Orchestration of Robotic Activities in Classrooms: Challenges and Opportunities

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Abstract. Bringing robots into classrooms presents a new set of challenges for classroom management and teacher support compared to traditional technology-enhanced learning and has been left almost unexplored by the research community. In this paper, we present the opportunities and challenges of orchestrating Educational Robotics (ER) activities in classrooms. To support our discussion, we present a case study of 25 students working in pairs using handheld robots to engage in a computational thinking activity. While performing the activity, students' behavioral information was sent from the robots to an orchestration dashboard that was used in a debriefing activity. Although this work is in its preliminary stages, it contributes to framing the challenges that need to be addressed to realistically scale-up usage of ER in classrooms.

Keywords: Classroom Orchestration · Educational Robotics

1 Introduction

The main pedagogical advantage of learning activities with Educational Robotics (ER) is to facilitate constructivism activities, which gives the active role to students [1]. An open question in ER research is whether robots would be viable options for supporting learning in ecologically valid classroom environments [1]. To answer this question, we must consider what role the teacher plays with the use of robots in the classroom and the impact it has on classroom orchestration [3]. Classroom management, even in traditional classes, is a complex problem and adding multiple robots to learning activities creates new management challenges for teachers. There have been a few studies that presented awareness tools for ER activities, for instance by classifying students progress in an ER activity [4]. In this work, the main challenge addressed is to face the unpredictable nature of ER learning activities, which makes it hard for teachers to follow students work and may make teachers' interventions harder than in other TEL classrooms. Furthermore, the added complexity of robots increases the frequency of interventions for technical failures. However, these studies have not been mainly conducted around the core idea of orchestration, which is minimalist, teacher-centric deign [3]. Additionally, there is no concrete study in the literature that investigates ER classrooms from an orchestrational perspective, which is an essential step to design orchestration technologies. As the preliminary step of our work, in this paper, we present the findings around observations from a case study of running an ER session with two main goals: 1) what problems would teachers encounter in conducting ER activities? and 2) what do teachers need in terms of technology for conducting such activities? These finding pave the way through designing orchestration technologies for ER classrooms.

2 Study Context

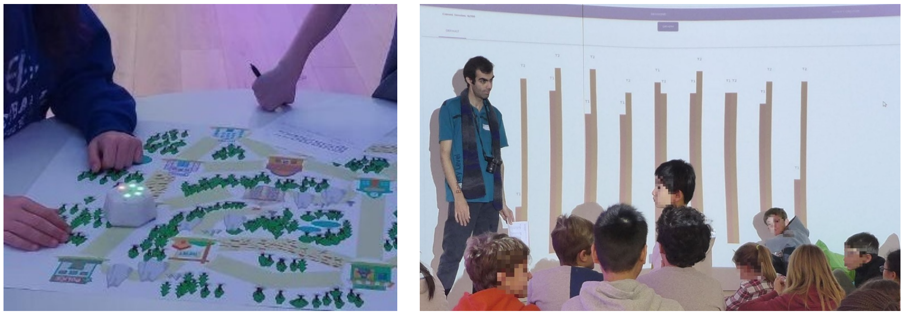
We conducted a preliminary study with 25 students, 11-12 years old and novice users with our robot, working in pairs (do to the quantity of available robots), on a computational thinking task in an hour long session. For the primary learning activity, which lasted thirty minutes, the students were asked to use a handheld, low-cost, tangible robot, *Cellulo* [5] to explore different paths on a paper map to find the optimal path, see Fig. 1a. Before the main activity, they had enough time to experience using the robots. During the activity, the students received feedback from the robot through LED lights that indicated the level of pretend battery, which depleted as the robot is moved on a route. During this activity, we collected the position of the robot on the map and remaining battery level to measure the exploration behavior of the students. More details about the experimental settings is available online[3].

After the path-finding activity, the students were given two short quizzes to assess their knowledge, one individual and one collaborative, before participating in a whole class debriefing activity. For the debriefing activity, a preliminary version of a dashboard was used that displayed the number of exploration trials (that robot is moved from home to target) that each team completed and battery level at target. During the debriefing, a member of the research team led a whole class session with the students to discuss these results and explained how the path-finding activity was tied to the concepts they were trying to learn, see Fig. 1b. Throughout the study, four experimenters conducted the activity and took field notes pertaining to the classroom orchestration. After the experiment, the research team discussed their observations to find common themes.

3 Challenges and Opportunities

We begin this section by evaluating the preliminary version of the dashboard used in the debriefing activity. Based on experimenters' observations, students were very engaged in observing their own behaviours and the review helped them to understand the learning goal of the activity. Experimenters suggested that using data from an ER activity in a subsequent debriefing activity and functionalities of making data flow between ER activities and other activities in the classroom can be very useful for teachers. For example, a teacher can use

[3] `https://github.com/chili-epfl/robot-analytics`



(a) Cellulo robot and a paper map (b) Debriefing activity

Fig. 1: An overview of the ER activity: a) Children working on the path-finding activity with a Cellulo robot in pairs b) Using an orchestration dashboard monitoring robot sensory data in a debriefing activity to explain learning goals and discuss children's performance

students' activity data as an example to prove a point in his/her lecture or show the classroom performance on a central screen during an ER activity to increase competition between groups. In the continue of this section, the experimenters' notes and discussions around them are summarized as four points:

1) Managing robot technical failures: All the experimenters insisted the emergence for monitoring the technical status of robots. In our case study, although the technical system had an overall acceptable performance, three robots failed during the activity and required intervention. In a classroom with one teacher rather than four experimenters, it could take some time for the teacher to be notified about the problem, which is not efficient time management. This case happened for us since the robot technical failures were hard to diagnose for experimenters during the session.

2) Teacher control over robotic activities: Experimenters mentioned their interests to be able to control robots for fostering the meta-cognitive skills of the students, such as through changing the difficulty level of an activity or inhibiting the running of robots to regulate learners' reflection and stopping them from playing too much with the robot, which is one of the challenges with open-ended ER activities [2]. The latter could be achieved by providing simple orchestration commands over robots, like pausing them.

3) Managing collaboration in ER group activities: Due to the cost of educational robots, in the group activities, one robot is shared between group members, which could lead to social loafing as we also observed in our case study. Although this problem is not specific to ER classes, the interaction patterns that students have during the activity are different than traditional collaborative activities and the awareness and interventions need to be designed differently. An open question that arose from the experimenters' notes was: how can students' activity data with robots be used to raise teachers' awareness about social loafing and how can teachers intervene using control over robots to solve the problem?

4) Improving teachers' distributed awareness: Experimenters mentioned several features of robots that can enhance teacher awareness: 1) in contrast to tablets or laptop screens, robots materialize learners' activity and collaboration patterns in groups on tables, giving the activity more visibility. 2) In learning tasks that require student interactions with both tablets and robots, like programming a robot, working with a robot reifies what is happening in the screen for teachers to see. In other words, instead of going to each group's desk and checking whether they finished the activity or cluttering the teacher dashboard with more information, teachers can easily understand the class performance by having a glance at all robots in the classroom, which is not possible with laptops/tablets.

4 Conclusion and Future Works

Taking into account the findings from observing our case study in the third section, we propose the following features in orchestrating tools for ER classrooms: The teacher dashboard should aware teachers about 1) robot technical status to notify teachers about technical problems and 2) students' interaction patterns with robots to represent students' progress and collaboration behaviour. Also, orchestrating tools should provide 1) teacher control over robots for interventions like meta-cognitive support for encouraging reflection and 2) aggregating students' activity data with robots in teachers' lectures and debriefing activities regarding our observation of implementing such a system. In the way of designing orchestration tools with the mentioned functionalities for ER classrooms, there are still important open questions such as: what type of information from students' activities with robots is useful for teachers, and considering the mentioned potentials of robots in providing awareness in classroom, can they be utilized as distributed orchestration tools instead of orchestrable tools? We believe that answering these questions will create new insights to research on both educational robotics and orchestrating technology-enhanced learning.

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