Sensing, Tracking and Modelling with Ignition – a framework for supporting classroom collaboration

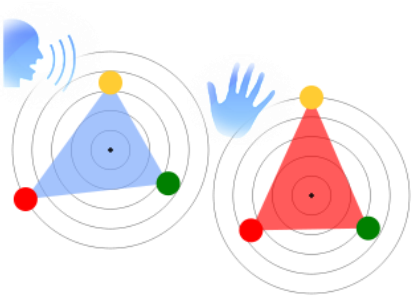

Figure 1. Visualisations of participation at the tabletop for a three-person group working symmetrically: The left radar represents the amount of speech and the right radar the amount of meaningful actions on the tabletop interface. Each coloured marker represents a student (yellow, green and red). The further the marker is from the centre the more active the student was.

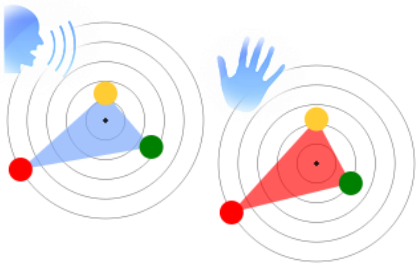

Figure 2. Visualisations of participation for a three-person group in which one student (red marker) dominated both the conversation and the actions at the tabletop.

Roberto Martinez Maldonado, Andrew Clayphan, Judy Kay, Kalina Yacef and Christopher Ackad
School of Information Technologies
The University of Sydney
NSW, 2006, Australia
roberto@it.usyd.edu.au, andrew.clayphan@sydney.edu.au
{judy.kay,kalina.yacef,christopher.ackad}@sydney.edu.au

Abstract
Both collaborative learning and learning to collaborate require the development of skills that ought to be closely supported by teachers or facilitators. However, in practice, teachers need to divide their attention between multiple groups working simultaneously. This paper proposes a digital framework to support collaboration at the classroom by providing both support to learners and awareness tools for their teachers in a multi-tabletop classroom. We present the key features of this framework, which include: *touch input identification, learner modelling, audio capture and context.*

Author Keywords
Context awareness, collaborative learning, interactive surfaces, learner modelling, tabletops.

CHI'12, May 5–10, 2012, Austin, Texas, USA.
ACM 978-1-4503-1016-1/12/05.

ACM Classification Keywords
H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces—collaborative computing.

Introduction
Students working in small-group activities in the classroom commonly engage and participate differently. Teachers have to manage the multiple learning activities and adapt them in real time according to students' requirements [3]. Teachers need to divide their attention between groups that have different needs. Currently, teachers have no way to track collaborative processes, individual contributions or equity of participation. This means that they are less able to facilitate effective learning for each student. We envisage capturing learners' digital footprints to create visualisations such as those shown in Figures 1 and 2.

Emerging pervasive technologies have the potential to support teachers and provide novel ways for students to collaborate [4]. At the same time, these technologies open new opportunities to capture and analyse the collaborative processes of face-to-face interaction. These include: *shared devices* for supporting collocated collaboration (e.g. interactive tabletops and digital whiteboards); *personal devices* that provide private and personalised content; and *sensors* that monitor the learning environment.

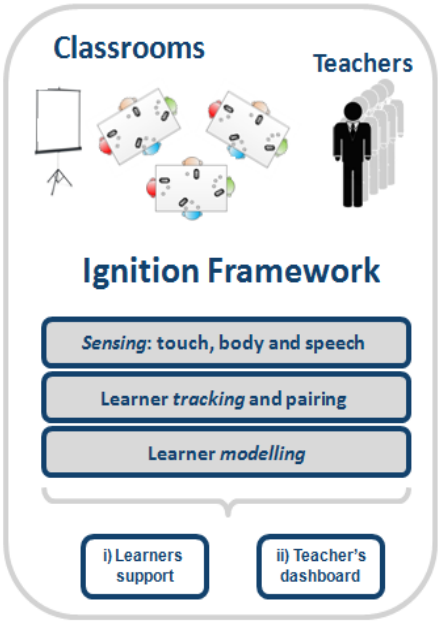

Figure 3. The Ignition Framework.

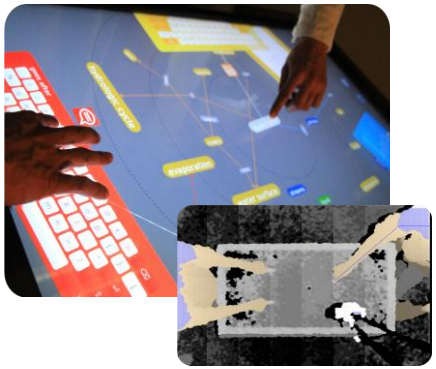

Figure 4. Touch identification using the Kinect sensor.

This paper presents Ignition, a framework that makes use of these technologies to *identify* students around the tabletop and *track* their physical and verbal interactions, with the purpose of providing *support* for learners and their teachers, and of better understanding each group's activity. The goal is two-fold: (1) to aid learners, for example by suggesting the inclusion of relevant content, personal documents or alerts that make them aware of their group's dynamic; and (2) to support teachers by presenting information about groups that is not evident to them so they can determine when to intervene.

Ignition: a framework to identify, model and support collaboration

Figure 3 depicts the parts of the framework. First, it relies on a number of sensors to make the tabletop system aware of students' activity. This module serves to identify who is touching the tabletop, capture verbal participation differentiating speakers and recognise students' proximity and location.

The second part includes the tracking system that follows students around the tabletop to provide continued user identification during the activity even if they change position. This module of the system tracks physical disposition around the tabletop and pairs it with identities once a learner has "*logged in*".

The third part of the framework includes the module for integrating the system to the learners and group models. The system records the learners' digital footprints to individual learner models and also accesses learning outcomes of other related activities. The learner model can then be presented to teachers in the form of a dashboard that contains visualisations of groups' progress and alerts if undesired behaviour is detected. Additionally the model can be used to provide personalised attention or deliver specific content to learners at the tabletop.

The goal of this framework is to offer a number of services to students, teachers and researchers. This will help: understand what each individual student is doing; be aware of group interactions; and provide a means for reflection and review. We will provide examples in the context of three learning applications.

Sensing

According to principles of collaborative learning, in order to study and model group dynamics, it is a requirement to analyse learners actions both physically and orally [2]. Grounding on these requirements, we previously built an environment called Collaid [6]. With the flexibility to be used with any interactive tabletop, Collaid augments the capabilities of the hardware with a set of key features: identification of proximity of learners around a tabletop and authorship of each touch (using a depth sensor[1] situated on top of an interactive surface device as shown in the bottom right of Figure 4), recognition of people speaking (by implementing a radial microphone array[2]) and capture of multimodal data about collaboration (video, audio and application logs in a common repository). This means that any touch or oral participation around the tabletop is automatically traced, with its author, and logged.

Learner Tracking and Pairing

Identifying who is doing what is a partial solution to keeping track of a student's activity. In real classrooms the context is variable, students move, change position and ask questions to their teachers. The system ought to

[1] Kinect sensor device: *http://www.xbox.com/kinect*
[2] Microcone recorder: *http://www.dev-audio.com*

Figure 5. Personal Smartphones used to pair learner with the system using the Collaid environment and personal information from the Smartphone.

Figure 6. Tabletop Brainstorming Interface. A group categorising ideas together.

be aware of these changes to effectively track, capture students' activity and offer support to students and their teachers. There has been little work on full identification methods at the tabletop.

We aim to provide means to seamlessly *identify* and locate students around the tabletop, keeping track of moderate changes of location and activity around the interactive tabletops by pairing a tracked person with an identifier. Our solution integrates the use of personal devices (e.g. Smartphones – Figure 5) to establish a link between the traces of a person around the tabletop and a learner by placing the learners' personal devices over the interactive surface at the beginning of the activity. This way, the system keeps track of the location, actions and verbal participation of each learner, during the activity as well as across sessions.

Learner Modelling

The representations that learning systems have about individual learners and groups are commonly used to provide personalised content or visual means for teachers to understand groups better. This is an unexplored area in the context of face-to-face collaborative learning. We aim to make the most of the opportunity to capture the digital footprints of learners through interactive tabletops by exploiting the data contained in the user/group models through machine learning and data mining techniques. This offers the potential of looking for patterns of behaviour that can alert the teacher in case some groups need support or to inform about the progress of the task.

Additionally, keeping a learner/group model permits continued tracking and visualising learners' activity (for example dashboards that show an overview of groups activity), not only when they use the tabletop application, but also when they work individually using other applications or collaborate through other means, for example, online tutoring systems or mobile applications.

Learning Applications

Each learning domain or activity has its own particular requirements. This framework aims to provide tools and data to provide support according to students but also to the learning activity. We will evaluate its effectiveness in three specific collaborative learning domains. These are: brainstorming; collaborative concept mapping; and meeting support management.

Brainstorming

Brainstorming is a collaborative activity that helps groups of people generate original ideas. It encourages egalitarian participation and enhances collaboration within groups. Interactive digital tabletops combine natural face-to-face discussion found in conventional brainstorming with increased flexibility that is gained from computerised support. Brainstorming on a tabletop allows the collaborative process of generating ideas to be captured. This can permit learners and educators to review and reflect over work [1]. Its interface allows for rapid idea generation and fluid discussion for idea categorisation (Figure 6). The Ignition framework will allow for a deeper understanding of the categorisation phase through tracking each learners' active contributions.

Collaborative Concept Mapping

Concept mapping is a technique that permits learners to externalise their own knowledge about a given topic in graphical form. In a collaborative scenario, this technique has proven effective in permitting groups to confront different perspectives to solve misunderstandings and

Figure 7. Tabletop Concept mapping Interface. A group creating propositions.

Figure 8. Meeting Support at a Tabletop.

build new knowledge. Cmate [7] is an interface that permits learners to merge their individual concept maps in face-to-face sessions at the tabletop (Figure 7). Concept mapping can be used in different domains, for example to describe biological processes, discuss social topics or learn about health issues. User identification provides the opportunity to model each group member's participation and knowledge to mirror back these indicators to their teachers so they can best guide the collaborative process.

Meeting Support Management

Supporting meetings over a long term is important in developing the ecosystem for continued use of technology. A *smart* classroom must allow collaborators to save and retrieve work at a later time. The Ignition framework will allow this application to track users automatically over time and several meetings, providing teachers with an ongoing and complete history of student interactions over time. The meeting management application (Figure 8) gives support to face-to-face meetings by giving access to a web-based project repository[3] at the tabletop. This type of interoperability with existing systems furthers a learner's education and helps facilitators keep track of what has been accomplished.

Conclusions and Future Work

We presented a position paper that describes an ongoing project using available technology to enhance the study and practice of face-to-face collaborative learning in the classroom. The Ignition framework described can be used on pre-existing tabletop hardware so the implementation of the proposal can be tested in common classrooms. The data that this system will collect can be exploited using a range of quantitative techniques, such as statistics, data visualisations or machine learning [5], and potentially enhance the empirical judgement of teachers at the classroom and study of collaboration.

[3] Trac project management system: *http://trac.edgewall.org/*

Acknowledgements

This work is partially funded by the Smart Services CRC.

References

[1] Clayphan, A., Collins, A., Ackad, C., Kummerfeld, B. and Kay, J. Firestorm: A brainstorming application for collaborative group work at tabletops. *Proc. of ITS'11*, ACM (2011), pages 162-171.

[2] Dillenbourg, P. What do you mean by 'collaborative learning'? *Collaborative Learning: Cognitive and Computational Approaches. Advances in Learning and Instruction Series*. Elsevier Science (1998), pages 1-19.

[3] Dillenbourg, P., Zufferey, G., Alavi, H., Jermann, P., Do-Lenh, S. and Bonnard, Q. Classroom orchestration: The third circle of usability. *Proc. of CSCL2011* (2011), pages 510-517.

[4] Dunn, A. and Brusse, T. Designing Classroom Technology to Meet the Needs of All. *Second Workshop on UI Technologies and their Impact on Educational Pedagogy* (2011), pages 26-29.

[5] Martinez, R., Yacef, K., Kay, J., Kharrufa, A. and Al-Qaraghuli, A. Analysing frequent sequential patterns of collaborative learning activity around an interactive tabletop. *Proc. of EDM'11* (2011), pages 111-120.

[6] Martinez, R., Collins, A., Kay, J. and Yacef, K. Who did what? who said that? Collaid: an environment for capturing traces of collaborative learning at the tabletop. *Proc. of ITS'11*, ACM (2011), pages 172-181.

[7] Martinez, R., Kay, J. and Yacef, K. Visualisations for longitudinal participation, contribution and progress of a collaborative task at the tabletop. *Proc. of CSCL2011* (2011), pages 25-32.