Doing collaboration and learning fractions with mobile devices

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Abstract: This paper presents a system for learning collaboration while doing a fractions activity using personal mobile devices. Equipped one-to-one with a smartphone, each primary school student is assigned a fraction and has the task of forming a whole unit of one out of single fractions from other students. Thus they leverage on their mathematical knowledge as well as social relationships to complete the task. They are required to work both on the technological and semiotic levels to form small groups of different sizes. The paper presents the design of the activity and some initial findings arising from a conducted trial involving 16 students.

Keywords: mobile learning, collaborative learning, cooperative learning, fractions

1. Introduction

The proliferation of networked computers supplemented with adequate software applications has provided us with a new network-based medium to be exploited when designing educational services. This has been justified by multiple studies in the field of mCSCL (mobile computer supported collaborative learning) (e.g., Liu & Kao, 2007; Zurita & Nussbaum, 2004).

This paper builds on the prior studies in mCSCL and tries to propose the design of in-class mobile collaborative synchronous learning with flexible, but still small group sizes. At the technological level, students communicate with mobile devices via the 3G network using custom-designed software. At the semiotic level, students follow or adapt the collaboration rules imposed both by the teacher and by the system. Both the teacher and the system scaffold and facilitate the process: the teacher provides macro-level guidance and advice, and the system scaffolds micro-level activities that students are engaged at the specific point in time. In order to complete the collaborative learning task, they have to draw upon their social relationships with other students and negotiate acceptable solutions.

This paper focuses on the technical design of the mobilized fraction learning system. Due to the space constraint, we will give a simple, not full-fledged, description of a trial run that we conducted to evaluate the usability and demonstrate the potential of its educational value. By using the system, learning will happen in two main directions: students will acquire new collaborative and skills and learn the content which is in this case adding fractions and finding equivalent fractions.

2. Collaborative mobile learning

mCSCL is a specialisation of the field of CSCL. Team work and interaction are crucial for successful CSCL. Coordination of activities mediated by technology is therefore important since it contributes to better team member communication (Inkpen, Booth, Klawe & Upitis, 1995). Nevertheless, some students could experience difficulties in communication, coordination and interaction with their fellow team members (Curtis & Lawson, 1999). Two most important difficulties are the lack of visual contact and body language. The real strength of CSCL is not in collaboration around computers, but in collaboration through computers as a base for social networks exploiting the advantages of available personal contacts (Haythornwaite, 1999).

Independence of the time and location and the potential of supporting interactive communication among students are the major features that have convinced a lot of researchers that mCSCL is the next logical step in the development of the area of collaborative learning. By employing mobile devices, learning becomes personal and students are able to participate in collaborative learning activities when and where they want to (Looi et al., 2009). Research has shown that the use of mobile devices in classrooms could significantly impact the student collaboration (Tseng, Hwang & Chan, 2005). Students leverage on their own mobility and the mobility of the devices in order to coordinate collaboration.

One important research tackles the use of mobile connected devices in the education of children of aged six to seven (Zurita & Nussbaum, 2004). Children were given the language and maths tasks they had to solve by working in groups. In the process, they had to exhibit a certain level of interaction and communication in order to complete the group tasks. Authors reported the use of wireless networks opened up many educational possibilities and that mobile devices advanced all components of collaborative learning (Kreijns et al., 2002): enhanced the learning material organisation, social negotiation space, communication between team members, coordination between activity states and the possibilities for interactivity and mobility of team members. As the main advantages of mobile versus classical computer supported collaborative learning, the authors state the enhanced possibility for communication, negotiation and mobility (Zurita & Nussbaum, 2004).

According to the presented conclusions, the authors extend the model of collaborative learning (Kreijns et al., 2002) by introducing the additional component of mobile devices in order to neutralise the identified drawbacks of collaborative learning. The network of mobile devices is shown as a tool which leverage on its high mobility to minimise the drawbacks of collaborative learning. Team members utilise networked mobile devices to extend their area of communication and mutual interaction both in the semiotic and technological area (Zurita & Nussbaum, 2004).

Latest developments in the field of mCSCL extend the idea of handheld technology mediated learning with the collaborative scaffolding in order to include both social and epistemic collaboration scripts encouraging small group participation (Nussbaum et al., 2009). The design of collaborative scaffolding should encourage social interactions, facilitate joint problem solving, lead to richer knowledge construction and in the same time take into account different and emerging roles, joint group goals and actions and facilitate verbal explanations.

3. Learning fractions

3.1. Activity and system architecture

We developed the Fraction software to leverage on the affordances of mobile devices and student personal relationships. Although students’ mathematical content knowledge was on generally good, the level of collaboration was not satisfactory. To improve their collaborative skills, students were presented with some rules of collaboration with mobile devices prior to the activity: the physical position they had to take as the activity progresses, the way they should talk to their peers, the ways of negotiating with their peers, etc. In addition to the rules of collaboration, the Fractions software provided a certain level of guidance. After agreeing on the semiotic level, students had to put their decision into practice through the mobile device which may or may not be possible, depending whether they have chosen a correct solution.

The activity was designed in the principle of providing redundancy for the students to rely on their personal relationships. On the other hand, the activity leaves enough space for collaborative conflicts to emerge creating situations where negotiation is inevitable. The students were therefore required to leave their comfort zone and extend their social circle to complete the task with the aid of mobile devices.

Fractions are depicted on students’ mobile devices in form of circle sectors (slices). Students have to collaborate in order to merge (add) fractions. They have to identify peers with complementing fractions and therefore form groups. The main goal of the assignment for each (ad hoc) group is to form a full circle (a whole) by combining circle sectors (graphical representations of fractions). Some groups might not be able to form a full circle because the other groups used their fractions. This case is resolved by inter-group collaboration and negotiation necessary to complete the task.

Students are equipped with wireless network-connected mobile devices in one-to-one basis. The activity is typically performed in-class with students starting the Fractions software application which serves as an interface between the technological and semiotic layers. The software utilises the 3G network connections and records students’ presence on the server-side component (see Figure 1). Teachers can monitor the technological layer on their teacher’s version of the Fractions software in order to see the available students for the activity.

3.2. The three phases of learning fractions

Phase I: Fraction distribution

As soon as all the students have turned their devices on and the teacher started the activity, the system generates a random sequence of fractions and distributes them to all students (Figure 2).

In the Figure 2 the system detected five students as potential activity participants and assigned them with randomly generated fractions. The generated fractions are 1/2, 1/2, 1/2, 1/3 and 1/6 and are displayed on

students’ mobile devices. In this first phase of the activity students reflect on their “own” fraction and try to find out what are the other generated fractions to figure out the possible ways of merging fractions and forming whole circles.

**Phase II: Negotiation and exchange**

To identify the potential candidates in order to form a whole, student can work in several directions: they can approach the problem as purely face-to-face and detect the potential candidates through conversation. On the other hand they can rely on the graphical user interface of their mobile devices and browse through the list of all available students and their fractions (Figure 3a).

In order to form the groups, students switch to the middle application tab called Groups, select the desired peer and click Invite. This action results in social invitation being converted into an invitation request dispatched to the server side which forwards it to the invited student first on the technological and then to the semiotic level (Figure 3b).

Through a series of invitations, accepted and rejected requests student form groups and the activity progresses. Students typically have some misconceptions about the fractions which result in groups that cannot be advanced towards a whole, similar to the one depicted in Figure 4.

As the Figure 4 shows, although student C is left without a group, joining any of the available groups is not an option since the circle would overflow. Therefore, students have to once again negotiate and transform the groups in order to achieve their individual goal, which is forming a whole.

**Phase III: Towards a group oriented goal**

In addition to the individual goal, students have to work collaboratively in order to achieve the common goal which consists of all groups having a full circle. Nevertheless, while some groups might have formed their wholes (individual collaborative goal is achieved), the others might be blocked and be unable to proceed. This is a situation where students are required to put the group goal before the individual goals and to try thinking collaboratively about other possible solutions or group configurations. Only when all groups have formed the full circle is the activity over.

4. A Trial Run

To test the functionality of the system, we conducted a trial run that involved Primary 3 (9-year-old) students in a neighborhood school. All these students had been involved in a one-to-one (one device per student) mobile learning project (see: Looi et al., 2009) and had the access to their assigned HTC Tytn II smartphones 24x7 for more than half a year. In addition to the software installed on the device (i.e., voice recorders, cameras, Pocket Word) and GoKnow’s suite of mobile learning applications students were provided with the custom-designed Fractions software for learning fractions.

The trial runs involved two classes (C1 and C2) with 16 students from each class in total. In the first round, each group of 16 students was split into two subgroups (A and B) of 8 students. Subgroups C1-A and C2-A were briefly introduced to the Fractions software application while the subgroups C1-B and C2-B received additional instructions on how to collaborate. Prior to the second round, students from subgroups B had to teach their peers from subgroups A the rules of collaboration. In the second round the subgroups were merged and the activity was done on a group level with both groups of students.

Toa analyse the trial, a coding scheme covering spatial, group and gender dimensions was employed. Male students are coloured blue and named with abbreviations starting with M, while the female students are red coloured and named starting with F. Their position and mutual distance in the picture reflects actual position and distance taken during the game. In the beginning of the activity students started exchanging ideas about

arranging fractions (denoted by the two-direction arrows) (Figure 5). The discussion started to expand from pairs to groups of three and four students coming together to discuss the options of forming fractions (Figure 6).

![Figure 5. Initial student arrangement in the trial run](image1)

![Figure 6. Students discussing available options](image2)

As the activity progressed, two groups were almost simultaneously formed, indicating positive outcome of the negotiation activities. Subsequently, the third group was formed (Figure 7). Although the system provided student with flexibility coming out of the redundancy (M1, M3, M4, F1, F2, F4 could all make pairs with each other), personal and gender preferences influenced the way groups were formed. This had an impact on the dynamics of the activity: as it progresses the overall number of the possible combination decreases making the choice of partners more straightforward.

Two students (F3 and M2) were still out of the groups and decided to seek peers’ assistance in identifying the possible solution for the activity (Figure 8). Not able to independently make the decision, student F2 was dispatched to seek the assistance from the teacher. In the meantime the discussion between other team members continued (Figure 9).

![Figure 7. First groups created in the trial run](image3)

![Figure 8. Remaining students in the trial run seeking help from their peers](image4)

![Figure 9. A trial run student F2 seeking for help from the teacher](image5)

![Figure 10. All students found a group – end of the trial run](image6)

After some additional consultation with the other teams and some teacher facilitation, students F3 and M2 finally managed to form a group leading the overall team effort towards the end (Figure 10).

5. Students’ learning experiences

Data from the trial was collected using several instruments: video recording, sound recording and software logs. From the collected data it is obvious that a student is likely to discuss with another peer who is nearby, providing an instance of social coordination. There were also instances where a student viewed the fraction of another student, and then moved over to communicate or negotiate, providing an instance of technological coordination. There was a rich interplay of social and technological coordination in which students negotiated at the technological as well as semiotic levels.

After the activity has ended students were asked about their opinions. Teacher, once again, facilitated the discussion (Table 1).

The presented post-activity interview shows students enjoyed the activity very much. Nevertheless, they were not able to pinpoint content knowledge concept they learned. This is partly to the fact the particular group has already been introduced to the concepts of fractions. Nevertheless, some students with weaker content knowledge were able to do the revision during the activity. On the other hand, students seem to appreciate working with their peers. During these situations a solution, a narrative activities which can easily be parameterized for collaborative activities was introduced by their teacher in order to identify cognitive conflicts. Nevertheless, some conflicts emerged requiring the students without assistance to resolve them. Along the way, technological infrastructure for different collaborative activity design, both face-to-face and technological.

| Teacher: “Did you enjoy the activity?” | Students (all eight of them): “Yes!” |
| Teacher asks M2: “Why did you enjoy the game?” | M2: “Because it is good to do things with your friends. If you don’t know something you can ask your friend.” |
| Teacher asks F3: “Why did you enjoy it?” | F3: “Because it teaches team work.” |
| Teacher asks F3: “Is that important?” | F3: “Yes!” |
| Teacher asks M3: “What did you like about the activity?” | M3: “We learned new things!” |
| Teacher asks M3: “What did you learn?” | M3: “Fractions!” |
| Teacher asks M3: “What about fractions? Anything you did not know in the past and now you know?” | M3: “No!” |
| Teacher asks M3: “But you still feel that you learned?” | M3: “Yes!” |
| Teacher: “Who feels you have learned something new today?” | Three students out of eight raise their hands. |

### 6. Conclusion and future plans

This paper presented an approach using collaboration mediated by mobile devices to foster collaboration and application of mathematical knowledge. Students were required to apply the rules for collaboration briefly introduced by their teacher in order to identify other student with whom they were able to solve mathematical problem. By using their mobile devices, choices were materialized in form of created groups as shown on their mobile devices. The technological layer was used as a scaffold to direct students towards a solution therefore resolving their cognitive conflicts.

The activity was designed to provide space for students to leverage on their personal preferences when forming groups. Nevertheless, some conflicts emerged requiring the students without a group yet to enter the process of negotiation with their peers. During these situations, some peer instruction emerged, illustrating the importance of existing common goal intentions in the collaboration.

The system was piloted in a primary school in a class of 40 students, starting with smaller groups of around 8 and then gradually progressing towards larger groups of 16 to 40 students. Along the way, technological difficulties emerged but will be addressed to eventually improve system stability and usability. In addition to evaluating whether the system scales well in terms of activity and the number of participants, a generalized model of the mobile collaborative learning activities will be devised. The main idea is to provide a common infrastructure for different collaborative activities which can easily be parameterized for collaborative activities other than for mathematics.

In our attempt to clearly depict how the system enhances negotiation, collaboration and learning we will extend our preliminary pilots to include around 80 students in total. The collected data will be analyzed in order to identify both the possibilities of embedding the solution into curriculum and concrete lesson plans and to examine the impact of the intervention on student learning and collaboration skills. Since the curriculum remains quite static, we will look into the ways of making some lesson activities run on mobile devices to be collaborative in nature.

### References


