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# Toccata: an Activity Centric Orchestration System for Education

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**Abstract**

This paper describes Toccata, an activity-centric system for classroom orchestration. Through preliminary fieldwork, we identified three main challenges in the management of digital activities in classrooms: 1. Poor infrastructures lead to breakdowns in the activity 2. Activity structures are idiosyncratic (they vary widely and are rarely shared); and 3. Orchestration is difficult because teachers lack an overview of the unfolding activities. We developed Toccata to support activity scripting and orchestration in situations with unreliable connectivity. Based on a preliminary trial, we outline directions for activity-centric orchestration systems: 1. Focus on timing; 2. Provide several levels of awareness; 3. Support activity suspend and resume in changing contexts.

**Author Keywords**

Learning; Activity Based Computing; Orchestration; CSCL.

**ACM Classification Keywords**

K.3.1 [Computer Uses in Education]; H.5.3 [Group and Organization Interfaces ]

**Introduction**

Over the past decade, teachers have increasingly built into their curriculum pedagogical activities that foster co-construction of knowledge through independent and group work, while leveraging new technologies.

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Yet, in the numerous schools we studied over the years, the adoption of digital tools to conduct such activities has been slow and on a case-by-case basis. We explain this by teachers' beliefs, the heterogeneity of the technological infrastructure (network, devices and OS available), the restrictions (technical, organizational or administrative), and the wide disparity of tools supporting pedagogical activities [13].

Moreover, teachers lack appropriate tools to prepare and run pedagogical digital activities. Technical issues are one part of the problem, but the construction of pedagogical scenarios is also challenging, especially as teachers must to offer a coherent structure to the class while following and guiding learners' individual progress.

We propose Toccata, an activity-centric system for education, based on concepts from Activity Based Computing (ABC) [3, 8] and Orchestration [4]. Toccata aims at facilitating the management of digital pedagogical activities by supporting the creation, sharing, and real-time orchestration of activities by teachers and learners.

## Motivation

### *Preliminary Interviews*

Based on interviews with seven teachers [9] (from June to October 2017), we identified a set of recurring challenges for creating and conducting digital pedagogical activities.

**Technical challenges** We observed a diversity of equipment in schools. Some schools offer a variety of devices and operating systems to teachers and students. In others, students had their own devices. We also observed a variety of infrastructure constraints (various levels of WiFi availability, filtered ports, availability of charging carts, etc.). Interviewees emphasized how the network was rarely sta-

ble, and how disconnections and slow performance were frequent, even in "model" schools. This was a very significant barrier to activities involving digital elements.

**Different focal points** Teachers and students have different attention points when preparing and conducting activities. Teachers keep a global view to coordinate the activity, while also paying attention to the progress of groups or individual learners, and how this aligns with their original plans. Whereas learners mostly focus the tasks they are given.

**Activity Management and Awareness** Interview results emphasize the lack of tools for teachers to script and conduct pedagogical activities, especially in the classroom. Teachers should be aware of individual learners, groups, and the whole class to properly orchestrate their activities.

Learners also need tools to conduct their activities. They need tools to collaborate and get an overview of their progress. They need to manage their time and tasks (for self-regulation). In collaborative activities, they need to be aware of other groups (for shared-regulation).

### *Requirements*

From this preliminary study, we derive a set of requirements to orchestrate rich activities: Req-1. Support a variety of devices, OS, input modalities, screen resolutions; Req-2. Resilience to network problems and ability to cope with disconnections; Req-3. Different actions and views according to users roles and objectives. e.g: conducting and coordinating the activity and the classroom for teachers and conducting group or personal activities for learners; Req-4. Support awareness at different levels: individual task progress, group work, class status.

1. Association of rich resources
2. Suspend/resume of activity
3. Activity roaming
4. Activity adaptation
5. Activity sharing
6. Context awareness

**List 1:** Principles of ABC

## Related work

Two approaches developed in HCI and Technology Enhanced Learning are relevant to the needs we identified: Classroom Orchestration and Activity-Based Computing. Orchestration [7] proposes principles to structure the timeline of a pedagogical activity, taking into account a number of practical constraints [4, 5] and factors to improve activity progression. Orchestration was later enriched to account for the preparation process, identifying constraints, pedagogical objectives, and elaborating scenarios with resources available in class [4].

Creation and coordination of teaching activities form the core of Orchestration with importance put on activity scripting ("*envisaging how a set of means should be used in order to address teaching objectives*" [12]) and conducting. Orchestration emphasizes the importance of taking into account a wide range of constraints [4, 5], and awareness of progression both for teacher and students [6, 10].

Activity Based Computing [3] is a framework inspired by activity theory with six principles (see List 1). ABC envisions to integrate applications, documents, and activities into an overarching structure on Desktop computers. It proved to be particularly useful in collaborative ubicomp settings, e.g. nomadic work of medical workers [1], collaborative spaces of development [2], biology laboratories [11], etc.

Whereas Orchestration fulfills some of our pedagogical requirements, ABC is particularly suited to the mobile and ubiquitous aspects of school activities [3]. Especially, four principles of ABC (Suspend and Resume, Roaming, Adaptation and Awareness) support to work in pervasive environments. Until now, ABC systems did not consider role-specific abilities and rarely supported scripts or scenarios.

## Toccata

We developed Toccata to enable teachers to script digital activities, share them with students and teachers, and orchestrate them in the classroom. Activities can be scaffolded, and contain a sequence of sub-activities. Teachers define an activity by associating to it a set of instructions (Figure 1.b), resources (Figure 1.c) and applications (Figure 1.d). Teachers can embed any external web-based application. But Toccata also offers activity-enriched features to applications specifically developed for it. For instance a timer widget (Figure 1.e) for better awareness and better group management in a timed activity. Resources can be text (HTML), PDF, image, audio or video documents. Finally teachers can add students to the activity. The result is a collaborative activity with the a set of tools, resources and instructions for students in the activity. Sub-activities can be re-defined to offer other applications, resources, instructions and participants.



**Figure 1:** Toccata with the Scrumville activity loaded.





**Figure 2:** Toccata used to show and discuss tasks to be done



**Figure 3:** Toccata used during a construction step to pick tasks



**Figure 4:** Student using Toccata beside paper-and-pencil

Before a class, teachers can create student groups by duplicating an activity and sharing the copies with different groups. All the activities share the same template but are independent. In class, either the teacher or the students can load the relevant activity on the tablets.

**Progress** On their devices, students access the activities they are part of and can pick the ones they want to pursue. For any given activity, Toccata displays the steps at the top, the instructions, available applications, resources, and collaborators in a sidebar, and active applications in the center (Figure 1.f).

**Awareness** Toccata offers teachers two levels of awareness (Req-4): group awareness with a view of the group activity (sub-activity they are in (Figure 1.a), time left (Figure 1.e), tasks done (Figure 1.f) and class awareness (Figure 1 left) with a general dashboard resuming each group activity. Teachers can consult the two views and students only the view of their group.

**Orchestration** Teachers and students have different controls on the activity (Req-3). Teachers have access to an ongoing activities overview panel showing students or groups progression (Figure 1 left). They can duplicate the screen of any student or group on their own device for follow progression. Teachers can start, stop or reinitialize the timers (for example when they are explaining something to a group), whereas students can only start the timer.

**Implementation** To support different devices (Req-1), Toccata is a Responsive Web Application. It runs on any device (smartphone, tablet, computer), the screen layout adapts to the device, and accepts any input modality (stylus, mouse, touch).

We designed Toccata to be resilient to networks problems (Req-2). It is offline-first with database replication on each

client, which is synchronized with the main server databases. It works both when connected to a Wifi network or when using the tethering function of a mobile phone to quickly set-up ad-hoc networks. Two functions facilitate activity resumption: Storing data in devices (only changes are downloaded to devices) implies a smaller time to load the activity on a device; Keeping activity state (application and resources loaded, current step in the sequence) help to fasten activity resume and to save valuable time in the classroom. In case of disconnection, the client transparently stacks actions for later synchronization, while letting students pursue their activities.

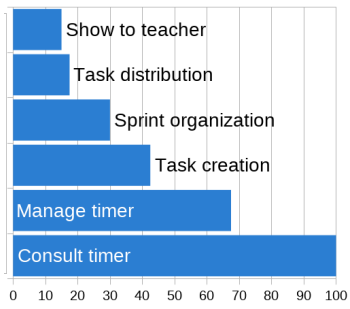
**Scrumville** For testing purposes, we implemented a pedagogical activity to teach Agile Methods, using Toccata. The activity, Scrumville, involves creating a lego or paper mock-up of a city following the Scrum methodology. The main activity lasts about two hours and is composed of four sub-activities (a preparation phase, followed by three iterations to build a city). The activity uses two dedicated applications: a Timer and a Kanban board. The timer is useful to teachers and learners to track progress, since each iteration is precisely time-boxed. Learners use the Kanban board to organize their work at the group level.

### Preliminary study

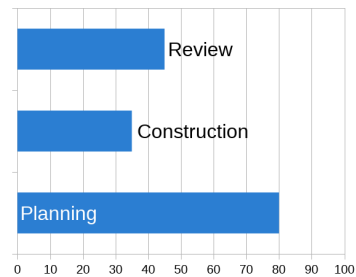
We tested Toccata in a course on SCRUM methods, using the Scrumville activity. We ran two sessions of 90 minutes.

**Participants** One tutor and 40 Master students (M:27, F:13). Each session was run with four groups of five students simultaneously.

**Procedure** Each group had to build a mockup of a city with paper following SCRUM principles. In this task, the tutor has the role of product owner whereas students played the role of a development team.



**Figure 5:** Percentage of participants who reported using the features Toccata



**Figure 6:** Percentage of participants who reported using Toccata for each stage of the sub-activity

Before the session, the teacher used Toccata to design the activity on a tablet. He structured the activity into four sub-activities corresponding to four sprints and including two applications: a timer and a Kanban table. For each sub-activity he defined the instructions for students. In each sprint, students had to go through three phases: 1. organize the work within the group (Figure 1.b); 2. build part of the city; and 3. debrief their work with the product owner/tutor.

At the beginning of the session, the teacher gave each group an android tablet (Figure 1) with Toccata loaded as well as paper strips and glue to build the town. The tutor had an android tablet for orchestration purposes.

**Data collection and analysis** We collected data from three channels: logs from tablets, video (of groups and screen recording of tablets) and student questionnaires about the activity. Users answered three main questions: (1) when did they use Toccata (Multiple choice questions and Likert scale); (2) what did they use it for (Multiple choice questions); (3) how did they use it (open questions).

**Results** Although our network connection was fluctuating, both sessions ran successfully, which reinforces our architectural choices. Our recordings show that although the tutor only touched his tablet three times to view the progress of groups and one time to launch a timer for a group who forgot to launch it, he also looked regularly at tablet throughout the two sessions to monitor group progress.

Students mainly used Toccata as an awareness tool to manage time and not so much to organize sprints or distribute tasks (Figure 5); Participants mostly interacted with Toccata during the planning activity (Figure 2, 3 & 6); Students reported that the timer was easy to use but could

better support awareness. They reported that the Kanban was easily used to report on the activity progress but less to plan the work or to communicate.

The tutor expressed the need for better awareness of the remaining time in the session and for each group, and of the time he spends with each group. He also expressed the need to have new ways to swap between overall class and individual group control.

## Discussion

Time monitoring emerged as a major challenge for students and teacher. Although this specific activity was particularly centered on time and task tracking, time management is related to larger orchestration and awareness dynamics.

For the teacher, switching focus between group progress and class progress was particularly challenging. It could have been improved with more salient visual indicators or other awareness mechanisms, but also with more support for orchestration. In order to support a large number of applications, Toccata supports any web-application, but does not provide dedicated controls or indicators feedback from the applications to the platform.

Students, could also have benefited from better awareness tools during and afterwards their activity to reflect on it.

## Conclusion

In this article, we presented the requirements and implementation of Toccata, a platform to create and orchestrate rich pedagogical activities. A preliminary study validated our system choices, participants raised and pointed out the importance of different levels of time and task management. Awareness of the activity is also critical, especially teachers who need to swap between classroom and group or individual control. Support for orchestration could be enriched.

We only tested one type of activities Toccata can support. Future work will focus on: 1. supporting more complex activity, involving more interactive tools; 2. scripting activities that are asynchronous and unfolding across remote contexts (at home, in libraries, etc.); 3. scripting activities panning over long time periods with activity suspend and resume (including in multiple and changing contexts).

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