Collaborative Learning Orchestration Using Smart Displays and Personal Devices

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Abstract. Pervasive classroom environments with interconnected smart devices permit enacting diverse pedagogical models in education. This paper proposes an extensible architecture integrating smart display, smart phones and wearable devices to support flexible orchestration of dynamic collaborative learning activities in face-to-face educational scenarios. The paper motivates an architectural design and describes its main components based on existing systems like Signal Orchestration System (SOS) and a multi-screen cooperation middleware. An applicable scenario illustrates the usage of proposed architecture in which wearable devices are used to indicate orchestration mechanisms (group formation, change of activity), a shared display visualizes tasks with summary of the orchestration and activity progress for collective awareness and smart phones are used to interact with the shared display and complete the activities.

Keywords: CSCL · Classroom orchestration · Devices for seamless learning

1 Introduction

Learning in groups or collaborative learning (CL) leads to effective learning when mediated by productive social interactions as many studies had shown [1–3]. In recent past research on integrating collaborative activities within physical classrooms and blended learning scenarios had drawn attention in the domain of Computer Supported Collaborative Learning (CSCL) [1]. Collaborative Learning Flow Patterns (CLFP) like Jigsaw or Pyramid are known as best practices [2] that specify how to structure (orchestrate) the CL activities on aspects like group formation based on policies, role allocation and resource distribution. When enacting CL activities, a traditional classroom could be converted into a smart space by seamlessly integrating interactive displays and devices [3]. Live didactic mechanisms and dynamic orchestration approaches catch student's attention and interest [2, 4, 5] if addressed with sufficient flexibility [6]. Existing classrooms are already equipped with shared display units like projectors and smart boards. Yet, converting these displays to be smart awareness boards that can be used to orchestrate activities in cooperation with smart phones and wearable devices has been addressed less [1, 3].

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This paper proposes an architectural solution to enact CL activities forming a smart classroom with prevailing artifacts and previously proposed technologies.

2 Opportunities for Smart Classrooms: CL Orchestration

Smart classrooms have been devised for different purposes including enabling extended tele-education, diverse learning activities and facilitating implementation of classroom dynamics. For example, Shi et al. [4] proposed a smart classroom design integrating voice-recognition, computer vision and other smart devices to provide tele-education experience in a real class. Another attempt used smartphones to enact an innovative collaborative activity to teach physics within a classroom [7]. Wearable devices and interactive furniture have been proposed as physical computing approaches to enhance classroom orchestration by indicating organizational aspects to students [3] or visualizing feedback about their progress to the teachers [5]. Yet, support for dynamic orchestration taking advantage holistically of smart classroom technology (including collective display devices, personal devices, etc.) has not being addressed. This paper highlights potential opportunities of integrating different devices (smart phones, wearable devices, collective displays, etc.) seamlessly with CL orchestration services implying pervasive computing methods to organize face-to-face CL activities in the classroom. These opportunities include displaying activity details and configurations to clarify tasks (e.g., in mobile phones); promote social awareness of progress among students and teachers (e.g., via shared classroom displays); indicate CL flow mechanisms, such as group formation, distribution of roles and resources, see for instance the CLFPs [2] (e.g., in wearable devices); facilitating dynamic modifications when required [8] supported by the transfer of the activity status and automatic configuration of the devices (through orchestration services comprising a "classroom middleware" interconnecting the devices).

3 Architectural Elements

The proposed architecture for holistic CL classroom orchestration is composed of systems proposed by the authors in previous research [3, 9] which are already devised [3] or has potential [9] to support classroom orchestration. The architecture proposes CL orchestration services with open APIs, enabling the extension of the architecture with the integration of additional classroom technologies [5]. Figure 1 shows the main components which relies on features of two service layers. First, orchestration services of the Signal Orchestration System (SOS) [3], which compute orchestration mechanisms to be transmitted as orchestration signals to SOS wearable devices (physical forearm bracelets rendering e.g., color signals indicating grouping, vibration signals for change of activities). Second, the Smart TV–Smart phone interaction middleware [9] enables a multi-screen cooperation model [10] based on loosely coupled publish/subscribe paradigm for message exchange. The Smart TV screen (or any HDMI-compliant display in the classroom) is complemented by mobile devices bringing seamless interaction capabilities rather than being only a display unit. The middleware integration enables coherent global orchestration of CL activities replicating relevant orchestration indications in different displays, when appropriate, or showing complementary information as suitable considering the affordances of the displays and the characteristics of the activities. The seamless transfer of orchestration status between devices enables dynamic modifications of the CL flow.

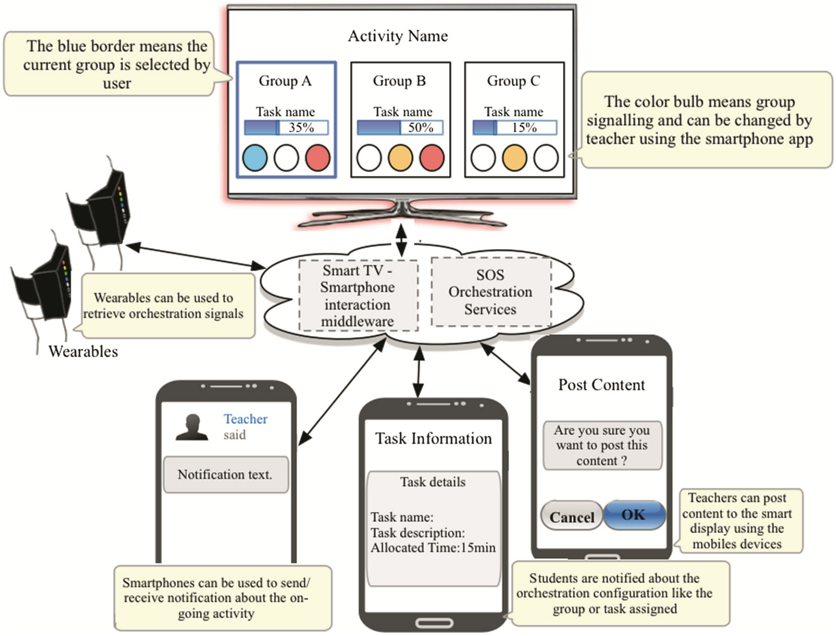

Fig. 1. Components of SOS and smart devices integration

4 Illustrative Scenario

Following scenario illustrates applicability of proposed architecture using Jigsaw CLFP [2] at a secondary educational context; yet can be extrapolated to other subject matters and educational levels. The application of the architecture is also of interest with other CLFPs. Jigsaw pattern promotes positive interdependence and individual accountability by dividing a problem into sub-problems, allocating sub-problems to individuals, forming expert groups (to address sub-problems) and jigsaw groups (groups with experts on each sub-problem, addressing the global problem).

In a secondary school curriculum students are required to gain knowledge while being able to critically contrast the three main different climates in Spain. To achieve this learning objective, the teacher designs a Jigsaw-inspired learning activity that spans for two classes which requires individuals do prepare at home for assigned climate zone provided they know their groups on the first day. The activity continues next day with the expert and jigsaw phases (supported by SOS wearable devices, mobile phones and smart display). When teacher configures sub tasks (3, in this) and uploads student list (30) using SOS manager, the services compute distribution of sub-problems and groupings (10 students read each sub-problem; 3 or 6 expert groups with 10 or 5 members with same sub-problem; 5 or 10 jigsaw groups with 3 or 6 members). In the class groupings are illustrated in the smart display for students to know peers. Further details required for the activity can also be visualized in the display and students can interact using smart phones. During activity enactment, expert groups are displayed enabling quick grouping, but teacher notices that 2 students are absent from previous class and requires regrouping to comply with Jigsaw constraints. SOS manager facilitates this and new expert groups would be 6 groups – 2 with 4 members and 5 with 5 members, and only 7 jigsaw groups with 3 or 4 members being at least one of them an expert on a sub-problem and these dynamic changes are reflected on-the-fly to the smart display. Students are not confused if peers are missing and they see the new group structure. Orchestration indications (vibration signal to indicate change of activity or color signals for phase changes or space allocation) are propagated to the wearable devices. Teacher posts questions to the experts to monitor knowledge and students answer using smart phones and their progress/performance is indicated in the smart display. Students make annotations of their discussions in phones, which are, later visualized in the shared display for a collective discussion.

5 Conclusion

This paper proposes a holistic view of technology-supported CL orchestration in the classroom that exploits use of personal devices (smart phones, wearable devices) and shared displays. The paper describes elements of an extensible architecture with services (computing CL orchestration mechanisms) and a multi-screen cooperation middleware (interaction and data flow with/between screens) based on previous work. The illustrated scenario shows the integrative use of wearable devices to indicate group formation, mobile phones to inform and support tasks, smart displays to offer awareness about activity progress and visualize individual and collective assignments with interactions. Future work includes evaluation and extensions of the architecture considering other classroom technologies and virtual learning environments.

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