CHALLENGE BASED LEARNING IN AN APPLIED CELL BIOLOGY COURSE FOR BIOMEDICAL ENGINEERING STUDENTS

S. Gulce-Iz, PhD[1]
Researcher, BioInterface Science Group,
Biomedical Engineering Department, TUe

J. de Boer, PhD
Prof, BioInterface Science Group,
Biomedical Engineering Department, TUe

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ABSTRACT

Thanks to the technological revolution, university students in the 21st century no longer face the challenge of access to knowledge, but, rather, often lack the opportunity to apply their knowledge to the creation of innovative solutions to real-world problems. To bridge this gap, students need to be encouraged to engage actively in their own learning processes. One method of achieving this in engineering education is challenge-based learning (CBL).

We have introduced CBL into an Applied Cell Biology (ACB) course within the Biomedical Engineering curriculum at Eindhoven University of Technology, along with blended learning and research-based learning as innovative teaching-learning tools to stimulate active learning in students. The aim of the course is to help students respond to educational and professional demands by teaching them how to elevate their factual knowledge to the metacognitive level, thereby finding innovative solutions for real-world scientific problems where fibrosis was introduced as a cellular biomedical challenge. In the course set up, as higher order thinking teaching-learning tools were used, the assignments were also designed according to asses student learning in different aspects where group projects, reports, peer review, peer grading and debating were introduced.

This paper describes the ACB course set up from the perspective of CBL, blended learning and research based learning along with the corresponding assessment plan. In addition, building on the results of the evaluation after the first run of ACB this year, a series of adjustments proposed which will be introduced in next year's course design will also be discussed.

[1] *Corresponding Author*
S. Gulce-Iz
s.gulce.iz@tue.nl

1 INTRODUCTION

An Applied Cell Biology (ACB) course within a Biomedical Engineering curricula needs to combine teaching and learning methods relevant for both multidisciplinary and interdisciplinary research to solve complex biological problems. As a multidisciplinary and interdisciplinary approach Challenge based learning (CBL) and research based learning (RBL) are used to encourage active learning and stimulation of higher order metacognitive levels as defined in Bloom's taxonomy in ACB course set up. In addition, online educational tools like blended learning and online experimental design tools are implemented along with formative and summative assessments for learning which were able to asses higher order student learning.

1.1 General Course Set Up

The main objective of the ACB course is to learn how to acquire advanced cell biology related knowledge and use it to solve clinical biomedical engineering challenges. For this purpose, in the first three weeks, blended learning and CBL were used. In blended learning, factual knowledge about fibrosis is given by online video lectures along with face to face inspiring lectures and expert lectures. In CBL, students worked in groups of six which are guided by tutors to find innovative cellular experimental designs to overcome fibrosis and they prepared recorded video presentations as an assignment. In the following three weeks, students conducted hands on experiments related to fibrosis in the laboratory, analyzed their data and create laboratory reports as groups. In the final two weeks, students debated on a given fibrosis statement in front of three referees with logical arguments to reflect their learning within the same groups and about the same CBL subject. A final exam composing of multiple choice and open ended questions were conducted to assess their factual knowledge about fibrosis to give individual grades.

1.2 Challenge Based Learning (CBL)

CBL can be defined basically as to find a solution for an unmet need. CBL is an efficient and effective framework for learning while solving real-world 'Challenges' which are provided as 'Big Ideas'. After the definition of a Big Idea, CBL offers a collaborative and hands-on framework consisting of three different concepts termed as Engagement, Investigation and Implementation. In engagement, all participants are asked (students, lecturers, experts…) to identify essential questions to personalize the Big Idea. In investigation, essential questions creates an organized learning experience providing relevant tools to create solutions. In implementation, after the definition of solutions, using the design cycle, learners will prototype, test and refine their solution concepts. Evaluation that provides the effectiveness of the solution is introduced as a final part of implementation [1].

In the ACB course, 'Fibrosis' was introduced as a 'Big Idea', and five different cases of fibrosis were defined along with essential questions to let students engage into the topics. In investigation, students defined different molecular pathways which trigger fibrosis formation and, they selected a target in one of these pathways to solve the fibrosis problem. For implementation, they formulated a research question and designed a cell biological experiment with proper controls. Student used the online experiment design tool Labbuddy to design their fibrosis experiments. Labbuddy has a custom design structure which allows students to select from an assay library and also allows them to add custom assays to their fibrosis experimental design.

1.3 Research Based Learning

Research based learning is an inevitable part of experimental sciences. Research based learning in ACB course compromises both experimental design and hands on practical laboratory work. The high number of students enrolled in engineering programmes makes it difficult to conduct extensive hands-on practical work. However, designing an experimental set up using online virtual laboratories are offering solutions for the high number of students.

In the ACB course set up, we used the online experimental design tool Labbuddy. In Labbuddy, two different experimental set ups were implemented. The first setting was 'in silico experimental design' where students developed a cell biological experiment to solve cellular fibrosis problem. Mainly, there were a range of biological assays where the basics of the assays were explained. Students either chose from these assays or they added custom assays by themselves with relevant controls. The second setting were called 'wet lab experimental design' where the real experiment which they would practice in the laboratory, i.e. the fibroblast to myofibroblast differentiation assay, was implemented. Students were asked to align each experimental step in the correct order to be able to enter the laboratory and do the real experiment.

In ACB, the real laboratory practice were not replaced completely by Labbuddy however the wet lab experimental design is simulated in Labbuddy from the first step to the end. Due to the high number of students they worked in groups in the laboratory. However, Labbuddy enabled them to work individually before entering the laboratory and master each step by themselves.

1.4 Assessment Tools

All the teaching-learning approaches are carefully implemented in the ACB course set up to meet the learning objectives of the course with relevant teaching material, teaching approach and assessment plan. That is why all these components have a unique assignment to ensure to measure student learning in a corresponding cognitive level of learning. And the grades corresponding to all these four assignments weighted meaningfully on the final grade. In ACB, recorded video presentation, experimental report, final exam, peer and tutor review for the CBL sessions and debating grades were given.

2 METHODOLOGY

2.1 CBL as a strategic learning methodology

Learning outcomes of the ACB course were developed regarding to higher order learning skills in Blooms taxonomy. After that, Dale Edgar's 'Cone of Learning Pyramid' considered to select the active enrollment learning activities for students to make them remember the most they learned. At the final step corresponding assessment tools to evaluate the higher order cognitive skills were chosen [2]. Thus, learning outcomes, teaching-learning activities and assessment tools are constructively aligned for the ACB course set up.

Amongst the three most common active teaching-learning methodologies, Design Based Learning (DBL), Problem Based Learning (PBL) and Challenge Based Learning (CBL), CBL was chosen to be implemented in ACB. In CBL, students, tutors and experts have more freedom to find an innovative solution for a societal problem while having more ownership. 96 students were enrolled the course, students chose their CBL cases by assigning themselves to a specific group. 16 groups of 6 students were assigned to 5 different CBL sub topics (Table 1).

Table 1. Big idea and related sub topics in CBL set up

Big Idea	Fibrosis	Fibrosis	Fibrosis	Fibrosis	Fibrosis
Sub Topics	Extracellular Matrix as a driver of fibrosis	Lung Fibrosis	Kidney Fibrosis	Ocular Fibrosis	Traet of Trigger Fibrosis
Student Enrollment	12 students (2 groups)	24 students (4 groups)	24 students (4 groups)	12 students (2 groups)	24 students (4 groups)

Tutors were recruited as experts from PhD students and Post-Docs working on related fibrosis topics . Each group had bi-weekly meetings with the tutor for the first three weeks. Tutors provided the guidance questions to the students in the first meeting, they gave feedback on the mind map that students prepared about the signaling pathways related to their specific fibrosis cases. Students chose a specific molecule on the pathway to target as a therapeutic strategy and build on their experimental design based on this target. As an assignment they prepared a recorded video presentation to present their innovative experimental design as a solution. Students also gave peer feedback during the CBL sessions which is a part of CBL grading along with tutor grades and lecturer grades.

2.2 The Coherence of the Fibrosis Case Throughout the ACB Course

At weeks 1,2 and 3, students were studied in CBL setting. Students got online learning material about Fibrosis, expert sessions, tutor guided discussions about Fibrosis. As an assignment, they delivered a recorded video presentation as a group. At weeks 4, 5 and 6 students focused on research based learning where they designed the flow chart of fibroblast to myofibroblast transition assay using Labbuddy (online customized experimental design tool) and learned an image analyzing tool then they conducted the experiment hands on in the lab and analyzed their images. At week 7 they debated about fibrosis related statements in the same CBL groups and CBL topics in front of three different referees.

Thus the fibrosis topic which were chosen in CBL setting were used as a topic of different teaching-learning methods throughout the course. This also enabled students to work on the same subject in different aspects and gain higher order meta cognitive skills. In Figure 1, the Applied Cell Biology Teaching-Learning Methods and Assignments in Line with Dale Edgar's Cone of Learning is demonstrated.

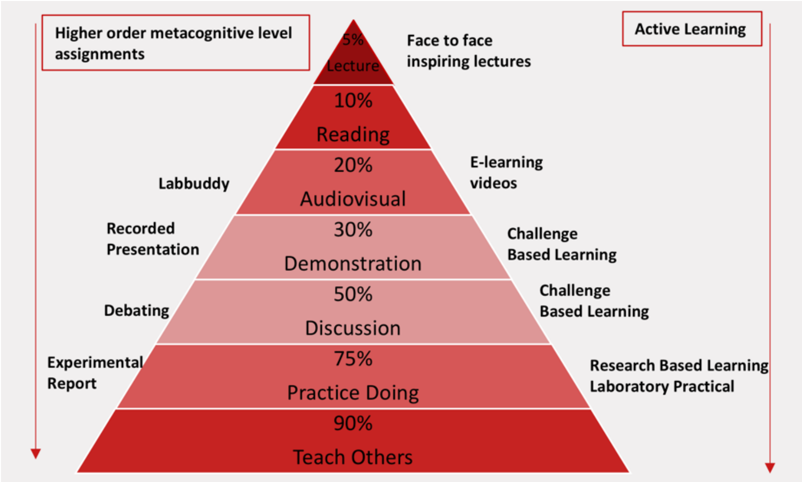

Figure 1. Applied Cell Biology Teaching-Learning Methods and Assignments in Line with Dale Edgar's Cone of Learning

3 RESULTS

3.1 Focus Group Student Meeting

A focus group meeting was organized with five volunteered students to discuss their experience with the first run of ACB course. Students were asked questions about general course set up, course material and administration. The students gave a 6.5 as an average grade for the course but stated that it has a potential to go 8.5.
About general course set up, they mainly like the building blocks of the course, challenge based learning (8), research based learning (8), debating (7.5), online lectures (7.5). Students stated that fibrosis challenge was a good topic to tackle. They appreciate the hands on laboratory work related to fibrosis experiment. They liked using Labbuddy for designing the experiments. They liked debating as a learning tool as they can reflect their ideas more in depth. However, they stated that the debating skills lecture needs to have examples of scientific arguments and scientific debating rather than political.
About course materials, they appreciate the content of e-lectures about fibrosis related topics. However, they stated that Canvas page set up and Labbuddy program set up needs to be communicated in a better way with the students. About course workload, they stated that the workload of this 5 ECTS course felt that higher than other similar courses. However, 5 ECTS corresponds to 140h (28hx5) student workload, and our calculated ACB student workload was 120+/-10 h. For this calculation, each component including face to face lectures, tutor guided meetings, e-lectures, self-study hours (both for the lectures and examinations) were considered.
Due to the first run of the course there were some unforeseen problems to tackle during execuation. However, the course execution and management plan will be implemented to run the course smoothly for next year by using the students' feedback.

4 SUMMARY AND ACKNOWLEDGMENTS

Biomedical engineering is an inherently interdisciplinary field composing of different engineering and biological sciences disciplines. The ACB course designed here fulfilled the gap between factual knowledge to applied knowledge as means of using existing knowledge, acquired data and create solutions within Biomedical

Engineering Curricula at TUe which is in line with university's educational vision 2030. Students engaged actively to the CBL topic, gain in-depth subject area knowledge, develop 21st century skills like effectively working in teams, ability to provide meaningful feedback and share their thoughts with society.

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