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Author(s)	Curran, Thomas P.; Doyle, Colleen; Cummins, Enda; McDonnell, Kevin; Holden, Nicholas M.
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AC 2010-1876: ENHANCING THE FIRST YEAR LEARNING EXPERIENCE FOR BIOSYSTEMS ENGINEERING STUDENTS AT UNIVERSITY COLLEGE DUBLIN

Thomas Curran, University College Dublin
Lecturer, Biosystems Engineering, UCD School of Agriculture, Food Science and Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland.

Colleen Doyle, University College Dublin
Student Adviser, UCD College of Engineering, Mathematical & Physical Sciences, University College Dublin, Belfield, Dublin 4, Ireland.

Enda Cummins, University College Dublin
Lecturer, Biosystems Engineering, UCD School of Agriculture, Food Science and Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland.

Kevin McDonnell, University College Dublin
Lecturer, Biosystems Engineering, UCD School of Agriculture, Food Science and Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland.

Nicholas Holden, University College Dublin
Associate Professor, Biosystems Engineering, UCD School of Agriculture, Food Science and Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland.

Enhancing the first year learning experience for Biosystems Engineering students in University College Dublin

Abstract

This paper outlines the development of a problem-based learning module called the Biosystems Engineering Design Challenge. The focus of the module is on designing and building a working, bench-scale device that solves a practical problem relevant to Biosystems Engineering. It provides an early opportunity for students to learn about engineering design, project management and teamwork. The module aligns well with the academic policy of University College Dublin to introduce alternative teaching and learning strategies compared to the conventional lecture.

While the original aim of the module was to enhance the learning experience specifically for Biosystems Engineering students, it was considered beneficial to adopt a multi-disciplinary approach by allowing students from a wide variety of programs to participate. Students are split into teams and meet an assigned mentor each week during a 12-week semester to solve a specified problem with several design constraints. The projects thus far have focused on flood barrier construction, water-driven electricity generation, treatment of gray water from domestic buildings, and biofiltration of malodors from food waste.

The student groups are formed in the first week when they meet their mentors and learn about the technical design constraints of the project and tips for good teamwork and time management. The second week provides a focus for literature research followed by brainstorming and evaluation of the key design solutions. A self-assessment is made of the teamwork in the sixth week and more guidance is provided on the requirements for the compilation of reports and posters. Weeks eight to ten focus on device assembly while technical performance is evaluated in the penultimate session. A panel of external technical experts visit the University in the final week to meet the students, mentors and faculty and to view a display of the devices and accompanying posters in the main Engineering building. The assessment criteria include teamwork, minimization of expenditure, device design, innovation, operational safety, system performance, project journal submission, report writing, poster presentation and appropriate use of biological and recycled materials. Prizes are awarded to the top teams. Students receive individual academic grades based on their contribution following a review by mentors and faculty at the end of the semester. Mentor assessment of students concentrates on meeting attendance, task completion and participation in the team.

Student feedback has been very positive. They like a "hands-on" approach to learning while solving problems within a team environment. Awards for the recognition of teaching excellence have been received from UCD College of Life Sciences and from the American Society for Engineering Education.

Introduction

The Agricultural and Food Engineering degree program at University College Dublin was rebranded as Biosystems Engineering six years ago to reflect the wide scope of research and academic activity within the discipline and particularly its relationship with biology and life sciences. The move was also compatible with international trends towards "bio" engineering titles, especially in North America. It was considered that the new title for the undergraduate program offered the opportunity to integrate engineering and biology in a more explicit manner.

After the successful outcome of an initial design competition[1,3] to coincide with the retitled program name, it was considered timely to introduce a new academic module with a similar format called "Biosystems Engineering Design Challenge". It was decided that the focus should be on designing and building a working bench-scale device that solves a practical engineering problem relevant to Biosystems Engineering and it should provide an early opportunity for students to learn about engineering design, project management and teamwork in an environment that is both rewarding and enjoyable.

The module aligned well with the developing academic policy of University College Dublin to introduce alternative teaching and learning strategies compared to the conventional lecture. The introduction of semesterization and modularization in all courses at that time also facilitated the launch of this new module.

Module themes and outcomes

The main objective of the module has been based on environmental themes, which rotate each year. The broad aims thus far have been to design, build and operate a bench-scale device to:

- Treat gray water from domestic buildings
- Provide electricity using a water-driven generator
- Treat malodorous air from food waste
- Protect against flooding

For example, the most recent running of the module in a 12-week semester involved the design, construction and operation of a bench-scale device to treat gray water from domestic dwellings.

On completion of the module, students should be able to:

- Describe the principles of engineering design, time management and teamwork.
- Solve a practical engineering problem.
- Locate materials, construct and operate a working bench-scale device.
- Use effective communication skills in writing a group report and presenting a poster.

Learning activity

While the module is compulsory for first year Biosystems Engineering students, it is a very popular elective choice among other disciplines, particularly within Engineering. The intake of students has increased from 23 in year one to 56 per semester in the sixth year due to the growing demand.

In week one of the semester, a description is given by the module co-ordinator on the technical aspects of the module along with a presentation from the Engineering student advisor on time management and teamwork. This is the only module in the University where a support staff member is involved directly with teaching and learning. Seven students are allocated to each team. The students are requested to select a team name and appoint a leader as early as possible. Efforts are made to ensure that there is a good distribution of students from various disciplines within each team. This policy is in line with a recommendation for a multi-disciplinary approach from a course accreditation visit by Engineers Ireland. Feedback from students suggest that team size should be smaller; however, the administration of student enrollment is quite difficult especially in the first few weeks of the semester when students have an opportunity to change registration.

A graduate student from Biosystems Engineering is provided as a mentor to each team to facilitate a one-hour meeting each week. The mentors meet the module co-ordinator before meeting their teams to ensure a clear understanding of their responsibilities during the semester including the assessment of student performance. The role of the mentors is not to provide specific technical guidance but to advise according to a timetable of activities (Table 1). A discussion is held with the module co-ordinator in the second week on developing information research skills in order to find reliable and useful documents for the project. The next few weeks are spent on compiling the relevant information and developing a small number of alternative designs. Students must also consider the scale-up of the design for a specific situation, e.g. a gray water treatment system for a typical suburban house.

Materials are located and assembled thereafter, followed by device testing (e.g. reduction of Chemical Oxygen Demand in two liters of artificial gray water) in the penultimate week of the semester. The maximum dimensions allowed for the bench scale device are 1000 mm long x 500 mm wide x 500 mm high. The device should weigh less than 10 kg. A poster and project report must be submitted in the final week. Devices and posters are then displayed in the foyer of the main Engineering building on campus. A panel of external experts meet the students and their mentors and assess the devices, reports and posters, after which the top teams are awarded cash prizes. Students are also reimbursed up to a maximum of 50 euro for expenditure on materials for each team. All expenses are sponsored by a leading waste management company.

Table 1. Timetable of activities

Week No.	**Milestones to Be Met**
1	Initial meeting, start team formation
2	Information skills seminar
3	Define problem; Brainstorming for alternative designs
4	Development of alternatives completed
5	Critique alternatives, select final design
6/7	Report/poster outline. Parts sourced, construction plan made
8	Start assembly of prototype
9	Prototype ready
10	Final changes made to assembled unit
11	Performance testing of device
12	Report and poster submitted. Device display, judging by external experts & prize announcements.

In order to track the learning process and to record the activities on an ongoing basis, each student must submit an online project journal each week. A journal template tailored to each week on the semester timeline is provided to students. An example of a project journal is shown in Figure 1 where the student is required to input the most relevant information sources found for the project in week 2. A recent initiative was the introduction of personality profiling[3] which is completed by each student in an online survey. The results from the profile are evaluated by the students and entered in their project journals in week 1, the idea being that this will help them understand how they can contribute best to their team during the semester. Students must also assess what aspects of the module (e.g. teamwork) they may find challenging. The final project journal is submitted based on the reflections of the student on the overall learning experience in the module. While most project journal entries tend to be brief and to the point, the final reflection usually draws very comprehensive and thoughtful replies.

Biosystems Engineering Design Challenge
Week 2 – Literature Research

Date:____________________

Student Name………….

Our Team Name is………….

List the relevant information sources you have found for the Biosystems Engineering Design Challenge

- Scientific Journal Paper 1………….
- Scientific Journal Paper 2…………
- Scientific Journal Paper 3………….
- Textbook………….
- High Quality Web Site………….

Figure 1. Project journal template for week 2

The module co-ordinator meets all the students for the third time in week 6, where a discussion is held regarding the outline of the project report and poster. The group dynamic is also evaluated in each team using Table 2 and suggestions are sought if improvements are required. However, this process does not form part of the formal assessment. It is merely a support tool. The teams tend not to be very critical of themselves at this point. This may be because there is quite a lot of work still to be done and it has not become clear if there are students who are not participating fully in the team activities.

Table 2. Evaluation of teamwork

Symptoms of Internal Meeting Problems	**Usually**	**Sometimes**	**Hardly Ever**
Team meetings generally begin 5-15 minutes late			
Members often arrive late, leave early, or never even show up for the meetings.			
One or two members monopolise discussion throughout the meeting.			
Members have not performed the necessary background research, or done what they were expected to do. Consequently, individuals are poorly prepared for meetings.			
With words or by appearance, some members clearly convey that they would rather be elsewhere			
Issues never get resolved, only put on the back burner until next time.			
No follow-up action plan is developed. Members are confused with regard to what the next step is and who is responsible for performing it.			
The same individual or individuals end up doing the majority of the work. The meetings run on and on with little to show for the time spent on them			
Tasks are not completed on time or are completed poorly.			

Assessment

The assessment criteria are shown in Table 3. The most important parameters are teamwork (based on mentor feedback), device performance and final report. The poster, project journal and overall device design are next. Teams must also take into account the safety of the design, innovation, and use of biological and recycled materials. The projects must also be kept within the allocated budgets; this is never a problem because of the incentive to use recycled materials wherever possible.

Table 3. Assessment criteria

Criterion Number	Description	Comment	Marks available
1	Teamwork	Based on assessment by judges & mentors. Weekly meeting attendance is critical.	15
2	Device performance	Chemical Oxygen Demand/odour reduction/electricity generation/water retention by device	15
3	Final Report	Including minutes of team meetings, outline of concept to implementation phases, photos of building and testing, device design calculations, full scale design, itemised lists of costs and receipts	15
4	Project journal	Completeness and submission by weekly deadline	10
5	Poster	Clarity and succinctness; ability to communicate	10
6	Overall device design	Final finish on device, ease of operation, durability, easy to carry & assemble	10
7	Safety	Safe to use	5
8	Innovation	Novel concepts	5
10	Biological materials	Use of biomaterials	5
11	Environmentally friendly	Use of recycled materials, low energy input	5
13	Expenditure	Cost of materials within budget	5
Total			100

The module co-ordinating committee (faculty and student advisor) meet with the mentors at the end of the semester to determine the individual student academic grades which are adjusted from the team average based on the mentor's evaluation of their contribution[6] (Table 4). The grade is further modified by the number of project journals submitted during the semester. The grade review meeting is very beneficial because it gives an opportunity to check that there is a reasonable approach taken to assessment across the various teams and individual students. Suggestions are also made regarding improvements that can be made to enhance the learning experience. This has ensured that modifications have been made on a regular basis.

Table 4. Mentor evaluation of students in a team[6]

Student name	Q. 1. Meeting attendance	Q. 2. Work before meetings	Q. 3. Do team tasks	Q. 4. Informed team if absent	Q. 5. Contributed in meetings	Q. 6. Listened to team mates	Average score out of 5 from Q 1-6	Draft grade from mentor (NG to A+)
Average								

Figure 2 shows the 2008/2009 winners of the prize for the top team in the module along with their bench-scale device and poster. They designed a biological filter to treat malodorous air from food waste.

Figure 2. The 2008/2009 winners of the Biosystems Engineering Design Challenge

Student feedback

Students enrolled in the Biosystems Engineering Design Challenge (BEDC) for the first semester of the 2009/2010 academic year were surveyed about their experiences during, and motivations for, the module. The survey was conducted on-line at surveymonkey.com

Twenty one students out of fifty three (40% response rate) completed evaluation forms. Of those who completed the survey:

- 17 were Engineering degree students
- One was an Agriculture degree student
- One was a Science degree students
- Two studied other programs (Social Science and Physiotherapy)

Of these students, 11 were in Stage 1, five were Stage 2 and five were Stage 3. The module is open to non-freshman students as an elective. Stage 1 students tend to do better when there are more mature students in the team.

Students were asked to scale their reasons for taking the module and their assessment on aspects of teaching and learning. A number was assigned to each point of the scale (1 = strongly disagree to 7 = strongly agree). A mid range score would be 4 (neither disagree or agree). The average scores for Semester 1 2009/2010 are shown in Table 5 alongside Semester 2 2008/2009 results.

Table 5. Student evaluation of the module

Survey section/question (Scale: 1 = strongly disagree to 7 = strongly agree)	**Semester 1 2009/2010**	**Semester 2 2008/2009**
Reasons for selecting the module		
It sounded interesting	5.8	6.2
I like a challenge	5.6	5.7
I like a hands-on approach to learning	6.1	6.1
I like working in teams	5.5	5.5
I prefer project work rather than lectures	5.6	6.2
I wanted to win a prize	4.0	5.1
How well did the module achieve the specified learning outcomes?		
Describe the principles of engineering design, time management and teamwork	5.1	5.1
Solve a practical engineering problem	5.2	5.6
Locate materials, construct and operate a working bench-scale device	5.1	5.6
Use effective communication skills in writing a group report and presenting a poster	5.1	5.3
Scale the usefulness of elements used in the teaching and assessment of the module		
Initial group session on technical information and teamwork	4.6	4.9
Initial guideline documents	4.9	5.5
Library information skills session	3.3	3.2
Information on Blackboard online	4.7	5.9
Mentoring system	5.8	3.9
Online project journal	5.1	4.6
On-line personality test (new in semester 1 2009/2010):	3.4	-

Students were asked to write “any other reasons for selecting this module”. Six students wrote comments in this section. Comments included:

- ‘It fitted in my timetable’
- ‘I was not interested in anything else’
- ‘I preferred to be assessed on a project rather than an exam’
- ‘It was relevant to my course’
- ‘No final exam will take a load off at the end’
- ‘It was a topic in my "in program" electives’

Discussion

It is considered that students taking the Biosystems Engineering Design Challenge learn many transferable skills as group problem-solving has emerged as an important aspect of management strategy in many organisations around the world[7]. Generally, participating students have positive experiences. They take the module because they are interested in hands-on practical course work and are attracted to a module that does not include an end-of-semester exam. These findings are in line with a Purdue University study that found that the best way to get students interested in engineering and technology may be to focus less on textbooks and more on interactive, problem-solving design projects[5].

Many of the survey scores decreased from Semester 2 2008/09 to Semester 1 2009/10. This may have occurred due to the change in the mix of students taking the module; more mature students take the course in Semester 1. Although responses to the on-line personality test were mostly positive, students were less positive about its usefulness according to the evaluation. This may mean that they do not see the link between how they work in teams and completing the challenge.

In the early years of running the module, there was a tendency for students to use the internet as the main source of information. Consequently, a library information skills session was introduced to highlight the importance of using reliable references when finding solutions to problems. However, students do not consider the exercise as particularly useful although they are required to find three journal articles, one text book and one high quality web site relevant to the project.

Mentoring received a substantial increase in votes for usefulness. This may reflect the fact that several of the mentors have now participated in the BEDC on more than one occasion. Students may also have a better understanding of the role of mentors in the project. The experience to date would suggest that assessment appears to be one of the most controversial concerns in problem-based learning[8]. While the mentors receive guidance from the module co-ordinator on their responsibilities during the semester, there is scope for more formal training to take place, particularly regarding assessment. The incorporation of teamwork exercises for students at the start of the module may also be beneficial.

Apart from student evaluation, the module has received other positive feedback from both inside and outside the University. Awards for the recognition of teaching excellence have been received from UCD College of Life Sciences and from the American Society for Engineering Education.

Most students appear to do well because they are highly motivated. It is well established that students learn well from their peers also. However, there is a risk that some students try to take advantage of a team environment in the hope of being supported by more capable individuals. Participating students are encouraged to develop their research skills in the module, so it is not surprising that many of them subsequently pursue graduate study. A team from the 2005/06 academic year co-authored a paper which finished runner-up in an international competition[4].

Conclusions

The Biosystems Engineering Design Challenge was introduced as an academic module open to a diverse range of students at University College Dublin. The module has promoted a rewarding and enjoyable learning experience for students with positive feedback received. Participants take the module because they like a "hands-on" approach to learning and solving problems in teams. Feedback was less positive about the online personality test and information skills session. Students appreciate the role graduate students play as mentors in supporting and facilitating the learning experience. Further developments could include the incorporation of teamwork exercises and more formal training of mentors.

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Bibliography

1. Ahlstrom, D. 2005. Keeping a close watch on that water. The Irish Times, Dublin, Ireland, January 28.
2. Buchanan, T. 2009. Five Factor Personality Test. http://www2.wmin.ac.uk/~buchant/wwwffi/
3. Curran, T. P., C. Blaney, E. J. Cummins, N. M. Holden, and K. P. McDonnell. 2007. The Biosystems Engineering Design Challenge at University College Dublin. ASABE Annual International Meeting, June 17-20, 2007, Minneapolis. USA. Paper 078037.
4. Delahunty, D., T. Delaney, G. Kennedy, N. Lacey, C. McNestry, T. O'Connell, D. O'Hanlon, J. Spollen. 2006. Integrating Engineering and Biology – The Final Frontier. UNACOMA Vision Award, EurAgEng/CIGR conference, Bonn, Germany, Sept 6, 2006.
5. Medaris, K. 2009. Hands-on Projects May be Best Way to Teach Engineering and Technology Concepts. Imperial Valley News. Yuma, Arizona, USA. 28 January 2009.
6. Oakley, B., R. M. Felder, R. Brent, and I. Elhajj. 2004. Turning student groups into effective teams. Journal of Student Centered Learning 2(1): 9-34.
7. Robson, M. 2002. Problem-Solving in Groups (3rd Ed.). Gower, Aldershot, UK.
8. Savin-Baden, M. 2004. Understanding the impact of assessment on students in problem-based learning. Innovations in Education and Teaching International 41(2): 223-233.