WEARABLE DEVICES SUPPORTING COLLABORATION IN THE CLASSROOM

Testing the Signal Orchestration System within the context of a Jigsaw activity in an authentic face-to-face setting

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To my family, to Martin

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Abstract

Under the umbrella of ubiquitous technologies, many computational artifacts have been developed in order to enhance the learning experience in physical settings such as classrooms or playgrounds, but just a few of them have been designed to address orchestration issues. Nevertheless, further research needs to be conducted so as to assess the real impact of the technological mediation in face-to-face settings. This research presents a systematic evaluation of the performance of the Signal Orchestration System (SOS) in the context of a Jigsaw activity in a authentic classroom setting. The SOS was developed by researchers at the GTI (Grup de Tecnologies Interactives) at Universitat Pompeu Fabra, and it is composed of wearable Personal Signal devices and an Orchestration Signal Manager. Teachers or facilitators can configure color and sound signals in the manager to be transmitted to the personal devices worn by the student indicating different orchestration aspects for collaboration. The comparison between the SOS and the paper-based method traditionally employed for the orchestration of the Jigsaw, showed that students in the former group spent significantly less time organizing the activity, obtained better results in the post-tests, experienced a stronger feeling of group awareness and reported having enjoyed the experience to a greater degree.

Keywords: Signal Orchestration System, technology enhanced learning, computersupported collaborative learning, wearable devices, augmented physical spaces

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Chapter 1

INTRODUCTION

1.1 Problem statement

As a result of extensive studies conducted during the 1990s on how college affects students (Pascarella and Terenzini, 1991) conclude that there is consistent evidence to suggest that collaborative learning approaches can significantly enhance learning. In addition, teamwork has been associated with high degree of effectiveness and efficiency and it is widely accepted that cooperative learning is supporting the success in learning in general (Hinze et al., 2002).

There are many reasons why collaborative learning is effective but, as proposed by (Barkley et al., 2005; Silverman, 1995), researchers tend to conclude that teachers cannot simply transfer their knowledge to students because learning is a process, not a product. Within a constructivist perspective, students build their own minds through an active process in which they take a concept or a problem solution and make it their own by adapting it into their own understandings. As Vygotsky argued, children do not develop in isolation and learning takes place when interacting with their social environment. The role of the teacher is to establish an interactive instructional situation where the student plays a key role as an active learner (Daniels, 2001).

Still, the term collaborative learning commonly refers to a wide variety of definitions and it may be necessary to pursue a more specific meaning. In *What do you mean by collaborative learning*, the author (Dillenbourg, 1999) researches through the existing literature in the field and proposes that those words describe a situation in which particular forms of interaction among people are expected to occur, which would trigger learning mechanisms. For (Stahl et al., 2006), collaborative learning not only requires individuals as group members, but also phenomena such as the negotiation and sharing of meanings, including the construction and maintenance of shared conceptions of tasks, which are accomplished interactively in group processes. However, in a group setting there is no guarantee that the expected interactions will actually take place.

The nature of social interactions is complex and there is evidence that free collaboration among individuals in groups does not necessarily lead to fruitful learning (Dillenbourg et al., 2009b). In certain scenarios, coordination and organization instructions should be provided in order to increase the plausibility of achieving a successful output (Hernández-Leo et al., 2012). In the face of these concerns, two fundamental concepts emerge: collaborative models or patterns and orchestration.

In the first case, there exist a number of didactic models being used by teachers in collaborative learning settings, which indicate the roles for teachers and students, the paths to problem solving, the manner in which students should cooperate, what to do when cooperation fails, and so on (Silverman, 1995). Commonly referred to as Collaborative Learning Flow Patterns (CLFPs), these models represent best practices that are repetitively used by practitioners when structuring the flow of collaborative learning activities. In other words, these are suitable ways of arranging participants in collaborative learning groups or resources in order to promote the achievement of the desired educational goals (Hernández-leo et al., 2006). Examples of CLFPs include Jigsaw, Pyramid, Brainstorming, Co-op-Co-op or Think Pair Share (Kohls and Wedekind, 2010; Aronson, 1997; Hertz-Lazarowitz et al., 1985).

Among the above mentioned, the Jigsaw has become a well-known technique for cooperative learning. It was developed in the early 1970s by Elliot Aronson and his students at the University of Texas and the University of California and has been associated with reduction of racial conflict among school children, promotion of better learning, improvement of student motivation, and increased enjoyment of the learning experience. A Jigsaw uses a redundant group structure, as it can be seen in figure 1.1: main groups and expert groups. The group task can only be completed with the knowledge acquired in the expert groups, and thus with the cooperation of all team members (Aronson, 1997).

It can be easily seen that in collaborative learning, instruction is learner-centered and therefore the role of the teacher changes from transferring information to students to being a facilitator in their own construction of knowledge (Chen, 2005). Collaborative patterns create the need for orchestration, understood as the teacher's action of managing the flow of activities across different social stages: solo, group or class (Dillenbourg et al., 2009b).

When orchestrating, teachers are the conductors, taking the lead to drive the whole activity. They are managing in real time the activities that occur at multiple levels (Dillenbourg and Jermann, 2010). In settings such as classrooms or play-grounds, orchestration of collaborative activities requires teachers to coordinate

students indicating them who belongs to each group, which working areas and resources are assigned to each group, and in which sequence they should interact with their peers (Hernández-Leo et al., 2012). Deficient of insufficient orchestration prevents students and teachers to concentrate on the main task (Alavi et al., 2009).



Figure 1.1: Structure of the Jigsaw Collaborative Pattern.

As an emerging branch of the learning sciences, Computer Supported Collaborative Learning (CSCL) addresses the challenge of enhancing learning through the combination of computing support and collaborative learning (Stahl et al., 2006). As Stahl argues, the field emerged in the 1990s in reaction to software that forced students to learn in isolation, either in online environments or face-to-face settings.

However, the rapid growth of Internet and the flourishing promises of e-learning conquered most of the research being conducted in the field during its first years of existence (Stahl et al., 2006). As a consequence, many solutions for the or-chestration problem have been proposed in the context of PC-oriented learning environments but almost none to provide coordination information to students in face-to-face settings so that the use of a PC is not required (Hernández-Leo et al., 2011).

Still, within CSCL it is agreed that face-to-face collaboration in physical environments is a highly effective way of fostering better learning (Hernández-Leo et al., 2012; Dillenbourg and Jermann, 2010). And even though devices to aid orchestration remain largely unexplored, under the umbrella of ubiquitous technologies, many computational artifacts have been developed in order to support learning by augmenting the physical space with digital information (Hoppe et al., 2007; Huang et al., 2009).

Nevertheless, as (Bachour, 2010) posits, it is fundamental to examine an approach in technology-enhanced learning that avoids deviation from pedagogical practices that are currently used by teachers as these are often reluctant to change. In order to achieve this goal we may develop technology that seeks to augment and support learning activities that are already taking place in authentic scenarios. At the same time, as pointed out by (Asensio et al., 2004), the effort dedicated to the development of useful CSCL applications can only be justified if these can be applied to a large number of learning situations and survive the evolution of functional requirements and technological changes.

This thesis project presents a systematic evaluation of the performance of the Signal Orchestration System (SOS), a prototype of wearable technology to support orchestration in physical environments, developed by researchers at the GTI (Grup de Tecnologies Interactives) at Universitat Pompeu Fabra. The experimental setup proposes a Jigsaw activity within the context of an authentic experience of collaborative learning in a face-to-face environment.

The SOS is composed of wearable Personal Signal devices and an Orchestration Signal manager. Teachers or facilitators can configure color and sound signals in the manager to be transmitted to the personal devices worn by the student indicating different orchestration aspects (Hernández-Leo et al., 2011). The obtained results support that the SOS is and efficient system for the orchestration of the Jigsaw activity, optimizing the organization of the collaborative tasks, enhancing the performance of the students and providing with group awareness.

The content of this thesis has been organized as follows: the first chapter contains the theoretical background to contextualize technology enhanced learning and collaboration, current research being conducted in the field and a literature review of the most relevant existing systems based on similar ideology. The research questions and hypothesis will also be argued. The second chapter describes the methodology behind the evaluation and testing of the system, along with a detailed explanation of the experimental design and procedures. The third chapter consists of an overview of all data gathered throughout the experiments for the evaluation of the system. The fourth chapter is dedicated to the discussion of the results, the limitations of the experimental design, an assessment of the validity of the study and a response to the research questions. The fifth chapter contains the conclusion and the recommendations for further work.

1.2 State of the art

During its two first decades, research in CSCL focused in the interactions within a team. Recently more attention is paid to the integration of teamwork in broader scenarios that include individual activities and class-wide activities (Tewissen et al., 2001). The classroom and the playground, as any other physical space plausible of being used for face-to-face interaction, have a fundamental role in collaborative learning because they can bring students together and influence their interactions. Places are not neutral and individual and social interaction is affected by the physical space of a room as much as it is influenced by the presence of a teacher or the technology (Bemer et al., 2009). A specific setting may trigger or disable exploration, experimentation, discussion and collaboration (Hernández-Leo et al., 2012).

1.2.1 Calm, pervasive, ubiquitous

The introduction of technologies in physical educational spaces can transform the learning experience by providing new possibilities resulting from the integration between the virtual and the tangible world. Embedding devices with computational power can augment spaces such as classrooms with digital information capable of supporting face-to-face collaboration and overall learning. Interactive furniture with specific affordances can easily connect to mobile phones, tablets and a great variety of wearable devices so as to create an interconnected ecosystem for technology enhanced education. As it it widely addressed in (Dillenbourg et al., 2009a), the successor of the isolated computers paradigm is that of the *networked computing*, where future developments will not be centered around what we now understand for the computer. Interactive computing technology will no longer appear with a uniform interface of screen, mouse, keyboard, but will augment our spaces with a variety of peripherals and different designs which will be embedded into spatial and physical roomware scenarios (Streitz, 2007).

The traditional notion of pervasive computing is a digitally-enhanced habitat where physical and digital devices are seamlessly integrated (Al-Muhtadi et al., 2004). In his seminal paper (Weiser, 1991) foresees the concept of pervasive or ubiquitous computing as invisible, context aware, embedded technology to serve users in a seamless and unconscious interaction.

In its pursuit of overcoming the desktop computer paradigm, technologyenhanced educational spaces use computing facilities derived from three fields: tangible user interfaces, ubiquitous computing and augmented reality (Huang et al., 2009). Tangible user interfaces involve explicit contact with the computing artifacts such as tabletops, interactive boards (Mercer et al., 2010), multitouch screens and building blocks (Hernández-Leo et al., 2012; Ishii and Ullmer, 1997). The growth of popularity of tangible interfaces reflects a larger emphasis on the role of the body and the environment in embodied interaction. As (Marshall, 2007) suggests, the field of learning sciences has given special attention to tangibles because of the general view within education that hands-on activities or physical manipulation can be beneficial for education. Nevertheless, more research needs to be conducted so as to deepen our understanding on the cognitive or social effects of using one or another type of interfaces for learning.

Computing facilities may be blended with the environment in the form of specific *tangible bits* (Ishii and Ullmer, 1997) which allow users to manipulate and grasp information. Moreover, coupled with ambient display media such as light, sound, airflow or water in an augmented space, tangible bits enables users to gain awareness of background information in the periphery of perception. Following a similar ideology, (Weiser and Brown, 1996) claim that such forms of ubiquitous computing will lead to a new wave of *calm technology* characterized by the existence of various computerized services around us in an implicit and unobtrusive way. This technology will no longer define the focus of our attention and will question the very concept of user (Huang et al., 2009).

Ubiquitous computing is a natural result of the improvements in computing power, hardware miniaturization, wireless communications, power supplies, etc, and augments learning spaces through roomware awareness tool devices, mobile phones, QR codes, radio-frequency identification tags and GPS devices (Hernández-Leo et al., 2012).

1.2.2 Augmented classrooms

(Jermann et al., 2000) reviewed a representative selection of systems aimed to support the management of collaborative learning activities. The authors established a framework addressing the different manners in which these technological mediations support the interactions in the classroom.

The proposed categorization allows us to see that different systems can provide support to different aspects involved in collaboration. Understanding their differences can help us address which implementations are more suitable than others in order to achieve the desired learning outcomes.

Jermann et al. classifies collaborative learning supporting systems into three classes:

• Mirroring systems display indicators to users. These tools automatically collect and integrate data about the interactions among students, and reflect this information back to the user (as graphical visualizations, for example). The aim of such systems is to raise awareness among students about their actions and behaviors.

- Metacognitive tools provide data about what the desired interaction might look like alongside a visualization of the current state of indicators. The received information allows students and teachers to diagnose the state of interaction. Users of metacognitive support tools are responsible for making decisions regarding diagnosis and remediation.
- Guiding or coaching systems perform all the phases in the collaboration management process, and propose a series of remedial actions to help the learners improve their performance. The desired model of interaction and the assessment of the current state are typically hidden from the students. The system makes decision over the collected data and tries to help the learners.

As I mentioned in the introduction of this report, there are more systems supporting orchestration in online environments than in face-to-face setting. Examples such as the Assistant FLE3 (Chen, 2005), a coaching system that monitors the collaboration, visualizes it and provides advice to the teacher on the subject domain and the collaboration process; or Synergo, a metacognitive tool for distance learning which monitors the activity, makes analysis and visualizes quantitative parameters such as density of interaction, symmetry activity among partners (Avouris et al., 2004), are well-known examples of the first case.

However, this state of the art focuses on systems used to orchestrate collaborative activities in face-to-face settings which, at the same time, do not require that learners rely on a desktop computer to use them. In order to justify my selection, I take into consideration the definition provided by (Alavi et al., 2009), for whom supporting orchestration is about providing a global picture that can support on-the-fly decision making within large classes.

Following similar ideology as the SOS, relevant examples are Shelf (Alavi et al., 2009), Lantern (Bachour, 2010; Alavi et al., 2009) and Reflect (Bachour, 2010; Bachour et al., 2008).

Shelf and Lantern have been created at the Craft research group at the Swiss Federal Institute of Technology in Lausanne. Both systems are awareness tools, designed to retrieve information on the changing status of participants in a collaborative activity, only by providing color signals, changing brightness and occasionally blinking.

Lantern, in figure 1.3, is a portable device made of five pairs of LEDs installed on a stub-shape PCB covered by a plastic cylinder, and one microprocessor. Each Lantern mirrors the status of one collaboration team. Users can turn and press the Lantern, which respectively result in changing color and switching blinking mode. At the same time, every user interaction is recorded and transmitted through the USB port for offline analysis. Shelf (figure 1.2) performs the same actions but the lamp-type devices are represented on a screen display. Users control de device with a remote control.

Lantern and Shelf, have been created to support interaction in recitation sections and provide with group awareness to the users. During recitation sections students work on their assignments with the presence of teaching assistants who gives on-demand help. As stated by the authors, a typical problem among recitation sections is that assistants cannot always follow or track the working process of students and in occasions these are more worried to get her attention before other group does, instead of focusing on solving the task (Bachour, 2010; Alavi et al., 2009). While using Lantern, each group of students collaborating holds a device on their tables. Each color shows the exercise that the corresponding team is working on, and there is a special color indicating that the team is receiving help from the teaching assistant. The brightness indicates the time that has been spent on the current exercise, starting with lowest intensity, gradually increasing with time. The frequency of blinking corresponds to the time that the team has been waiting for help.

Findings indicate that using Lantern considerably improved the quality of interaction not only between students and teacher assistants but also among collaborators. Also, students put significantly less effort to catch the attention of the assistant which leads to more productivity while waiting. On the other hand, stronger collaboration among teams has been observed which can be explained by pointing out to group awareness: knowing about a team progress could encourage others to seek their help (Alavi et al., 2009).



Figure 1.2: Shelf: the system relies on a display screen.

Reflect (Bachour, 2010; Bachour et al., 2008) is an interactive tabletop that measures the level of collaboration of participants sitting around it. By tracking the voice of each user, it displays the amount of talking through a visual representation that all the participants can see. The device is aimed at preventing unbalanced participation which is a known as a deterrent for effective learning. The table, a semiambient display, has the properties of being in the background of the collaboration process while at the same time remaining visible in a central po-



Figure 1.3: Lantern: the system is distributed and resembles a table lamp.

sition of the shared workspace. Results showed that users are more aware of their participation levels when using the table in speaker-based mode (they see their amount of talk), in the same condition underparticipators also increased their participation but the effect was not as strong as it was observed in overparticipators who gradually balanced their level of talk (Bachour, 2010).

Reflect shares concerns with other mirroring systems such as Second Messenger (Dimicco et al., 2007), a tool that when displaying information in real time pushed overparticipators to reduce their levels of participation but the effect was not as strong for underparticipators; or Conversation Clock and Conversation Votes (Bergstrom and Karahalios, 2007). In both cases, users can visualize onto a share surface the conversation levels. The Clock shows which member of the group spoke at each time and allows the users to track the conversation history being constantly displayed. On the other hand, Conversation Votes takes the interaction further by allowing collaborating peers to anonymously "vote" to indicate whether or not they agree with what is being said. Research using these devices suggests that there exists a variety of reactions to the visualizations especially in terms of reactions to long-term and short-term history, as well as changes in behavior among above and below average speakers.

1.3 GTI prototype, The Signal Orchestration System

Researchers at GTI have though of a prototype to support orchestration in the classroom. The Signal Orchestration System is composed of a set of wearable Personal Signal devices (PS-device), which have a visualization module and a communication module, and the Orchestration Signal manager (OS-manager), a graphical user interface that allows for remote control of the devices and monitor-



Figure 1.4: Signal Orchestration System. First PS-device prototype.

ing of the overall experience.

The visualization module in each PS-device (in figure) can display different color combinations associated to signals that teachers send to the students indicating orchestration aspects of the collaborative learning flow. The wearable devices consists of 4 LEDs (red, green, blue and yellow), which can be turned on and off individually or in pairs through a communication module. This module includes a transceiver RF12B that allows the PS-device to be remotely controlled by a central computer from up to 100 meters away. A central computer runs the OS-manager where teachers can configure the orchestration signals to be transmitted to the PS-devices (Hernández-Leo et al., 2011).

A key aspect of the wearable devices is that all signals become visible to the user as well as to the whole group, providing group awareness.

The hardware used in the development of the PS-devices is based on JeeNodes, a low-cost Arduino clone board. The board is powered by Lithium-ion polymer batteries and includes an ATmega328 microcontroller which supports embedding programmed logic. The system includes a master node that relays commands between the computer with the OS-manager and each PS-device.

On the other hand, a central computer (teacher's PC) runs the OS-manager with a uni-directional serial link with the master node. The OS-manager interface shows a canvas (1.6) with a visual representation of each PS-device. Through this visual interface teachers can configure two types of signals (a color or a combination of two colors) to be sent to each device. Besides the OS-manager has three



Figure 1.5: Signal Orchestration System PS-Devices.

buttons for controlling batch message transfer.

A unique number that matches the internal configuration and external labeling of each device identifies each PS-device in the OS-manager. The graphical box representing each device in the OS-manager contains an input text-field (see figure 1.7) in order to type the name of the student for quicker identification. Bellow each box, there is a button that for individual signal transfer so as to enable testing, individual correction, and group-membership readjustment. Each box can be dragged and dropped within the canvas, so that teachers can order them for a comfortable use (for example, arranging them to emulate the physical classroom arrangement).

1.4 Research questions

The aim of this research is to asses the efficiency of the Signal Orchestration System in the organization of the Jigsaw collaborative flow pattern through the assessment of the following questions:

- Does the SOS help reduce the time dedicated to Organization of the Jigsaw?
- Does the performance of the students increases due to the use of the SOS?
- Will students using the SOS have better group awareness?
- Do students in the SOS group complain less about group formation and assignation of resources?



Figure 1.6: Image of the canvas in the OS-manager.

1.5 Experimental hypothesis

The above mentioned research questions lead to the formulation of the following hypothesis which will be tested through an experimental procedure.

- H1 The SOS will reduce the time spent in organizing the Jigsaw activity.
- H2 The SOS group will obtain higher scores in the final test.
- H3 SOS group will have better group awareness.
- H4 SOS group will complain less about group and resources assignation.



Figure 1.7: Input text-field OS-manager for identification of each device.

Chapter 2 METHODS

The methods described in this section have been designed to test the efficacy of the Signal Orchestration System in the organization of the Jigsaw activity by measuring objective parameters such as organization time, group awareness, complains and scores. If the combination of all these parameters influences individual learning provided that there is a significant difference between the scores across groups, then this outcome will be argued in the discussion section of this report.

Previous research supports that the Signal Orchestration System is an efficient tool to orchestrate the Jigsaw collaborative flow within a classroom (Hernández-Leo et al., 2011, 2012). Such assumptions are based on the results obtained in an experiment where a group of master students used the devices to assist in the coordination of the Jigsaw. However, it has not yet been assessed whether this technological mediation outstrips the paper-based method traditionally employed by teachers.

The comparison of both systems becomes necessary in order to claim that the incorporation of a new technology in the classroom can bring fruitful outcomes or significantly increase the potential and efficacy of the collaborative dynamics.

The analysis of this thesis proposes a comparison between the Signal Orchestration System and the analogical method traditionally employed for the organization of the Jigsaw collaborative flow, in a real classroom environment. It is my aim to determine whether the technological mediation allows for the improvement of the traditional method, which will serve as the control system.

2.1 Development criteria and strategies

With the objective of comparing the performance across conditions, the experimental and the control groups realize the same Jigsaw activity but with different orchestration systems: the former uses the Signal Orchestration System whereas the latter uses the paper-based system. Four dependent variables will be measured in accordance with the hypothesis of this work: scores (comparing the difference between those obtained in the pre-test and post-test), time (spent in the organization of the different phases of the Jigsaw, through video coding and observations), group awareness (reported by participants in a likert-scale type questionnaire and observations) and number of complaints (regarding the group each student was asked to work with, assessed via questionnaires and observations). Figure 2.1 represents an outline off the independent variable, dependent variables and data gathering techniques.



Figure 2.1: Experimental set-up.

For the sake of statistical analysis, all measurements will be taken on individual bases even though the proposed activity is meant to be realized in groups. With the objective to reach at valid conclusions, a mixed methods approach will be implemented and gathered data will be triangulated (Creswell, 2003) so as to explain complex phenomenon in situations such as comparisons and to generate a more realistic vision.

2.2 Experimental design and set-up

A Jigsaw activity about human rights is proposed (figure 2.2) where students have to form specialist and Jigsaw groups in order to solve a task. Two classes of high school students are merged and subdivided so as to obtain two even groups of participants. Only ten human rights have been selected out of the 30 contained in the Universal Declaration of Human Rights proclaimed by the General Assembly of the United Nations in 1948, excluding those that could induce sensitive states among participants.

A Jigsaw uses a redundant group structure: main groups and expert groups. The group task can only be completed with the knowledge acquired in the expert groups, and thus with the intensive cooperation of all team members (Hinze et al., 2002).

The same activity, materials and schedule are assigned to both groups where only the orchestration method is altered: group A uses the Signal Orchestration System whereas group B uses the control system: the traditional Jigsaw paperbased method.

The stated methodology aims to determine whether the SOS system allows for a faster organization of the Jigsaw in its different phases and if this optimization of time increases the performance of the students in the final test. Last, the comparison between groups will also allow for the observation of differences in group awareness and the overall rating of the activity by the participants. I expect the results to bring insight into the the benefits and limitations of an application such as the SOS in the context of face-to-face collaborative learning.

2.3 Independent variable I: the SOS

Participants in the experimental group used the Signal Orchestration System (SOS) to support the orchestration of the proposed Jigsaw activity. As previously explained in the Sate of the art, the SOS is a system aimed at augmenting the physical environment with digital signals in order to indicate collaborative learning flow orchestration aspects to students. The system consists of a desktop application (the manager) and a set of signaling devices that can be worn by participants or embedded in the physical space. All the devices receive the visual and/or audio signals that are sent from the manager; colors to indicate group members, sounds to announce change of activity, for example.



Figure 2.2: Jigsaw collaborative flow.

2.3.1 Redesign of the wearable devices

For the aim of conducting these experiments, the SOS was re-designed and optimized. In previous research (Hernández-Leo et al., 2012) participants had made comments about the devices being uncomfortable. Moreover, observations during the activities lead to the realization that female participants avoided hanging the devices around their necks, on top of their breasts. A new design was created (2.3) in order to improve the robustness of the personal devices and make them more comfortable to wear.

Since it is relevant for the system to provide with group awareness, the place of the body where the device should be worn is fundamental. Being the chest not an optimal solution, the new design can be placed on the forearm allowing the user to see it as well as any other members in the group. On the other hand, if the participants sit down, the forearm remains visible and therefore the signals sent to the device are still publicly displayed. The new design also includes one white LED which allows for more and different color combinations and signals.



Figure 2.3: New design of the Signal Orchestration System PS-Devices.

2.4 Independent variables: the control system

As for the control system, students used the paper-based method that teachers usually employ when organizing Jigsaw type activities. As shown in figure 2.4, in a rectangular shaped piece of cardboard a number and a letter are written. The former indicates the expert group whereas the latter refers to the Jigsaw group.

One of these cards is assigned in an upside down position to each student at the beginning of the activity. Students are asked not to turn the card around before it is indicated by the instructor. Once the activity starts, students look for all those peers who have received the same number (1, 2, 3, 4 or 5). Following, groups can gather and pick out the envelope corresponding to their letter and solve the task within.

After having finished the expert phase, the teacher indicates to the class that they should find their Jigsaw groups. Students look at the letter in their card (a, b, c, d or e) and find those who have the same sign.



Figure 2.4: Individual cards for paper-based orchestration.

2.5 Dependent variables and data gathering techniques

As shown in figure 2.5, four dependent variables were measured. Time, scores, complaints and group awareness. All variables were measured in an individual base, per student, using specific data gathering techniques.

Three researchers observed both sessions and took notes according to a preestablished template. Also, the whole activity was video recorded with three different cameras especially located in order to cover the complete space of the classroom. The noise during both sessions was also recorded using an audio-recorder.

Figure 2.5 presents an outline of all dependent variables and the data gathering technique to be implemented in each case. Comments provide more information justifying the use of these techniques.

2.6 Participants

The experiment was conducted at the Escola Gavina, in a town called Picanya in the city of Valencia, Spain. Escola Gavina is a co-operative school (also known as co-op schools), and pays special attention to collaborative learning dynamics. Teachers and students are familiar with group work and cooperation even though the chosen classes did not have previous experience with the Jigsaw pattern.

As the school only has one class per course, students in the second and third courses of secondary school, 13 to 15 years old, were merged and divided into two

new groups (2.6). Participants were randomly allocated into each group keeping an even distribution of female and males across groups. In addition, the teachers of the courses along with the psychologist of the school assessed that the allocation of participants to one group and or another was equal in terms of individual and group performance of the students.

As a result, two groups of 26 participants were formed, where:

- 1. Group A: N=26 (15: male + 11: female)
- 2. Group B: N=26 (14: male + 12: female)

Concerning the previous knowledge of participants in the subject of the activity, in Spanish education, human rights are introduced to elementary and secondary school students in a transversal manner. While each school is free to teach about the subject in any activity related to civic education, officially such content is taught within the course Education for Citizenship and Human Rights. The course was designed for the last cycle of the primary and all secondary education in Spain by the socialist government of Rodriguez Zapatero and approved in 2006 by the Spanish Parliament in accordance with the Organic Law of Education . It consists in the teaching of democratic values and constitutional affairs (BOE, 2007).

2.7 Pre-test

One month before the experiment, both groups of students took a pre-test which consisted of 17 multiple choice and true or false type questions about the 10 human rights that had been selected for the experimental activity, as seen in picture. The aim of the pre-test was to find out whether students had been equally allocated to control and experimental groups in terms of previous knowledge and performance, as well as the time required for answering the questionnaires. In addition, the test included 5 likert-scale type questions assessing previous experience with collaborative activities within the classroom and the level of likeness of these activities. In both cases no significant differences where found with regards to the performance of the groups, neither with the time required to solve the test. Both groups expressed equal levels of likeness for groups activities and collaboration. Both pre-tests and post-tests can be found in the annex of this report: 6.2 and 6.3; 6.4 and 6.5.

2.8 Task description

For the aim of this experiment the traditional Jigsaw flow has been modified so as to have more control over the variables: two phases have been added. In the first phase, each student reads the same text which contextualizes the topic of the activity and introduces the first three human rights in the official declaration. Also, a final phase has been added where each group has two minutes to share their findings with the rest of the class. The decision to include this final phase aims to aid one of the main downsides of the Jigsaw: if one of the experts does not perform well, his Jigsaw group will lack the portion of knowledge that he was supposed to teach to them. As this research proposes a pre-test and post-test comparison to assess differences between groups, there is a need to reduce the impact of those students who did not perform well in the expert phase so as to avoid biased results.

After finalizing the group activity students go back to their individual seats. Post-test are distributed and solved individually. Students can leave the room after they hand in their test. The complete activity has a duration of 50 minutes approximately including all of its phases. Figure 2.7 represents the design of the activity according to the proposed Jigsaw collaborative learning flow. The information is organized in three columns (phase of the Jigsaw, specific activity, distribution in the classroom and signal required) and four rows explaining what happens at each phase of the activity.

2.9 Realization of the experiment

Experiments were realized at the Escola Gavina in Picanya, Valencia, Spain, on May 14th 2012. One classroom of the school where students usually take class was allocated to conduct the experiments. Three cameras were located in different corners of the room in order to have a 360 degrees recording of the space.

Experimental group was tested first. The activity was presented and students were told that they could leave the room at any moment if they felt uncomfortable. One student left without providing further explanation and the Jigsaw groups were immediately reorganized by the researchers.

In the case of the control group, two students did not attend to class on the day of the experiment and for that reason the group had 24 participants. As in the first case, Jigsaw groups were reorganized.

Both groups received the same explanation about the activity and the materials. In the experimental group the SOS devices were assigned to the students and a 10 minute demonstration activity was organized so as to reduce the surprise caused by the novelty of the device and to allow participants become familiar with the technology. In the control group each student received a cardboard signal. It is important to mention that in order to reduce the impact caused by the device across groups, students in the control group were also given PS-devices to be worn on their forearms. Even though SOS were not active during the activity, participants did play with them for a few minutes before the experiment started.

In both cases the activity begun with the individual phase. Students were given a paper document introducing to the issue of human rights, the activity proposed and the first three human rights in the official declaration. They had five minutes to read it.

Following we sent participants the first signal in order to meet with the expert groups. In the experimental group the signal arrived directly through the devices whereas, in the control group, students were asked to turn their cards around so as to see the number indicating their expert groups. After grouping with their peers, students collected the indicated material and proceeded to realize the task.

Ten minutes later, students had to move on to their Jigsaw groups (experimental group received new signals in the device and control group looked at the letter indicated in the card). Again, they collected the appropriate material and completed the activity.

In the following phase, each group had two minutes to share with the whole class their findings. In the experimental group only those group members whose device was blinking had to share the findings. In the control group, the researcher indicated the turn of each group for sharing the conclusions.

After the activity, students were asked to answer the post-test, as it can be see in figures 2.9 and 2.8. As they handed in the questionnaires they could leave the room.

Dependent Variable	Data gathering technique	Comments
Time	Video-coding	The whole session will be recorded. Each subject's timing will be tracked in specific events in each phase of the activity: Expert and Jigsaw. • time spent in group formation* • Looking for other group members • meeting at chosen location • gathering resources • sitting down • discussing *Final time measurement will be calculated from the moment the participant sees the signal to the moment when he is sitting down with his group mates.
Scores	Pre-test and post-test	Individual final assignments will provide an individual score. Each group's mean will be compared to the one obtained in the pre-test. Individual scores reduce the possible effect of outliers in group performance.
Group awareness	Likert- scale type Questionnaire s	Self-reported group awareness through questionnaires post- activity. Data will be compared across groups.
Complaints	Likert- scale type questionnaires + Observations	Counting how many times students complain about group formation in both conditions.

Figure 2.5: Experimental set-up. Dependent variables and data gathering techniques.



Figure 2.6: Participants answering pre-test one month before the experiment.

2		
Phases of the Jigsaw Collaborative Learning Flow Pattern	Specific activity for learning about human rights	Distribution in the classroom and signal required
Initial phase: Students read an introduction to the topic of human rights and the overall activity. All students read the same text individually. • Duration of the phase: 5 minutes	The text that all students are asked to read includes the first three human rights contained in the official declaration by the United Nations. These rights are the basis for contextualising the rest and comprehending the general	In this initial phase, since the activity is individual, each student is sitting at any chair and table of his choice. There is no need to team up with other group members. Orchestration signal required: - Experimental group: Voice command provided by the coordinator to start
kinkai bakense	concept underlying the ethics of human rights.	activity. -Control group: idem.
Expert phase: Students meet in groups of five members. They pick up the assigned envelope. Each expert group receives a set of two human rights- members have to become specialists of these rights by reading and discussing about them. • Duration of the phase: 10 minutes	In order to have Expert Groups of a reasonable size, a total of 5 Expert groups will be formed. Since each class has 26 students, there will be four groups of five participants and one group of six. The members of each Expert group will meet and become specialists of two human rights. All ten chosen human rights will be covered (2 human rights X 5 Expert groups).	After receiving the indication, students will find the other members of the group and sit at a chosen table. Five tables have been organized in the classroom. Tables do not have signals indicating to which group they belong since this would affect the measurement of group awareness (students would just meet at the table instead of trying to find their mates first.) Orchestration signal required: - Experimental group: color combination sent to PS-Device indicating Expert group. Five sets of signals are sent to students. - Control group: voice command provided by the coordinator. Students check the
Jigsaw phase: Students form Jigsaw Group. Each member contributes with their expertise in order to solve the assigned task. • Duration of the phase: 12 minutes	The members of each Jigsaw group will meet. Together they know ten human rights. Each student will teach his expertise to the others. They will have to solve a real journalistic case where some of the studied rights have been threatened or vindicated. They will have to reach an agreement and state which are the human rights pertinent to this case and why. Each Jigsaw group will solve a different case.	After receiving the indication, students will find the other members of the group and sit at any chosen table. Orchestration signal required: - Experimental group: color combination sent to PS-Device indicating Jigsaw group. Five sets of signals are sent to students. - Control group: voice command provided by the coordinator. Students check the number written on the right half of their card.
Group phase: Aims to aid one of the main downsides of the jigsaw: if one of the experts does not perform well, his jigsaw group will lack the portion of knowledge that he was supposed to teach to them. This phase allows for the general sharing of knowledge. All ten human rights should be mentioned during this phase. Duration of the phase: 2 minutes per group. 10	A delegate of each jigsaw group has two minutes to share with the rest of the class their findings. Cases have been chosen so that each group at least reflects on two specific human rights. When each delegate shares the group's findings, then the whole class is exposed two the ten human rights selected for the activity.	Students have already been asked, as part of the Jigsaw task, to choose a group leader who will be in charge of communicating the group's findings to the rest of the group. Orchestration signal required: - Experimental group: blinking LEDs on the PS-Device of each Jigsaw group's leader. - Control group: voice command provided by the coordinator. End of the activity.

Figure 2.7: Experimental set-up. Activity flow.



Figure 2.8: Participants in the control group during the activity.



Figure 2.9: Participants in the experimental group during the activity.

Chapter 3 RESULTS

I have compared the time spent during organization of the Jigsaw activity in two phases, expert and jigsaw, between groups. I have also compared the scores obtained in the test. Finally, I have analyzed the data gathered through the Likertscale type questionnaires to asses questions regarding group awareness and complaints. The following results have been organized in accordance with the research hypothesis.

- H1 The SOS will reduce the time spent in organizing the Jigsaw activity.
- H2 The SOS group will obtain higher scores in the final test.
- H3 SOS group will have better group awareness.
- H4 SOS group will complain less about group and resources assignation.

3.1 Time

I have calculated the time that each participant has spent in organization of the Jigsaw activity in two phases, expert and jigsaw, excluding those phases where the activity was individual or did not require finding group members or changing position within the classroom. The resulting time is the sum of seconds between the moment when the participant sees the signal and the moment when he is sitting at the table with other group members. The data was collected using video coding technique.

Data was processed using MatLab for the statistical analysis of all time comparisons between groups. In order to reach equal sample sizes I removed one participant from the experimental group whose values were matching those found in the mean. The distribution is normal according to Lilliefors test. A Leven's test was ran and obtained results (p=0.26) fail to reject the null hypothesis of equal variances on different samples. Therefore, an independent-samples Wilcoxon t-test was conducted to compare time spent during organization of the expert phase in the Signal Orchestration System and paper-based orchestration conditions. As seen in figure 3.1, there was a significant difference in the time for SOS (M=30.25, SD=11,61) and paper-based (M=40.54, SD=9.06) conditions; t(23) = -4.14, p < 0.01, which allows us to reject the null hypothesis.

With regards to the second phase of the activity, the jigsaw phase, no significant difference was found between groups.



Figure 3.1: Results show expert group was significantly faster than control group

3.2 Scores

Concerning both group's performance in the baseline pre-test, statistical analysis showed that there was no significant difference. Consequently, I have calculated the scores that each participant obtained in the tests after realizing the activity. The data was collected using paper-based questionnaires and it was processed using

MatLab. Since data did not meet the normality assumption, a non-parametric test was ran. A Mann-Whitney test indicated that scores were greater for those students using the Signal Orchestration System (Mdn = 17) than for those in the control group (Mdn = 15), U = 411.5, p <0.01, r = 0.51. As shown in figure 3.2 results reject the null hypothesis.



Figure 3.2: Results show expert group scored significantly better than control group

3.3 Complaints and group awareness

Data was gathered through a 5 point Likert-scale type questionnaire for the comparison of self-reported group awareness and complaints. The questionnaire for both groups contained six questions addressing different variables. Since gathered data did not meet the assumption of normality, for each array I ran a non parametric Mann-Whitney Rank Sum test. Figure 3.5 shows statistics for all questions from one to six. Stars indicate those results where significance was found.

1. When I am at class I like doing collaborative activities.

- 2. In the activity that we did today I did not like the group that I had to work with.
- 3. During today's activity we wasted time organizing the groups.
- 4. During today's activity it was clear what we had to do in each phase.
- 5. During today's activity it was easy to see who were the other members of my group.
- 6. I liked today's activity.

The first question was intended to establish a baseline for comparison of likeness of collaborative activities between groups. After running a Mann-Whitney Rank Sum test, I found no significant differences between groups.

3.3.1 Complaints

Questions two and three were addressing the dependent variable complaints:

- 2. In the activity that we did today I did not like the group that I had to work with.
- 3. During today's activity we wasted time organizing the groups.

In both cases, a Mann-Whitney Rank Sum test was run. I found no significant differences between groups and therefore fail to reject the null hypothesis. Qualitative data gathered by three observers supports these results.

However, I can still observe a tendency that sets a difference between groups regarding question 3 (During today's activity we wasted time organizing the groups). As shown in figure 3.3, over 50 per cent of the participants agreed (31,3) or strongly agreed (18,8) that they had wasted time while organizing expert and jigsaw groups. In addition, only 18,8 percent strongly disagreed. Perception of time efficiency was higher in experimental group where 34 per cent agreed (24) and strongly agreed (8) with the same assumption, see figure 3.4. In contrast, 36 per cent of the participants in the experimental group strongly disagreed that they had wasted time organizing the groups.

3.3.2 Group awareness

Questions four and five were addressing the dependent variable group awareness:

• 4. During today's activity it was clear what we had to do in each phase.



We wasted time organizing the groups (Control group)

Figure 3.3: Experimental group perception of time efficiency.

• 5. During today's activity it was easy to see who were the other members of my group.

After running the Mann-Whitney Rank Sum test, responses to question four indicate a significant difference between groups. Students using the Signal Orchestration System (Mdn = 5) reported having a better understanding of what they had to do at each phase of the activity compared to those in the control group (Mdn = 3.5), U = 92, p <0.01, r = 0.63.

Concerning question five, "During today's activity it was easy to see who were the other members of my group", results show a significant difference between groups. Students using the Signal Orchestration System (Mdn = 5) reported better group awareness than those in the control group (Mdn = 4), U = 92, p=0.02, r = 0.47. Results allow us to reject the null hypothesis.

3.3.3 Enjoyment of the activity

Question six addressed the overall enjoyment of the proposed activity:

• 6. I liked today's activity

Students in the experimental group (Mdn = 5) reported having enjoyed the activity significantly more than their peers in the control group (Mdn = 4), U = 97, p <0.01, r = 0.83. Data supports that those students using the SOS rated the activity higher that their peers using the paper-based system.



Figure 3.4: Experimental group perception of time efficiency

3.4 Acceptance of the device

Students in the experimental group had two extra questions addressing the acceptance of the device:

- 7. The device that we used for organizing the activity was useful.
- 8. I would like to use the device next time we do group activities.

The SOS had great acceptance among its users. As shown in figure 3.6 80 per cent of the participants manifested that the SOS device was useful for the orchestration of the Jigsaw activity.

Also, as 3.7 shows, 70,8 per cent of the participants would like to use the SOS again if they had to do group activities in the classroom.



Figure 3.5: Five point Likert Scale type questionnaires results.



Figure 3.6: 80 per cent of the participants manifested that the SOS device was useful to organize the Jigsaw



Figure 3.7: 70,8 per cent of the participants in the experimental group would like to use the SOS again.

Chapter 4

DISCUSSION AND EVALUATION

4.1 Discussion

In this research I have assessed the performance of the Signal Orchestration System in comparison with a paper-based system for the orchestration of the Jigsaw collaborative pattern flow, in the context of a face-to-face activity.

The main objective of this analysis is to evaluate if the incorporation of this technological mediation brings benefits to the organization of collaborative activities.

I have aimed to test these benefits by measuring four dependent variables: time, scores, complaints and group awareness. This study has revealed three important implications that support the adequacy of the SOS in the proposed context.

First, it reduces the time that students spend while trying to find their peers and organize their groups. Collected data supports that the SOS group spent significantly less time than the control group during the expert phase. However, no significance was found in the following phase of the activity when the students had to form the jigsaw groups. I speculate that limitations in the design of the control system affected the dependent variable since students in the control group had been given a card that was indicating both groups: expert and jigsaw, by providing a number and a letter respectively. Observations support that while working along with their peers in the expert phase, students where already trying to find out which other students belonged to their jigsaw groups. This can also be seen in the video recordings where some students are showing their cards to each other.

Even though students in the control group had this extra information (those in the experimental group did not know which group they belonged to until the reception of the signal in the PS-devices), participants in the former group did not find their mates faster than those using the device. The fact that there was no significant difference between the time spend by both groups in the jigsaw phase allows us to support that the SOS reduces the time spent in the organization of the Jigsaw.

Second, participants in the experimental group obtained higher scores than their peers in the control group. Both groups had answered the same pre-test a month before the experiment. No significance was found in their performance, establishing a common baseline in scores. Then, during the activity they received the exact same materials and realized the same activity. However, those in the experimental group scored significantly better that those in the control group. Also, results showed no significance with regards to the participants perception on how much time they had spent organizing the activity. Neither do they reported not being at ease with the group that they had to work with. Then, if it is not the feeling of having wasted time or not having liked the groups they collaborated with...why did students in the experimental group performed better than those in the control group? Further research needs to be conducted in order to understand the cause of this difference. Nevertheless, there is evidence that good levels of group awareness, which can be defined as knowledge about the social and collaborative environment the person is working in (e.g., knowledge about the activities, presence or participation of group members (Buder, 2010; Bodemer and Dehler, 2011), improve collaboration, motivation and performance (Janssen et al., 2011; Phielix et al., 2011; Alavi et al., 2009)

Third, compared to the control group, students using the SOS rated the overall activity significantly higher. In the Likert-scale type questionnaires both groups reported that in general terms they enjoy collaborative activities in the classroom and no significance was found between them. However, the experimental group enjoyed the experience significantly more that the control group: U = 97, p <0.01, r = 0.83. Even though this can be related to the fact that the novelty of the gadget caused an increase in the motivation, it could also be argued that there is a correlation with the fact that these participants reported a stronger feeling of group awareness: U = 92, p <0.01, r = 0.63 and that lead to better social climate in the classroom. As (Salomon, 1989) posits in *When teams do not function the way they ought to*, information regarding group awareness can reduce the efforts that group members invest in the coordination of their actions and can also increase efficiency by reducing the chance of errors.

4.2 Problems faced and future work

Conducting controlled experiments in an authentic experience is always a risky matter. The richness of the experience is equally proportional to its complexity. Even though I tried to control the variables and measurements unexpected situations always occur: two students did not attend class the day of the experiment, one participant in the control group had to leave earlier and one in the experimental group decided to leave the classroom when the activity started. Because the Jigsaw collaborative flow requires that there is one expert of each topic in each jigsaw group, if students are missing then some reorganization is required. When using the SOS, in the experimental group, these issues were easily solved just by changing the signal that some students were supposed to receive for the new ones. Participants never knew that there was a problem as they just received a signal like everyone else. However, in the case of the control group where participants had been given cards with a letter and a number identifying expert and jigsaw groups, we had to cross out the number and write a new one. In all three cases where this occurred students showed their disconformity. The fact that this occurred remarks another advantage of the SOS where group organization decisions become less evident to students. On the other hand, I consider that there is still room for improving the robustness of the SOS PS-devices.

The results of in this research project suggest promising future work. The experience questions the relevance of the time variable and increases the importance of issues such as group awareness. Even though the experimental group spent significantly less time forming groups than the control group in one of the phases, I do not have enough information to deeply understand the way in which those students took advantage of the extra time. Further research should be conducted in order to support if this was the reason why they outscored their peers.

There is evidence to suggest that something more relevant happened among the experimental participants and that lead to their success: they enjoyed the activity significantly more than their peers, had a better understanding of what they had to do at each phase and performed better in the post-test. Future work could take in consideration the theory of cognitive load (Kirschner, 2002) to deepen insight on these findings. The SOS is a passive technology that only sends very specific signals just when they are required. A person has a limited amount of cognitive resources which they must allocate amount all mental tasks being concurrently performed. Students may quickly rely on their personal devices to give them the appropriate data and free their minds from having to think of organizational aspects.

Cognitive load refers to the total amount of mental activity on working memory at an instance in time. There is evidence that short term memory is limited in the number of elements it can retain simultaneously (Sweller et al., 1990). This is an important issue for technology and instructional designers because if a design requires the user to hold too many items in short term memory it might not effectively lead the expected outcome. In addition, as the cognitive load of a user increases, his ability to perform effectively slowly decreases until reaching a point of cognitive overload. Since a person starts with a very limited pool of cognitive resources, a poor design can easily exhaust it. At that point, performance drops and frustration and error rates are dramatically increased (Tracy and Albers, 2006).

Chapter 5 CONCLUSION

In this project I have tested the efficacy of the Signal Orchestration System compared to the traditional paper-based method for the organization of the Jigsaw collaborative learning flow. Results provide solid evidence that those students using the SOS spent less time in the organization of the activity, obtained better scores, reported a better sense of group awareness and finally rated the overall activity significantly higher than their peers in the control group.

My findings support that the SOS is a highly efficient tool for the orchestration of collaborative flows in face-to-face settings. Students have found the device useful and have also expressed their desire to use it again in the future. The system is flexible to adapt to a wide variety of orchestration signal requirements and to fix organization issues in a rapid way which does not disturb the flow of the activity neither distracts the learners.

On the other hand, this report suggests future lines of research to better understand the correlations that lead to the superiority of the experimental group by further exploring and applying the theories of group awareness and cognitive load.

The significances that have been found in the variables time, scores and group awareness evidence that there is a bright future for CSCL and the development of passive technologies that can easily enhance collaboration processes among students, as well as boosting their performance and enhancing the sense of group awareness.

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Chapter 6 ANNEX

Figures 6.1 and 6.2 show the pretest that participants took before the experiment. The same day, all students were also asked to answer a Likert Scale type questionnaire which can be found in figure 6.3.

Figures 6.4 and 6.5 show the post-test answered by participants in both, control and experimental, groups.

Likert Scale type questionnaire answered by participants in the control group are shown in 6.6. For the questionnaires assigned to the experimental group, please see 6.7. All the texts appear in the original version in Spanish.

Haz un círculo alrededor de la opción que consideres correcta

- 1- Sólo las personas que viven en países democráticos gozan de derechos humanos
 - a-Verdadero
 - b- Falso
- 2- Todas las personas son iguales ante la ley
 - a- En cualquier caso
 - b- Siempre y cuando tengan un abogado
 - c- Depende de su nacionalidad
- 3- Una persona puede ser tratada como culpable de un hecho hasta que no se demuestre lo contrario
 - a-Verdadero
 - b- Falso
 - c-Depende el delito que se le impute
- 4- Las personas tienen derecho a cambiar de religión si así lo desean
 - a-Verdadero
 - b- Falso
 - c- Depende de la religión que tengan y el país donde estén
- 5- Toda persona tiene derecho a participar en el gobierno de su país, directamente o por medio de representantes
 - a-Verdadero
 - b- Falso
 - c- Solo aquellas personas que hayan ido a la universidad
- 6- La Seguridad social es un derecho de las personas que
 - a- Trabajan
 - b- Están desempleadas
 - c- Todas las personas tienen derecho a la seguridad social
- 7- Todas las personas que hacen el mismo trabajo tienen derecho a recibir el mismo salario
 - a-Verdadero
 - b- Falso
 - c- Depende del sitio donde trabajen
- 8- Las personas no pueden ser obligadas a hacer un trabajo que no quieren hacer
 - a-Verdadero
 - b- Falso
- 9- Las personas tienen derecho a elegir a la gente que les gobierna.
 - a-Verdadero
 - b- Falso
 - c-Solo si pertenecen a un partido político
- 10- Los trabajadores tienen derecho a formar un sindicato
 - a- Solo si el estado lo permite
 - b- Solo si cobran el mismo salario
 - c-No se qué es un sindicato
 - d- a y b son incorrectas
- 11- Las personas son libres:
 - a- Desde que nacen
 - b- A partir de que cumplen 18 años
 - c- A partir de que cumplen 21 años

Figure 6.1: Pre-test answered by participants in both conditions.

12- Leer la correspondencia (las cartas, por ejemplo) que le ha sido enviada a otra persona

a- Es una travesura

b- Está bien porque es importante saber con quién se relacionan los otros

c- Es una violación a la intimidad

13- Si alguien públicamente dice mentiras sobre mi y daña mi imagen ante los otros

a- Es una mala persona

b- Tengo derecho a ser protegido por la justicia

c- Todos somos libres de decir lo que pensamos de los otros

14- El gobierno de mi país puede prohibirme que viaje a otro sitio o que regrese a mi país

a- Las personas tienen "libertad de movimiento"

b-Las personas que enfrentan una causa judicial deben ser retenidas en el país

c- a y b son correctas

d- todas las respuestas son incorrectas

15- Juan ha llamado a la radio para explicar por qué él considera que el presidente está haciendo mal su trabajo

a- Juan debe ser interrogado por la policía ya que no es legal hablar mal de quienes nos gobiernan

b- Juan tiene derecho a expresar lo que piensa

c- No es correcto utilizar los medios de comunicación para dar opiniones personales

16- Derecho a la democracia significa que

a- Las personas pueden votar para elegir a sus representantes

b- Los partidos políticos eligen a quienes nos gobiernan

c- Las personas que estudiaron política pueden trabajar en el gobierno

17- Es un derecho de todos recibir educación pública

a- Verdadero

b- Falso

b- La escuela pública es solo para quienes no pueden pagar la privada

Figure 6.2: Pre-test answered by participants in both conditions.

Del 1 al 5, cuánto estás de acuerdo con las siguientes afirmaciones		
18- Cuando estoy en clase me gusta hacer actividades en grupo		
1-Totalmente en desacuerdo 2- En desacuerdo 3- Ni de acuerdo ni en desacuerdo	4- De acuerdo	5- Totalmente de acuerdo
19- Muchas veces sucede que no me gusta el grupo con el que me toca trabajar		
1-Totalmente en desacuerdo 2- En desacuerdo 3- Ni de acuerdo ni en desacuerdo	4- De acuerdo	5- Totalmente de acuerdo
20- Cuando hacemos actividades grupales en la clase perdemos mucho tiempo organizando los	grupos	
1-Totalmente en desacuerdo 2- En desacuerdo 3- Ni de acuerdo ni en desacuerdo	4- De acuerdo	5- Totalmente de acuerdo
21- Cuando hacemos actividades de grupo nadie sabe bien qué tiene que hacer		
1-Totalmente en desacuerdo 2- En desacuerdo 3- Ni de acuerdo ni en desacuerdo	4- De acuerdo	5- Totalmente de acuerdo
22- Aprendo más cuando intercambio opiniones con mis compañeros que cuando estudio solo		
1-Totalmente en desacuerdo 2- En desacuerdo 3- Ni de acuerdo ni en desacuerdo 4- De a	cuerdo 5- Tota	Imente de acuerdo

Figure 6.3: Likert Scale type questionnaire answered by participants in both conditions before experiment.

Haz un círculo alrededor de la opción que consideres correcta

- 1- Solo las personas que viven en países democráticos gozan de derechos humanos
- a- Verdadero
- b- Falso
- 2- Todas las personas son iguales ante la ley
- a- En cualquier caso
- b- Siempre y cuando tengan un abogado
- c- Depende de su nacionalidad

3- Una persona puede ser tratada como culpable de un hecho hasta que no se demuestre lo contrario

- a- Verdadero
- b- Falso
- c- Depende el delito que se le impute
- 4- Las personas tienen derecho a cambiar de religión si así lo desean
- a- Verdadero
- b- Falso
- c- Depende de la religión que tengan y el país donde estén
- 5- Toda persona tiene derecho a participar en el gobierno de su país, directamente o por medio de representantes
- a- Verdadero
- b- Falso
- c- Solo aquellas personas que hayan ido a la universidad
- 6- La Seguridad social es un derecho de las personas que
- a– Trabajan
- b- Están desempleadas
- c- Todas las personas tienen derecho a la seguridad social
- 7- Todas las personas que hacen el mismo trabajo tienen derecho a recibir el mismo salario
- a- Verdadero
- b- Falso
- c- Depende del sitio donde trabajen
- 8- Las personas no pueden ser obligadas a hacer un trabajo que no quieren hacer
- a- Verdadero
- b- Falso
- 9- Las personas tienen derecho a elegir a la gente que les gobierna.
- a- Verdadero
- b- Falso
- c- Solo si pertenecen a un partido político
- 1.000
- 10- Los trabajadores tienen derecho a formar un sindicato
 - a- Solo si el estado lo permite
 - b- Solo si cobran el mismo salario
 - c- No se qué es un sindicato
 - d- a y b son incorrectas

Figure 6.4: Post-test answered by participants in both conditions.

11- Las personas son libres:

- a- Desde que nacen
- b- A partir de que cumplen 18 años
- c- A partir de que cumplen 21 años
- 12- Leer la correspondencia (las cartas, por ejemplo) que le ha sido enviada a otra persona a- Es una travesura
 - b- Está bien porque es importante saber con quién se relacionan los otros
 - c- Es una violación a la intimidad
- 13- Si alguien públicamente dice mentiras sobre mi y daña mi imagen ante los otros
 - a- Es una mala persona
 - b- Tengo derecho a ser protegido por la justicia
 - c- Todos somos libres de decir lo que pensamos de los otros
- 14- El gobierno de mi país puede prohibirme que viaje a otro sitio o que regrese a mi país a- Las personas tienen "libertad de movimiento"

 - b- Las personas que enfrentan una causa judicial deben ser retenidas en el país
 - c- a y b son correctas
 - d- todas las respuestas son incorrectas
- 15- Juan ha llamado a la radio para explicar por qué él considera que el presidente está haciendo mal su trabajo
 - a- Juan debe ser interrogado por la policía ya que no es legal hablar mal de quienes nos gobiernan b- Juan tiene derecho a expresar lo que piensa

 - c- No es correcto utilizar los medios de comunicación para dar opiniones personales
- 16- Derecho a la democracia significa que
 - a- Las personas pueden votar para elegir a sus representantes
 - b- Los partidos políticos eligen a quienes nos gobiernan
 - c- Las personas que estudiaron política pueden trabajar en el gobierno
- 17- Es un derecho de todos recibir educación pública
 - a- Verdadero
 - b- Falso
 - b- La escuela pública es solo para quienes no pueden pagar la privada
- 18- ¿Cuántos derechos humanos existen?
 - a- 30 b- 27

 - b- 40
- 19- En qué año se firmó la Declaración Universal de los Derechos Humanos?
 - a- 1938
 - b- 1945
 - b- 1948

, 20- ¿Cuál es el nombre de la organización que proclamó los Derechos Humanos?

- a- Organización mundial de los Derechos Humanos
- b- Organización de las Naciones Unidas
- b- Organización mundial de Naciones y Derechos

Figure 6.5: Post-test answered by participants in both conditions.

Cuánto estás de acuerdo con las siguientes afirmaciones

```
21- Cuando estoy en clase me gusta hacer actividades en grupo
A-Totalmente en desacuerdo B- En desacuerdo C- Ni de acuerdo ni en desacuerdo
                                                                                          D- De
        E- Totalmente de acuerdo
acuerdo
22- En la actividad que realicé hoy no me gustó el grupo con el que me tocó trabajar
A-Totalmente en desacuerdo B- En desacuerdo C- Ni de acuerdo ni en desacuerdo
                                                                                            D- De
             E- Totalmente de acuerdo
acuerdo
23- Durante la actividad de hoy perdimos tiempo organizando los grupos
A-Totalmente en desacuerdo
                            B- En desacuerdo C- Ni de acuerdo ni en desacuerdo
                                                                                            D- De
             E- Totalmente de acuerdo
acuerdo
24- Durante la actividad de hoy estaba claro qué teníamos que hacer en cada etapa
A-Totalmente en desacuerdo B- En desacuerdo
                                                     C- Ni de acuerdo ni en desacuerdo
                                                                                          D- De
             E- Totalmente de acuerdo
acuerdo
25- En la actividad de hoy me fue fácil ver quiénes eran los otros miembros de mi grupo
A-Totalmente en desacuerdo B- En desacuerdo C- Ni de acuerdo ni en desacuerdo
                                                                                          D- De
             E- Totalmente de acuerdo
acuerdo
26- Me gustó la actividad de hoy
A-Totalmente en desacuerdo
                             B- En desacuerdo C- Ni de acuerdo ni en desacuerdo
                                                                                            D- De
             E- Totalmente de acuerdo
acuerdo
```

Figure 6.6: Likert Scale type questionnaire answered by participants in the control group.

Cuánto estás de acuerdo con las siguientes afirmaciones

21- Cuando estoy en clase me gusta hacer actividades en grupo A-Totalmente en desacuerdo B- En desacuerdo C– Ni de acuerdo ni en desacuerdo D- De E- Totalmente de acuerdo acuerdo 22- En la actividad que realicé hoy no me gustó el grupo con el que me tocó trabajar A-Totalmente en desacuerdo B- En desacuerdo C- Ni de acuerdo ni en desacuerdo acuerdo E- Totalmente de acuerdo D- De 23- Durante la actividad de hoy perdimos tiempo organizando los grupos A-Totalmente en desacuerdo B- En desacuerdo C- Ni de acuerdo ni en desacuerdo acuerdo E- Totalmente de acuerdo D- De 24- Durante la actividad de hoy estaba claro qué teníamos que hacer en cada etapa A-Totalmente en desacuerdo B- En desacuerdo D- De C– Ni de acuerdo ni en desacuerdo E- Totalmente de acuerdo acuerdo 25- En la actividad de hoy me fue fácil ver quiénes eran los otros miembros de mi grupo A-Totalmente en desacuerdo B- En desacuerdo C- Ni de acuerdo ni en desacuerdo D- De E- Totalmente de acuerdo acuerdo 26- Me gustó la actividad de hoy B- En desacuerdo A-Totalmente en desacuerdo C– Ni de acuerdo ni en desacuerdo D- De E- Totalmente de acuerdo acuerdo 27- Creo que el dispositivo que utilizamos fue útil para organizar la actividad A-Totalmente en desacuerdo B- En desacuerdo C- Ni de acuerdo ni en desacuerdo acuerdo E- Totalmente de acuerdo D- De 28- En la próxima actividad de grupo me gustaría volver a utilizar el dispositivo A-Totalmente en desacuerdo B- En desacuerdo C- Ni de acuerdo ni en desacuerdo acuerdo E- Totalmente de acuerdo D- De

Figure 6.7: Likert Scale type questionnaire answered by participants in the experimental group.