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Can one-to-one computing help children learn cooperatively?

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Abstract: This paper proposes and examines a design of technological scaffolding for cooperative learning. An application for learning fractions with handheld devices was designed and tested in a primary three classroom. The outcomes were interpreted according to a two-dimensional framework consisting of the cooperative learning principles (maximum peer interaction, equal opportunity to participate, individual accountability and positive interdependence) and the observed interplay of social, technological and teacher scaffolding which emerged throughout the activity. The focus of our analysis is the technological scaffolding and the support it can give to cooperative learning activities based on the feedback received from two sources: primary school children using the software and a group of teachers trying out and reflecting on our design.

Keywords: Mobile learning, Fractions learning, Cooperative learning, One-to-one computing

1. Introduction

In our three-year study on mobile learning, we have been working on both the design of new technological solutions and the application of new pedagogies in learning [5]. To empower our students with the 21st century learning skill set, we have designed a solution for cooperative learning in which students cooperate around the mathematical concept of fractions. Even though the activity includes forming full circles out of single pre-assigned fractions, it is not only mathematics students have to master. They have to engage in exchange, negotiation, peer instruction, and other forms of communication and mutual meaning making in order to complete the task.

In addition to teacher and social scaffolding, our platform provides the students with technological scaffolding. In this paper, we evaluate our platform against the well-known principles of cooperative learning, namely, maximum peer interaction, equal opportunity to participate, individual accountability and positive interdependence. Although there are no strict boundaries between the three-level scaffolding (teachers, social and technological), in this paper we discuss whether and how our technological design has promoted these cooperative learning principles. To get both practical and unbiased insights into the system, we designed both in-class activities for the primary school students and presented it to the teachers taking a course on cooperative learning.

2. One-to-one Computing for Cooperative Learning

Cooperative learning is much more than competition and individualistic learning although it does encompass some of these. The main difference is that in cooperative learning students must learn how to “sink or swim together”. Building on a vast amount of research body, cooperative learning is based on eight main elements (or principles): heterogeneous

grouping, collaborative skills, group autonomy, maximum peer interaction, equal opportunity to participate, individual accountability, positive interdependence and cooperation as value [2].

Early research in computer supported cooperative learning (CSCL) tends to foreground the role of computers as the focus of attention. Typically, each student uses a fixed-location glued-to-the-desk computer as the tool for group work. Both the focus on the tool and the lack of cooperation lead to some skepticism in initial CSCL making it clear that social interaction does not simply happen with a computer-based environment, thus emphasizing social and psychological dimension of the desired social interaction [3]. In advocating their approach to future classrooms organized around WILD (Wireless Internet Learning Devices), Roschelle and Pea [8] argue that CSCL should leverage on application-level affordances such as augmenting physical spaces, leveraging topological spaces, aggregating coherently across all students as well as on the physical affordances of mobile devices. Some research studies have shown that the use of mobile devices in classrooms could significantly impact student collaboration [9]. Students leverage on their own mobility and the mobility of the devices in order to coordinate cooperation and to exchange information simultaneously over the wirelessly connected devices [4, 7].

3. Designing for Cooperative Learning: The Form-A-One (FAO) System

In order to support cooperative learning activities, the Form-A-One (FAO) technological scaffolding for cooperative learning was designed and used to support learning fractions. Each student is initially assigned a single fraction (circle sector) (see Figure 1) and has to identify peers with complementary fractions (with respect to getting a sum of 1) and then invite them to form groups (see Figure 2). The main goal of the assignment for each emerging group is to form a full circle (a whole) by combining circle sectors (graphical representations of fractions).

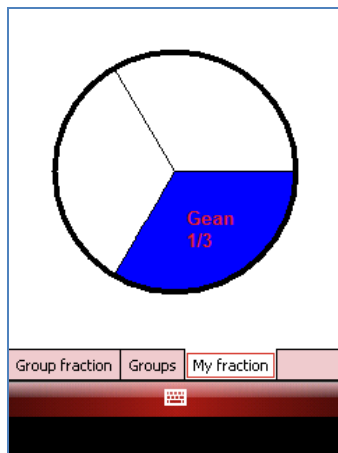


Figure 1. A fraction assigned and displayed on a student's mobile device

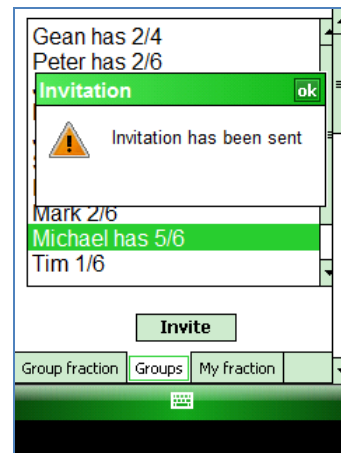


Figure 2. Student issuing a group invitation to his classmate

The proposed design was evaluated through a series of trials with Primary 3 children roughly aged 8-9, from a mixed ability class in a neighborhood school in Singapore. Each trial involves 8 and 16 students. In the first trial, we introduce students to the software and the “ways of doing the collaboration”. Students had some prior experience in using different mobile learning tools and needed just a brief overview of the FAO software.

Through the conducted trials several sources of collaborative scaffolding were identified: technological, teacher and social scaffolding. All the three components are the sources for collaborative rules which structure student participation in the activity both in the sense of social interactions and task completion [1]. Technological scaffolding provides technology-embedded structures or rules for sending and receiving messages through the handhelds. It relies on a specific rule structure and their interconnection. It is triggered via the user interfaces transmitting the messages. Social scaffolding, on the other hand, builds on top of collaborative rules predefined by the teacher but draws from the emergent collaborative practices such as peer instruction, sharing through discourse, and mediation. The teacher scaffolding provides contextual assistance supplementing both technological and social scaffolding but mainly builds on top of the existing individual and collective group competence.

4. Examining FAO as the Technological Scaffolding for Cooperative Learning

4.1 Proposing a Framework

Our socio-technical design revolves around and is influenced by the three levels of scaffolding: technological, teacher and social scaffolding [6]. In analysing cooperative learning practices we limit ourselves to the four main cooperative learning principles: positive interdependence, maximum peer interaction, equal opportunity to participate and individual accountability. The focus of our attention is the technological scaffolding and the opportunities it brings (or can potentially bring) to cooperative learning by strengthening the four cooperative learning principles. Although we are primarily interested in the affordances of technologies driving cooperative learning, we do not neglect the effects of both social and teacher scaffoldings driving the technology supported cooperative activities (Figure 3).

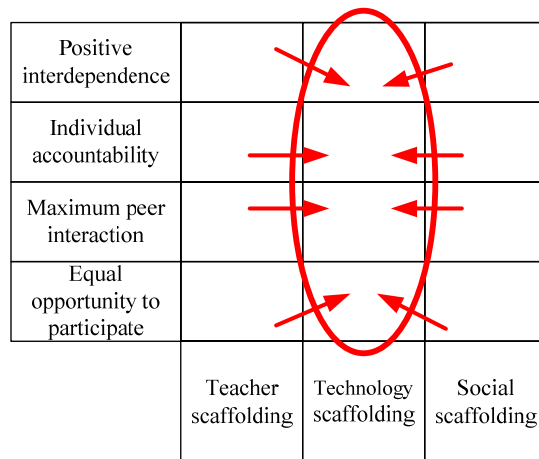


Figure 3. A Framework for Examining Scaffolding in Cooperative Learning

Our examination encompasses trials conducted with primary three children using the FAO system and teachers taking a master course in cooperative learning examining the affordances of the technology through the cooperative learning lenses. From the collected video, audio recordings and software logs, we make conclusions about whether and how the FAO technological scaffolding drives the cooperative activity. On the other hand, the master teacher's perspective provides us with the practical advice on how to strengthen the cooperation.

4.2 The Affordances of the Technological Scaffolding Identified Through the Trial Runs

In the FAO activity we examine students cooperating around a concept of fractions which are generated by the system in the beginning of the activity. The system is able to determine how many students hold the device and which of them have decided to participate in activity and accordingly generates and disseminates fractions to them. The algorithm ensures that there is at least one global solution possible. This means the system has to ensure the generated fractions can be combined into at least one final configuration of groups of students in which every student belongs to a group and every group completes has reached its local solution (formed the full circle with their members' fractions). Equal opportunity to participate does not come only from the technological scaffolding. By setting activity parameters through the technological network, the interplay of social and teacher scaffolding can be fine-tuned. For example, the teacher might decide to generate "easier" fractions or distribute "more difficult" fractions to some students.

The technological scaffolding took the role of facilitator in overcoming students' impasses. For example, the students were surprised by the system message warning them they are not allow to form a group of just two members (e.g. students with $\frac{2}{3}$ and $\frac{1}{2}$). To get out of this situation, they had to question or relook at their strategy of merging any two students and looking for the third member to complete the group. In contrast to overcoming personal preferences in achieving both individual and group goals, some students built on their personal relationships and spontaneously offered help to their colleagues. After a group of two girls was created based on personal preferences, they together decided one of them should accept a new group invitation. After their group was dismantled, the girl left alone was offered some help in identifying her new mates.

4.3 Teachers' Point of View

In order to determine the suitability of FAO for cooperative learning, we presented it to in-service K-12 teachers taking a part-time Master course in cooperative learning in the National Institute of Education, Singapore. There were 33 teachers teaching variety of courses, divided into 6 groups, generally comfortable with using the technology. They were required to go through two trial runs of the FAO activity and comment on its suitability for cooperative learning related to the principles of cooperative learning.

The session was split into three main parts: initial exploration, experiencing the system, and evaluating and reflecting on the experiences. The teachers thought maximum peer interaction during the session was encouraged on the quantitative side since all teachers were able to find partners to group up. The system provided enough redundancy and options for the participants to choose appropriate peers. As a means of promoting maximum peer interaction, the introduction of time limit into the activity was proposed. Therefore, the participants would be required to complete the activity in a specific period of time and would be motivated to help each another. In order not to become too passive by receiving instructions from other and just behaving passively according to their instructions, some cooperative skills could be used. For example, when inviting other teachers into their groups, they might be requested to state a clear explanation why they want to invite a student into a group.

The FAO activity scored well in the terms of promoting individual accountability and equal opportunity to participate according to the teacher evaluation. The teachers noted that every participant has to participate and therefore do his or her share of work for the activity to end. If only one participant is left without a group, the activity cannot end for all other participants because the global goal of the game is not fulfilled.

5. Conclusion

This paper presented a FAO technological and activity design for learning fractions with handheld computers. Throughout several trials of the system, students were cooperating in order to complete both their local goals of forming wholes out of single fractions and their global goal of having all groups completed the local goal. The system was analysed in two ways: by having primary three students using it and by discussing its affordances with the teachers interested in cooperative learning. In order to perform the analysis we adopted a two dimensional framework with three-component scaffolding on one level and main cooperative learning principles on the other.

In order to strengthen maximum peer interaction, the system should be upgraded with the “invite with reasons” option requiring students to justify their cooperative decisions. Introducing new cooperative “sponge activities” and a point-based reward activity mechanism might create better positive peer interdependence throughout the activity.

Acknowledgements

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