ADAPTIVITY IN SYNCHRONOUS MOBILE COLLABORATIVE LEARNING

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Abstract

The paper presents research in the field of mobile computer supported collaborative learning (mCSCL). The aim of this research is to enhance synchronous collaborative learning activities in primary school context by introducing adaptivity. In order to determine the best niche for such adaptivity support, a set of trial experiments were designed in a primary school. In the experiments, students were asked to complete mathematics assignments on tablet computers in a one-to-one mobile learning setup. They were working in groups of two and three in three main roles: authors, editors and checkers. Log files were analyzed in order to extract students' activity performance in the assigned roles. The analysis results showed differences in task completion time as well as in efficiency when working in specific roles. To overcome the identified issues, adaptive support model consisting of adaptive group formation, adaptive role assignment and adaptive task assignment is proposed.

Keywords: Adaptivity, mobile computer supported collaborative learning (mCSCL), technology enhanced learning, tablet computers

1 INTRODUCTION

Collaborative learning is widely accepted instruction method that positively affects students in terms of academic performance, motivation, and social skills [1], [2]. Advances in information and communications technology facilitate the process of design and implementation of collaborative learning activities within the field of computer supported collaborative learning (CSCL). Nowadays, computer supported collaborative learning activities are often performed with the help of hand-held devices (i.e. smartphones and tablets). By taking advantage of student and device mobility, learning across various contexts and locations is enhanced, offering opportunities for different modes of interaction among students [3], [4]. To further contribute to the intended learning outcomes, providing adaptive support [5] to collaborative learning activities should be considered [6], [7].

The research presented in this paper was conducted within the SCOLLAm project [8] that explores seamless and collaborative mobile learning on tablet computers. The project aims are to advance elementary education by combining innovative educational technologies and modern pedagogical approaches, such as the ways to enhance synchronous mCSCL activities by introducing adaptivity. With a focus on early age mathematics learning, a set of experiments was conducted with second grade primary school students. By comparing students' background characteristics and overall performance in the activities, several issues regarding the group work organization and the tasks included in the activities were identified, and an adaptive support model consisting of adaptive role assignment, adaptive task assignment and adaptive group formation proposed.

2 BACKGROUND

2.1 Mobile computer supported collaborative learning (mCSCL)

Contemporary approaches to mobile learning emphasize the need for collaboration which can be organized as small-group or whole class collaboration and conducted inside or outside the classroom [4], [9], with the positive effect of using mCSCL in classrooms being reported in numerous studies [3], [10].

Examples of studies to facilitate mathematics learning in primary schools include a mobile application for learning fractions [11] and virtual Tangram puzzle for learning geometry [12] where students interact in real-time. During such synchronous collaborative activities, mobile devices are used as the infrastructure through which students communicate and collaborate "through technology" where every student has his/her own mobile device and shares work on common screen [13]. Conversely, students can be gathered around one device in order to collaborate which is known as the "around technology". For example, students are supposed to solve geometry assignments in triangles on a single large display screen [14].

Groups for collaborative learning activities can be created randomly. However, there are many advantages of employing adaptive support, which takes into account students' characteristics [5], [6]. The decision on whether to form homogeneous or heterogeneous groups will primarily depend on the objective of a collaborative learning activity [15]. In addition to adaptive group formation, students might benefit from peer interaction support or domain-specific support [6], including adaptive task selection [16], [17]. Students' characteristics that influence the effectiveness of adaptation support include knowledge level, background data, learning styles [5], personality [16], gender [17] etc.

2.2 Designing synchronous collaborative learning activities with the Author system

One of the most important components of the SCOLLAm system is the Author application, a digital lessons authoring tool similar to an everyday presentation editor. Each slide of a digital lesson consists of multimedia contents enhanced by user-defined actions, rich content, variables, custom interactive widgets etc. In order to design collaborative learning scenarios, widget creators can use the available communication interfaces including those for exchanging messages between one or more students on one or more mobile devices. Digital lesson designers use the Author system to parametrize the widgets (i.e. select students who will be grouped, maximum number of group members etc.).

Two widgets for learning mathematics were developed: individual timed drills and collaborative exercises widgets. While the timed drills are used to build speed and accuracy skills, the primary aim of collaborative exercises is to encourage discussion regarding the given problem in small groups. By discussing the steps of solving a problem, students have the chance to correct possible misconceptions and work together towards the correct solution. Therefore, individual timed exercises are better suited for students who are still struggling with the steps of mathematical procedure they should apply. However, as students gain in confidence, even collaborative exercises can be used to build speed and accuracy.

3 METHODOLOGY

3.1 Materials

For the purposes of the research, collaborative exercises for mathematics learning were designed and used in the collaborative learning widget. Each exercise contains a number of addition and subtraction tasks in accordance with the Mathematics syllabus for primary schools in Croatia. The tasks within each exercise were about the same complexity. To complete the exercises, students were grouped in pairs or triplets.

3.1.1 Exercises in pairs

In this type of exercise students work in pairs and solve addition and subtraction tasks involving numbers up to one hundred. The tasks of adding two digit numbers without carrying over (e.g. 32+26) were considered less complex than the ones which require carrying over (e.g. 46+17). Each student pair member is assigned one of the two available roles: an editor or a checker role. An editor is supposed to solve the task given by the system while a checker is to determine whether the solution is right or wrong. After the checker submits his/her decision, both students receive feedback messages on the overall success. In case of correct solution, students are directed onto the next task, while in the case editor or/and checker made a mistake, they are advised to discuss their solution and try again (it will not be explicitly revealed who made the mistake, editor, checker or both).

3.1.2 Exercises in triplets

This type of exercise contains textual problems and is solved in triplets. Group members are assigned one of the three available roles: an author, an editor or a checker role. An author is expected to process the text of the given problem and write an equation, an editor should solve it, and a checker is expected check the entire solution. As an example a group could be asked to solve the following problem: “There are 10 apples and 6 oranges in the basket. How many pieces of fruit are there in the basket?”. During the process of solving the problem, the author is expected to submit the expression “10+6”, the editor should calculate it and submit “16”, while the checker is expected to mark the solution as correct (OK) or incorrect (C), as illustrated in Fig. 1. After solving a task, all group members receive the feedback message on the joint solution. In the case of a correct solution students get to solve the next task, while in the case of errors students are advised to discuss and try again (again, there is no indication about who made a mistake, author, editor or checker).

3.2 Participants and procedure

Participants in the conducted experiments were students from two second grade classes of the Primary school Trnjanska, Zagreb, Croatia. In the first class (A) there were 8 male and 9 female students while in second class (B) there were 6 males and 8 females, amounting to 31 participants in total, all of age 7-8.

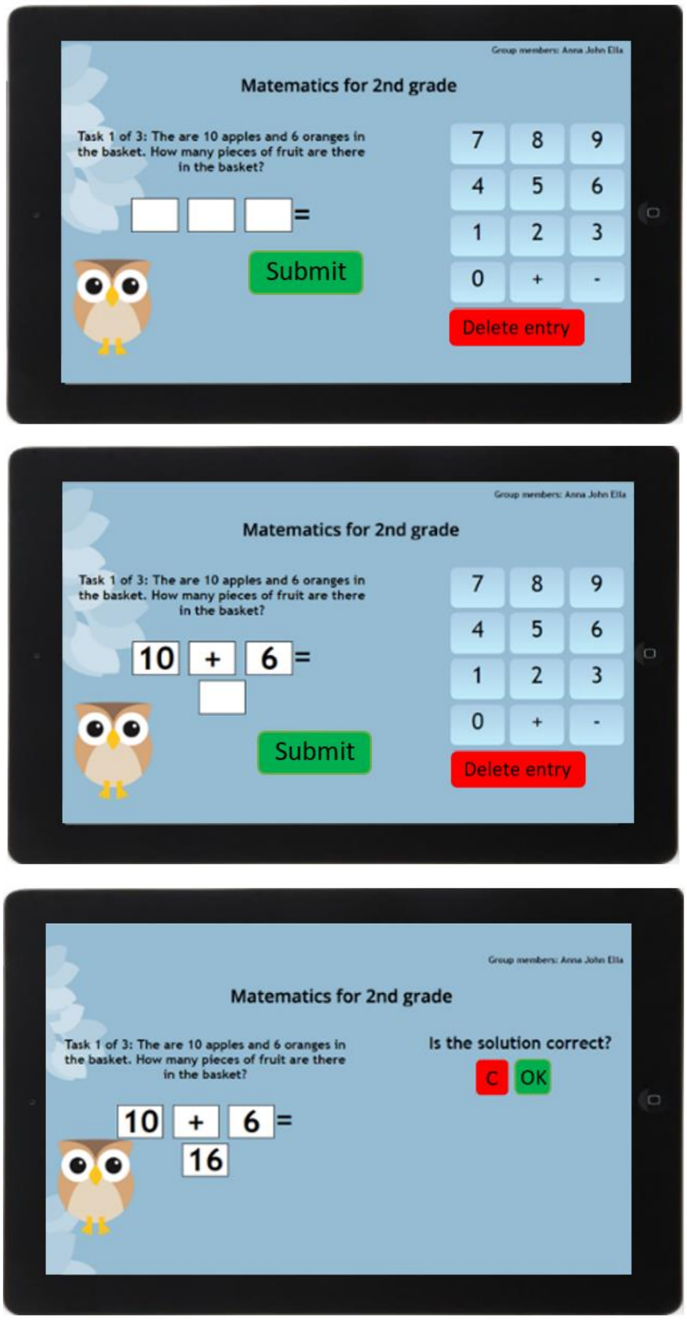

Figure 1. The process of solving a mathematical word problem in three different roles (the author, editor and checker roles).

Two experiments were conducted in December 2016 using internet-connected tablet computers (one device per one student) preloaded with the custom developed mCSCL widgets. During the first experiment, students were expected to complete two mathematics exercises in pairs (each exercise contained 10 tasks). In the second experiment students were expected to complete two exercises in triplets (one with 6, and the other with 3 tasks).

In the beginning of each exercise, the students were automatically randomly grouped by the Author system and the roles were randomly assigned. While working with tablets, students were encouraged by teacher and researchers to move around the classroom and find their group members. The teacher and researchers also provided help with the use of the software or helped during technical difficulties, when needed.

In order to explore the collaboration process, software log files were collected and analyzed. The analysis included examining the average time needed to complete a task by student, role and task. Additionally, the number of unsuccessful task completion attempts by task and role was calculated.

3.3 Research questions

This study explores mobile computer supported collaborative mathematics learning by early primary school students in different roles (authors, editors and checkers) in order to propose the ways in which adaptivity can be utilized to enhance the mCSCL lesson completion time and process. The following research questions are explored in detail:

1. What are the differences in time needed to complete the mCSCL mathematics lessons for early primary school students in different roles (authors, editors or checkers)?
2. What are the differences in process exhibited in the mCSCL mathematics lessons for early primary school students in different roles (authors, editors or checkers)?
3. How does student background (academic performance and engagement) data relate to the time students needed to complete the mCSCL mathematics lessons for early primary school students in different roles (authors, editors or checkers)?

The answers to the proposed research questions are expected to give insight on the role-based mCSCL learning process and possible relationship between student background information and task completion.

4 RESULTS

As part of the data log collection, data from each group of students and for each problem solved was recorded including the time for taken by each student to work in different roles. Table 1 shows mean values for two randomly selected problems (as an illustration) and the mean time for all students performing in author, editor and checker roles (in case of an incorrect solution, total time to for all attempts to solve the problem is used).

Table 1. Mean time needed to solve a problem for three roles (total and for example selected tasks).

Task	Author	Editor	Checker
35+7	AVG=81s	AVG=27s	AVG=5s
43-6	AVG=88s	AVG=17s	AVG=4s
All tasks	AVG=115s (STDEV=97s)	AVG=23s (STDEV=8s)	AVG=6s (STDEV=5s)

To further explore how the process of solving an exercise that consist of a sequenced task, a linear regression model was created using the average for two lessons, one with 6 and the other with 3 problems. The diagrams in Figs. 2 and 3 depict the trend of the changes in time needed to solve a problem throughout the exercise according to three different roles.

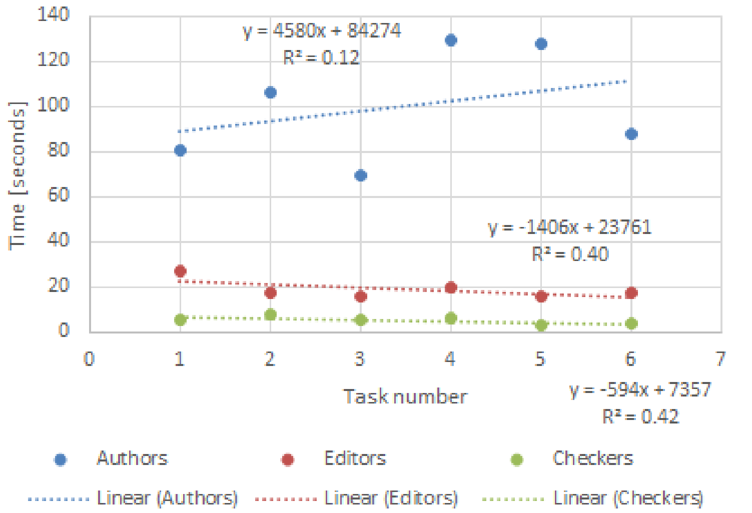

Figure 2. Linear model of the time per task change needed to complete the 1st exercise.

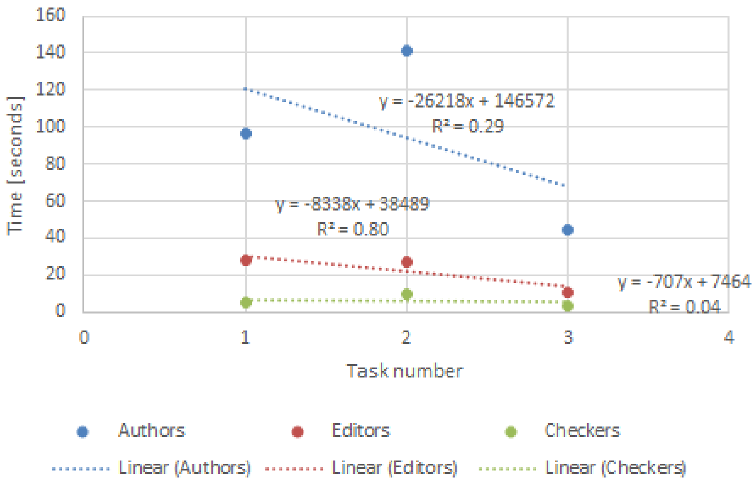

Figure 3. Linear model of the time per task change needed to complete the 2nd exercise.

Background data on student prior academic performance (range 1-10) and engagement (range 1-3) was collected from the class teachers (higher value means better academic performance or engagement). To objectively measure the background characteristics, the data was elicited via a structured interview with the teachers due to the fact that there is no objective grading in lower primary classes in Croatia (almost all students get A grades in their exams). These were then correlated with the mean time each role (author, editor and checker) needed to complete the task. The majority of correlations were negative, as presented in Table 2.

5 DISCUSSION - TOWARDS ADAPTIVITY IN MCSCL

Based on the presented data, there are three different areas of adaptivity by which the employed mCSCL design could be enhanced: adaptive role assignment, adaptive task assignment, adaptive group formation. The following sections describe and provide explanation for the identification for each level.

The data clearly shows that different roles come with differing complexity primarily reflected in the times needed for students in each role to complete the assigned tasks. The author role in the employed mCSCL design takes the most time to be completed by the students, followed by the editor and checker roles. The complexity of the author role is reflected in the fact that the most productive discussions happens during its operation. The most obvious example are the 4th and 5th tasks in the 1st exercise where even though the editors and checkers made mistakes, the students in the author role spent a large amount of time reevaluating the overall team solution.

Table 2. Correlations of mean time for each role (for the 2 exercises) and background data (academic performance and engagement).

Mean time for role	Academic performance	Engagement
Author (exercise 1)	-0.483	0.019
Editor (exercise 1)	-0.706*	-0.08
Checker (exercise 1)	0.06	-0.314
Author (exercise 2)	-0.62*	-0.425
Editor (exercise 2)	0.134	-0.149
Checker (exercise 2)	0.152	-0.728*

*p<0.05

Interestingly, the authors made only 5% of the total errors, while the editors made the most mistakes, and checkers on some occasions just agreed with the offered solution, without thoroughly thinking it through and not catching editors' mistakes.

The analysis shows negative correlation for the large majority of role mean times, however only some are significant: there is indication that more academically inclined students require less time in the author and editor roles, while more engaged students require less time in the checker role.

The different nature of the roles and the fact that certain types of students manage better in certain roles (i.e. one student can perform much better in one role than the other) warrants for a more balanced approach to role assignment. Given the fact that mCSCL designs should be able to employ designs where roles differ, the role assignment should be adapted in two main ways: 1) by adaptively assigning roles to students with different academic performance and the engagement background characteristic, and 2) by continually alternating role assignment.

In addition to the adaptive role assignment, this study identifies the need for adapting contents to the students participating on the activity. This is especially evident in the case of highly academically inclined students and the academically not well versed. The former group needs to be challenged, while the latter needs to be encouraged to proceed with more effort. The tasks need to be weighted and the the number of exercise tasks should be balanced. Additionally, the groups themselves differ in the exhibited task completion time opening up the opportunity for adapting contents to groups as wholes. This could be achieved by adaptively forming groups: making homogeneous and heterogeneous groups. Heterogeneous groups that keep the differences between group members high but not extreme will allow students to learn from each other. On the other hand, homogeneous groups are ideal for drill exercises for those who already possess good knowledge of the area but need to perfect it.

6 CONCLUSIONS

The paper presented results of a mCSCL study in an early primary school setting. The differences in student mathematics task completion time were detected prompting the need for the introduction of adaptation mechanisms into such activities. Based on the analysis of students' performance in different roles and the analysis of how student background affect their performance in different roles, adaptive support to role assignment, task assignment and group formation in mCSCL activities is proposed.

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