Computers in Human Behavior 43 (2015) 183–188

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

A comparative analysis of interactive arithmetic learning in the classroom and computer lab

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ARTICLE INFO

Article history:

Keywords:
Interpersonal Computer
Individual feedback
Teaching arithmetic
Educational computer lab
1:N education
1:1 Education

ABSTRACT

One of the main benefits of using technology in education is the opportunity it provides for student interactivity. The best place to implement interactive learning technology in schools has been a topic of debate, with the classroom and computer lab the most common choices. This paper joins the debate by studying whether there is any difference in learning when comparing individual interactive work in the classroom using a Shared Display Interpersonal Computer with individual work in a computer lab using personal computers. Comparisons were made between (1) classroom work using a Shared Display Interpersonal Computer with an individual mouse for each student, (2) work in a computer lab using a personal computer, and (3) a mixed model using a combination of the two. Both systems used the same unit-based arithmetic software, with the same functionality and interface. In the Shared Display Interpersonal Computer group, the children shared a single screen, while in the computer lab group each child had their own PC and monitor. The results of the study favor classroom groups working with a Shared Display Interpersonal Computer. Possible explanations for this include greater interaction between peers and increased teacher support for students in the classroom. However, this is beyond the scope of this paper and must therefore be validated by future work.

1. Introduction

One of the main benefits of using technology in education is the opportunity it provides for student interactivity (Zurita & Nussbaum, 2004). Furthermore, technology supports reflective thinking (Beauchamp & Kennewell, 2009) and enables students to play a central role in their own learning (Infante, Hidalgo, Nussbaum, Alarcón, & Gottlieb, 2009). The interactive learning process can be supported using a number of different technologies, such as the 1:1 model (One Laptop per Child Foundation, 2006), multi-touch surfaces (Morris, Fisher, & Wigdor, 2010) and Interpersonal Computers (Kaplan et al., 2009), among others.

The Interpersonal Computer allows multiple users located in the same physical space to simultaneously interact on a single computer by using their own input device (Kaplan et al., 2009). A common application of the Interpersonal Computer is the Shared Display (Yang & Lin, 2010). The use of a Shared Display can facilitate collaboration by promoting a common understanding of the workspace and increasing awareness of the actions of other students. This is because the Shared Display allows each participant to see what the others are seeing (Scott, Mandryk, & Inkpen, 2003). Results have also shown that students controlling their own input device on a Shared Display show fewer signs of boredom and disruption, and that they are more active during activities (Paek, Drucker, Kristjansson, Logan, & Toyama, 2004).

The best-known Shared Display Interpersonal Computer application are clickers, which aid the process of asking multiple choice questions to a group of students (Crouch & Mazur, 2001; Trees & Jackson, 2007). While clickers only provide group-level feedback to students, other applications allow a greater degree of simultaneous involvement for everyone in the classroom (Paek et al., 2004; Scott et al., 2003). The most common alternative so far has been to use the mouse as an individual input device for each student (Pawar, Pal, Gupta, & Toyama, 2007).

The Shared Display Interpersonal Computer is a good alternative, particularly in low income economies, as it allows for personalized interactivity at a cost of approximately US$1 per child per year (Trucano, 2010). Various uses of the mouse as an input device have been developed, including Mouse Mischief (Moraveji, Inkpen, Cutrell, & Balakrishnan, 2009). This program lets students

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http://dx.doi.org/10.1016/j.chb.2014.10.031
0747-5632/

answer multiple choice questions before providing feedback on the class' performance as a group. In order to find a way of providing individual feedback, Alcoholado et al. (2012) demonstrated how useful this technology is for teaching basic arithmetic. Szewkis et al. (2011) proposed the use of this technology to promote collaboration among students. In their analysis, the authors noted that students that were not sitting next to each other worked together without talking in a process they called "silent collaboration".

The best place to implement interactive learning technology in schools has been a topic of debate, with the classroom and computer lab the most common choices. Davis and Shade (1994) suggest that integrating technology into the classroom leads to greater appropriation of the curriculum. Conversely, some authors argue that the computer lab is more conducive to developing students' ICT skills (Rule, Barrera, & Dockstader, 2002), although this technology has been shown to be more intimidating for teachers (Hepp, Hinostroza, Laval, & Rebién, 2004; Salomon, 1990; Trucano, 2011).

When interactive learning follows the students' learning pace, the students' needs are aligned with the activities. This has been shown to improve the learning outcome of the activity (Chen, 2010). The environment where this takes place can act as a variable. A Shared Display Interpersonal Computer in a classroom provides a space where students can compare their work and support each other (Alcoholado et al., 2012). It also develops increased situational interest, which improves learning (Plass et al., 2013). Furthermore, fostering student interaction in the classroom might add an affective component, which has been shown to be important in learning (Park, Plass, & Brünken, 2014). The affective mediation assumption suggests that motivational factors mediate learning by modifying the cognitive engagement (Gottfried, 1990). However, the in-classroom student interactions may also lead to a decrease in learning as they could be an extraneous cognitive load, i.e. an overhead which does not contribute to the understanding of the material (Brünken, Plass, & Leutner, 2003).

Given the opportunities for classroom work provided by the Shared Display Interpersonal Computer and the predominance of personal computers in school computer labs, our research asks the question: Is there any difference in learning between interactive work carried out in the classroom using a Shared Display Interpersonal Computer, and work done in a computer lab using personal computers? If there is such a difference, why does it occur?

The technologies used in this study are outlined in Section 2. The methodology used during the experiment and its results are detailed in Section 3. A discussion of the findings is presented in Section 4. Finally, conclusions and future work are presented in Section 5.

2. Technologies used in the study

For the interactivity of a piece of software to be effective, it must provide students with feedback, considered by some authors as the foundation of learning (Biggs & Tang, 2011; Brown & Knight, 1994). One model that takes this need into account is Formative Assessment. This model looks to provide feedback on each student's performance, with the aim of accelerating the learning process (Sadler, 1998). Using this concept, two systems were designed to teach arithmetic by providing students with instant feedback.

Both systems present students with a series of exercises to complete. The exercises are created dynamically and based on the Chilean national curriculum (Mineduc, 2014). The content is divided into 65 units, 18 of which relate to addition, 18 to subtraction, 13 to multiplication and 16 to division (Alcoholado et al., 2012). The units are presented in order of difficulty and the students must work on them sequentially. To advance to the next unit, students must answer the first ten questions correctly without making any mistakes. If a mistake is made, they must then answer five additional questions. By the end of this, the students must have answered at least eight questions correctly, including three of the five additional questions. If they fail to meet these requirements they must continue to answer questions until they do.

The teacher played the role of supervisor in both systems by providing the students with support. The students were sat side-by-side in both the classroom and the computer lab, but the desks were arranged differently in each case. The desks in the computer lab were arranged in traditional rows and columns, whereas in the classroom they were arranged in a horseshoe (Fig. 3).

2.1. Web-based system

The first platform used in this experiment was a web-based system. Each student could remotely log into the software and work individually from their browser. The information is displayed on their individual screen (Fig. 1). Each student can be identified on the screen by a specific symbol (a triangle in this case) and is presented with an exercise (4 + 4 + 1 in Fig. 1). Below this exercise, a space is provided where the student can work on their answer by selecting the correct digits. The student then submits their answer by clicking on their symbol and receives feedback from the system. On the right hand side of the screen, a vertical bar indicates the student's progress for the current level. The feedback is given in green, indicating a correct answer; yellow, indicating that one mistake has been made; or red, indicating that two or more mistakes have been made when attempting to solve the exercise.

When a student answers an exercise (Fig. 2a) they are given feedback as to whether the answer was incorrect (Fig. 2b) or correct (Fig. 2c). If the answer is correct, the student is given a new exercise. If the answer is incorrect, the student must repeat the exercise until they get the correct answer. As described previously, the student can only advance from one unit to the next by meeting a series of requirements. The system indicates when a student has completed all of the work for a given unit (Fig. 2d).

The teachers were not provided with real-time feedback on the students' performance.

On the other hand, the software did not have to be installed and therefore the only setup time required was to ensure that the computers were connected to the internet.

2.2. Shared Display Interpersonal Computer

The second system uses a computer where the students share a single screen using a projector. Each child has their own individual input device, in this case a mouse. The mice are connected to the

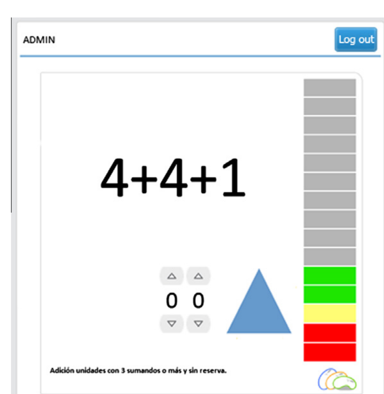

Fig. 1. Student interface for web-based system.