Over a decade of experience with computer aided learning in geotechnical engineering

Plus d'une décennie d'expérience dans le domaine de l'enseignement assisté par ordinateur dans le domaine de l'ingénierie géotechnique

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ABSTRACT: While Computer Aided Learning has become a valuable part of the palette of tools available in developing and teaching university courses in geotechnical engineering, it is not the universal panacea and requires careful planning, didactic considerations and high quality in the delivery. The 'Institut für Geotechnik' (IGT) at ETH Zürich has been using an e-learning platform for the last 12 years to teach basic soil mechanics to students at the bachelor level in German. The notes are embedded with quizzes, virtual and real laboratory exercises, frontal lectures and accompanying lecture videos. A second generation knowledge-based platform GEOTip (GEOTechnical Information Platform) was developed inhouse using PHP and MySQL to stay abreast of advances in web technology and to ensure ongoing sustainability. All materials have been translated into English and extended using podcasts and accompanying videos to cover additional multidisciplinary courses for students in geophysics, environmental sciences and engineering. This paper describes concepts, key features and technical background for GEOTip. A summary of the students' course evaluations is also presented and the change in the students' perception of the platform over the years is analysed as well.

RÉSUMÉ : Bien que l'enseignement assisté par ordinateur (EAO) soit devenu un élément précieux de la palette d'outils à disposition pour développer et enseigner des cours d'université dans le domaine de l'ingénierie géotechnique, il ne s'agit pas d'une panacée universelle. L'EAO demande une planification attentive, des considérations didactiques et une haute qualité de distribution. L'« Institut für Geotechnik » (IGT) à l'ETH Zürich utilise une plate-forme d'e-learning depuis 12 ans pour enseigner en allemand les bases de mécanique des sols aux étudiants de niveau bachelor. Les notes de cours sont incorporées à des quizz, des exercices virtuels et réels en laboratoire, des cours magistraux et des vidéos de cours. Une plate-forme de connaissances de deuxième génération, GEOTip (GEOTechnical Information Platform) a été développée en interne en utilisant PHP et MySQL afin de se maintenir à la pointe des avancées dans le domaine de la technologie du web et d'en assurer la durabilité. Tous les documents ont été traduits en anglais et complétés à l'aide de podcasts et de vidéos d'accompagnement pour couvrir les cours multidisciplinaires supplémentaires pour les étudiants en géophysique et sciences de l'environnement. Cet article décrit les concepts, les caractéristiques-clé et le contexte technique pour GEOTip. Un résumé des évaluations des cours par les étudiants est aussi présenté et le changement de la perception de la plate-forme par les étudiants est aussi analysé.

KEYWORDS: knowledge-based platform, embedded multi-threaded geotechnical resources, e-learning

1 INTRODUCTION

Early developments for Computer Aided Learning in geotechnical engineering existed as part of the GeotechniCAL reference package funded by the UK Higher Education Funding Council Teaching and Learning Technology Programme and were led by Dr Leslie Davison, Professors David Muir Wood and John Atkinson. Subsequently, a pilot project for an introductory course in German in soil mechanics at Bachelor level, CALICE (Computer Aided Learning in Civil Engineering), was funded in 2000 ((Sharma *et al.*, 2001; Springman *et al*., 2003). This was part of a Swiss-British initiative under the umbrella of the ETH World Virtual Campus, to promote a step-change in the students' development, understanding and acquisition of knowledge. The resources developed included:

- online reference material for information,
- simulations designed to encourage reflection,
- open ended questions linking theory to practice,
- multiple choice descriptive and numerical questions to consolidate learning and assess progress.

All Bachelor and Masters courses from the Chair for Geotechnical Engineering have been mounted on the second generation, inhouse knowledge-based platform GEOTip (GEOTechnical Information Platform) since 2007. Subsequently, the introductory Bachelor course in soil mechanics has been extended for several different versions of multidisciplinary Masters' courses in geophysics, environmental sciences and engineering, in English. This paper describes concepts, key features and technical background and the students' evaluation of the progress.

2 GEOTIP: CONCEPT FOR THE GEOTECHNICAL INFORMATION PLATFORM

2.1 *Key features*

GEOTip was developed in house using PHP and MySQL to host the existing multi-threaded geotechnical resources. These included videos of the frontal lectures for streaming for later viewing, a script with embedded media, online quizzes, practical site-specific challenges and virtual laboratory demonstrations with associated questions for ongoing assessment of learning. Each student's performance is summarised on their personalised home-page.

Eight chapters of the bachelor's course soil mechanics listed below form the basis of the content with quizzes, virtual laboratory tests and challenges associated with each one. A final chapter about the construction of the Monasavu Dam in Fiji provides a useful opportunity to apply a simple form of 'problem-based' learning.

- 1. The ground
- 2. Stresses in the ground

- 3. Groundwater
- 4. General deformation behaviour of soils
- 5. Shear strength
- 6. Slope stability
- 7. Settlement
- 8. Compaction
- 9. Monasavu dam: fundamentals

The Masters' courses in English are running at capacity and students from a variety of engineering and science backgrounds are more inclined to choose virtual resources that suit their respective needs, learning styles, and language, while using the same core learning materials. A further range of innovative learning opportunities including online laboratory guides, pod- and vod-casts, which have been embedded in mindmaps to improve the clarity of the overview, efficiency of delivery and to empower students to access a variety of resources, each fulfilling several different didactic needs.

The pedagogical aim of the courses offered is to provide students with a variety of didactic methods, so each individual may choose the resources that suit their learning style best, and therefore learn efficiently. Assessment is then made through the quizzes (automatic, meaning students receive their marks instantly), challenges and virtual laboratories (wholly or partly marked by hand).

Students must solve all the quizzes, scoring a minimum of 40% of the total points, in order to earn credit for the course. These interactive animations illustrate some of the most complex geotechnical processes, supported by probing questions. These animations are a part of the mandatory exercises that the students have to complete successfully. Challenges are more complex problems derived from real life projects. These projects are explained using pictures, video-clips, blueprints, geological profiles and text. Helping students to understand from a practical, rather than just a theoretical, standpoint is a challenge in all engineering courses. It is with this issue in mind that the Monasavu dam chapter, online laboratories (chapter 3.2) and other challenges were written.

Exercises are a compilation of multiple-choice questions and arithmetical problems. They offer the student a chance to test their knowledge and to prepare for the quizzes. While solving the problem, the student receives immediate feedback whether their answer is correct or not. A hyperlink provides easy access to the corresponding chapter in the script.

Student course evaluations are enabled so that ongoing feedback can be obtained, although the frequency of responses has dropped off in recent years. Consistently high marks were gained from student evaluations, although there has been change in the students' perception of the platform over the years, which is analysed as well.

2.2 *Technical background*

GEOTip is an in-house developed database driven website using PHP and MySQL. Since both programs are open source and widely used, ongoing sustainability is ensured. In addition, an Adobe Media server is being used to stream the video material.

Technically, GEOTip consists of three parts:

1. the knowledge based system, where text parts, pictures, videos, animations and equations are stored in a common categorized tree structure (multiple categories are possible) combined with Meta tags;
2. the exercise questions, which are also stored using the same tree structure;
3. the e-learning courses then make use of the contents stored in first two parts.

New e-learning courses can easily be put together through the integrated Content Management System by accessing the knowledge base part to create an online script. Virtual laboratory exercises, challenges and recorded lectures can be added in the same way.

The platform has been programmed as a multi-language system using German and English to serve the needs of international students better. Users can choose the language of the platform in the profile settings, while the language of the content can be changed at any time. Adding a further platform language could be done at any time, without needing a major re-write of the base code.

GEOTip uses a multi-level access system, allowing IGT to retain control of intellectual property. While unregistered guests only have access to limited selected content, registered users, who are taking a course, have access to all the content stored in the knowledge base part of the website.

To make it as simple as possible for authors to create content for the platform, a Content Management System (CMS) has been incorporated. Through the CMS text parts can be written and pictures and videos uploaded. The CMS also includes an inhouse developed intuitively usable equation editor based on Adobe Flash (Fig. 1).

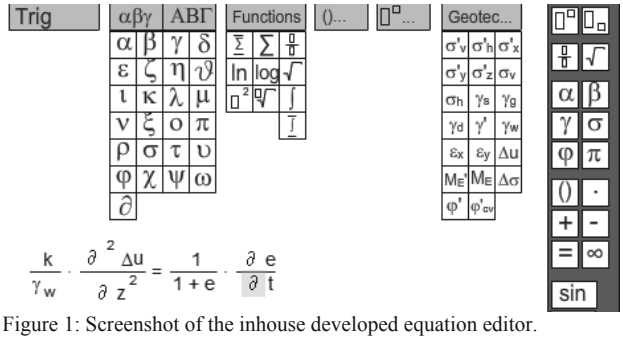

Figure 1: Screenshot of the inhouse developed equation editor.

An Adobe Media server is used for all the video streaming services. An inhouse developed flash player interface is used to access the videos on the Media server. From the client-side only, a browser with the Adobe Flash plugin (animations and video services) and Java (virtual lab exercises) is needed. To maximise browser compatibility, the website does not use java-script for the student pages. This solution enabled the development of a double screen feature for the lecture videos showing the recorded projector picture in a large screen and the lecturer in a smaller screen. About a third of the lectures are re-recorded for the German course in "soil mechanics" every year, to ensure the material is up to date.

Single and multiple choice questions and calculation exercises can be created through the CMS. The numbers in the question for the calculation exercises and corresponding answer can be varied from student to to discourage copying in two different ways. The first, classical option is to upload a csv formatted file containing different numbers and the solution per line. The second option makes use of an adapted equation editor, in order to store the equation for the solution in the platform. This reduces the time to develop a calculation question. The accuracy demanded for the solution can be set for each calculation exercise or globally for the whole course.

2.3 *Summary of course evaluations*

An anonymous course evaluation system was implemented in order to assess student acceptance and to be able to continue to improve the platform. It is possible to display multiple-choice questions with this system, as well as to give free answers to text questions in the context dependent frame to the right of the main content on the webpage.

The survey consists of approximately 110 questions about course understanding, assessment of the quizzes, virtual labs and challenges and about the handling and layout of the platform itself for the bachelor-level course "soil mechanics". In order to have the best quality answers, the survey is not just

shown at the end of the semester but questions are gradually introduced over the course of the semester shortly after the corresponding topic has been covered. Nevertheless, the participation of the students significantly decreases over the course of the semester.

Student participation has also decreased over the years. While in 2007, the year GEOTip was introduced to the students, 38 % of all possible questions were answered; this percentage decreased to 12 % in 2011 and then rose again to 19 % in 2012 (see Figure 2).

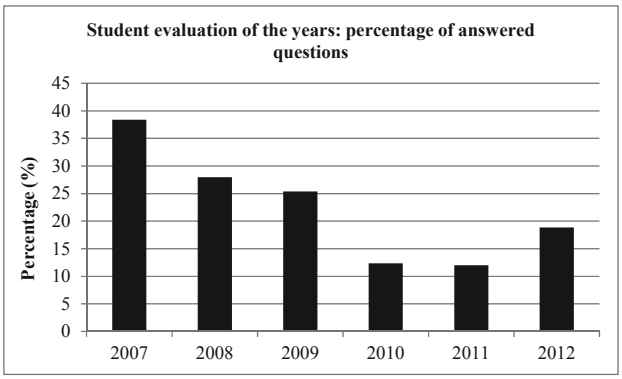

Figure 2: Student participation over the years since 2007.

Figure 3 shows that students generally judge GEOTip to be better than other computer aided learning systems. Astonishingly, the number of students without prior experience of computer aided learning systems increases over the years since its introduction.

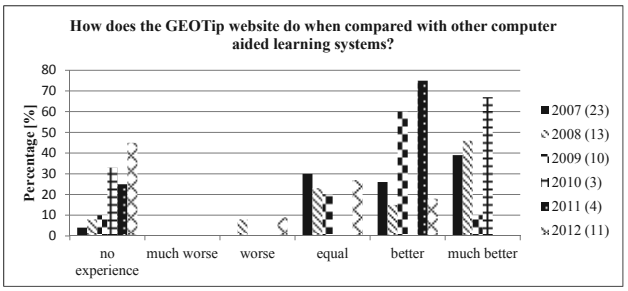

Figure 3: Development of the comparison of GEOTip with other computer aided learning systems over the years. The number of answers is given in parentheses.

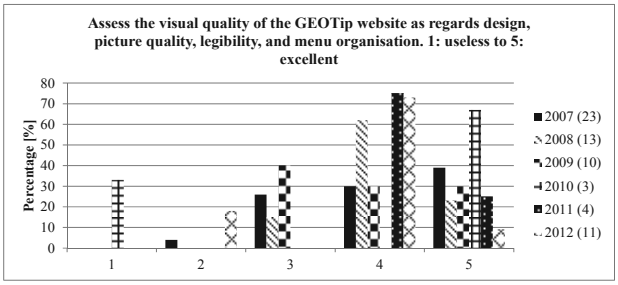

Figure 4: Development of the assessment of the design, picture quality, legibility and menu organisation over the years. The number of answers is given in parentheses.

The GEOTip website is mainly given marks of 4 and 5 out of 5 for design, picture quality, legibility and menu organisation (Figure 4). It can be seen though that a decreasing number of students award the mark 5 (excellent) although objectively the content and design of the website has not changed. This could be a hint that students' perception changes with time and that continuing improvement is needed to keep students' acceptance at a high level.

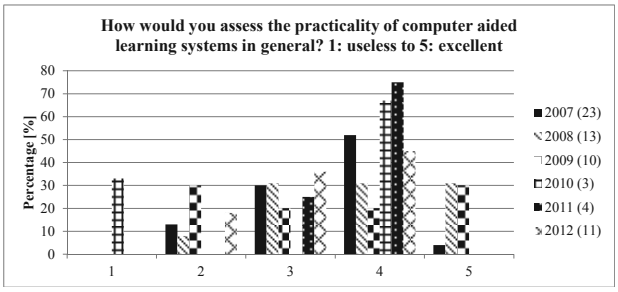

Figure 5: Development of the assessment of the practicality of computer aided learning systems over time. The number of answers is given in parentheses.

3 INNOVATIONS

Funding from an ETH Zürich Innovedum grant was received in August 2011, in order to upgrade the services offered by GEOTip for students from outside civil engineering, who study soil mechanics as a part of their course. Work began on a series of recorded lectures based on a set of mindmaps, which were designed to introduce basic concepts, and also on a series of recorded experiments, designed to explain to students and new staff members how each experiment works and how to use the equipment within the IGT laboratory. Work also began on revising and updating the script – a bilingual purpose written textbook, designed to take students through the course.

3.1 *Recorded lectures*

In order to reduce time burdens on professors and assistants, a series of online lectures, based on mindmaps and the online scripts have been created using a combination of voiceovers over moving images, taken using screengrab software, displaying the section of the mindmap, the script or the graphic being discussed. Each of the 7 lectures is between 1-3 hours long. Since fundamental but complex issues are covered, it is pieced together so that single sections may be used as stand-alone lectures in order to allow students to focus in on one issue rather than being side-tracked by confronting many topics at once. The main aim was to give students a method of learning basic concepts from geotechnical engineering at their own pace, and allowing them to revisit some of the more complex ideas as many times as required. "Jump points" embedded both into videos and corresponding mindmaps allow students to go straight to a chosen section and revisit the same section on multiple occasions.

3.2 *Online laboratories*

Online laboratories are recorded videos of an assistant performing many experiments (such as oedometer, Proctor and plastic index tests) used to produce one of a series of commonly-used engineering parameters.

The rationale behind the online laboratories was twofold – firstly it allows bachelors and masters students to learn how data that they will use throughout their career is produced, and what common inaccuracies and mistakes are. Secondly, it will allow project students and new members of staff to understand how to use the equipment in the laboratory, while reducing commitments for the laboratory manager and technician.

Within the recorded demonstrations explanations of how to perform the experiment, reasons why the experiment is done in a particular way, and common mistakes made are embedded. The demonstrations are not designed to be watched whole, but to be used as reference guides, with viewers skipping through sections and repeating other sections.

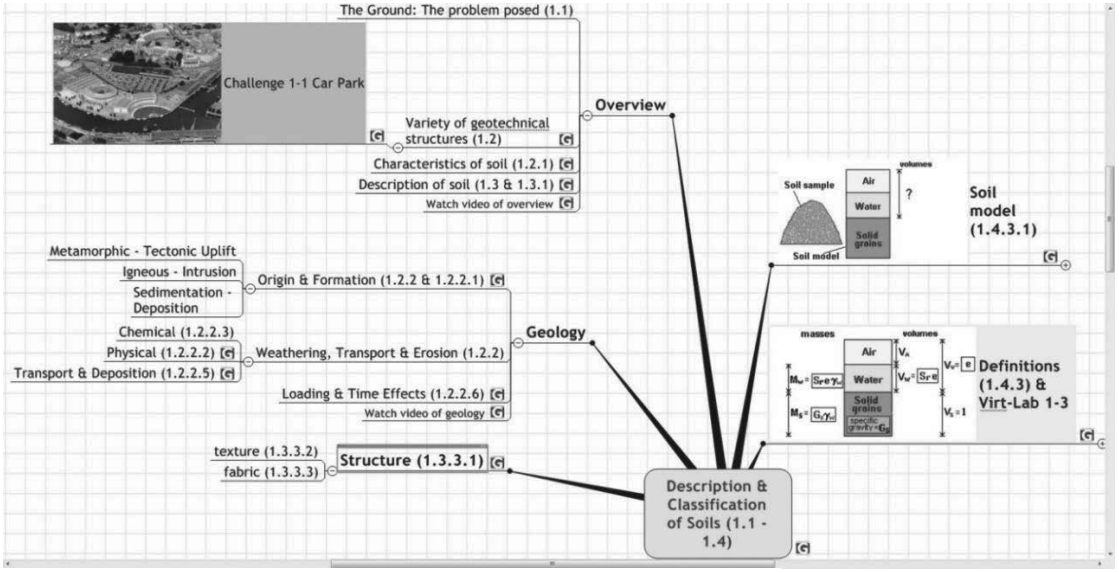

Figure 6: Part of a central mindmap, which forms the basis of courses taught using GEOTip.

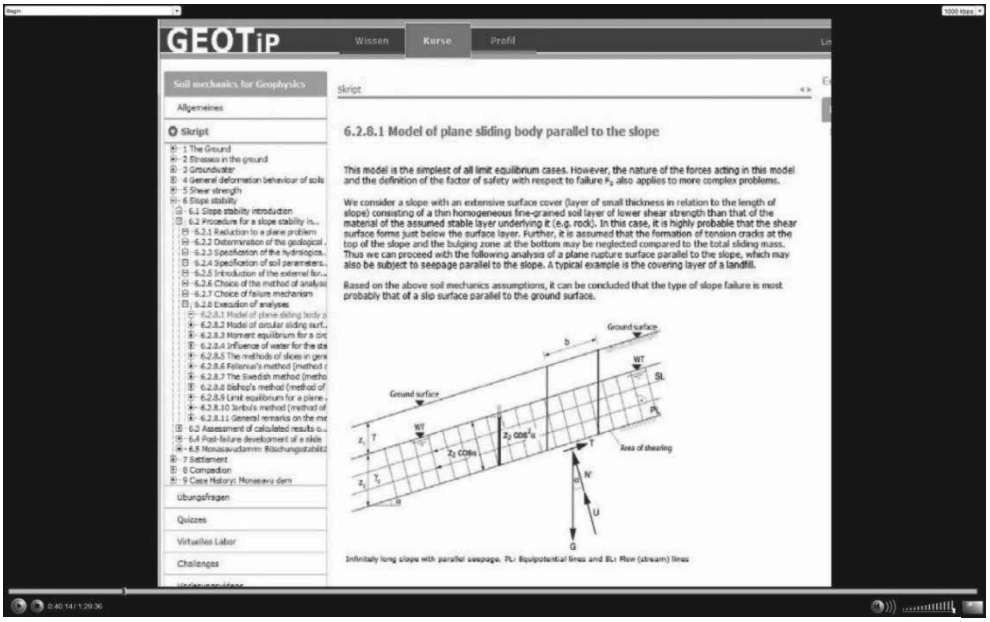

Figure 7: Still showing the purpose written script being used as the basis for a recorded lecture.

4 CONCLUSIONS

An online learning platform has been developed and evolved successfully to optimise teaching of the fundamentals of Geotechnical Engineering to bachelors and masters students. The site was developed using state of the art inhouse methods and freeware PHP and MySQL, allowing for constant regeneration and updating, and recent work has provided more base material in the form of lecture videos, vod-casts and on-line labs to allow students to learn at their own speed.

Evaluations have shown that GEOTip is well received by students, who are able to learn using one or more of the many didactic methods available (lectures, exercises, script, mindmaps), however responses are becoming less positive with time, showing the need for constant updating.

5 ACKNOWLEDGEMENTS

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