Design Centered Learning in China: Learning Skills and Mastering Concepts

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Abstract: Design Centered Learning (DCL) is a new and now well-proven revolutionary educational method, where the design of a solution for a problem is a central focus. It stimulates the student to develop the skills mentioned below, by working in a small team, where the skills brainstorming, project management, team interactivity, creativity and initiative are learned by doing. The project's topic has depth, societal relevance and invites to a multi-disciplinary approach. DCL has been developed in the Netherlands, with great success, and might be an excellent model to introduce in biomedical engineering teaching in China.

Introduction

Healthcare and healthcare industry in China is rapidly increasing in volume and complexity. The goal of biomedical engineering education is to develop an excellent student base. The general Chinese student is smart, hardworking, social, and their intake of knowledge is OK, but they are weak in problem-solving skills and confidence. There has been a traditional culture of rote learning[2] for centuries, but it now widely accepted that more conceptual learning, and learning by exercise, practice and derivation leads to deeper understanding[8]. A new range of *skills* are needed: the European Union in EAHE lists the following: self-learning, critical thinking, use of ICT[4], problem solving, technical communication and team work. CDIO, ABET and CEAB require disciplinary knowledge and reasoning, methods and tools, analytical reasoning and problem solving, multidisciplinary teaming, inquiry, listening and dialogue, engineering project finance and economics, and understanding needs[5]. Typically these skills are not part of the current curriculum. Students do acquire some of these skills in off-study activities, but it should be part of the curriculum, and substantial time should be made free for this. Mastering these problem-solving skills has been shown to have great positive effect on the quality, effectiveness and self-confidence of the student [8]. This however needs some serious change, both with the teaching staff, the time slots of the curriculum, even the layout of the building, and the students. The need for and realization of the change in teaching style may be the most important and urgent for the teaching staff[4]. The effects of rote learning (in second language learning) was studied in Taiwan by Xiaping Li (2006)[3]. He notes that Chinese learners stick to the tradition of rote learning, as being an integral part of their culture. It will take much time to bring about the change, which needs to be accompanied by appreciation of the new teaching style in wages appreciation, making time for it in the curriculum, get proper acknowledgment of the higher levels, quantitative feedback that it is effective from long-term teaching experiments, and a general Chinese appreciation.

There has also been a shift in the methods of assessment from one based almost solely on traditional assessment tools to ones that include both the traditional, mainly standardized exams, and new ones that seek to measure more than simply knowledge but competency, the ability to employ that knowledge. These trends are contained in both The Washington Accord dealing with international program accreditation and The Bologna Accord which provides an accreditation frame work for European Higher education.

This contribution is about the student's skills. The average student in China, when compared to average European or US students, is more reluctant, shyer, more obedient, and often lacks initiative or pro-activeness[9], see also Fig.1. Group discussions as part of the curriculum are relatively rare, while they are wide-spread everywhere in the Western academic world.

Nation-wide a realization is emerging that a didactic change is needed. Students are exposed to new methods, as Massive Open Online Courses (MOOCs), lectures by foreign experts, television and internet, and begin to ask for these innovations. Many students dream go abroad, to be exposed to new education and higher levels of science. They do not all return. China realizes the problem of the educational catching-up needed, and invests heavily in international scholarships, foreign experts, and is investing heavily in new campuses, equipment, and new buildings.

Fig. 1 A Foreign Student, Present among a Group of Chinese Students, Often Takes the Lead

Design Centered Learning for Biomedical Engineering at NEU

The Sino-Dutch School of Biomedical and Information Engineering (BMIE) of Northeastern University (NEU) in Shenyang, now over 600 students, was established in 2006 by 4 partners: Neusoft (Shenyang), Philips (Netherlands), Eindhoven University of Technology and NEU. It was decided to introduce DCL into the curriculum of BMIE from the beginning. Multiple DCL rooms have been allocated in the building. The results at BMIE over the last 5 years are very positive. Students learned to speak out better during class, developed project management skills, and were clearly more motivated for the research topics taught. It is now time to quantify this successful development, so it can be a template for further implementation of DCL in China. This quantification is best done in a collaborative setting between BME departments.

DCL Introduction and Experience at TU/e

Before the mid-nineties, all engineering education programs at TU/e consisted of traditional courses and lab practices. At that time, Maastricht University (MU, Netherlands) was showing quite some success with the Problem-Based Learning (PBL,[6]) method in their medical curriculum, and it was decided to gradually introduce components of this innovation into the classical curriculum of the Dept. of Mechanical Engineering at TU/e, in a few years leading to a completely revised curriculum (1995/1996) [2]. It was a mixture of courses with lectures and Design Centered Learning (DCL, an adapted version of PBL, which will be described below). The experience with this mixture of education entities was very positive.

Fig. 2 A DCL Group Discussion

DCL is a further evolution of the concept of Problem Based Learning, initiated at the Medical School of MU, and adopted and improved by TU/e into their curriculum. It was shown, by in-depth studies in the form of student and teacher's evaluations, that although students in the Maastricht PBL Medical Education program did acquire similar knowledge as students in a classical program, their problem solving skills are better. It was decided to adopt PBL at TU/e. It was carefully monitored, and in the first years, good prospects were shown, especially when considering the added working in groups (project work, so-called 'case studies'), dedicated tutorials, and directive teaching. However, when studying the cognitive effects of PBL, mixed results have been reported on the effectivity of PBL concerning basic knowledge acquisition [10]. It turned out that PBL had certain limitations, which makes it less suitable as an overall and generic strategy for engineering education. Therefore, PBL was changed into DCL. The main characteristics are:

PBL: Knowledge acquisition and integration, required to complete the case study. No need for lecture courses.

DCL: Integration of knowledge acquired in prior courses, with some additional knowledge required to complete the case study. So, for DCL a combination with lectures is required.

DCL overcomes the limitations of PBL for engineering education. It has been specifically adapted for technical and scientific education: students are taught and stimulated to cooperate and to actively work on cross-disciplinary design problems. DCL consists of motivating and relevant cases, and companion training sessions, not only for application of the acquired knowledge (practices, experimenting) and for the integration of engineering, sciences and the life sciences, but also for acquiring typical (biomedical) engineering skills as working in groups, communication, brainstorming, project management, being aware of ethical issues, etc.

The initial results at BMIE over the last 5 years are very positive. Students learned to speak out better during class, developed project management skills, and were clearly more motivated for the research topics taught. It is now time to quantify this successful development, so it can be a template for further implementation of DCL in China. This quantification is best done in a collaborative setting between BME departments.

Northeastern University and Southeastern University will collaborate, and carry out a stepwise introduction, and quantitative evaluation of DCL in their BME curriculum over the next 3 year period (2015-2018). Goal is to have measurable parameters to substantiate the introduction of DCL. DCL aims at the application of knowledge from various disciplines (usually from courses presented in the preceding semester) to solve problems relevant to the field of Biomedical Engineering. Solving the (biomedical) problems requires a thorough understanding of the topic and the capability to combine and integrate prior knowledge.

Initially, DCL only aimed at solving relevant BME problems. At a later stage, design was added to DCL: students were asked to reflect on "what steps are needed to come to the solution", and "what can one do with the outcome of the case". Moreover, greater depth had to be obtained. It became also clear that Design-Centered-Learning (DCL) in a BME environment specifically requires that the design component (creating value in accordance with predefined requirements and desires) should receive much attention. Therefore:

- Cases were doubled in duration.
- Cases were more systematically linked to the contents of preceding courses.
- To maintain unity between education and research the cases were explicitly linked to the research areas of the various divisions, and cases had to be altered to become more evenly distributed over the divisions when the divisions grew at different rates.
- Specific skills training sessions were introduced and/or expanded.
- Personal skills got more attention.
- More explicit attention was paid to ethics and science philosophy.
- Communicative and general scientific skills were educated in a more structural way. A matrix of skills is used to ensure the skills development in a logical and consistent way.

Main features of Design Centered Learning

- To become a mature student, capable of a contextual view of the presented knowledge, to understand how to innovate, learn from others, and to communicate the knowledge and the problem statement, a range of skills is needed, learning him/her to: integrate, to think multi-disciplinary, to create, to professionalize, to activate, and to be co-operative.
- The previous requirements led to the formulation of the didactic concept for Biomedical Engineering education: the acquisition of knowledge and the development of skills require different teaching entities: use both courses and DCL.
- Offer methods to apply recently acquired knowledge in a variety of ways; not only in DCL, but also in the courses.
- Integrate Biomedical Engineering and Sciences with Life Sciences.
- Integrate education and research.

Education is provided as courses (60%) and as Design Centered Learning (DCL; 40%), including lab practices. The two modalities contribute in a different way to the level of the Bachelor. Courses consist of lectures and guided self-tuition for conceptual and theoretical background. The courses comprise basic knowledge in all fields related to Biomedical Engineering: mathematics, the sciences, and the life sciences. Integration of the various disciplines (including life sciences) occurs whenever possible and appropriate.

Each course offers students support to apply the acquired knowledge; problems are being solved in Guided Self-Tuition sessions where the lecturer(s) and assistants are available to discuss the remaining obstacles and elaborate on the prior taught material to improve the level of understanding. The Guided Self-Tuition sessions follow after each oral lecture. Students work in small groups with a student-assistant or tutor at hand, but are also expected to study independently at home. This cycle of lecture, guided self-tuition, and self-tuition allows students to digest the material properly. Acquiring knowledge mainly occurs in the courses. The results are tested in written examinations. During the Bachelor's program, the goals gradually shift from the process of how to get to a solution (the case studies) towards the actual result / application (the projects). Parallel to this shift the number of students/group is reduced.

DCL Case Studies

DCL starts with case studies in the first 2 years with groups of 8 students. A case study presents a biomedical problem. To understand and solve the problem, the students have to analyze the problem, define their own goals within the framework of the case, and present a solution. They may have to perform experiments and computer simulations. The groups meet 2 times per week in the presence of the tutor. In case the students deviate too far from what is expected, their tutor will provide extra information to keep them in the right direction. The end products are evaluated in various ways: a (short) written report, an oral presentation, a measurement report, a research proposal, software, an extended abstract in English, a poster, and finally for several cases a presentation and a written report at the format of a publication. The quality of the end product is graded by the case coordinator, personal performance as a professional and attitude by the tutor. Peer review[7] is part of the evaluation.

DCL Projects

In the third year (interdisciplinary) projects are studied in groups of 4 students. In projects, emphasis is on the result. The group may also comprise students from other engineering departments, even from other universities. This results in awareness of differences between disciplines and adds to problem solving skills of the students. The Bachelor's program is concluded with skills labs for individual students or groups of 2 students. The projects are used by the students for orientation towards the Master tracks and research groups.

Learning Objectives of BMT Projects

The overall objective of the projects is to focus on (re)design and innovation, in order to solve (realistic) BME research problems. In the Bachelor program focus is on (re)design. To solve realistic and cross-disciplinary Biomedical Engineering problems, one needs to acquire and pass on old and new knowledge, combine theory and practice, integrate and apply cross-disciplinary knowledge and skills, and solve the problem by means of (re)designing a "system" [a prototype, a mathematical model, an experimental setup, a software program, a measurement procedure, an hypothesis, etc.].

Group work makes communication essential. They acquire considerable experience in management and group skills such as attending meetings, reporting, presenting, discussing, feedback, peer review, self-reflection, roles and tasks within a group, time planning, etc.

The students show their group's results in a plenary meeting t the end, where all groups present a short 5-minute presentation. This gives a highly competitive element. The presentation language can be chosen to be English, to mimic participation in an international conference event. A 2-head jury, chosen from the faculty staff, judges the presentations, and selects a winning team (with a small award and group picture taken for the Schools website). All members help to assemble the final presentation.

Role of the Tutor

The tutor is not leading the group meeting, participates at the round table, but holds away, and looks at the process from a distance. The students appoint a chairman, a secretary and a whiteboard writer at every session. The tutor will only intervene when the discussion blocks, if some new suggestions for directions may be needed, or if the students face any other difficulty.

Discipline, Peer Review and Grading

The attitude and discipline of the team members is best controlled by the group. Students are more direct than the tutor, and have a realistic feedback on someone's performance. Critique and praise are also more taken into account and appreciated when from direct colleagues. A peer review session, with the tutor passively participating, is held half-way the project, and at the end.

Summary

Design-centered learning is much appreciated by the students, which clearly acquired more personality skills in addition to the knowledge, and felt they broadened their horizons. Future discussions and experiments with DCL should be focused on the more traditional staff and existing school's regulations.

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