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Supporting Mobile Collaborative Activities through Scaffolded Flexible Grouping

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ABSTRACT

Within the field of Mobile Computer-Supported Collaborative Learning (mCSCL), we are interested in exploring the space of collaborative activities that enable students to practice communication, negotiation and decision-making skills. Collaboration is via learning activities that circumvent the constraints of fixed seating or locations of students. This paper presents one such collaborative learning activity that involves young students forming groups to achieve a specific goal (get the fractions on their handhelds to sum to one). Collaborative scaffolding is provided by the designed mobile collaborative application as well as by the students' social relationships and the teacher's facilitation. We report on our initial trials which show that the socio-technical design of the activity helps students in identifying their own strategies and stimulates collaboration. Beyond this specific application, we propose a generic model for mobile computer supported collaborative activities that can support a range of other tasks in learning languages, science or other disciplines.

Keywords

mCSCL, collaborative scaffolding, mobile learning

Introduction

The field of mobile computer supported collaborative learning has emerged in recent years spawning numerous technological designs for learning (Liu & Kao, 2007; Yin, Ogata, & Yano, 2007; Zurita & Nussbaum, 2004). Regardless of many contemporary mobile learning attempts focusing on out-of-class and contextualized learning, such as science centre visits, museum visits, field trips etc., (W. Chen, Tan, Looi, Zhang, & Seow, 2008; Y. S. Chen, Kao, Yu, & Sheu, 2004; Cupic & Mihajlovic, 2010; Fertalj, Hoic-Bozic, & Jerković, 2010; Jurcevic, Hegedus, & Golub, 2010; Kennedy & Levy, 2008; Klopfer & Squire, 2008; O'Malley & al., 2004; Rogers & al., 2002; Sharples, Lonsdale, Meek, Rudman, & Vavoula, 2007), we further investigate the potential of collaborative mobile technologies supporting collaboration in small groups (Colella, 2000; Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996; Nussbaum, et al., 2009) in classrooms. As we want to promote collaborative learning amongst the students, we sought about designing collaborative activities in science and mathematics using these smartphone computers (Chan, et al., 2006; Looi, et al., 2010).

This paper presents a design for mobile computer supported collaborative learning in primary school classrooms in Singapore. Our research context is that we have been doing a two-year longitudinal design research study with a primary school in Singapore. We co-designed a whole year's worth of lessons in science which are delivered through handhelds, specifically smartphone computers, and enacted these lessons over the course of one year. As such, the students in our experimental class are familiar with using their handhelds.
Our three-year study initially focused on science which inspired us to design a collaborative activity for math learning. In this activity, after students are assigned a fraction on their handheld, they are asked to form a group with other students in which the sum of their fractions is one. The activity completes only if every student belongs to a group with such a solution, thus requiring students to collaborate and to avoid or get out of the preferred social arrangements in order to help their peers in completing the task. During this study, we do not only rely on rich technological infrastructure (modern HTC Tytn II mobile phones and reliable 3G broadband internet connection). It is the classroom culture of 1:1 handheld device per student (Chan, et al., 2006) which allows us to critically read the affordances of our design from the student trial runs.

Building on this prior work in mCSCL, we explore the design of in-class mobile collaborative synchronous learning with flexible, small group sizes. We want to explore the space of collaborative activities in which students have to search and form their own groups in doing the activity. Such a socio-technical design of our collaborative activity is intended to help students in identifying their own strategies of achieving the both the local and global goals via collaborative work.

This paper is organized as follows: in the next section, we provide a brief overview of recent developments in mCSCL in classroom settings. We will then present the design of our mobile-computer supported learning fractions activity. The subsequent section reports on our initial trials that seek to find out whether and how the collaborative scaffolding helps students in achieving both the local and global goals. In the final section, we propose a generic model for mobile computer supported collaborative activities that support a range of other tasks in learning languages, science or other disciplines.

Mobile Computer Supported Collaborative Learning

Early research in computer supported collaborative 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 collaboration. However, both the focus on the tool and the lack of collaboration actually happening have led to some skepticism in initial CSCL trials. It was felt that social interaction does not simply happen with a computer-based environment, thus emphasizing social and psychological dimension of the desired social interaction (Kreijns, 2003). In advocating their approach to future classrooms organized around WILD (Wireless Internet Learning Devices), Roschelle and Pea 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 (Roschelle & Pea, 2002).

mCSCL can be considered as a specialization of the field of CSCL. It alleviates the constraint posed by fixed times and locations for doing the collaboration activities. By employing mobile devices, learning becomes personal and mobile, and students are able to participate in collaborative learning activities when and where they want to (Looi, et al., 2010). Some research studies have shown that the use of mobile devices in classrooms could significantly impact student collaboration (Tseng, Hwang, & Chan, 2005). Students leverage on their own mobility and the mobility of the devices in order to coordinate collaboration and to exchange information simultaneously over the wirelessly connected devices.

One important research tackles the use of mobile connected devices in classrooms for the education of children of age six to seven (Zurita & Nussbaum, 2004). These students were given language and mathematics 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. The authors report that the use of wireless networks in the classroom opened up many educational possibilities and that mobile devices advance various components of collaborative learning, namely, 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 (Kreijns, Kirschner, & Jochems, 2002). Concerning the main advantages of mobile versus classical computer supported collaborative learning, enhanced possibility for communication, negotiation and mobility has been proposed (Zurita & Nussbaum, 2004). Together with appropriate design of learning activities, a network infrastructure of mobile devices can support collaborative activities in which students extend their area of communication and mutual interaction.

In their conceptual framework for mCSCL (Zurita & Nussbaum, 2007), the authors take an activity theory approach by building on the Engestrom's expanded Activity Theory (AT) model (Engestrom, 1999) and identify three main components of the mCSCL activity system: the Network component, the Rules and Roles component and the Collaborative Activity component spanning across so called social and technological activity dimensions.
Grouping criteria have also been claimed to have impact on mobile collaborative learning. In a study on the impact of grouping criteria on socio-motivational aspect commonly used to evaluate collaborative learning (Zurita, Nussbaum, & Salinas, 2005), authors have determined that "when the children select their group mates (so called Preference criterion) more social behavior aspects with significant improvement can be observed" (p.159). The study therefore foregrounds personal students' preference towards their classmates as the top grouping criterion in order to achieve a more collaborative environment.

We are interested in exploring and designing the space of collaborative activities which enable students to practice communication, negotiation and coordination skills in the process of forming their own groups to solve a group goal. In our approach we supplement the two-level (social and technological) network analysis with a spatial network. The spatial network allows us to more precisely pinpoint the social process in our pursuit of analyzing learning and collaboration occurrences. By employing flexible grouping approach, we allow students to choose their own groups depending on their personal preferences. Since there is a reported negative effect of personal preference grouping criterion on negotiation (Zurita, et al., 2005), we introduce more structure to the activity by using technological scaffolding in order to channel student grouping choices.

Design of FAO collaborative application

In this in-class activity each student has a handheld device. Once they launch FAO, their handhelds are connected to FAO server through a 3G wireless network. Fractions are depicted on students' mobile devices in form of circle sectors (slices) (Figure 1). Students have to collaborate in order to merge (add) fractions. They have to identify peers with complementary fractions (with respect to getting a sum of 1) and then invite them to form groups (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). Inter-group collaboration and negotiation may be necessary to complete the task.

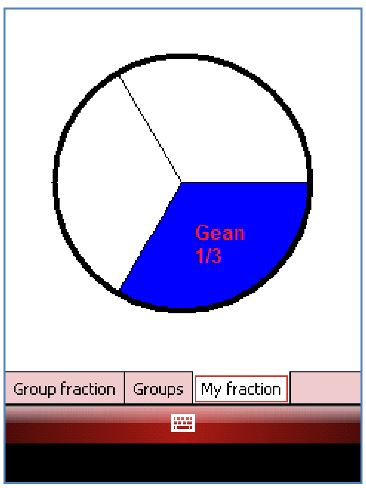

Figure 1. A fraction assigned and displayed on a student's mobile device

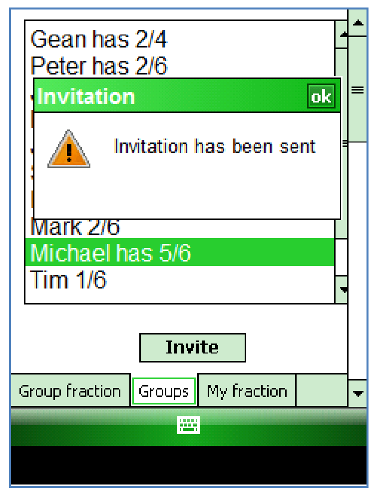

Figure 2. Student issuing a group invitation to his classmate

Collaborative scaffolding is provided by the designed mobile collaborative technology, students' existing personal relationships and the teacher's facilitation. We analyze student participation in the activity through three networks: technological, social and the spatial network which enables a form of embodied participation and is formed by the dynamical rearrangement of the students as they move about with their devices. The three networks together provide the infrastructure for supporting coordination, communication, negotiation and mobility.

Based on the screen information available on their handhelds, each student can access her own fraction as well as access the fractions of all other students in the class. This provides the technological level of support for the activity. The students also rely on their social network of close friends in the class. They are more likely to invite their own friends or their own gender friends to form their own group which provides the social level of support. As the students are mobile, they re-arrange their spatial configuration as they move. It is also likely that they interact with those who are near them spatially.

Phase I of activity: Distribution of Fractions

As soon as all the students have turned their devices on and the teacher started the activity, the server registers the total number of students and then runs an algorithm to randomly assign a fraction to each student (Figure 3). The algorithm ensures that there is a global solution, namely, a configuration of groups of students in which every student belongs to a group and every group completes its task. Although the random fraction distribution ensures fraction diversity, the teachers can control the type of fractions distributed therefore structuring and fine-tuning the activity.

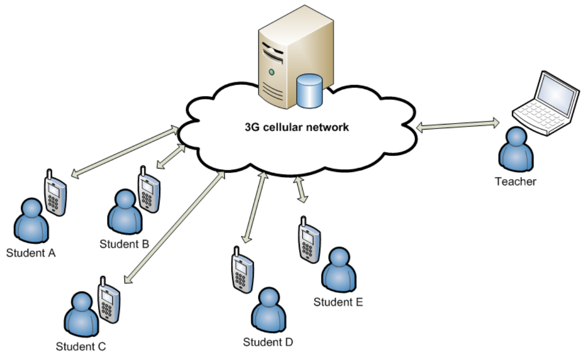

Figure 3. Learning fractions system architecture

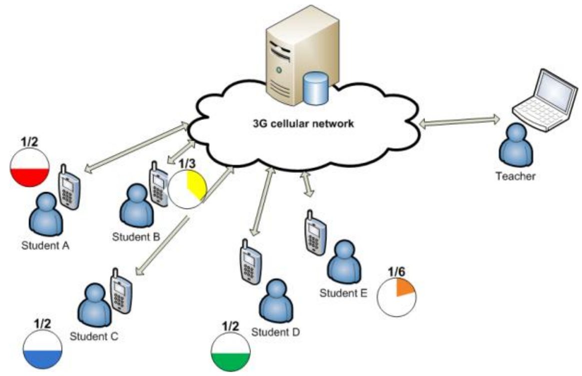

Figure 4. Fraction distribution: phase I of the Fractions activity

In Figure 4, 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 ponder about their individual fractions and try to find out what are the other generated fractions in order to figure out the possible ways of forming groups.

Phase II of activity: Negotiation and exchange

To identify the potential candidates in order to form a group, a student can rely on the graphical user interface of her mobile device and browse through the list of all available students and their fractions (Figure 5) or they approach the problem through face-to-face interactions and detect the potential candidates through conversation. When a student identifies another student with whom she could form a group, she uses her mobile device to issue the group invitation. The request is then dispatched to the server side which forwards it to the invited student (Figure 6). Through a series of invitations, accepted and rejected requests, students arrange themselves to form groups.

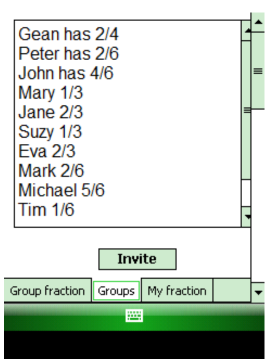

Figure 5. List of all available student in FAO

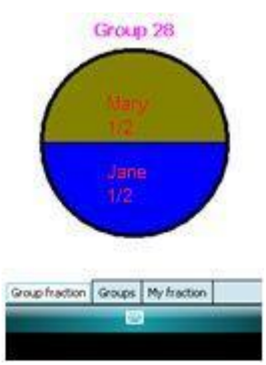

Figure 6. A group fraction in FAO

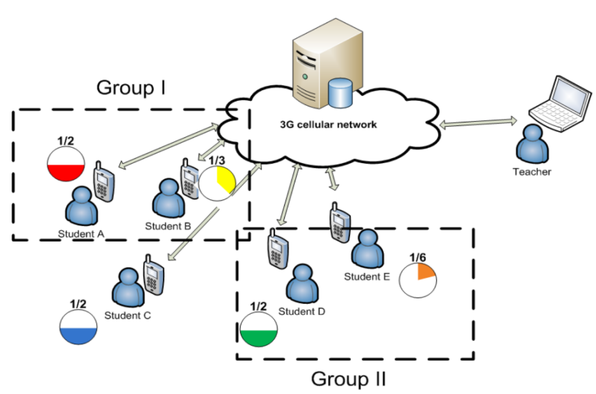

Figure 7. A group configuration of an impasse preventing students from achieving the global goal

Some students may have some difficulties with adding up the fractions or with reaching some local optimum (Figure 7). Local optimum presents a formed whole circle within a group. Although optimal for a group, it might not be optimal for all groups. Some groups might be blocked in reaching their local optimal solutions because one group reached a certain local optimum. The group then has to be broken and other groups have to be assembled, hopefully leading to optimal solutions for all groups which leads to the completed activity.

Phase III of activity: Towards the global-oriented goal of all FAO

Figure 7 shows an activity with six students who have already been assigned with fractions. Through the collaboration they were able to form two groups but are unable to accept the one leftover student (holding 1/2) since adding his fraction would make both group fractions larger than a whole. In order to achieve both the local and global goals, students have to negotiate and to re-form their group memberships. Thus, in addition to the individual goal of forming a whole, students have to work collaboratively in order to achieve the common goal of *all* groups having a full circle. Nevertheless, while some groups might have formed their wholes (their individual collaborative goal is achieved), the others might have reached a dead-end situation, and be unable to proceed. This is a situation where students are required to put the global goal before the individual or group goals and to try thinking collaboratively about other possible solutions or group configurations. Only when each group has formed a whole is the activity over.

Trials of the Collaborative Activities

The proposed design was evaluated through a series of trials with the primary school children roughly aged 8-9 grouped in groups of 8 and 16 students divided in two batches. The first batch of students was introduced 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. The second batch of students was not familiar with the "ways of doing the collaboration" such as how to invite other students to their groups, how to negotiate for their cause, align their personal goals with the overall group goal etc.

In order for the trials to mimic the actual classroom arrangement, the research team worked closely with the teachers of two classes. All students received the instructions on "how to do the collaboration". This included simple rules such as: "when you are in the same group stand together", "you are allowed to talk to other students in addition to working on the device", "do not automatically reject group invitations, and talk to your colleagues to see their needs" etc. Concerning the students' knowledge of fractions and fractions operations, it is important to note that understanding fractions do present a challenge to some of the students as one student critically commented: "Fractions are worse!" meaning the most difficult.

How Groups Emerged in one Trial Run

We look into how students perform in one trial run. We use a visual coding scheme which shows the spatial distribution of the students who are identified by their individual fractions, their current grouping, and their gender dimensions. Male students are shaded and named with abbreviations starting with M, while the female students have the names 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, the students started exchanging ideas about arranging fractions (denoted by the two-direction arrows) (Figure 8). The discussion started to grow from pairs to groups of three and four students (Figure 9).

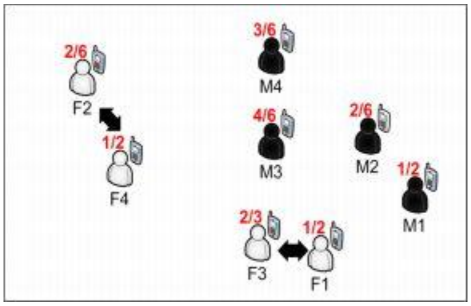

Figure 8. Initial student arrangement in the trial run

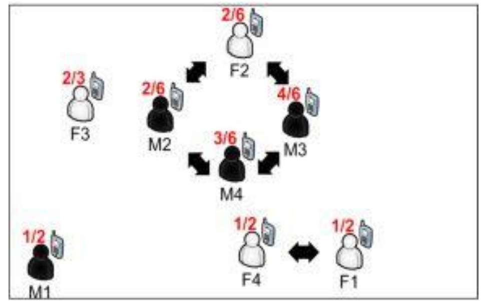

Figure 9. Students discussing available options

As the activity progressed, two groups were almost simultaneously formed indicating positive outcome of the negotiation activities. Following the successful creation of two groups the third group was created (Figure 10). Although the system provided the student with the flexibility of choices of choosing other students (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 and complexity of the activity: as it progressed, the overall number of the possible combination decreases making the choice of partners more straightforward.

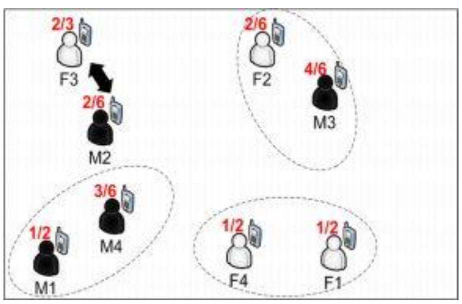

Figure 10. First groups created in the trial run

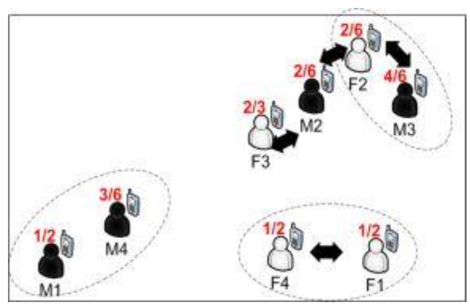

Figure 11. Students in the trial run without a group seeking help from their peers

Two students (F3 and M2) were applying the "combining same fractions strategy" and were not aware them joining could lead to a whole. They decided to seek peers' assistance in identifying the possible solution for the activity (Figure 11). 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 12).

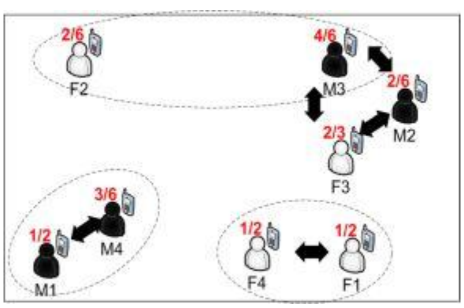

Figure 12. A trial run student F2 seeking for help from the teacher

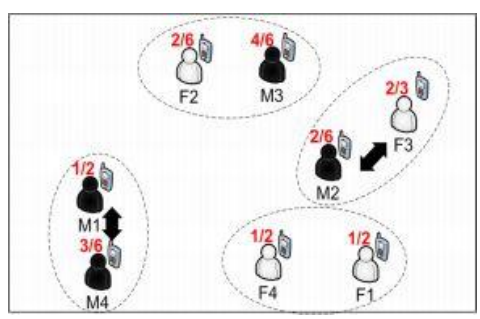

Figure 13. All students found a group – end of the trial run

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 13). Figure 14 illustrates the spatial group arrangement for all students while the Figure 15 provides a close-up view of the intra-group interaction during the activity.

Figure 14. Spatial arrangement at a specific point in the activity

Figure 15. Close-up view of the intra-group collaboration

Negotiating Local and Global Goals through Backtracking

The previous trial run is straightforward in the sense students did not have to backtrack, meaning there was no need to disassemble the groups they are in and to assemble new ones. The focus was on achieving individual goals and yet at the same time, the global goal is reached. There are other runs in which students get into groups which require them to disband and re-group, and enter into new negotiations leading to new group configurations in which every student belongs to a group which achieves the goal of having the sum of their fractions as one.

We discuss such a case in a trial run with 14 students using a series of screenshots from the teacher's console showing assembled groups. Figure 16 shows the 8th step (the 8th group configuration) in the activity. Students negotiated their way to this step in a fairly straightforward fashion: they employed a simple strategy of combining the same fractions to create the group (1/2 went together with 1/2, 2/4 with 2/4, 1/3 with 1/3 and 1/6 with 1/6). When several choices of students with the same fractions become possible, the students employed the strategies of personal and spatial preference in choosing their partners.

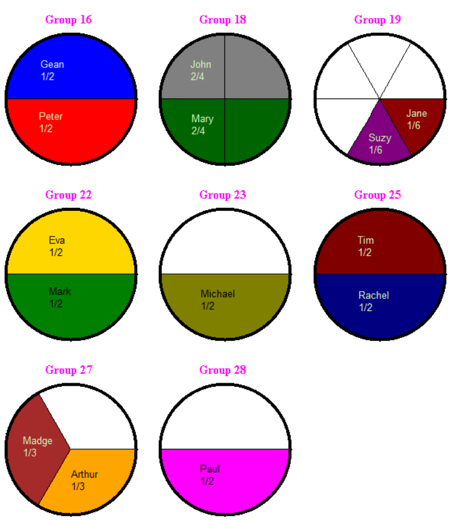

Figure 16. 8th group configuration in the FAO activity

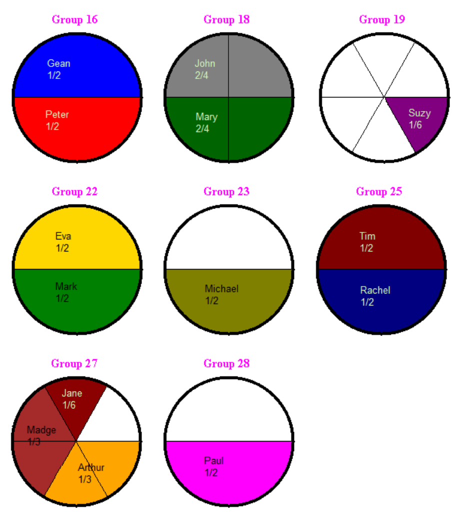

Figure 17. 9th group configuration in the FAO activity (after the change in the strategy)

After the 8th step, the students were faced with the consequences of the chosen strategy: they were not able to proceed by simply combining the same fractions because of a simple reason: there were not enough fractions to combine. On the other hand, there were other fractions they could use but their strategy had to be changed or supplemented. After a short period of discussion, social interaction, peer instruction and some scaffolding provided by the technology and the teacher, the students were able to advance to the next step of the activity. The teacher scaffolding in this case consisted of a teacher pausing the activity, explaining the current group configuration to students, explaining students they have break their current groups in order for the activity to proceed and helping them find the potential peers on their own (Figure 17).

As the activity progressed, the number of groups could only drop or remain the same. To identify the deadlocks due to the backtracking, the teacher tracked the number of active groups on her computer (Figure 18). If the number of groups remained constant throughout a longer period of time as shown in Figure 18, the teacher could intervene and provide some additional scaffolding by advising some groups to re-group.

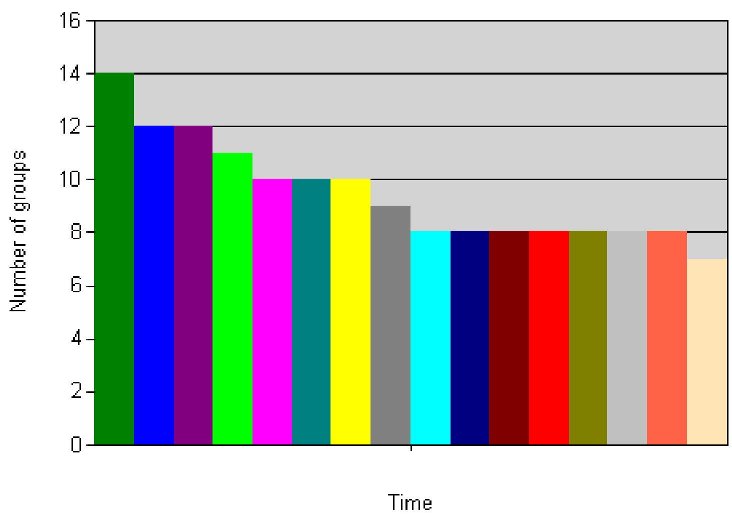

Figure 18. Graph of number of groups in the activity through time

Strategies adopted by students

The activity began with researchers giving some brief instructions to students on how to use the device and the software. The series of trials show that the children have no problems with the use of the technology mostly because they have had the chance to use handhelds (HTC Tytn II devices) throughout a prior series of lessons. They were both familiar with the pre-installed software solutions such as Excel and Word and were taught how to use custom-made software solutions for mobile learning. Therefore, there were no usability issues, and the students were able to quickly familiarize themselves with the user-interface and used the application effectively.

After the initial period of confusion, resulting in a short period of silence throughout which the problem of forming wholes out of fractions was mentally processed, the activity continued. In addition to individual effort of examining the list of all students and their assigned fractions, some strategies started to emerge and were shared amongst the participating students. The main strategies are: looking for the same fractions in order to form a whole, identifying students to invite to be in one's group based on what other fractions are needed to make a whole, gender and personal preferences, and just randomly sending out invitations.

Prior to distributing the fractions to students, the system generated the fractions with a specially designed algorithm designed to achieve two main goals: diverse randomized fractions and achievable final solutions (the global goal or solution). This means that some students received the same fractions (e.g. 1/2 and 1/2) They started looking for peers with the same fractions in order to create groups which in some cases turned out to be a successful strategy, while in other it caused impasse situations and required some backtracking prior to achieving the group goal. Here are some conversations of the students while exercising “choose the same fraction” strategy:

- One student explained her self-employed strategy: “*If I have 2/4 I go and look for other 2/4*”.

- One student asked out loud: "*Who does not have a fraction*?" He then approached a student without a group: "*How much do you need?*" Another student joined the discussion: "*You have 1/2!*, *you need 1/2*". The student without a group responded: "*But it is only Kenny [another student a bit further away] who has 1/2 and every time I invite he says do not want to*." The second student suggested the way for the student without a group to proceed: "*Then just talk to him*.“

- One student took on a mediating role and circled around the room trying to identify who should join with whom. After a while he suggested out loud: “*Clifford and Wendy both have 1/2*”. Then he spoke directly to Wendy: “*You will have to go with Clifford*”.

The technological layer provided some scaffolding during the process: the students had a list of all other students with their assigned fractions. In addition to the individual approach of identifying the same fractions from the list, the students could switch to the social and spatial network to receive some additional technological scaffolding from comparing concrete and abstract representations of their fractions.

The students had many different configurations to choose from when assembling the groups in order to reach the global goal. Most of them utilized the spatial network to approach physically nearest peers and try to make a group together with them. Since students’ personal and gender preferences controlled initial spatial activity arrangements, students were able to take some ownership of the activity.

One impasse faced by the students occurred when the software did not allow them to increase the sum of their fractions beyond one. These students were surprised by the system message of being unable to allow the group of just two members (e.g. members with 2/3 and 1/2). To get out of this impasse, they had to question or relook at their strategy of merging any two students and looking for the third member to complete the group.

Almost all students approached the activity only with the individual goals in their mind without thinking about the global goal. They had to be reminded on numerous occasions about it and were encouraged by the teacher to assist their peers in rearranging or perhaps even breaking their own groups. The understanding of the shared goals was perhaps the most difficult for the primary school children to grasp. Nevertheless, some students acted as mediators, being able to cover both the task and the ways of connecting individually oriented students.

Learning to collaborate

Learning how to collaborate proved to be another demanding task for the primary school students. Achieving the local and the global task goals required them to extend their social circles and go beyond their social comfort zones. The activities started with fixed socio-spatial arrangements: girls standing in line with girls and boys co-located with other boys. In order for the activity to progress, students had to exit these configurations: one of the first identified endeavours was “crossing to the other side” in order to negotiate a new group formation.

An interesting case emerged with a boy and a girl not able to collaborate even though the overall activity progress depended on it. Since the face-to-face negotiation was out of question for them, they relied on the technological layer to send out group invitations. It seems the technological medium facilitated to help them overcome their pre-established personal preferences.

In some cases in which the technological support was not adequate, social scaffolding came into play. Students encouraged each other to form new groups both verbally (giving explanations on why to go to another group) and physically (gently pushing their peers towards the potential partner). At times, social collaborative scaffolding was powerful enough to overcome personal preferences for group membership.

In contrast to overcoming personal preferences in achieving both individual and group goals, some students built on top of 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.

In the process of dealing with impasses and employing and testing the new strategies, the students provided peer instruction to help each other. For example, they had to convince their peers to adopt new strategies. One student identified that two fractions (2/4 and 1/2) can be merged in order to form a whole. In order to convince his colleague, he used this simple explanation strategy: "*You have to increase your fraction!*" Although the choice of words was not appropriate (one might understand it as to search for a larger fraction/number), the student later clarified his advice by pointing out that 1/2 equals 2/4.

Towards a Generic Model for Collaborative Scaffolding in mCSCL

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. 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, and 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. The teacher scaffolding consists of teachers stepping into the activity at critical points (e.g. students cannot move from one group configuration to the other) in order to facilitate the activity progress. The teacher typically starts a discussion about the problem students have, and try leading them to a possible solution. In the process, teachers can combine technological and social scaffolding thereby delegating some work to the technological infrastructure or the students (Figure 19).

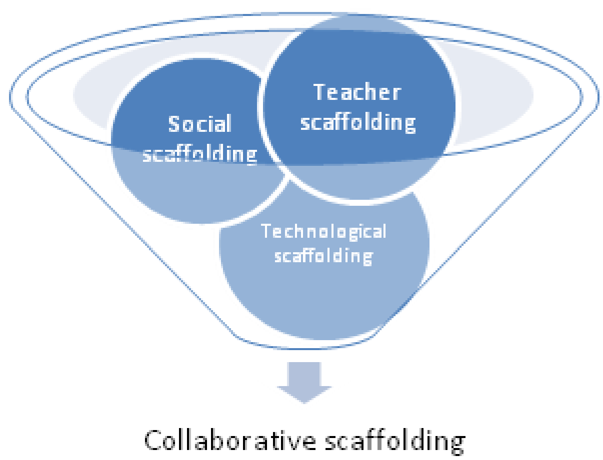

Figure 19. Social, teacher and technological scaffolding as the main elements of collaborative scaffolding

The collaborative scaffolding can be applied to different learning content. Besides activities for learning fractions, collaborative activities can take the form of composing sentences, or forming Chinese characters or idioms by using the same set of social and technological collaborative rules. In the software design, the rules and logic for a particular domain are specified in the Generic Content Rules and Logic interface (Figure 20). The system looks at any mobile learning content as the sequence of content elements that can be combined in a sensible unit, and distributes the elements (either generated automatically or as provided by the teacher) to students.

The content specific rules are separately defined for each mobile learning application. The fractions activity of FAO comes with rules which define answers to questions such as: How to combine fractions (by summing or some other operations)? What makes a whole or a solution? How to generate fractions prior to distributing them in order to have feasible local and global group goals? How to introduce complexity when generating fractions (such as having larger denominators)?

With a collaborative activity for the composing sentences, the basic content elements assigned to and manipulated by the students could be words and phrases. The rules and logic would need to deal with the following issues: How to combine words or phrases to form sentences? How to obtain or generate words and phrases prior to distributing them to students? How to check the validity of a constructed sentence in case there are more feasible solutions that the teacher predicted?

With a collaborative activity for forming Chinese characters, the basic content elements are radicals which are arranged spatially in correct ways to form legitimate Chinese characters. The rules and logic would need to deal with the following issues: What are different graphical layouts of Chinese characters? How to check whether a combination of Chinese characters produces a valid character? How to check the semantics in case there are more feasible solutions that the teacher predicted? Figure 20 shows our model for designing a generic collaborative software for supporting the design of different collaborative activities.

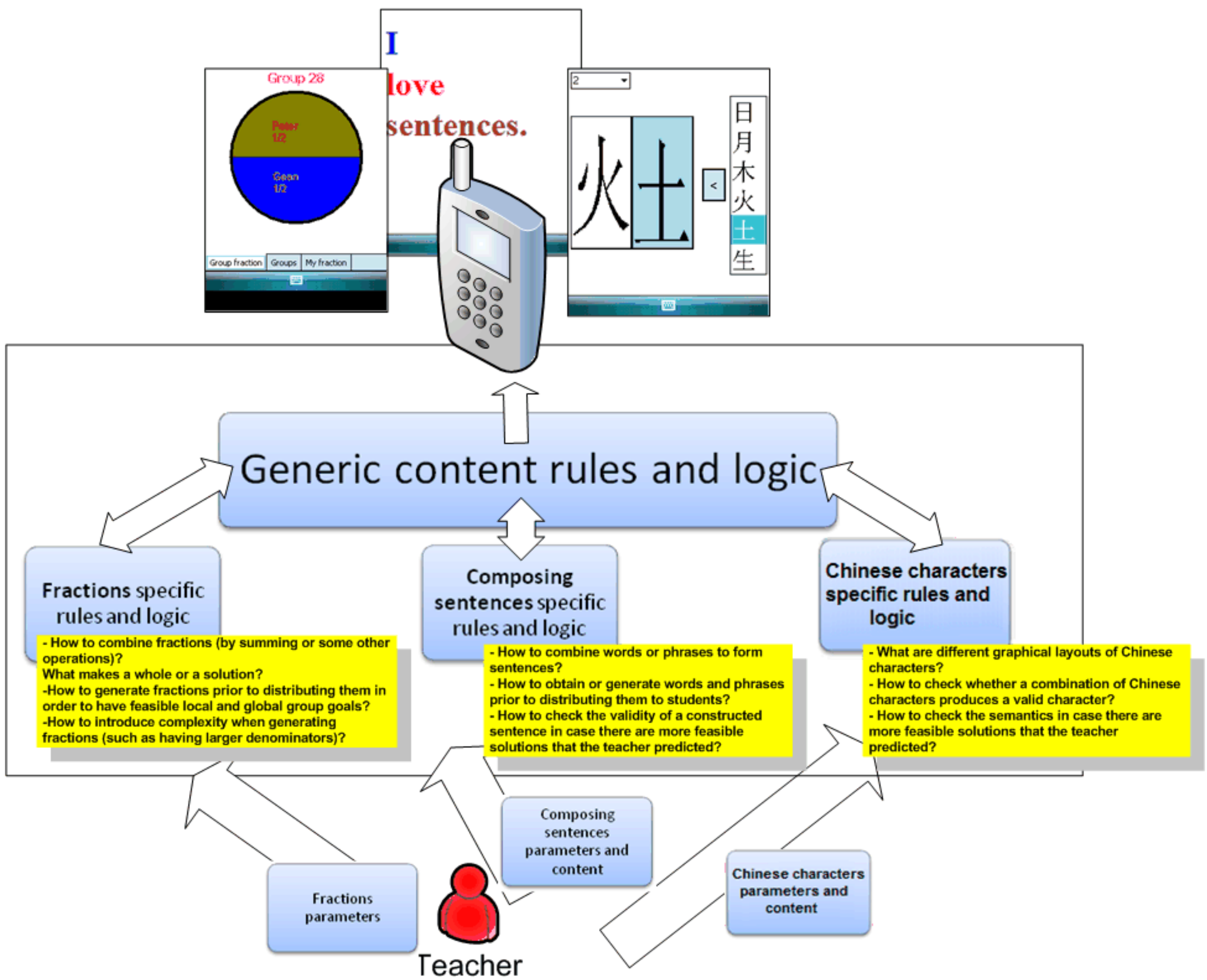

Figure 20. A Generic Model for Designing mCSCL Collaborative Activity

A feature is required for the teacher to be able to specify activity parameters that directly impact the complexity of the activity, and the possibilities for collaboration in the activity. For FAO, the teacher provides parameters which determine whether the visual pie-chart representation should be displayed alongside with the mathematical notation of fraction, which denominators are allowed to appear in the game, whether to show fractions subdivision etc. All of these determine the difficulty level of the activity and the level of scaffolding the students receive from the technology. In the sentence composition activity, the teacher inputs the text and specifies the way it should be distributed to the students. The teacher can choose to distribute a word per student or to decompose sentences into phrases. In the Chinese character activity, the teacher defines the set of Chinese characters or radicals to be made available to students, and therefore indirectly determines the range of different characters that can be composed.

It is not only the use of different content that makes the system generic. Collaboration rules that utilize the content are generic as well, allowing users to collaborate around different content bits (e.g. fractions vs. Chinese letters). Generic are the communication mechanisms as well, allowing the transfer of messages aimed at different content areas.

Conclusion

The paper presented the design of a collaborative activity of learning fractions with handheld computers and the findings of some preliminary trials. Primary three students used handheld devices and specially designed software to participate in a collaborative effort of achieving local goal of forming groups with wholes and a common global group goal. The activity as supported with collaborative scaffolding consists of three main scaffolding sources: technological, social and the teacher. Technology provides scaffolding in the sense of both generic and context-specific rules and logic, while the teacher acts as facilitator and helped the students in dealing with impasses. Social scaffolding is encouraged in order to increase student interaction and collaboration.

In our trials, students were able to come up with some ad-hoc strategies of doing the activity and solving the problem, some of which inevitably ended with impasses which had to be resolved with collaborative scaffolding. Students were able to modify their initially chosen strategies and realized the importance of achieving the global goal besides their group goal, therefore learning how to collaborate with these interdependencies.

We feel it was the interplay of technological, teacher and social scaffolding which contributed to the overall progress of the activity. The technological and social scaffolding were interchangeable depending on the personal preferences of the students. Students armed with good communication and negotiation skills relied more on the social scaffolding, while more introverted students used the device as a medium of carrying out actions that would otherwise probably never be externalized. It was the technological scaffolding that made the activity progress easier further advancing student problem solving skills. Instead of personally checking other students' fractions, students could refer to their devices and browse the corresponding lists. Furthermore, students were able to switch between different kinds of problem presentation and see their group artifact at anytime. The teacher scaffolding when introduced at critical moments bridged the gaps neither technological nor social scaffolding could therefore preserving the momentum of the activity.

Building on this specific application of a fractions activity, we propose a generic model for collaborative scaffolding in mCSCL that enables the design of collaborative learning scenarios for handheld computers in different domains such as sentence or character construction in language learning. The characteristics of our collaborative activities include interdependency on other students to form a group solution, agency in students to accept or reject invitations to join groups, reliance on collaborative skills to find collaborative partners, emergent groups instead of fixed groups, facing the tension between meeting a group goal vs. meeting the global goal, and willingness to backtrack group solutions in order to seek a global solution.

In our trials, we faced a host of issues ranging from classroom management to technical glitches. In the trials with large groups (whole classes of 40), the students typically exhibited the strategy of randomly sending out invitations therefore checking each other's progress (they had to wait a long time for each other's reply). In one particular case, as the waiting time between the steps in the activity went too long, the progress of the activity was disrupted. This leads us to a new cycle of system and user interface re-design in which students do not rely so much on the initially chosen request-response design paradigm, but rather choose from a set of available group configuration publicly displayed on the common shared screen.

In our approach, we have chosen the 3G network connection as the means of exchanging system messages triggered by users. We advocate this approach due to several factors: connection stability, signal coverage and the decreasing cost of such network connectivity. It is our belief that this presents a significant advantage over the free WiFi connectivity and opens up possibilities for activity and system extensions to outside of classroom boundaries.

In addition to the fractions activity presented in this paper, we have conducted a series of trials including Chinese character learning and plan for another full-fledged semester-long study dealing with the issues of regular lecture integration. With the redesigned technology and a slightly adjusted research design, we hope to more thoroughly explore the impact of this technological innovation in regular classroom environments.

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References

Chan, T. W., Roschelle, J., Hsi, S., Kinshuk, Sharples, M., Brown, T., et al. (2006). One-to-one technology enhanced learning: An opportunity for global research collaboration. Research and Practice in Technology Enhanced Learning, 1(1), 3-29.

Chen, W., Tan, N., Looi, C.-K., Zhang, B. H., & Seow, P. (2008). Handheld computers as cognitive tools: technology-enhanced environmental learning. Research and Practice in Technology-Enabled Learning,World Scientific, 231–252.

Chen, Y. S., Kao, T. C., Yu, G. J., & Sheu, J. P. (2004). A mobile butterfly-watching learning system for supporting independent learning. Paper presented at the 2nd International Workshop on Wireless and Mobile Technologies in Education.

Colella, V. (2000). Participatory simulations: building collaborative understanding through immersive dynamic modeling. Journal of the Learning Sciences, 9(4), 471-500.

Cupic, M., & Mihajlovic, Z. (2010). Computer-Based Knowledge, Self-Assessment and Training. International journal of engineering education, 26(1), 111-125.

Dufresne, R. J., Gerace, W. J., Leonard, W. J., Mestre, J. P., & Wenk, L. (1996). Classtalk: a classroom communication system for active learning. Journal of Computing in Higher Education, 7(2), 3-47.

Engestrom, Y. (1999). Activity theory and individual and social transformation: Cambridge University Press.

Fertalj, K., Hoic-Bozic, N., & Jerković, H. (2010). The Integration of Learning Object Repositories and Learning Management Systems. Computer Science and Information Systems, 7(3), 387-407.

Jurcevic, M., Hegedus, H., & Golub, M. (2010). Generic System for Remote Testing and Calibration of Measuring Instruments: Security Architecture. Measurement science review, 10(2), 50-55.

Kennedy, C., & Levy, M. (2008). L'italiano al telefonino: Using SMS to support beginners' language learning. ReCALL, 20(3), 315-330.

Klopfer, E., & Squire, K. (2008). Environmental Detectives—the development of an augmented reality platform for environmental simulations. Educational Technology Research and Development, 56(2), 203-228.

Kreijns, K. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. Computers in Human Behavior, 19(3), 335-353.

Kreijns, K., Kirschner, P., & Jochems, W. (2002). The sociability of computer-supported collaborative learning environments. Educational Technology & Society, 5(1), 8-25.

Liu, C.-C., & Kao, L.-C. (2007). Do handheld devices facilitate face-to-face collaboration? Handheld devices with large shared display groupware to facilitate group interactions. Computer Assisted Learning, 23(4), 285-299.

Looi, C. K., Seow, P., Zhang, B., So, H. J., Chen, W., & Wong, L. H. (2010). Leveraging mobile technology for sustainable seamless learning: a research agenda. British Journal of Educational Technology, 41(2), 154-169.

Nussbaum, M., Alvarez, C., McFarlane, A., Gomez, F., Claro, S., & Radovic, D. (2009). Technology as small group face-to-face Collaborative Scaffolding. Comput. Educ., 52(1), 147-153.

O'Malley, C., & al., e. (2004). WP4 – Pedagogical Methodologies and Paradigms, Guidelines for learning/teaching/tutoring in a mobile environment: MOBIlearn.

Rogers, Y., & al., e. (2002). Learning through digitally-augmented physical experiences: reflections on the Ambient Wood project (Technical Report): Equator

Roschelle, J., & Pea, R. (2002). A walk on the WILD side: How wireless handhelds may change computer-supported collaborative learning. International Journal of Cognition and Technology, 1(1), 145-168.

Sharples, M., Lonsdale, P., Meek, J., Rudman, P. D., & Vavoula, G. N. (2007). An Evaluation of MyArtSpace: a Mobile Learning Service for School Museum Trips. Paper presented at the 6th Annual Conference on Mobile Learning, mLearn 2007.

Tseng, J. C. R., Hwang, G.-J., & Chan, Y. (2005). Improving learning efficiency for engineering courses in mobile learning environments. Paper presented at the x. Retrieved from http://www.wseas.us/e-library/conferences/2005athens/ee/papers/507-124.pdf

Yin, C., Ogata, H., & Yano, Y. (2007). Participatory simulation framework to support learning computer science. Mobile Learning and Organisation, 1(3), 288-304.

Zurita, G., & Nussbaum, M. (2004). Computer supported collaborative learning using wirelessly interconnected handheld computers. Computers & Education, 42(3), 289-314.

Zurita, G., & Nussbaum, M. (2007). A conceptual framework based on Activity Theory for mobile CSCL. British Journal of Educational Technology, 38(2), 211-235.

Zurita, G., Nussbaum, M., & Salinas, R. (2005). Dynamic Grouping in Collaborative Learning Supported by Wireless Handhelds. Educational Technology & Society, 8(3), 149-161.