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Integrating industrial seminars within a graduate engineering programme

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The benefit of external, often industry-based, speakers for a seminar series associated with both undergraduate and graduate programmes is relatively unchallenged. However, the means by which such a seminar series can be encapsulated within a structured learning module, and the appropriate design of an accompanying assessment methodology, is not so obvious. This paper examines how such a learning module can be formulated and addresses the main issues involved in the design of such a module, namely the selection of speakers, format of seminars, method of delivery and assessment methodology, informed by the objectives of the module.

Keywords: industry seminars; multiple choice questions; graduate education; e-learning; renewable energy

1. Introduction

For professional programmes, including programmes in engineering, medicine, law, etc., it is vital that students are exposed to the working aspect of their chosen profession, so that they can place the education content they receive in their undergraduate and graduate programmes in a professional context. In addition, it is also the responsibility of educators to ensure that this professional exposure is absorbed and, traditionally, the only method to ensure this is the association of assessment with such professionally oriented activities.

In particular, the US-bases Accreditation Board for Engineering and Technology (ABET 2011) stresses the need to prepare students for engineering practice, while Engineers Ireland (a member of the European Federation of National Engineering Associations) (Engineers Ireland 2007) emphasise the need to be familiar with general engineering practice and with the particular practices of their discipline. Typically, there is a requirement that such profession-oriented components are guaranteed as learning outcomes through the use of appropriate assessment methodologies, in order for professional engineering programmes to be accredited.

Within the general discipline of engineering, educators have long realised the value of incorporating industry-relevant content within both undergraduate and graduate degree programmes (Sobol 1990). Traditionally, it has been used to inform instructors and students of industrial

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needs (Beckman et al. 1997) and to provide a window into the real world of engineering industry as a motivational tool. The use of industry seminars within engineering programmes can be summarised as:

- Use as a motivational tool to bring academic subjects to life and show their application in practice.
- Coverage of a number of technical topics not covered elsewhere within the engineering programme.
- Helping to bring an element of the (industrial) state-of-the-art to an engineering programme in a rapidly developing discipline.
- An integrative tool in showing the synergies and inter-relationships between diverse engineering topics.

However, for the bulk of the aforementioned uses, the seminar is used an as information dissemination tool and while attendance may be mandatory and recorded, formal assessment of the seminar material is seldom used.

In this paper, the possibility of using seminars in a more formal educational mode is examined. Consistent with the educational programme and target student body (full-time and part-time masters students) for which the seminar series is run, there are constraints on the variety of in-class and electronic learning modalities which can be accommodated with similar constraints on the assessment methodologies which can be employed. Nevertheless, it is important to engage with the reflective consideration promoted by Ramsden (2003) in trying to optimise the student's experience and alignment between educational goals in the design of a new educational module, even within strict constraints. However, it is also true to say that much of this reflection has a greater value with the benefit of some experience, particularly with new teaching/assessment combinations. Some of these *a posteriori* reflections are documented in Section 5. We note, however, that it is not the objective of the seminar series to give students explicit practice of problem solving, but rather that they be exposed to examples of professional real-world problem solving in action and this would provide some inspiration for the application of such skills in the accompanying technical modules within their engineering programme.

2. Programme and subject context

2.1. *The Master of Engineering in Renewable Energy Systems*

Ireland has a poor indigenous supply of fossil fuels and is negatively disposed towards nuclear energy, but is endowed with an abundance of renewable energy sources, particularly wind and wave and, to a lesser extent, tidal energy. Ireland's agricultural fertility also gives considerable potential to the development of biomass and biofuels, albeit in competition with the use of agricultural land for food production. This opportunity has led to an aspiration to be one of the leading countries in Europe in the use of renewable energy for electricity production (Irish Government 2007) and Ireland currently has the distinction of having the highest wind energy penetration of any island utility, which brings its own set of new technological problems (Eriksen et al. 2005). As a result, there is a need to produce engineers who are competent in specific renewable energy technologies, as well as having some understanding of how such technologies can be combined and integrated into an electricity grid with a variety of generation sources. In addition, some appreciation of the regulatory and market frameworks, required to facilitate efficient operation of the deregulated electricity supply system, is necessary. To this end, a number of education offerings at undergraduate and graduate level have appeared over the past decade (Bhatttacharya 2001), including the Master of Engineering (ME) in Renewable Energy Systems (RES) at NUI,

Maynooth. This programme is certified under the Higher Education Authority Graduate Skills Conversion Programme, which aims to promote graduate programmes of strategic national value, where the intake can be from a range of undergraduate routes. In line with this 'conversion' ethos, the ME-RES accepts application from students with an undergraduate degree in a numerate discipline, ideally engineering or applied physics. The ME-RES programme, equivalent to 90 European Credit Transfer and Accumulation System (ECTS) credits (European Commission 2009), is run over one calendar year in full-time mode, or two years part-time. The ME requires the completion of a 30 ECTS credit project and 8 modules, each worth 7.5 ECTS credits. A Postgraduate Diploma in RES can alternatively be obtained, by omitting the project. The selection of modules is given in Table 1.

The ME-RES is run on both a full-time and part-time basis with both remote and on-campus delivery. Remote delivery uses an e-learning environment, with no stipulation as to whether either student cohort exclusively use one, or other, delivery modes. In practice, most students use a blended form of delivery. Finally, the vast bulk of assessment is through assignment submission, with practically no requirement for campus-based completion of assessment components. This gives maximum student accessibility, considering both graphical location and personal circumstances.

2.2. *EE684: the External Industry Seminar Series*

For EE684 (the External Industry Seminar Series), there are a number of challenges in operating within the parameters of the ME-RES programme:

- Learning materials must be accessible via the e-learning system, in addition to on-campus.
- Assessment must be facilitated through the e-learning system.
- A level of equity of treatment must be achieved for remote and on-campus attendees.

The environment, via which the learning materials are made available electronically, is described in Section 3, while the assessment rationale and methodology is documented in Section 4. In addition to the three basic requirements listed above, there are a number of issues that need to be highlighted to ensure the effectiveness and success of the module.

The seminar series is intended to pursue a set of educational objectives consistent with Levels 2–4 in Marzano's taxonomy of educational objectives (Marzano 2001), namely comprehension,

Table 1. Modules available on the ME-RES programme.

Compulsory	Group 1: foundation/integrative modules
EE616	Optimisation Theory
EE620	Applied Computing for Engineers
EE682	External Industry Seminar Series
Choose 4	Group 2: Technology modules
EE641	Solar Energy (Heating and Photovoltaics)
EE642	Climate Modelling
EE681	Grid Integration and Storage
EE684	Ocean Energy (Wave and Tidal)
EE685	Wind Energy
Choose 1	Group 3: Ancillary modules
EE608	Data Modelling and Analysis
EE612	Advanced Control Theory
EE619	Knowledge Management/Intellectual Capital
EE686	Power Electronics

analysis and knowledge utilisation, respectively. One objective of the module is to understand the diversity and breadth of the renewable energy sector, while also gaining at least an outline knowledge of specific company/agency activities. In addition, it is desirable that students should be able to analyse information and data presented in the seminars, through simple calculations and to utilise this information to make conclusions. The achievement of these objectives within the constraints of a particular assessment methodology, will be further examined in Section 4, consistent with the need to align the assessment with learning methodology (Biggs and Tang 2007).

In order to maximise the impact of the seminar series, relatively high profile (typically CEOs or other senior executives) speakers are sought. If speakers of such stature make themselves available, it is important that a good sized audience be available in class (a) out of courtesy to reflect the fact that a senior engineer/manager has given freely of his/her valuable time and (b) to ensure that a lively discussion takes place after the presentation component of the seminar. In general, students have responded well to this issue by request, without the need to impose mandatory attendance or sanctions. The fact that many of the students are mature and are using the programme as a considered change of career direction makes their engagement with the programme very active and they are keen contributors to the discussion sessions following the presentation.

Some care must be exercised in selecting the speakers, or industry/agency areas they represent, to ensure a broad coverage of the renewables sector. The renewable energy sector in Ireland, as in most other countries, is underpinned by a regulatory framework (e.g. the Transmission System Operator, the Office of the Energy Regulator, consenting systems in relation to planning permission and foreshore licensing, etc.), national agencies that promote and support the sector (e.g. Sustainable Energy Authority of Ireland, Ocean Energy Development Unit, Marine Renewables Industry Association, Irish Wind Energy Association, etc.), power companies (ESB Electric Ireland, Bord na Mona Powergen, Scottish and Southern Energy, Vattenfall, etc.), device developers (e.g. Wavebob, OpenHydro, etc.) and service providers, including installers (e.g. EcoEvolution, Cylon Controls, etc.) and renewables portfolio management services (e.g. ServusNet). Since most of the renewables programme modules are focussed on specific technologies, the seminar series fills in many of the gaps in the broad renewables industry context and, ideally, should sample all areas. This is a secondary objective of the seminars, insofar as it is possible with 10–12 individual seminars. A broad coverage also has the advantage of presenting a variety of employer types to students, who will be considering where to focus their career ambitions. The seminar series also provides an informal networking environment between prospective employers and employees.

EE682, like all other MR-REN modules, is allocated 12 teaching weeks. The first week is devoted to an introductory session which details the module motivation, the seminar session formats, the likely speaker lineup and the assessment format and criteria. The first session also includes a seminar presented by the module co-ordinator covering the complete breadth of the renewables space, which is non-examinable. Each of the regular weekly sessions, which take place from 16:00 to 18:00 to suit part-time students, is organised into a 1-h presentation followed by a 1-h open discussion, moderated by the module co-ordinator.

3. Module implementation

The e-learning system Moodle (Rice 2007), which has been adopted by NUI, Maynooth, was used to host the EE682 module. The EE682 module area contains content relating to module organisation, motivation, assessment and seminar a/v material. Seminars, *normally* presented using the Powerpoint® (Microsoft) presentation tool, are recorded using Camtasia® (TechSmith), via a fixed podium microphone and laptop computer. Only the presentation (slide show + audio) component is recorded, in view of the necessity to obtain the written consent of all seminar

attendees to allow their voices to be recorded, if the discussion session is also recorded. Note that seminars are also attended by University members (staff and students) beyond the EE682 module student cohort. In general, there is a relatively streamlined procedure leading to and through the recording and production process to allow relatively consistent provision of the seminar record, though there are a number of challenges, including:

- Since there is a diverse variety of presenters, a variety of presentation media (Powerpoint, PDF and video) may be used and presenters may use different software releases.
- A/V file sizes are typically 130 MB for 1 h, leading to extended production times.
- Speakers have different vocal strengths and may wander around the microphone location, in spite of guidelines, leading to poor audio S/N ratio.

The Camtasia® files are produced as Flash® (Adobe) and deployed in Moodle as a SCORM/IMS content package. Unfortunately, Camtasia® essentially records screen images on a fixed sampling rate, rather than on an information change basis, leading to excessive file sizes relative to the information content. However, a sampling rate can be user defined, which is set at 1 frame/s. Any video utilised by presenters is separated out from the slide presentation and deployed separately as Moodle content. In order to avoid excessive download durations, the slides (in PDF format) and the accompanying audio file (in MP3 format) are also available for download from Moodle.

4. Assessment

The choice of an appropriate assessment mechanism is crucial. On the one hand, it should require students to critically assess and note important seminar materials, while ideally fitting within the Moodle capability and not presenting an excessive workload to the module co-ordinator. It was decided to assess students on each of the seminars, given the fact that many of the areas covered do not appear elsewhere in the ME-REN programme. Two different assessment methods were used for the 2010 and 2011 EE682 versions. In 2010, students were required to complete a four-page report covering the company/organisation profile (which may need to be separately researched), the main presentation points and conclusions. Marks were assigned on the basis of:

- Overall professionalism of report (20%).
- Technical/insightful content (50%).
- Company profile (15%).
- Conclusions (15%).

In practice, students presented reports beyond the page limit which, combined with the healthy class size (32) and the requirement for one report per week (12 weeks) resulted in a significant assessment overhead for the co-ordinator. A further difficulty was experienced in differentiating sufficiently between various qualities of report leading to mark clustering. During the module, students were polled (via Moodle) on the possibility of using multiple choice questions (MCQs) as an one-off experimental assessment mechanism (Bennett, Rock, and Wang 1991). With a majority (19:5) agreeing to the experiment, albeit with a reduced weighting, a single automated MCQ was delivered via Moodle, reducing the average mark from 74% (reports) to 71% (MCQs), but increasing the standard. deviation from 7.6% to a more healthy 16.7%.

For the 2011 and 2012 courses, MCQs were adopted as the sole assessment method, with one required per seminar. Co-ordinator preparation time for each MCQ was approximately 3 h, but the workload is independent of the student numbers, since all marking and feedback are handled automatically within the Moodle. In contrast, feedback for the reports (both general and individual) was time consuming. While the module co-ordinator became more proficient at forming MCQs

as the course progressed, the students also became more astute at answering them, resulting in a slowly upward-creeping average mark. This inflation occurred, despite the fact that MCQs were quite varied, from looking up specific information delivered either in visual or audio form, to performing statistical calculations on data and graphs presented during the seminar. Each MCQ had 20 questions, with 30 min allowed for completion. Only one attempt was allowed, but the quiz could be taken at any time within a 4-day window. Both question order and answer order were shuffled to minimise any potential exchange of quiz answers between students. The option to orally examine any student was also reserved.

While the need to operate a time-effective assessment methodology, which can operate within the constraints of the Moodle e-learning system, is important, the degree to which the chosen assessment methodology satisfies the learning objectives is of paramount importance. Student reports (on each seminar), while having useful benefits in forcing students to summarise and conclude on key points, do not permit any meaningful analysis of the seminar material (unless particular questions are articulated), leading to achievement of only level 2 (comprehension) educational objectives. MCQs, on the other hand, pose specific questions on each seminar material and, by creative question writing, can elicit both analysis and utilisation of the seminar material. Of course, with MCQs, students can still guess (from 3 to 5 possible choices), but with appropriate specification of penalties for incorrect choices, a meaningful assessment is achieved. Typically, students may be asked to examine trends in displayed data or to make broad conclusions based on sets of statistics and data in presentations.

Both summary reports and MCQ are established assessment methods, and available in the Moodle e-learning environment, though the use of MCQs to assess analysis and utilisation of seminar material has some novelty.

5. Module evaluation

Module feedback was elicited through the Moodle environment, using 16 MCQs and 3 free-format questions. In general, the feedback was very positive, with response rates of 86% and 71% in 2010 and 2011, respectively. Roughly 50% of EE682 students took the module remotely over the two academic years. Table 2 shows the feedback for fixed-format questions, with 1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree and 5 = strongly agree.

Feedback comments specific to the 2010 course suggested that assessment requirements were clear and reports were fairly marked. In relation to the 2011 course, many commented that a very good understanding of the material was required for the MCQ assessment and careful concentration throughout the seminar and follow-on study were necessary, while others thought independent research outside the course material should be required. There was a general feeling that the MCQs force students to 'work hard to get the answers'. In 2011, some students indicated that the 30-min window for the MCQ was too small, but the average module mark (at 77%) possibly suggests

Table 2. Feedback for a selection of fixed-format questions.

Question	2010	2011	2012
Among the best courses I have taken	4.0	4.0	4.0
Difficult in comparison with the other courses	2.7	2.5	2.0
Module is well organised	4.6	4.5	4.3
The seminar format is appropriate for module material	4.2	4.0	4.6
Format of online material is appropriate	4.1	4.3	4.3
The seminars I attended were stimulating	4.2	4.4	4.5
Module format is appropriate for Master's level	3.9	4.3	4.3

otherwise. Following adjustment of the level of question difficulty in the 2012 course, the average module mark was reduced to a more healthy 64%, with a standard deviation of 9.5%. In general, students were happy with the in-class and online delivery mechanisms, though some students requested full video and an interactive online experience. With the current pace of advancement of e-learning tools, this may be relatively straightforward and inexpensive in the near future. Overall, virtually all students found the course to be 'very interesting and educating', some even keen to sit in on the course in future years! It is rewarding for both the organiser and speakers that the students find the module interesting and, subjectively, most educators would believe that elevated interest levels ultimately lead to improved learning. Indeed, the connection between interest and learning effectiveness has been formally established by a number of researchers, including Hidi (1990), Schiefele (1991) and Ainley, Hidi, and Berndorff (2002).

6. Conclusions

Overall, this has been a very rewarding 'course' to deliver. It requires roughly the same time to co-ordinate as a regular lecture module takes to teach, though is more prone to scheduling and technical problems, with the heavy reliance on external personnel and recording technology. However, the engagement is very encouraging and the module forms an important integrative function within the ME-REN programme. There are a number of useful benefits that accrue from a seminar series of this form, including an archived list of past seminars which may be re-used, though the currency of seminars needs to be maintained, given the rapid rate of development in the renewables area. However, having a repository to draw on can be especially helpful if a speaker has an emergency on the day of, or leading up to, a particular seminar date. One of the particular features of the seminar series is the exposure of particular commercial opportunities in the renewables sector, which might not be among the mainstream activities and not obvious to students. One example here is energy farm portfolio management, where a specific company successfully ported a telecommunications software platform for wind farm management. In a related comment, students noted that the seminar series gave them a number of career ideas which might not be obvious from a cursory perusal of the renewables industry.

There is no reason why such a seminar series could not be employed for other technical areas and disciplines. Obvious benefits include the healthy industry/student engagement and the provision of real-world input to educational programmes. However, the dynamic and relatively immature nature of the renewables industry makes the case for such a seminar series even more compelling.

The most important future development will focus on ways in which post-seminar discussion session can be more fully included within the formal seminar content and assessment framework.

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