Designing Spaces for Collaboration in Practice-Based Learning

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Abstract: In order to support equity and access in collaborative learning, it is important to understand the nature of collaborative learning itself. One approach is to look at the physical aspects of how students collaborate while engaged in open-ended group-work during Practice-Based Learning (PBL) activities. By analysing how students and teachers move and interact in relation to each other, the space they are in and the objects within it, we can gain a greater understanding of the physical nature of collaborative group-work. This understanding can help us to create a learning environment that intrinsically but unobtrusively supports access by all user profiles who seek to engage with it, thus promoting equity of engagement and participation. Using the example of the design of a Learning Analytics System (LAS) and the educational furniture in which it is implemented, we will show how the physical design of a CSCL implementation can support increased collaboration.

Keywords: Computer Supported Collaborative Learning (CSCL), Learning Analytics, Practice-Based Learning, learning environment, educational furniture, collaboration, equity, access.

Introduction

Recent studies have shown a lack of diversity in the technology sector workforce (NEC, 2015). One of the contributory factors for this is the poor take-up of science, technology, engineering and mathematics (STEM) subjects in secondary level education and technology related courses at third level among some student groups, thereby leading to a resultant skills shortage and under-representation of these groups in the technology sector workforce (EU, 2015). By promoting collaboration in the delivery of education in the relevant subject areas, potential solutions to address this lack of diversity can emerge. Computer Supported Collaborative Learning (CSCL) is a pedagogical approach which can be used during educational activities in many of the STEM subjects relevant to the development of a technology proficient workforce (Do-Lenh et al., 2012). The premise of CSCL is that enhanced learning takes place when students interact and collaborate during the completion of computer supported educational activities (Dillenbourg, 1999). Our approach in this paper, is to pose the question, what is the physical nature of collaboration, movement and interaction during practice-based learning activities? Taking the example of a series of user trials during the research and design of a LAS and a suitable physical embodiment in which to implement it, we seek to demonstrate how a greater understanding of the physical nature of collaboration can help in the design of an educational environment. Through understanding and facilitating increased interaction and collaboration, the authors seek to make participation in CSCL activities more equitable and accessible, which may encourage greater engagement with STEM activities through CSCL by a broad and diverse range of user groups.

Background

The work described in this article has been carried out as part of the PELARS (Practice-based Experiential Learning Analytics Research and Support) project, a three year, European Union funded, research and design project that seeks to create a LAS suitable for implementation in the teaching of practice-based learning activities in three learning contexts, secondary (high school) STEM subjects, third level (university) interaction design and third level engineering education. Given the diverse user profile associated with these three contexts, consideration of equity and accessibility were of paramount importance to the project partners from the outset. The project seeks to understand how students learn while engaged in open-ended Collaborative Problem Solving (CPS) in PBL activities (Cukurova, et al, 2016). Typically, the physical design of CSCL interventions and the environments in which they are implemented is driven from an instrumental and technological viewpoint rather than ergonomic and human factor affordances provided to the proposed user group (Jones et al., 2006). In order to fully support interaction and collaboration, we need to understand and consider the physical design of the collaborative workspace. By designing a learning environment taking into account movement and interaction on a macro (classroom) scale, we seek to encourage collaborations on a meso (group) and micro (individual) scale.

Methodology

The aim of the design of the physical aspects of the PELARS project is to consider as diverse a range of potential users at the outset of the project and define a set of requirements based on these user profiles. Through the translation of these requirements into a design brief which is iteratively prototyped, tested in a series of user trials, evaluated and incrementally improved, an empathetic design process develops which ensures that the end product meets the needs of the user group in an equitable and accessible manner. There are two aspects to the design of the physical elements of the project - the educational furniture in which the LAS technology is embedded and the implementation of that furniture within an educational space. The section below outlines the key human factors for consideration in the design of both aspects. The furniture prototypes were tested in a series of user trials to examine various aspects of the design, two of which are listed below.

Educational furniture (Meso level)

Key human factors relating to the proposed users regarding equity and access to be addressed in the design process were identified in the research phase of the project and are listed below:

1. Physical profile and ability - design to allow usage by a broad range of abilities.
2. Ergonomics – ensure height, reach, sight-lines etc. are suitable for the user group or are adjustable.
3. Skill level – intuitive in use.
4. Maturity – design to account for intentional misuse, safety considerations.
5. Teacher/student interaction - design to enable equitable interactions in terms of dynamics and time.

Trial 1

This trial was constructed to test the factors listed above. The hypothesis of the trial is that students engaged in a PBL task at standing height tables would physically move more than those seated at standard height tables and that these movements would give rise to more interactions with their peers. Six 18mm thick wooden table tops were produced for this trial, two circular tables (1,000mm diameter), two hexagonal tables (1,000mm width) and two square tables (900mm width). One table top of each shape was mounted at 770mm (sitting height) and at 1,020mm (standing height), creating six test scenarios. Groups of three students were randomly asked to carry out a task at each of the six tables while being observed and video recorded. The task was to assemble the components of a programmable kit and code it using a laptop to control the movement of a laser pointer to hit a target. The task lasted 57 mins 45 seconds. The results of this trial are listed in the results section.

Furniture implementation (Macro level)

During the analysis of the data from Trial 1, it was noted that examining the usage of the furniture at the "meso" or group scale during an activity does not necessarily give a full picture of what is happening in the classroom. Movements of students away from their designated table (and where and why they moved), of the teacher/ facilitator through the class and interactions away from the table were not captured, creating potential gaps in the LAS data set. In order to evaluate the design intent of the furniture, i.e. that it encouraged more collaboration and interaction between groups, a method of capturing the all these movements and interactions (using multiple video cameras and time-lapse photography) was devised and implemented for the next user trial.

Trial 2

The purpose of this trial (along with testing the LAS) was to record the movement and interactions of students engaged in a practice-based learning task at specially designed standing tables with circular table tops to allow comparison with those of their peers seated at standard height rectangular tables. It further sought to track the movements and interactions of the teachers / facilitators during the activity. In the trial sixteen secondary school students were divided into five groups. Two groups of three students were randomly selected to work on specially designed standing height round workstations while the remaining three groups (two groups of three and one of four students) were seated at standard desk height rectangular tables. Following the briefing, the activity lasted 92 minutes and involved the construction of an interactive toy using an Arduino programmable kit.

The evaluation methodology of both of the trials below consisted of a combination of quantitative and qualitative data gathered from multi-modal data sources ranging from heuristics, interviews, video and sound recordings, still and time-lapse photographs, data provided by the LAS system and student generated feedback via "sentiment" buttons and an on-line mobile application (Healion & Russell, 2016). All the above data was analysed, with the results prioritised and used to inform the next iteration of the relevant design element. In this paper, we focus on the analysis of student movements and the frequency of their interactions.

Results

Trial 1 - Test of table height and shape

Our results show that high tables at which students stand seemed to encourage greater physical movement of the students during a PBL activity. During the activity, there was a total of 88 separate moves away from the three high tables (Average 29.3) compared to total of 14 from the low seated tables (Average 4.6). This greater ease of movement seemed to encourage students to initiate more frequent interactions with their peers in other groups. There was a total of 19 separate peer interactions initiated by students from the three high tables (Average 6.3) compared to total of 11 from the low seated tables (Average 3.6) – although eight of these 11 were initiated by one outlying student. Groups at the high tables were much more likely to change the group configuration during the activity and to reform it according to their needs and changing roles within the activity giving a total of 45 group configuration changes by students at the three high tables (Average 15) compared to a total of one from the low seated tables (Average 0.3). Of the groups at the high tables, the round table seemed to encourage the most configuration changes (23), followed by the hexagonal table (17) and the square table (5). From observations, it was noted that the facets or sides on the hexagonal and square table seems to act as locators for students to denote positions that they were more likely to return to – the more defined the facet, as in the square table, the greater the likelihood that the students return to their previous position. The high tables seemed to encourage the students to work closer together physically. Typically the standing students stood shoulder to shoulder as close as personal space would allow to view a laptop, discuss the task or during the component building in angles between 90 to 180 degrees, whereas students at the low tables sat at 90 degrees or faced each other.

Trial 2 - Analysis of movement and interaction

Time spent by each individual student at their appointed table ranged from 100% of the activity (Students 11, 15 & 16 – low tables) to 72.3% (Student 5 – high table) with an average of 91.48% (Average at high tables 88.7%, 93.2% at low tables). The number of student location changes ranged from an outlying 46 (Student 9 – low table) to 0 (jointly Students 11, 15 – low table) with an average of 14.1 changes (Average at high tables 16.7, 12.7 at low tables). The number of interactions (per student) with other student groups ranged from 0 (Student 15) to 8 (Student 14 – low table) with an average of 3.25 interactions. (Average at high tables 3.5, 3.1 at low tables).

In general, increased physical movement and location changes around the classroom correlated with increased interaction with other groups, but not always as evidenced by Student 9, who had the highest number of location changes (46), but the joint lowest number of interactions with other groups (1). Assignation of roles within the group also has an effect on duration of time present at the workstation. The selected diagrams below were chosen from the ten diagrams generated to show the most amount of student movement (Fig. 1(a) Student 5) and movements of the main facilitator (Fig. 1(b) Facilitator 1). Each line represents a return movement for the subject involved unless an onward movement is indicated.

(a) (b)

Figure 1. Spaghetti diagram showing the movements of Student 5 (a) and Facilitator 1 (b) during the activity

The results detailed above, combined with heuristic evaluation and anthropometric considerations have informed the design of the current iteration of the PELARS furniture which is composed of two distinct units, designed to work together as part of a flexible classroom layout. The first, is a table that provides a circular surface for collaborative group based learning. The height and surface form of the table was developed in response to trials which indicated that a raised surface and circular form promote increased collaboration and movement. The scale of the surface ensures physical accessibility to project work (Healion & Russell, 2015). The raised surface height may promote a greater sense of equality within the classroom as student and teacher are both working at the same level and posture. The second, is a frame that integrates the LAS technology whilst also supporting a digital display, two whiteboards and an additional work surface. The frame is developed to support equitable visibility of, and access to, the graphical user interface. It can be positioned against the table at any point and provides good line of sight for all students at the table. Our trials have shown that existing furniture can result in individuals monopolising delivery of certain tasks, whether programming based or relating to physical assembly. The combined shape of the table and the positioning of the monitor support shared task completion and learning across the group. The design and placement of these furniture elements within the learning environment has been shown from the trial results above to have a positive effect on the number of movements and interactions between the student groups and seeks to facilitate ease of access through the ergonomic and anthropometric considerations. The resultant increase in mobility and interactions are key to enable effective collaboration among and within groups in dynamic PBL environments.

Conclusion and discussion

The analysis of student and teacher movement through the classroom while engaged in CPS in PBL activities has meaningful implications for the design and development of CSCL implementations. By understanding the nature of collaboration and interaction between peers and student to teacher at the macro level while engaged in PBL activities, more effective, equitable and accessible educational and learning environments can be created. This approach has shown to be effective in the design of the current iteration of the PELARS furniture, the form of which has been directed by a deeper understanding of collaborative learning achieved through the user trials. The current design has been shown to promote movement and interaction within the learning environment, which then can lead to more effective collaboration between groups as well as amongst group members. Improved learning environments that promote equity and access can assist in the engagement of a diverse range of students with STEM subjects and activities with the potential to generate a greater interest and take-up of these subjects at third level, creating a more diverse workforce in the technology sector

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