Supporting Learning Interaction in a Distributed Learning Environment with Tangible User Interfaces

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Abstract: Tangible User Interface (TUI) brings an embodied learning experience and provides a good solution for collaborative learning in the distributed learning environment, such as the Interconnected Smart Classrooms (ISC) in this study. In the ISC, multiple classes are interconnected with a single teacher in one classroom and teaching assistants in the distributed classrooms. Students sat and studied in groups. However, ISC had the problems for learning interaction (1) between students, teaching assistants, and the teacher; (2) within group and between groups; (3) within classroom and between classrooms. Our study will: (1) analyze the requirements of learning interaction in the ISC; (2) design and implement four TUI prototypes to support above interactions; (3) discuss how to design TUIs for collaborative learning in a distributed learning environment.

Introduction

While our overall goal is to design TUIs to support learning interactions in the Interconnected Smart Classrooms (ISC), this paper provides the following contributions: (1) an analysis of the learning interaction requirements in the ISC; (2) four initial prototype concepts which aim to support these interactions; (3) a discussion about how to design TUI support learning in the distributed learning environment.

During a practical university class, 19 master students supervised by a team of 3 HCI researchers developed 4 tangible prototypes for ISC. The developments followed an iterative design process to generate insights based on the research through design approach. Final prototypes have physical functions, which include the required casing, sensors, actuators and electronics.

stayFOCUSed (see Figure 1) is a TUI that uses light projection on the ceiling and light-feedback on the device to support ISC learning activities. Group work is supported by light-feedback on the device that indicates the remaining time via a progress bar in traffic light colors (see Figure 1-1). To uncover the voting the light beam is focused via rotation of the projector lens. Subsequently, students can discuss the outcome of the poll. Colored disks are used to communicate group work status (green = finished, red = help) to other groups and the TAs (see Figure 1-1). Empty disks can even be used to write and share information freely (see Figure 1-4).

Figure 1. *stayFOCUSed* experience prototype (1. Prototype structure; 2. Progress bar in traffic light; 3. Rotate the projector to show answers; 4. Hand-write in the disk)

Group Hexagon (see Figure 2) is a modular TUI that supports different ISC learning activities. Via a secondary smart-device, the teacher can change the working mode of *Group Hexagon* (see Figure 2-5). Each group has one group-hexagon and six individual hexagons (see Figure 2-5). The individual hexagons are used in the detached mode by the students to pick answer options (see Figure 2-1) or if connected to the group-hexagon to show solutions of working tasks (see Figure 2-5). For the interaction with *Group Hexagon*, touch gestures are used for selection tasks and miscellaneous interaction (see Figure 2-1).

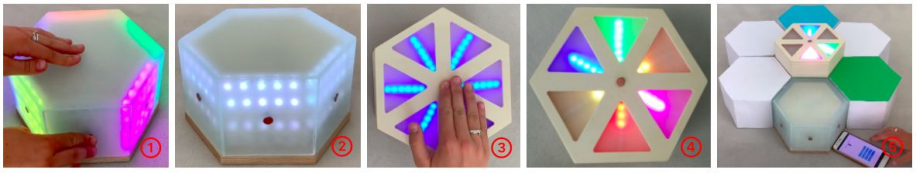

Figure 2. *Group Hexagon* experience prototype (1. Choose the answer with individual-hexagon; 2. Remaining time shown in the individual-hexagon; 3. Help seeking with group-hexagon; 4. Answer distribution shown in group-hexagon; 5. Teacher chooses the working mode)

Tower (see Figure 3) is designed to show the interactions both within and across groups. By placing magnets on the outer grid on the device surface, students can participate in voting. Different colored magnets are used to indicate students' certainty regarding their answers (see Figure 3-2). The rows of the grid demonstrate the response options and the columns represent the individual group member's work space. The top of the *Tower* is used for seeking help and signalizing the working status (see Figure 3-3). For communication and interaction with other groups such as (1) call for help from peers or provide them help, (2) rate your own or other groups' work, or (3) participate on discussions an App on students' personal mobile devices is used (see Figure 4-1).

Figure 3. *Tower* experience prototype (1. Discuss with other groups through App; 2. Place magnets on the *Tower* to choose an answer, green is "I'm confident", white is "I'm not sure"; 3. Rotate top bulb for help; 4. Touch top bulb to show finished)

Glowing Wand (see Figure 4) is a personal handheld TUI which is used by students to participate in ISC learning activities. It is modeled after a magic wand and thus motion gestures are used to control *Glowing Wand*. Different gestures indicate to change *Glowing Wand*'s color, whereas the inclination regulates its brightness (see Figure 4-1). The combination of color and brightness communicate the current working state of the student or can be used to quickly get an overview of the participants opinions in voting situations. Simple gestures that are considered to be broadly understandable and associated consistently are mapped to the traffic light color schemes. This system fits well into ISC learning activities, but can be used in self-defined cases or group processes such as voting due to its open design and tool character.

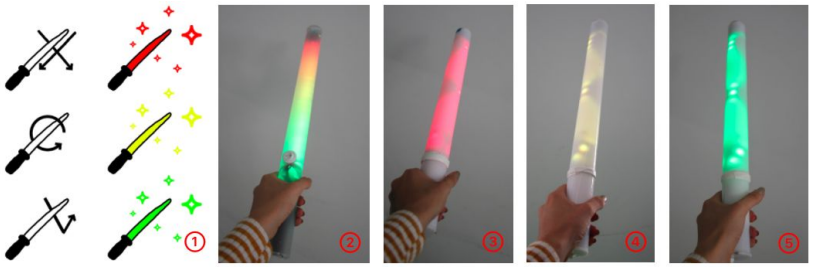

Figure 4. *Glowing Wand* experience prototype (1. Gesture designs; 2. Switch for a rainbow feedback; 3. Negative tick gesture to red light; 4. Circle gesture to yellow light; 5. Tick gesture to green light)

Conclusion

The study aims to support learning interactions with TUIs in the ISC learning environment: (1) communication in diverse learning contexts: group (within and across) and classroom (the same and different); (2) group process which contain different interactions (student-student in the same group, student-student in different groups, student-student in different classrooms, student-TA, student-teacher) at the same time. Four TUI experience prototypes were developed to: (1) support the learning interaction within group, inter-group, with teacher, with TAs, and across the classroom; (2) support learning activities in the ISC. The discussions, such as *how to design TUIs for learning* and *TUI for ISC: Closed or open* provide an insightful perspective for future study. As a unique distributed learning environment, ISC is a unique learning environment which contains the interactions among different users at the same time. The study is a good example to show how to provide a TUI solution for collaboration learning in the technology supported learning environment.

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