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Virtual reality tool to improve collaborative work in the university context

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Abstract

The development of collaborative work skills is an important issue during students' academic training. In a globalized and competitive world, employers consider this type of skill as a fundamental requirement when hiring professionals. When analyzed in depth, the way in which people work in collaborative environments has not changed significantly over the years. Moreover, technology has not managed to displace the use of traditional collaborative work tools. For example, studies show that paper and pencil are still widely used in collaborative design. This paper presents a study that describes the design and implementation of a low-cost multi-touch desktop system that encourages and facilitates the evaluation of collaborative work within a classroom.

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Keywords: Multi-touch system; Educational environments; Collaborative work in the classroom.

1. Introduction

Information and communication technologies (ICTs) have come to revolutionize human life in many aspects and the educational field has not been an exception. Mobile learning (m-learning) is defined as the delivery of education

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and training through mobile devices. It is considered a natural evolution of e-learning or electronic learning, differing from that in that the use of mobile technology gives flexibility to learning, since students can learn anytime, anywhere [1].

M-learning is a concept relatively new in the pedagogical field of learning. The first published work that focuses on mobile learning comes in 2000, in Computers & Education magazine, where Mike Sharples (2000) examined the potential of new designs supported by mobile technologies that could improve lifelong learning programs and adult continuing education opportunities. Many, if not all, of the ideas raised in this Sharples paper continue to evolve and are of great interest in m-learning today. Sharples is one of the most active researchers in the field of mobile learning [2].

Teaching based on collaborative work activities is one of the aspects on which higher education has been focused lately. Today, educators design activities, such as group projects and assignments in and out of class, that encourage collaborative work in and out of class [3].

The design of collaborative activities poses a major challenge for teachers, especially those related to assessment. The process of evaluating a collaborative activity becomes especially difficult because the teacher usually has the final version of the students' work. The traditional tools used do not provide information on the workload invested by each student, their contribution or the quality of it, which would allow the teacher to objectively evaluate and assign a qualification to each student [4].

Currently, there are four kinds of MMT systems in the literature: digital tables [5], work tables [6], drawing tables [7], and collaborative tables [2]. This research work focuses on the design and implementation of a collaborative table for education, which allows for improved analysis and subsequent evaluation of the collaborative work carried out by a group of students.

This document provides a description of the requirements that were considered for the development of the proposed system and then a description of its implementation. Afterwards, the methodology used in the experiments is described, where the research context, the functionality tests, the usability tests, the details of the experiments performed and the results obtained are explained. At the end, the results are discussed and recommendations for future research are presented.

2. Proposed multi-touch system

2.1. Characteristics of the design

The following describes the design features that were defined for the proposed system:

1. Multi-user support: As with the solutions reviewed [8], this feature is necessary to provide the ability to use the system by multiple users at the same time.
2. Interaction with tangible objects: provide the student with tools that are more natural to use as they lead to less cognitive burden [9].
3. Freedom of movement: Unlike other revised solutions, the system must allow free movement of students.
4. Data entry support: Like TATINPIC, it supports data entry via tablets [10].
5. Differentiation of contributions based on color: this characteristic was considered in order to make it easier for the teacher to distinguish between individual student contributions.
6. Monitoring and storage of user actions: it is intended to provide the teacher with tools to control multiple work groups simultaneously. In addition, to provide a job storage functionality, to offer the teacher the facility to evaluate the jobs once the assignment sessions are over.

2.2. Physical layout

Students can interact with the system through a multi-touch collaborative surface, digital pens and tablets. Figure 1 shows a view of the physical layout of the proposed system.

1. Hardware: The projector and Optitrack are located on a tabletop. A collaborative application is projected on the table, where students interact through pens with infrared markers and use tablets to enter text [11].

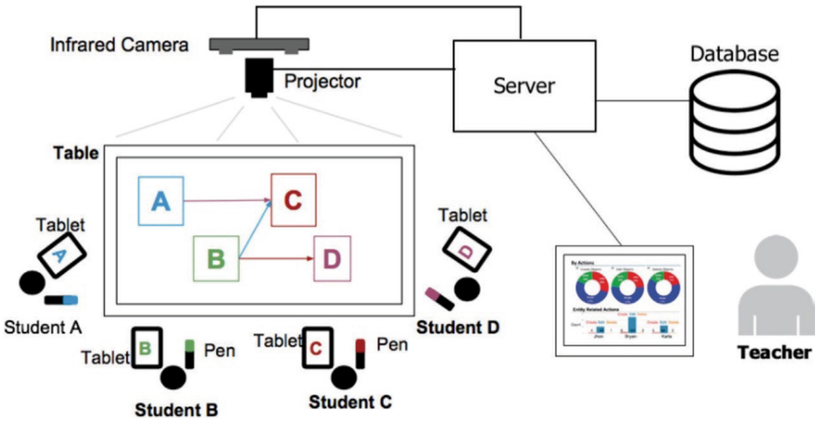

Fig. 1. Physical diagram of the collaborative surface

2. Software: The system is composed of: the collaborative control client, the Server Tracking, a Web system for the student and a Web system for the teacher. The student web application allows to log into the system and edit text in the collaborative application using the tablet. The client was implemented in the Multitouch for Java framework (MT4J). Each trace made on the surface is processed by the PaleoSketch Library [12]. This library converts the traces into shapes such as rectangles, circles and lines. The traces are made using pens with 3 infrared markers. The tracking server keeps track of the pens using the Camera SDK library provided by Optitrack. When a student draws on the surface, a "touch" event is generated using the TUIO (Tangible User Interface) protocol and sent to the collaborative control client. The figures and text made by each student are drawn with different colors to differentiate each member of the group [13].
3. On the other hand, the teacher's web interface allows the teacher to evaluate the students' activities. The system measures the activity levels of each student. In real time, the system presents colored alerts that change from green to yellow or red, depending on the level of activity that the student has had in the last 5 minutes (Figure 2a). Green means that the student is actively working, red means that the student has stopped doing actions in the last 5 minutes. The system also allows you to view a summary of each student's contributions to the collaborative work. In this, the percentages of contribution to the task are shown, and at a more detailed level, the percentage of participation for each type of action performed is also shown (Figure 2b). Finally, the teacher is able to use the JSON file that provides the collaborative surface in order to reproduce, in its Web interface, the whole process of collaborative diagram creation (Figure 3).

2.3. Design of the interaction

The proposed interaction is based on tangible objects and suggests the use of pens with infrared marks to draw on the interactive surface. Figure 4 shows an example of interaction designed for drawing Entities in a database design application. The first thing that is done is to draw a square that is painted with the color corresponding to the pen; once the line is recognized, an entity of the same color is drawn [14].

3. System components

Figure 5 shows the main components and interfaces that provide the necessary requirements for the proper functioning of the proposed system. First, the motion capture component or so-called Tracking Server allows to know the position of the feathers at all times to determine the interaction with the projected surface. Secondly, the collaborative visualization and control component or Graphic Client [15] is in charge of the visual representation of the objects on the collaborative surface, in addition to recognizing the traces made by the users. Finally, the individual authentication and control component or Web application allows users to authenticate themselves and enter information into the collaborative work, and at the same time, is used to provide the teacher's monitoring and evaluation interface.

a) b)

Fig. 2. (a) Color alerts used to indicate each student's activity. (b) Percentages of student participation

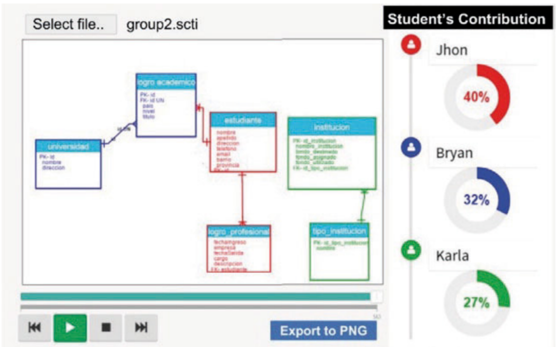

Fig. 3. Player used to observe the collaborative task development process

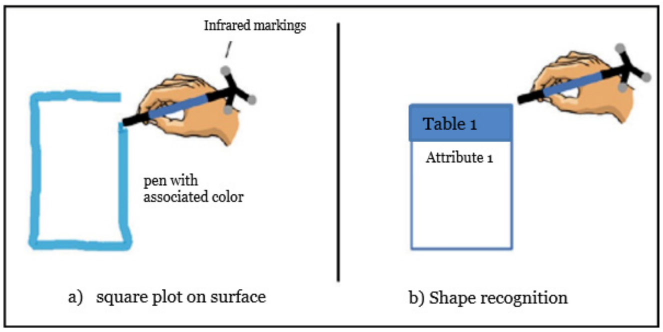

Fig. 4. Pen interaction on the collaborative surface for the creation of entities

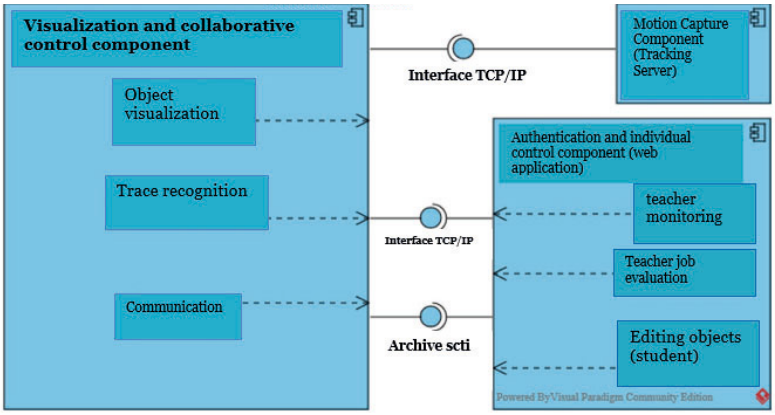

Fig. 5. System component diagram [16]

4. Experimental results

Once implemented, a functionality test was performed to measure the degree of compliance with the defined requirements. These tests had a black box approach. The designed test cases are defined in a document that complies with the IEEE 829-1998 standard. A usability test was also performed in order to validate the system. This test measured three aspects of usability: ease of use, user satisfaction, and usefulness of the system. In this sense, 10 teachers from the area of computer science engineering who are related to the teaching and/or evaluation of database modeling were selected. Also, 22 students from the Database I course participated. The experiments were organized in two groups, that of teachers and students.

Experiment 1: teachers participated in a pre-post test, a questionnaire was used where they were asked about their perception of their experiences in group work in relation to the following variables: equity of workload; ease of assigning an individual and group grade. The variables were measured using the Likert scale. Later, a work session was conducted that consisted of the participation of the teachers in the monitoring and evaluation of a collaborative work session using the implemented solution. The teachers were able to monitor and evaluate the work sessions through the solution's Web interface. Once the experiment was finished, a second observation was made in which the same variables were measured again.

Experiment 2: the students participated in two experiments with a pre-post test scheme, 7 weeks apart; they were assigned to work groups in which 3 to 4 students participated at random. Students assigned to the experimental group participated using the collaborative surface. Students in the control group participated using traditional tools, which were: colored markers, flip chart and stikers; or the LucidChart web tool. A questionnaire was used to ask them about their perception of the following variables: equity of workload, ability of the tools to reflect their actual contribution; and compliance with their individual and group grades. Similarly, the variables were measured using the Likert scale.

The functionality tests performed on the 3 system components that represent the collaborative surface, were successfully accomplished in all cases (see table).

Table 1. Descriptive statistics and teacher perception tests.

Variables	Pre-Test	Post-Test	Z	P
	Median	Median		
Easy to assign a individual qualification	4	6	-2,96	0.005
Easy to assign a group qualification	3	6	-2,57	0.019
Workload Equity	3	5	-2,14	0.020

Table 1 summarizes the results obtained in the experimentation with the teachers where the descriptive statistics are shown with the corresponding values of Z and P. It can be observed that, once the proposed system is used, the teachers responded that the ease of assigning individual and group grades was greater. In the same way, their perception of equity is reported to be higher in the post-test than in the pre-test.

5. Conclusions and future research

This paper aims to describe the implementation of a multi-touch system that promotes and facilitates the evaluation of collaborative work in the classroom. As could be evidenced in the literature, collaborative design activities are difficult to evaluate due to the great effort that the teacher must put in observing each student in the performance of collaborative activities.

The students perceived that with the use of this type of system the learning is more significant compared to the traditional approach (using, for example, pencil, paper and blackboard).

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