Measuring Group Dynamics in an Elementary School Setting Using Mobile Devices

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Abstract
Mobile instrumentation provides researchers and professionals the opportunity to collect data on several aspects of human life. In this paper we discuss our initial experiences on collecting data via mobile instrumentation in an elementary school. We augmented a classroom with mobile phones and Bluetooth beacons to capture student experiences as well as their relative distance to each other during a collaborative group project. We describe the study, and present lessons learned when instrumenting such a unique school setting with young participants.

Author Keywords
Education; mobile sensing; context; ubiquitous computing; ESM; collaboration; primary school;

ACM Classification Keywords
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Introduction
In 2016 a new curriculum will be implemented across Finnish elementary education, highlighting the importance of collaborative classroom practice [5]. Collaboration can be defined as a "*coordinated,*

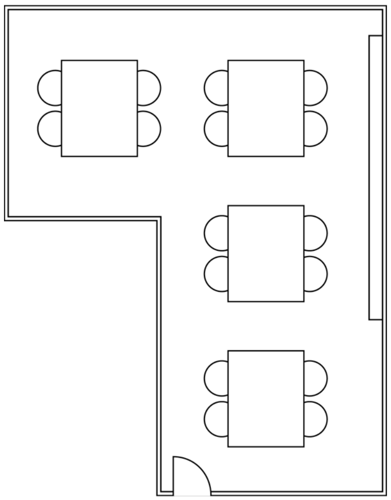

Figure 1 – Layout of the classroom during the study.

synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" [12]. However, measuring the "success" of collaboration is challenging, and requires instrumenting individuals with technology [11].

The mobile instrumentation study we describe took place in the context of a real elementary school project called "*Tämä toimii!*" ("*This works!*"). The overarching goal of *This works* is to raise understanding of interacting with technology, and increase childrens' interest in technological subjects [10]. In this case, the project provided 5th graders (aged 10-11) with a demanding, collaborative task of conceptualising and creating a functional prototype toy.

For the purposes of our study the elementary school administration allowed us to instrument and follow a classroom of four groups over the course of 3 individual 4-hour sessions (over 3 weeks). We employed the Experience Sampling Method (ESM) [8] to collect participant thoughts throughout their ordinary project activities. Using the ESM, we set out to gather insight into how the students experience collaboration with their project teammates. Practically, the participants were each given a mobile device to respond to ESM questionnaires, as well as for connecting to one of the installed beacons for localisation purposes.

We discuss our observations from the study and discuss how mobile devices can be used to sense human behaviour in an elementary school setting.

Related Work

In a methodologically similar study, Colombo & Landoni [2] apply the ESM to measure the user experience of children using e-books. A combination of technical problems and a lack of participant responses resulted in a relatively low response rate of 22%. Boschma [1] defines five dimensions of proximity; *geographical*, *organizational*, *social*, *institutional*, and *cognitive*. Each dimension of proximity can have both positive and negative effects on human interaction, cooperation, collaboration, and learning. Geographical proximity is defined as "*spatial distance between actors, both in an absolute and relative meaning*" [1].

The literature consists of opposing views on the need for physical proximity for successful collaboration. According to Boschma, proximity in the modern world is "*neither necessary nor sufficient condition*" [1], since other forms of proximity can serve as substitutes. On the other hand, Werker & Cunningham suggest that geographical proximity "*can be crucial for collaborations*" [3], highlighting the importance of functional closeness of actors. Kraut *et al.* [6] suggest a link between individual's physical proximity and their level of collaboration, something that holds true even in the age of telecommunication. These papers mainly concern collaboration among grown-ups.

Mobile instrumentation

We provided mobile devices (mostly Nexus 7 tablets) for all 15 study participants. The mobile devices given to the participants were instrumented with the AWARE framework [4]: a middleware framework for mobile sensing. We also developed a separate application for the participants to launch an ESM questionnaire. To measure the participants' experiences before, during, and after each session we repeated the same questionnaire over the course of the study. The questionnaire focused on collaboration and project work

Figure 2 – Average values of three ESM questions over the three different sessions for four different groups.

and was piloted on paper prior to the study. Due to the flexible and often erratic nature of (elementary) education, we did not implement an *interval contingent* notification scheme. To align the ESM questions with the lesson plan, the teachers simply instructed pupils when to launch and complete each questionnaire.

In addition, we installed four Bluetooth beacons on the desks of the project groups (see **Figure 1** for the classroom layout). These beacons (KST Ion [7]) broadcast their unique ID, thus enabling coarse indoor localisation. Participants' mobile devices continuously scanned nearby Bluetooth devices and stored both the Received Signal Strength Indicator (RSSI) values and beacon IDs. This allowed us to estimate the distance between the beacons and the students. Using RSSI for indoor positioning is a commonly used [9] technique for indoor positioning.

Results

ESM data

With 15 students, 8 questions, and 3 questionnaires over 3 sessions, a total of 1440 ESM answers could be collected. We collected a total of 1363 ESM answers (response rate of 94.7%). The presence of the teacher and allotted time slot to answer the questionnaire contribute to this high response rate.

We wish to highlight three particular questions to discuss our results, as visualized in **Figure 2**. Participants generally enjoyed the project at hand, and rated the importance of their current activity as high. For 2 student groups, enjoyment and importance (first and second graph in **Figure 2**) of the activity seem to correlate. Project progress did not seem to influence the participants working relationship (final graph).

RSSI data

We deployed the four beacons in the classroom at the centre of each group's working space. The collected RSSI data of each participant's phone indicates the relative distance between a participant and the group's desk. **Figure 3** shows the average RSSI value for each group over the duration of the study. As a result of students walking back and forth between the classroom and other rooms in the building (*e.g.*, material room, lunch cafeteria), connection with the beacons was often lost. This is particularly clear in Session 2, where group 4 seems to almost disappear, most likely as the result of the project group continuing their work elsewhere. Missing RSSI data of group 3 in session 1 is likely the result of a technical problem during data collection.

Teacher observations

We interviewed the classroom teacher after the completion of the project. He observed and interacted with the students during all three sessions as their main teacher. Primary goal of the interview was to obtain information on the success of the project groups, interpersonal interaction among group members, and observations on the interaction with the installed mobile instrumentation.

Only two of the four groups managed to complete the projects task (groups 2 and 3). According to the teacher, this was the result of a strong group leader (group 2) and a surge of inspiration in the final project session (group 3). Group 1 had a good project idea and started highly motivated, but lost motivation among the way due to a problematic group member. This is in line with the literature: disruptive behaviour of one student can lower general academic engagement and outcome [13]. It should be noted that this individual was the

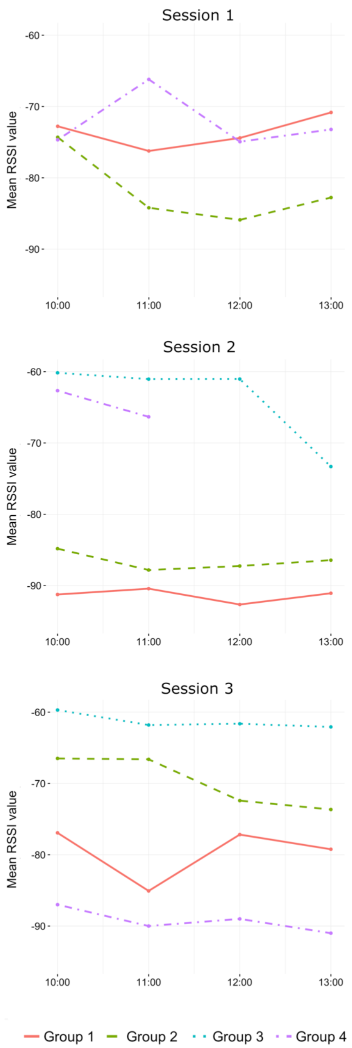

Figure 3 – Average group distance to their respective classroom table.

only student who chose not to participate in the data collection. Group 4, although containing two very good members, did not finish due to similar problems.

Discussion

The self-reported ESM data expresses a different story than teacher observations. This can be due to the (disputed) "Hawthorne effect", which causes participants to report what they think researchers want to hear. Another interpretation is that the ESM questions asked to the participants do not sufficiently reflect their ability to successfully complete the project. However, since the ESM self-reports are completed by each individual student, we argue they can be used to provide insights to the class teacher during day-to-day lectures. Additional context data, such as the location data collected in this study, can be used to further augment these reports and provide information to the teachers about their pupils' behaviour.

The unique context and environment of an elementary school provided challenges which we wish to highlight here. The majority of the used devices, although lightweight and compact, were not practical to carry around in one's pocket. Due to local legislation and ethical issues, we were also not able to provide participants with a necklace to carry the device without obtaining additional guardian consent. Students reported no discomfort due to answering ESMs. Size of the devices did however put some strain on the students as they were required to carry them around.

Students were not restricted to a single room during the 3 sessions, but were able to freely roam the corridors and other areas of the school. As a result, the obtained location data through the beacons were often incomplete. This made it sometimes impossible to determine where the participants were, and whether or not they were together. We therefore choose to display this data as each group's average (**Figure 3**). Complete availability of this data on participant level would allow for a more fine-grained analysis. Future studies should consider the erratic nature of elementary school activities to successfully capture the entire participant experience. In addition, social peer-pressure among elementary school students might have had a large effect on student responses.

Conclusion

Our study is an early experiment on using mobile sensing to measure collaborative processes in a classroom environment. While the collected data are not perfect, the methodology and data together act as proof of concept for our goal. We found no link between students' physical proximity and their respective project success. In addition, we find the self-report data of the students to be in contrast with the comments from their teacher. This raises questions on self-reports in educational settings as well as on teacher observations. We argue that mobile instrumentation can reveal new insights in this area, but should take into account both the technical and social obstacles that are unique to this context. This includes the unpredictability of the environment and peer-pressure among the students.

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