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Creating Smarter Teaching and Training Environments: Innovative Set-Up for Collaborative Hybrid Learning

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Abstract. This paper brings together previous work from a number of research projects and teaching initiatives in an effort to introduce good practice in setting up supportive environments for collaborative learning. The paper discusses prior use of social media in learning support, the role of dashboards for learning analytics in Global Software Development training, the use of optical head-mounted displays for feedback and the use of NodeXl visualization in managing distributed teams. The scope of the paper is to provide a structured approach in organizing the creation of smarter teaching and training environments and explore ways to coordinate learning scenarios with the use of various techniques. The paper also discusses challenges from integrating multiple innovative features in educational contexts. Finally the paper attempts to investigate the use of smart laboratories in establishing additional learning support and gather primary data from blended and hybrid learning pilot studies.

Keywords. Optical Head-Mounted Displays, Google Glass, Intelligent Technology support for education, Global Software Development, Dashboards, Learning analytics

1. Introduction

The U.S. National Science Foundation (NSF) awarded a grant to support the investigation in Global Software Development learning teams in a project that involved several universities residing in different countries including US, UK, Panama and Turkey. Over the years the original team of researchers extended invitations to further institutions that wished to join the consortium and participate in pilot studies. The original work focused on investigating the impact of technology in interactions among group members. The aim of the pilot studies that were to ensure that the use of technology would ensure that there would be no interruptions in workflow throughout the project [1]. One of the early assumptions made by the authors was that the lack of traditional cues that are usually present in face-to-face communication would affect the performance of teams collaborating with the aid of technology. This was based on

evidence that project failure was also linked to the lack of temporal reference points (e.g. mannerisms, gestures) that could be used for coordinating workflow [2]. The lead author was amongst the participants of a project involving students from UMIST, Durham University and Keele University resulting that the less the transmissions within a group the higher the number of technical problems the group would face [3].

As part of the project, the participating institutions were involved in collaborative projects simulating the interactions usually taking place between virtual teams and in particular Global Software Development (GSD) teams. A typical setting would include students from a number of institutions participating in joint teams sharing common goals towards designing and developing a software artifact (e.g. database design, system interface, privacy statement for application of Data Protection Act principles) while collaborating over distance and time zone differences. The element of culture was also of importance as all pilot studies involved culturally heterogeneous teams to some extent.

In this paper we will discuss how work in a number of related areas was integrated in creating smarter teaching and training environments. The paper will present ongoing work in a number of areas and explain how the have helped enhancing learning experienced and improve teaching practices. As GSD is a field that requires continuous professional development and training not only in development practices but also in procedures used for communication and collaboration, the paper attempts to provide guidelines for GSD set-ups. Emphasis is given on hybrid learning and the special requirements it has for supporting the learning process.

2. Background and related areas of work

The scope of the pilot studies was to investigate a number of issues relating to the learning process in the field of GSD, as well as impact of technology, culture and time zone differences in training individuals in becoming effective members of such teams. For example a key finding involved the structural factors affecting performances of GSD teams [4], while of importance was the investigation of interaction patterns among GSD learning teams [5]. Our work also considered the impact of various factors relating to online collaboration on GSD performance [6], as well as investigating success criteria for distributed student teams [7].

In parallel to the core of the work, some of the authors investigated a number of areas relating to computer supported cooperative learning and e-learning applications. The impact of using social media for creating effective e-learning settings [8] and the use of data mining and learning analytics for assessing social media impact in education are of particular interest [9].

Previous work has been mainly in the fields of e-learning and blended learning, including the creation of pedagogies for delivering e-content. For several years focus was on enhancing the learning environment. A lot of effort has been invested in proposing principles for good design of learning environments. It is important to note that in the literature we can find work that is dedicated in the enhancement of learning environments intended for practitioners, including decision-makers [10]. There is a significant part of the literature investigating the importance of creating realistic learning tasks in order to train individuals in professional tasks and real-life problems [11].

Learning environments have evolved over the years and research in learning spaces has span across several fields. We have opted to investigate the role of 3D virtual environments in supporting pedagogies [12], the role of virtual world architecture in enhancing e-learning experience [13] and the design of ubiquitous 3D virtual spaces [14]. We have experienced though that a significant body of work has shifted towards what emerged as hybrid learning. For example emphasis is given on the need for education to provide opportunities for students to engage in authentic instances of practice, which is referred to as 'work integrated learning'. This, in theory, allows students to experience settings that are more practical and enable them move more effectively into their selected educational practice [15]. This meant that more emphasis was given on creating realistic learning scenarios and even expanding the workplace to become a learning environment by supporting management and training processes with the necessary educational tools and procedures. This has been for years the core focus of work based learning and life-long learning initiatives.

For the purposes of this paper we adopt the term 'hybrid learning', as explained by Zitter and Hoeve [16]. Their work "instead of merely combining, connecting or joining aspects of learning in school and experiences in work settings or the other way around by expanding workplaces with learning features", is are interested in how they might be integrated and merged.

Figure 1. Integrate and merge: interweave learning and working processes.
(as cited in Zitter and Hoeve)

As shown in figure 1, the aim of Zitter and Hoeve is to "interweave learning and working processes to benefit from the strengths of both formal, school-based learning and real-life experience" [16]. This perspective of hybrid learning allows combining formal learning practices in workplace learning. It is a philosophy suitable for those who advocate that focus in a learning environment may shift from learning theories to working practices and vice versa. A hybrid learning environment facilitates learning provides and instructors to design learning sessions according to the real needs of those who are trained. For example a classroom-based setting that follows face-to-face instruction practices may be used for teaching certain skills and theoretical aspects of a particular domain. However, a hybrid learning environment would allow the facilitation of self-paced study model where individual learners would select the level of engagement with activities and other interactive features via e-learning tools. Finally the introduction of a work-based learning framework would allow the application of theory in practice with the use of online resources as needed.

It is evident that in the GSD field, a hybrid learning environment would be ideal for supporting dispersed practitioners who would engage in learning processes. However, there is a major challenge relating to the way collaborative hybrid learning activities are set up. The challenge is how to ensure that both teams and individuals are

effectively managed, monitored and supported throughout their learning process. The following sections will briefly visit on-going work in four areas and conclude in the way the current findings can be combined in a set of guidelines leading to a proposed set-up for collaborative hybrid learning. The four areas we will be discussing are as follows:

- The role of social media in collaborative learning.
- The role of dashboards in managing learning information
- The role of learning analytics in managing learning activities
- The role of Optical Head Mounted Displays in providing feedback

3. The role of social media in collaborative learning

A significant amount of work has been published in the role of social media in education. It appears that the most common approach is for instructors to consider the use of social media as an enhancing set of tools and functions for transforming traditional virtual learning environments. The scope of using social media in educational contexts usually includes the participation of students in active learning, the engagement of students with a range of interactive features, the creation of an online community and the use of a familiar environment for sharing content and engaging students with their instructors and their peers.

A popular theme in this work is the exploitation of Web 2.0 technologies and in particular the use of a range of tools in educational contexts [17]. The scope is to asses which features can be used for mediating and enhancing instruction in different domains, while addressing issues relating to the lack of formal learning structures, the element of trust and the ability to concentrate on learning tasks alone. Several researchers focus on investigating the role of Web 2.0 technologies in replacing traditional virtual learning environments and serve as learning spaces. Their focus is creating network-centric learning spaces where peer support and communication is essential for effective learning [18]. The use of social media in learning triggered the creation of innovative pedagogies that valued self-paced study, self-regulated learning, personalised learning delivery and the role of social applications in supporting learners [19]. Finally there is a significant body of work providing constructive criticism of how educational technologies have evolved and the impact Web 2.0 technologies would have in the sector [20].

Our work in the role of social media and social learning networks in modern education has included several pilot studies with further and higher education institutions [8]. The primary investigation involves the assessment of how students communicate during learning activities that are supported through the use of Facebook. The studies involve self-evaluation and reflective portfolios in the way the social network affects the learning process. Participants provide their views on how they used the medium and their perception of their learning experience through the platform. As learners and instructors use the medium to communicate and interact, it is evident that the available functions are more suitable for certain learning activities. Instructors have used the platform primarily for (i) quizzes, (ii) polls, (iii) monitoring learners' activities, (iv) providing comments, (v) asking questions, and (vi) providing feedback. Some of the most common features used by individual students included uploading video or text

files, commenting on tutor's question or request, expressing likes or dislikes, tagging pictures or presentations, participating in instant messaging, uploading files through IM, setting privacy features on for the same group, commenting or tagging other members, and poking others.

As students participating in the studies engaged in discussions and provided input for a number of surveys, NVivo was used for rich text analysis. The tool's hierarchical coding helped in monitoring and comparing contributions of team members. Student contributions were organised under a number of key themes (e.g. strategy, evaluation) and a number of child nodes were identified corresponding to factors affecting student learning. Text search queries and word search queries were conducted on sources and nodes and results stored as child nodes. Each node created was represented with a word frequency query to identify the most popular themes. As shown in figure 2, the objective was to provide a visualization of the main factors identified by learners in each of the learning themes. This approach would help assessing contributions on brainstorming activities. As shown in the figure, text coding can be used to illustrate the main nodes of the keywords used by learners to describe the perception of Facebook's use for enhancing learning activities Similarly word trees can be used to demonstrate the most popular keywords used.

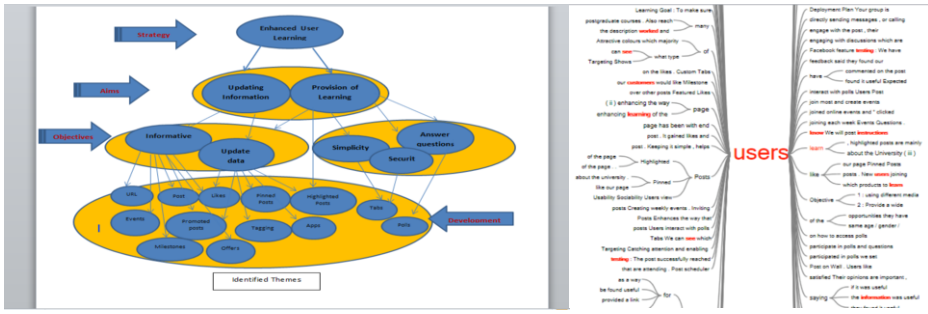

Figure 2. Project coding visualisation through node and word trees.

The use of word clouds was another feature helping us to assess patterns of keywords present in their contributions towards certain collaboration dimensions. Our work is based on the hypothesis that learners engage in activities that affect one or more of four dimensions known as PUFS:

- Performance – interactions focusing on achieving specific objectives.
- Usability – interactions focusing on effective use of the interface.
- Functionality – interactions focusing on using certain features.
- Sociability – interactions focusing on establishing rapport with peers

The use of word clouds (see figure 3) provided a very useful visualization of the popularity of keywords and concepts under each theme. The impact of such visualisations is that they help individual students and teams to reflect on their perceptions and how they are aligned with the entire cohort. At the same time, instructors are able to assess whether the anticipated concepts are discussed to the expected extent and they received the forecasted attention by the learners.

Figure 3. Word cloud.

4. The role of dashboards in managing learning information

As part of our previous work in supporting learning enhancement through synchronous and asynchronous communication via virtual learning environments, we have experimented with the use of visualization features providing learners with useful information on their individual and team performance. As shown in figure 4, a couple of techniques were used to ensure that learners would get an appreciation of how their efforts contributed to the overall goal, but also to reflect on their contribution in relation to their peers.

Initially the objective of the team cohesion feedback feature was to help student teams to visualize how different members' contributions were misaligned. It proved that this was a very useful tool for managing overall projects. With up to 12 project teams involved in certain pilot studies, the visualization of the team cohesion would help to spot any teams that were facing problems easier. It became evident that there was scope for introducing gamification practices in an effort to enhance communication and collaboration in software engineering teams [21]. The second screen shown in figure 4 demonstrates how a red-amber-green system was used to illustrate individual member performance for each team. Similar illustrations were used for team performance based on a number of criteria including interaction, file uploads, communication with peers, etc.

Although there is significant work in the field of gamification for educational purposes, "more substantial empirical research is needed to determine whether both extrinsic and intrinsic motivation of the learners can be influenced by gamification" [22]. Typical game mechanisms used include (i) points, (ii) badges, (iii) levels, (iv) leader boards, (v) virtual goods and (vi) avatars. Typical applications of gamification practices included courses without online support, massive open online courses, blended learning courses, e-learning sites and gamification support platforms. A typical example would include the use of leaderboards and badges for a traditional course

indicating individual status and student engagement, which could be implemented for a course without online support [23].

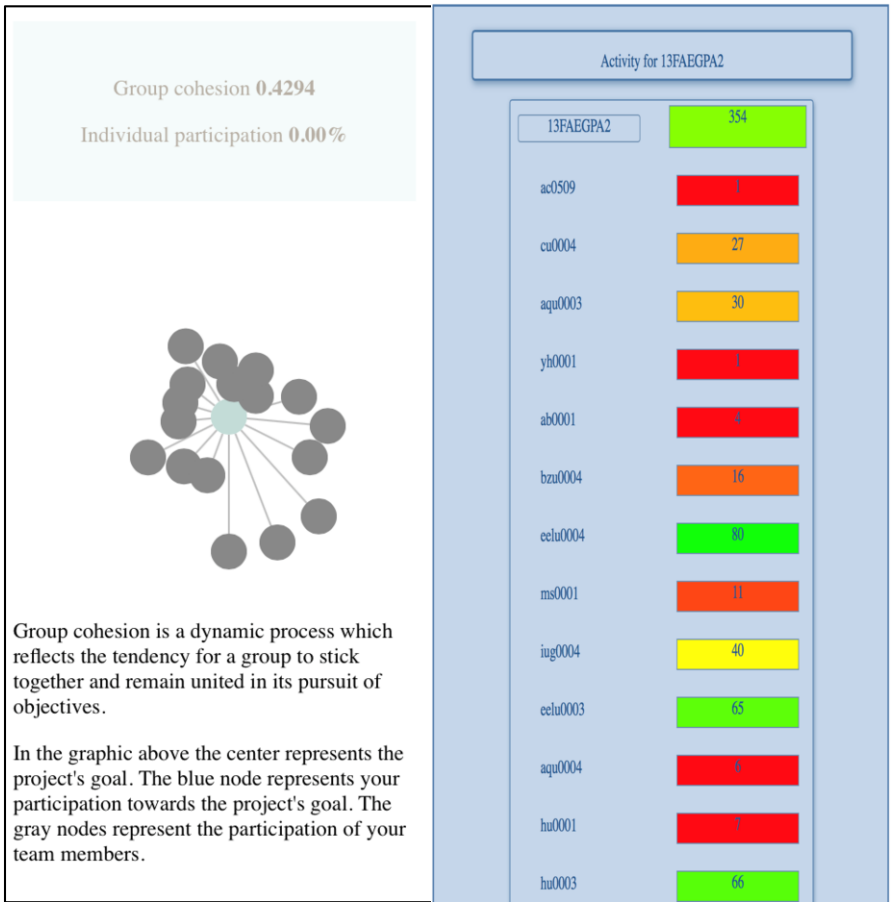

Figure 4. Gamification visualisations.

The popularity of the gamification techniques used in some of the pilot studies triggered an interest in providing a mashup for GSD team data that could be used to assess patterns in communication and collaboration among previous pilot studies. As shown in figure 5, a GSD collaboration analysis provides information about a selection of GSD projects that have been undertaken in the past few years. One of the primary features is demonstrating the use of the forum (asynchronous discussion) and chat (synchronous discussion) over time. Summarised activities and communication types over time are also displayed, while it is possible to filter the data according to institution, team or individual learner. Ranking frequently used keywords as well as participation from different countries also help to demonstrate how communication and collaboration is affected by location and culture. The customization of the dashboard and the creation of additional functionalities so the analysis of near real-time data of current projects is possible is anticipated for the immediate future.

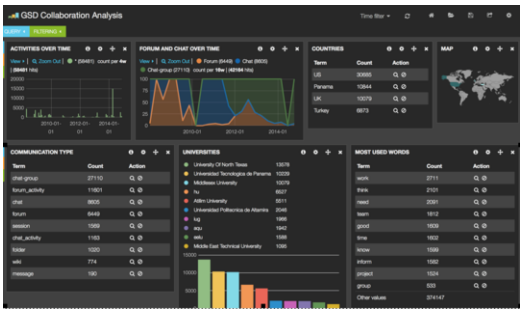

Figure 5. Sample of a customized GSD dashboard.

5. The role of learning analytics in managing learning activities

The introduction of the dashboard provided a very useful tool for illustrating how teams worked in various projects. It was however important to provide more detailed information about the way each team performed for certain tasks. The role of learning analytics in visualizing performance of GSD learning teams was one of the most recent investigations taking place during our pilot studies [9]. Emphasis was given on illustrating the way teams interacted as well as individual contribution, as shown in figure 6.

The first part of the figure shows the user contribution for particular topics in one of the student teams, showing a pattern of a strong core working together for certain milestones but also several team members being less active with fewer message exchanges during the project. The second part of the figure demonstrates the daily message frequency for each university, illustrating how members of each institution contributed to their team communication across a number of project stages.

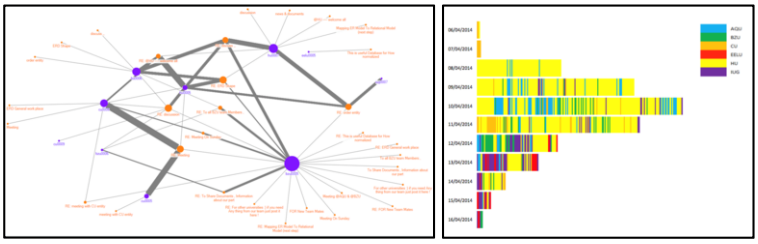

Figure 6. Sample of a customized GSD dashboard.

Currently the production of these graphs is based on manual analysis of data collected through social media discussions and server logs from synchronous and asynchronous communication. The next step is to provide a real-time analysis of communications, which would help team leaders assess a number of team performance indicators such as (i) more active members, (ii) tasks triggering frequent communication, (iii) periods with increased or decreased interactions, (iv) changes in the volume of interactions from certain sub-groups or individuals and (v) frequency of communication over the project's lifetime.

6. The role of Optical Head Mounted Displays in providing feedback

The final area of concern discussed in this paper is the use of Optical Head Mounted Displays (OHMD) for the provision of feedback to individual learners as well as teams. For the past couple of years Google Glass has been used to provide feedback to individual learners who presented their work, as well as teams while received feedback on their reports. The OHMD technology has been used to provide photographs with vignettes offering different types of feedback messages to learners. This has received impressive responses from learners (publication still under review) leading to an additional experiment where OHMD is used to provide feedback on the way instructors help learners understand certain tasks. The scope of this project is to provide an alternative way of teaching environment where feedback is provided through a portfolio of illustrations with tags corresponding to different assessment criteria.

Figure 7. Using OHMD for individual and team feedback.

Figure 7 shows the settings of the two different uses of OHMD and two of the graphics used as feedback for learners' content and posture during individual presentations. At the same time as seen in the pictures, video recordings and photographs are taken, for future tagging according to learners' behavior. Tags include evidence of confusion, assurance, confidence, pressure and similar feelings affecting learners' performance.

7. Setting up for collaborative hybrid learning

Following the previous sections we can summarise the four areas contributing towards creating an innovative set-up for collaborative hybrid learning. The proposed set-up involves the following arrangements:

- Gathering communication logs to be coded with the use of node and word trees, and word clouds (communication context).

- Using a dashboard to demonstrate performance indicators (participation and engagement).
- Providing learning analytics illustrations to show performance management (contribution and performance).
- Introducing OHMD technology to provide feedback (behavior)

Future work includes a pilot study with the involvement of more than 70 students who will be reside half in Germany and half in Panama. The learners residing in Germany will be from five institutions and two different cultural backgrounds. The setting will include the data collection techniques discussed earlier in this paper. The pilot study is part of a summer school involving several participating isntructors. The learners will be divided in three teams, each consisting of six sub-teams. Collaboration will take place using a single virtual learning environment, while each team will hold a daily SCRUM meeting. Participating instructors will provide support via daily briefs, video conferencing sessions offering feedback and up to date analysis of team and individual performance.

8. Conclusions

This paper attempted to integrate work in four different fields in order to provide a set-up for collaborative hybrid learning. The paper's contribution is in the form of a set of guidelines of how to set-up data collection and analysis practices for pilot studies that support Global Software Development in an educational context.

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