation skills are always favored by the collaborative language laboratory, with a medium effect size (Cohen's $d > 0.62$). The use of collaborative learning in a language laboratory therefore contributed significantly to the development of pronunciation skills when compared to an individual language laboratory or a class without technology. These skills have been analyzed in the literature, particularly the use of computer mediation in developing listening and pronunciation skills (Bodnar, Penning de Vries, Cucchiarini, Strik, & Hout, 2011). Although the reported results show that these kinds of tools improve learning, they do not take into consideration the incorporation of collaborative work (Yamada, 2009).

The development of students' collaborative skills will be evaluated in the programme for international student assessment test from 2015 onward. This will be done by measuring students' capacity and willingness to solve problems by interacting with each other (Davidson, 2012; De Jong, 2012). The collaborative language laboratory's differentiating element is the opportunity it provides for peer-to-peer communication within the groups, based around solving the proposed exercises. This happens when the solution requires the students to reconstruct the sequence of a sentence, and where the semantics vary depending on the skill being practiced. Another opportunity for observed communication is when some of the peers do not pronounce the word correctly. The design of the activities enabled mutual reinforcement of pronunciation between participants based on shared listening of the recordings generated by each student in the group. This allowed students using the collaborative language laboratory to develop their pronunciation skills significantly

better than the others students. However, the collaborative and individual language laboratories do not show improved results in the acquisition of grammar and vocabulary skills when compared to a lesson which does not use technology.

In response to the second research question, "when learning a language in a collaborative, face-to-face activity, which are the most relevant conditions of collaboration to be fulfilled?" we look to understand how collaboration assists learning. In order to do this, we analyzed how the conditions for collaboration detailed in the introduction are present in the proposed collaborative laboratory. This analysis was based on the results obtained in the in-class observations using the observation guidelines.

An important aspect to highlight is that in the fourth session, the values for the communication variables are higher than in the rest of the sessions. This could be due to the comparatively large number of words in the grammar activity, which required greater dialog to solve each task. This also affected several of the other qualitative variables such as mutual trust, acceptance and tolerance, motivation and interest, all of which produced lower values than in the other sessions. As mentioned in the previous section, this could be due to the influence of a greater number of peer-imposed solutions within the group.

In communication, Table 6 shows that positive interdependence is related to the larger number of person-to-person versus person-to-group dialogs. It is also related to the fact that each peer is responsible for the participation and learning of their classmates, based on the existence of a common goal. Another fact that supports this is that, while remaining constant over time, receiving help increases in proportion to the number of peer-imposed solutions, indicating that there was an awareness of the role played by peers within a group. This is also explained in terms of joint rewards, since the feedback is shared among peers and allows them to help one another.

As was mentioned in the results, the qualitative variables in the interaction, coordination, and appropriation categories are closer to the maximum value, 3, than the minimum value, 1. In interaction, we can observe how the constantly high value of the mutual trust variable across the sessions contrasts with the variables of acceptance and tolerance and positive interdependence. These latter variables do not become constant until the 10th session. This occurs because the students initially show behavior centered on accepting help from their peers, especially regarding the pronunciation of words. However, this becomes more participatory as there are fewer peer-imposed solutions and each student begins to acknowledge that their presence and the presence of others is essential to accomplish each task. This is confirmed by the peer-imposed solutions variable (communication) that decreases over time, with the exception of the fourth session, as explained previously. Although the decrease itself was not statistically significant, the decreasing value also allows us to confirm the existence of individual accountability. This is because the students participate more as they become more confident in sharing their work and ideas with the rest of the group in order to achieve the common goal. The development of individual accountability, evident in the decrease in the number of peer-imposed solutions, has been observed in cooperative language learning tasks where no single student can dominate proceedings and discourage other members from participating (AbuSeileek, 2012). This is also confirmed by the relation of the quality of brainstorming, acceptance and tolerance, and positive interdependence variables, which increase until the 7th and 10th sessions before becoming constant (p-value <0.0001, Table 6).

In the field of language learning, the use of positive interdependence and individual accountability have been analyzed separately, demonstrating that the latter presents significant advantages regarding the development of communication (AbuSeileek & AbuAlshar, 2012). In this study, the activity's design considers the use of mechanisms that attempt to

fulfill all of the conditions for collaboration previously described. In a future study it would be interesting to analyze these conditions separately. This could be done by incorporating mechanisms that independently benefit each condition and using different versions of the same platform, as described by AbuSeileek and AbuAlshar (2012).

Furthermore, we conclude that better planning in solving the exercises (quality of brainstorming) shows acceptance and tolerance and positive interdependence. In the literature, the development of brainstorming has been considered as evidence of collaborative work and cooperation (Lee, 2011). It has also been considered as an opportunity for individual work prior to a face-to-face activity, where all students share their results (Long, 1990; Wen, Looi, & Chen, 2011). In the platform proposed in this project, the development of brainstorming is analyzed as a transversal element in the discussion generated by the students throughout the course of the activities. Based on this, we can suggest that the platform leads to higher quality discussions whenever the students plan how they would like to solve an exercise together. However, it is difficult to say which specific aspects could have benefited from this, since there is no phase explicitly designed for the development of brainstorming. This is something which as of yet has not been examined in the literature. Therefore, analyzing how specifically incorporating the development of brainstorming among peers into the design of collaborative language learning activities remains an interesting topic for future work.

The improvement over time in disciplined work (coordination) allows the students to coordinate and communicate better among themselves, something which is also related to the gradual improvement in the quality of brainstorming. Requested support (requested mainly from the teacher) remained constant from the thirrd observed session onwards. This shows that their help was always necessary in solving the exercises, especially in the later sessions. Quality of brainstorming and requested support can be connected to studies that have evaluated learner autonomy in relation to their own learning process in on-line language learning. Here, the same trend is present over time (Dang & Robertson, 2010). Based on this, we can suggest that autonomy benefits from the platform proposed in this project. This is achieved by developing the quality of brainstorming and requests for support, which in turn is proof of coordination and communication between peers and individual accountability.

With regards to appropriation, the students were able to behave according to rules established by the activity almost from the beginning. This can be seen in the improvement in the behavior towards the system between the first and second observation (fourth session) and the fact that it remains constant from then on. On the other hand, we observe that the gradual increase in the suitable handling of material variable also influenced the students' motivation and interest, the level of which increases over time (with the exception of the fourth session). This occurs because better use of the system helps the students to solve the exercises, and therefore improves their willingness to use the system as a team.

Finally, in terms of the specific work done with the orchestrations for the various activities, there was no rigorous follow-up. This was because this was not one of the main objectives of this study. However, the teacher in charge of leading the class did follow them and found them to be useful, making the necessary changes and modifying approximately a third of the original script. Most of these changes related to teacher interventions, and were made in order to allow the teacher to adapt the orchestrations to their own teaching style. This shows us that an orchestration is a valuable guide for the teacher, and that it should be sufficiently flexible for them to adapt it to their own needs. Future studies could be done on the impact of orchestrations on student learning and an analysis of to what degree this is accepted by the teachers.

In this study, activities were developed to develop vocabulary, grammar, and listening skills, with integrated pronunciation practice. The model used consisted of assigning objects to students, which then had to be put in order by following the defined logic (Zurita & Nussbaum, 2004b). The aforementioned skills can be practiced using other models, such as identifying, categorizing, or completing sequences, or associations (Nussbaum, Rosas, Peirano, & Cardenas, 2001). It can be left as future work to enhance the laboratory using these various models and see which skills are better developed through collaboration in each case.

6. Conclusions

Our first research question was: when learning a language through integrated practice of the four skills, what advantages does a collaborative laboratory hold over an individual laboratory? We conclude that the proposed collaborative language laboratory can further improve English language learning, particularly pronunciation, when compared with an individual laboratory or a lesson without technology. Further studies must be carried out with a larger number of students, and spanning an entire school year in order to be able to evaluate the significance of these results. Our second research question was: when learning a language in a collaborative, face-to-face activity, which are the most relevant conditions of collaboration to be fulfilled? We conclude that among all of the potential aspects of a language learning activity, communication, and coordination are the most important, since they form the basis of positive interdependence, the nucleus of good collaboration, and the mechanisms for accomplishing individual accountability and awareness.

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Appendix 1. Example of orchestration

Class 2 Orchestration

Subject Area: Foreign Language: English	**Unit Name:** My Family	**Designated Time:** 1 pedagogical hour (45 minutes)

Number of Classes Per Week:	**Grade (s):** 6

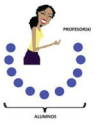
Difficulty: (X) Easy ( ) Medium ( ) Difficult	**Language Skills:** (X) Listening ( ) Reading (X) Speaking	

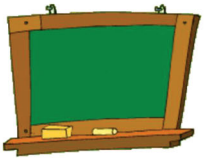
Unit Learning outcomes:
Demonstrate understanding of commonly used phrases and expressions in brief and simple dialogues or oral presentations that use direct language.

Skills and Attitudes to develop:
Listening comprehension.
Speaking

Class Objective:
Present family members vocabulary, then use it to perform reading comprehension and oral production tasks.

Necessary Prior Learning Skills:
Personal Pronouns: I, he, she, it, we, you, they.
Vocabulary: Nuclear Family members

Class Stage	Class Activities	Pedagogical Materials	Designated Time
Beginning of Class: Introduction of Contents	 The teacher **begins the class** showing students a family photo where they can identify the following members: father, mother, brothers and sisters, grandparents, among others. Then the teacher **asks**: ***- Who are the people in this photograph? How are they related to me?*** Students are expected to respond orally to these questions, hypothesizing about the picture and the people that appear in it. Then students are expected to identify that the picture is of the teacher's family and identify the names of the family members. Next, the teacher **explains** to students what today's class is about: ***- Today we are going to review vocabulary about family members in an activity on the computer to exercise and put into practice what we've learned.***	-Family Photo	**5 minutes**

Class Stage	Class Activities	Pedagogical Materials	Designated Time
Class Progress: Exercising Contents	*This part of class consists of 2 activities: brainstorming and recall on the board, and a listening exercise integrating the unit vocabulary, with supplements from ICT resources.* **Activity 1**: The teacher draws a tree on the whiteboard and asks students if they know what a family tree is and how to make one. The teacher **invites** the class to make a tree together, writing the names of family members in Spanish. **The objective here is to recall keywords referred to in the unit.** Next, the teacher sticks a label with the name of each family member in English next to each name in Spanish. Then the students are invited to practice pronunciation, repeating the words individually and as a group.  Once the students have understood and practiced pronouncing the vocabulary, the teacher must **give the following instruction**: ***-Now that we've remembered the keywords for this topic, we're going to work in groups on the computer practicing this vocabulary by listening to a story. Let's go to the computer room.***	- Whiteboard. - Marker. -Labels (names of family members in English)	**Activity 1.5 minutes**

Class Stage	Class Activities	Pedagogical Materials	Designated Time
Class Progress: Exercising Content	**Activity 2**: Next the teacher invites the students to work in groups, listening to a paragraph and ordering three words that appear in it. The teacher reminds students that listening closely, identifying words, their order, coming to a consensus and practicing pronunciation are crucial to positive results in the activity.  During the course of the activity the teacher: **Monitors** the **students' work and helps t**hose that appear to need more help with pronunciation. **Registers** the **words with the highest level of appropriation** in pronunciation, to include in new activities. **Registers** the **phonemes that cause the greatest** problems in pronunciation, to work on in new activities.	Computer room set up for the task. -Listening exercises: 3, 7, 14, 16, 21,22,24	**Activity 2.3 minutes**

Class Stage	Class Activities	Pedagogical Materials	Designated Time
End of Class: Final Content Review	*At this time the class consists of 1 activity: oral expression in a group setting and synthesis of the content learned.* **Activity 1**: The teacher **invites** students to describe a member of their family physically, in English. In order to do this, the teacher writes a list of physical features and the following phrase on the board: **"My…is…"** Students are expected to mention a member of their family and the feature, based on the work done in class. At this time the teacher monitors and registers the appropriation of vocabulary practiced in class, and **makes a list of the most repeated words** to start introducing new words in the following classes.	-No extra materials required.	**Activity 1: 5 minutes**

Figure A.1: "My family" orchestration

Appendix 2. Example of pre–post-test items

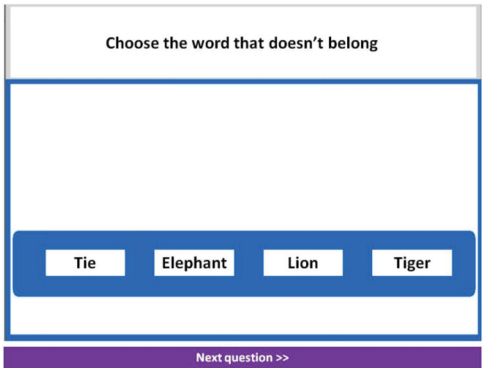


Figure B.1: Vocabulary item

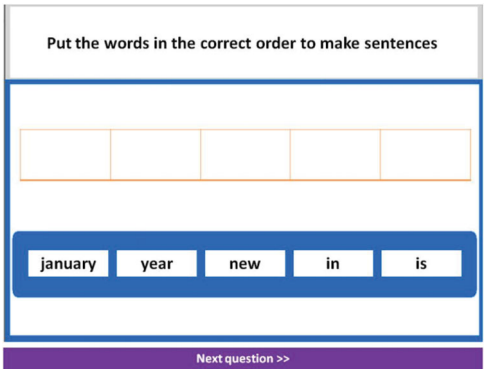


Figure B.2: Grammar item

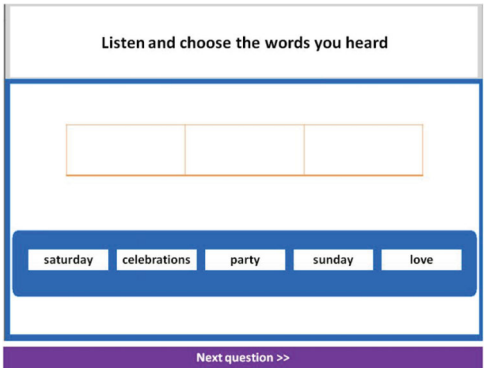


Figure B.3: Listening item

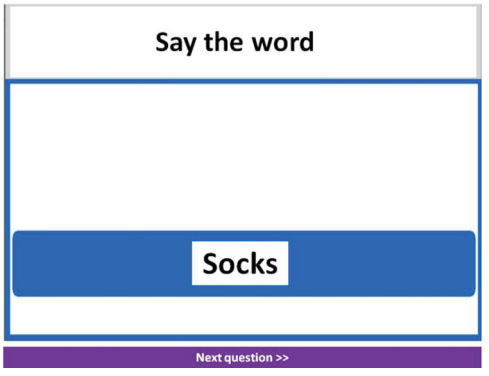


Figure B.4: Pronunciation item

Appendix 3. Observation guideline

Observation guideline

Session/ Date	
Level:	6to básico
Assignment:	English
Unit	

STUDENTS

GROUP:

1.	
2.	
3.	

Start **End**

Category	Variable	Metric	Type*	1	2	3 / G
Communication	Person to person	# dialogues	I			
	Person to group	# dialogues	I			
	Receive support	# requests	I			
	Request for support	# requests	I			
	Imposition	# events	G			
Interaction	Positive interdependence	Scale of 1 to 3	G			
	Mutual trust	Scale of 1 to 3	G			
	Acceptance and tolerance	Scale of 1 to 3	G			
	Motivation and interest	Scale of 1 to 3	G			
	Quality of brainstorming	Scale of 1 to 3	G			
Coordination	Disciplined work	Scale of 1 to 3	G			
	Requested support	Scale of 1 to 3	G			
Appropriation	Suitable handling of material	Scale of 1 to 3	G			
	Behavior towards the system	Scale of 1 to 3	G			

* (I) Individual; (G) group work

Figure C.1: Observation guideline.