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Embedding technology to support the development of problem-solving skills in Geotechnical Design students

Intégration de la technologie pour soutenir le développement des compétences de résolution de problèmes chez les élèves de conception géotechniques

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ABSTRACT: The aim of this study is to explore the design of an effective learning environment to support the development of problem-solving skills through introduction of real-world case studies where the students are challenged to design a solution within a simulated work environment. The project focus is on the potential for enhancement of the delivery and assessment of the Geotechnical Design module using technology that will support student learning and the development of problem-solving skills. Action research methodology was used to develop and implement a new blended learning activity for undergraduate Geotechnical Design students which introduced online learning activities and environments to deliver essential parts of geotechnical engineering curriculum such as design reporting which is a requirement of the current Eurocodes. The action had a positive impact on the development of real world problem solving skills of the students and allowed the students, on top of acquiring the technical skills, to assume responsibility and take control of their own learning while sharing knowledge. The posing of an open-ended real-life problem and the technology-supported learning were critical in motivating the students to learn and enhancing their learning experience.

RÉSUMÉ : Le but de cette étude est d'explorer la conception d'un environnement d'apprentissage efficace pour soutenir le développement des compétences de résolution de problèmes grâce à l'introduction d'études de cas du 'monde réel' où les étudiants sont mis au défi de concevoir une solution dans un environnement de travail simulé. L'objectif du projet est sur le potentiel d'amélioration de la prestation et l'évaluation de un module géotechnique en utilisant la technologie qui appuiera l'apprentissage des élèves et le développement des compétences de résolution de problèmes. méthodologie de recherche d'action a été utilisé pour développer et mettre en œuvre une nouvelle activité d'apprentissage mixte pour les étudiants de premier cycle d'études géotechniques qui ont introduit des activités et des environnements d'apprentissage en ligne pour fournir des éléments essentiels du programme d'études d'ingénierie géotechnique tels que les rapports de conception qui est une exigence des Eurocodes actuelles. La pose d'un problème réel ouvert et l'apprentissage assisté par la technologie était cruciale pour motiver les élèves à apprendre et à améliorer leur expérience d'apprentissage.

KEYWORDS: geotechnical design, problem solving, wiki, learning technology, action research.

1 INTRODUCTION

The focus of engineering education in the UK is on providing students with understanding and generic skills that can be applied in different employment environments (Goodfew, 2010). In order to apply the skills and understanding learned at the university in the professional practice, a link between the learning environment at the university and the 'real world' has to be established during the years in higher education. This link is especially important for engineering students as their discipline is described as 'being about three things: applied science and mathematics; solving problems, and making things' (Pawley, 2009). Students need to develop problem-solving skills in order to apply the science and mathematics learned at the university in designing solutions for real life problems. However, many engineering courses are often criticised for lack of linkage to the 'real world' (Felder et al 2000) albeit the importance for engineering students to relate realistic case studies to what is being learned at university is recognised.

The development of problem solving skills is a critical graduate learning outcome for engineering students as these are often required by the employers and professional bodies who recognise the apparent lack of developed problem solving skills in graduate civil engineers (QAA, 2010; Hounsell 2011).

The teaching on the geotechnical design modules is usually curriculum driven (Mourtos et al. 2004) and it does not include the reporting and presentation requirements stipulated in the current Geotechnical Design standards (BS EN ISO 1997, 1990) which produces engineering graduates that take quite a long time to adjust to the demands of the designer's job due to

lack of connection between the theory and practical geotechnical applications.

This study had an aim to explore the design of an effective learning environment to support the development of geotechnical design skills through introduction of real-world case studies where the students are challenged to design a solution within a simulated work environment. The focus of this study was on the potential for enhancement of the delivery and assessment of the geotechnical design module using technology that will support student learning, geotechnical design reporting skills and, thus, address the challenges in geotechnical engineering education (Conrad et al 2012). The challenge here was the application of the conceptual problem solving skills used in conjunction with the acquired specific practical skills towards the delivery of an engineering objective (i.e. geotechnical design/solution; Prince, 2004). It was hoped that through learning-oriented teaching and support (Davis and Wilcock, 2004), the skills acquired through this experience could transform the student's perspective of geotechnical design, their behaviour towards problems of similar type, but also demonstrate best practice in geotechnical engineering education.

2 METHODOLOGY

To achieve the aims of the study, action research (AR; Fig.1) methodology was used throughout this project. AR is an inductive approach to investigation, attempting to solve real-life problems (e.g. development of problem-solving skills; Norton, 2009) but also to improve the geotechnical practice through systematic analysis of the research methods and expertise of the

teachers (Rees et al., 2007). The action research stages are detailed in the section below. The primary data was generated and recorded through a questionnaire research (Norton, 2009), with the survey designed to address the aims and focus of this research.

2.1 Action Planning

In this stage it was planned to align the learning outcomes (development of problem solving skills) with the teaching activities (blended learning, groupwork) and the assessment (formative synoptic) using the principle of constructive alignment (Biggs and Tang, 2007).

The focus of the action was planned to be on social constructive perspective where small self-selected groups of learners (up to 6 persons) actively construct new ideas through collaborative activities and dialogue within an interactive blended learning environment (Virtual Learning Environment - VLE and face-to-face - F2F) for knowledge-building. The groups were self-selected in order to avoid potential clashes in scheduling of group meetings and to have sufficient numbers to effectively share the workload but also to forge the sense of identity, responsibility, and cohesion which was the situative perspective of the design (HEFCE, 2009).

The choice of case study was guided by the principles that the problem posed should be from real life (Goodhew, 2010), internationally relevant, and be open-ended, i.e. allow different solutions based on designer's experience, numerical and analytical capability. The case study, although from Scotland, illustrated an engineering problem occurring globally (construction activities on or near slopes) – a challenging problem requiring describing, explaining, relating and applying (Biggs and Tang, 2011) as activities needed to achieve the learning outcomes while actively engaging students in deep learning while providing the associative perspective of the activity (HEFCE, 2009).

The introductory case study materials were prepared taking care of the balance between the challenge, the objective capabilities of the students, and the learning outcomes such as the development of problem solving skills. These were available for the students in the VLE at the start of the module. The students were also introduced to wikis (Choy and Ng, 2007) and design presentations through online tutorials and podcasts. These materials were planned to help the students in developing their transferable skills which would be assessed together with the technical and numerical skills.

To put the problem solving in context of geotechnical design and to introduce the Geotechnical Design Report (GDR; BS EN ISO 1997, 1990) as a tool for reflection, podcasts and GDR preparation guidelines were made available on the VLE. The task included preparation of a GDR on the real-life problem introduced at the start of the module. The GDR was to be prepared and presented in form of a group wiki, envisaged to improve the digital literacy (HEFCE, 2009) and provide flexible learning as an accessible tool for collaborative reflection on the technical aspects of the design in order to decrease potential team management problems and maximise the learning potential.

The assessment was carried out using the WebPA environment (Lodding et al, 2010) in order to provide the students with an opportunity to reflect on their work and the work of their peers during the assignment but also to help the teachers to identify any 'passenger' students.

2.2 Action

The action was to deliver a new experiential blended learning activity - a multi-session problem-based tutorial – by adapting Woods' problem-solving model (Woods, 2000). The idea was to shift the lecture/tutorial focus from a default teaching method

to a learning/teaching situation (Biggs and Tang, 2011) and to include on-line learning activities and environment all of which will have a focus on student learning (Fig.1).

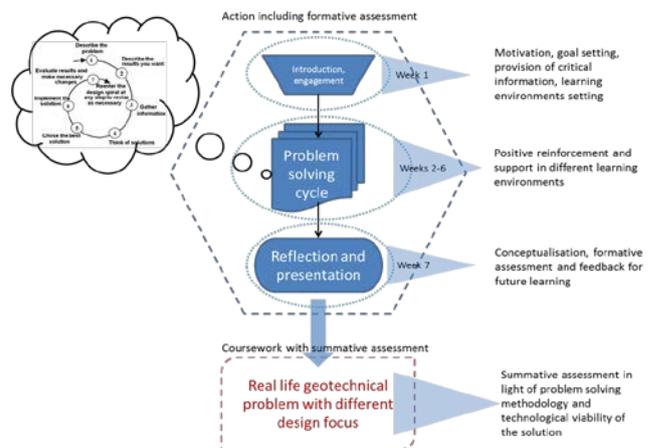


Figure 1. Action framework (hexagonal shape) detailing the different stages from learning perspective, timeline and respective foci from teaching/support perspective. Action Research methodology (AR) shown within the cloud shape.

Introduction (problem definition): Placing the learning in a simulated context of a graduate engineer's job, the students were asked to attempt solving the problem using the theory and concepts taught in the geotechnical design and other modules, expecting that students will identify their own learning needs, find and use the available resources appropriately, and develop individual skills such as information gathering and analysis, but also transferable skills such as group working, time management, and communication skills (Davis and Wilcock, 2004). The learning objectives of the activity and the importance of groupwork as social dimension of learning and real life problem solving skills on their future employability were outlined to the students in class. For additionally motivation, the concept of self- and peer-assessment was introduced and outlined to the students as a relevant real life concept of quality assurance in the engineering practice to make it relevant and to demonstrate "what's in it" for them.

Discussion (problem contextualization): In order for the problem to be better understood and approaches to solutions derived, the context of the problem and the importance of problem-solving skills in geotechnical engineering were introduced in the classroom which corresponded to the objectives of the "think about it" stage of Wood's problem solving method. Positive reinforcement was provided throughout the discussions without too much involvement in the group work so as not to remove the element of trial or discovery (Atherton, 2011) from the learners.

Learning support: At this stage it was envisaged that the students will be developing functioning knowledge (Biggs and Tang, 2011) using the academic declarative knowledge gained from the lectures. By giving them extended access and choice which is an added value to the experience of learning by self-management of pace and place, they were envisaged to be planning and designing a solution to the problem (Woods, 2000). The support for this was provided via a combination of F2F and online learning/teaching activities such as webinars and numerical modelling tutorials. The flexible access to the team wikis was used to identify any issues associated with the constructed knowledge (UKPSF, 2012) and to bring them up for discussion during the next F2F session.

De-construction of problem-solving approach: at the end of the module the student teams simulating design consultants had to look back at the design process and present their design

solutions in front of the module team who simulated the potential employer. After the presentations, the proposed design approaches were discussed with the class in order to help the students to conceptualise the problem solving which they can apply in similar situations in the future.

Assessment and feedback: Based on the wikis and the oral presentations generic formative assessment and feedback was provided to the students after the last session reinforced with an audio feedback in an accessible format. A detailed formative synoptic feedback was provided to each team in order to confront and correct any misconceptions (Biggs and Tang, 2011) on the theoretical and applied aspects of the problem the students may have had. In the summative part of the feedback, the performance of each team against a set of technical and transferable skills criteria reflecting a generic problem solving method (Woods, 2000) was assessed, feeding forward on the areas that need development. Through the online self- and peer-assessment system the students provided feedback on the group work dynamics and learning which allowed assessment of the effectiveness of the action and reflection in view of enhancement of the module delivery.

3 RESULTS

The majority of the respondents were full-time, UK students (60% and 80%, respectively) comprising a representative sample. The response rate on the questionnaire survey was 65%, with the respondents attending on average 76% of the sessions during the action, which was on average 15% higher than during the rest of the module. The attendance at the oral presentation was also very good with 92% of the registered students attending. This shows that different categories of students found the action interesting and motivating which was the premise of the problem-solving method (Woods, 2000).

When posed the question of motivation for participation in the activity, the students quoted perceived lower workload in a group (28%, Figure 2) while acknowledging different aspects of social learning such as work with international students and sharing knowledge (16%) as important motivation drivers. Taking responsibility for own work and working on a challenging problem (36%) were the major reasons for participating in the action from the aspect of individual learning which mirror some of the professional values stipulated by the engineering professional bodies (QAA, 2010).

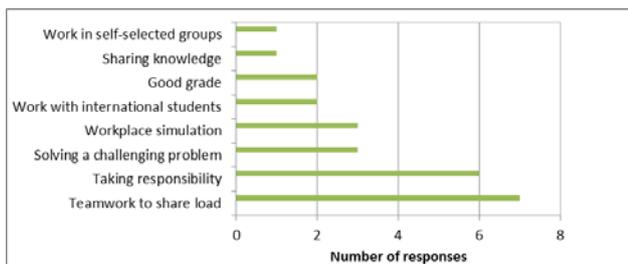


Figure 2. Factors motivating the students to attend the sessions during the action.

The majority of the respondents (68%) considered that the action contributed towards development of their problem-solving skills which they can transfer to engineering practice (e.g. value engineering, option selection or design; Fig.3) where an optimal solution is sought from a number of remediation options involving concepts and knowledge from other disciplines - the main goal of teaching problem-solving (Woods, 2000).

The formative feedback provided was mostly used for learning through self-correction (Muscara and Beercock, 2011) with majority of the respondents (64%, Figure 4) taking

responsibility of a particular section and only 8% revisiting the whole wiki/GDR for improvement and consistency.

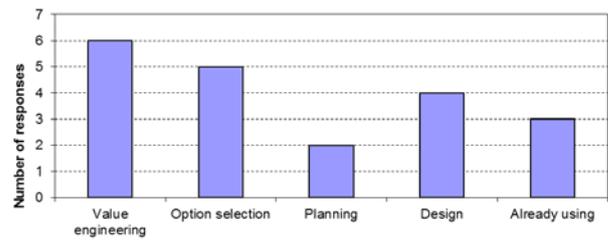


Figure 3. Student perception on the skills developed during the action

This trend may be due to the task division within the team and taking responsibility for own work for the majority of the team members, while one person would be in charge of insuring consistency of the presentation and content after all individuals have acted upon the formative feedback.

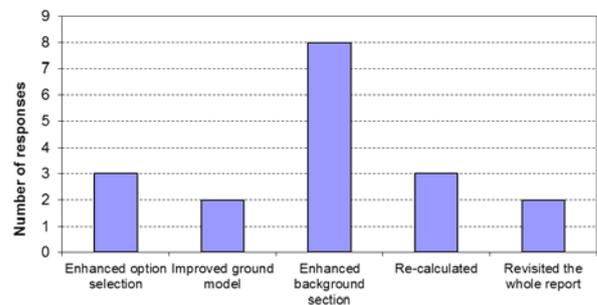


Figure 4. Student response/action after the formative feedback received during the activity

While recognising that the activity had been delivered in a way that increased student confidence in real-life problem solving (no changes needed and good guidance throughout, Fig.5), the respondents considered that more practical tutorials based on real-life case studies would further enhance their experience.

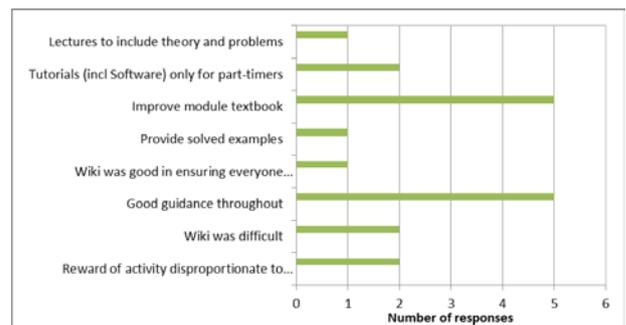


Figure 6 Student comments on potential improvements of the module delivery in the future.

4 DISCUSSION AND CONCLUSIONS

Although limited in depth and breadth, the action had a positive impact on the development of geotechnical problem solving skills of the students. The action design of working in small, self-selected groups, on an open-ended real-life problem while simulating workplace environment allowed the students to assume responsibility and take control of their own learning which aligns with the development objectives of the

professional organizations (e.g. ICE, BGA) and acts as a basis for lifelong learning (Biggs and Tang, 2011).

The results of this study show that the blended learning environment was effective in improving students' skills in reflection. The students used a standard reporting requirement (GDR; BS EN ISO 1997, 1990) in a novel way, not only for familiarising themselves with an area of geotechnical design that is not usually covered with the curriculum, but also for reflection on the problem-solving process and evaluation of their own solution of the problem. The work they produced was of good quality and was reflected in high marks on the summative assessment that followed the action as well as on the examination at the end of the term. The only negative aspect of the blended approach was the perceived difficulty of completing and editing the wiki for the GDR. While all of the teams produced wikis of good quality, it is likely that the limited functionality of the current software embedded in the VLE and the previous experience in working with a standard word editing software (Muscara and Beercock, 2010) may have been the main reasons for the negative response.

The results show that the students liked working online and in groups as it allowed them to share the workload, interact with students with different backgrounds and opinions while designing solutions for a real life problem which was the intended outcome of the action. Additionally, the groupwork allowed the home and international students as well as part- and full-time students to share experience and build knowledge in a situated learning environment (Norton, 2009) which enhanced the employability of the students as engineers for geotechnical contractors or consultants.

The response from the students showed that the activity enhanced not only their reflective skills but also their technical skills such as value engineering and design. It was important to give this opportunity to the students to try out their ideas and get an immediate feedback from both peers and teaching staff. With this, the students were able to work within the Zone of Proximal Development thus bridging the gap between "the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under ... (professional) guidance, or in collaboration with more capable peers" (ZPD; Vygotsky, 1946). It is believed that once the students master the technical tasks with the benefit of the assistance from the teachers and peers (within ZPD), they will be motivated and confident to perform the task on their own. Additionally, the value engineering and design skills developed through the activity are most likely to contribute towards the development of engineering judgement which is one of the development objectives required by the professional bodies.

The 24 hour access to the VLE where the learning part of the action was mostly based, gave the students a greater independence and freedom to learn collaboratively at their own pace and locations, ensuring presence and inclusion in all development phases of the problem-solving cycle (Walters and Sirotiak, 2011). Such permanent availability also proved to be of high practical value to part-time students who were not able to work on the project face to face due to work commitments. From a didactic point of view, the introduced flexibility and accessibility allowed for an unobtrusive insight into the individual contributions and group output and the opportunity for close and personalised guidance without the potential 'cooling down' of the projects (Muscara and Beercock, 2010) during the week. It also allowed for timely identification of issues and problems which could be addressed at the following F2F session.

Embedding self- and peer-assessment within the activity enabled a dialogue through interactive environments as a pedagogic strategy for teaching the skills part of the course and increasing the self-esteem of the students (Nicol et al., 2013).

The student learning based on the formative feedback and assessment can be considered to have been effective as the design 'engaged' the learners in and out of class (Gibbs and Simpson, 2004) but also prompted them into self-regulation (HEFCE, 2009). This was achieved by developing learners' understanding of the assessment criteria before they commence an assignment, ensuring that learners have time to reflect and act on the feedback they receive (Nicol et al., 2013). However, the failure to make feedback more of a dialogue which could be attributed to the limited F2F contact (Muscara and Beercock, 2010) or clarity of assessment criteria can be considered as a downside of the approach adopted in this study and further efforts should be made to make it work in the future.

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