LECTURE DISCUSSION TASKS: PEDAGOGIC AND TECHNOLOGICAL APPROACHES TO HELP BREAK DOWN BARRIERS IN LECTURES

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Abstract: We still tend to educate students in a 'Victorian' way, with lecture contact-hours providing the bulk of the knowledge base for students and where students are in a passive mode. The paper suggests ways that 'lectures' *can* be improved, especially to provide a more personalised experience for all. Personalization allows for individual idiosyncrasies and those requiring some form of special needs. Just-in-time teaching interventions can be incorporated as 'micro-learning' opportunities. Lectures can also be halved, the last part to problem solve, check threshold concepts, provide rapid feedback an especially to, get students to discuss and communicate. These 'lecture discussion tasks' promote nodes of active learning. When coupled to 'Cloud' services and tablet technologies, discussion opportunities make effective use of students' mobile devices, synchronously or asynchronously. Such ubiquity allows tutors to promote active learning in any location, even in lecture theatres as part of an ecology of higher education by way of 'mycorrhizal learning' that includes subject competences. Competences can also be developed using chatbots and virtual reality devices that will be of use in employment.

Keywords; tablet technologies, lectures, active learning, student participation, micro-learning, lecture discussion tasks.

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1. INTRODUCTION

We still tend to educate students in a 'Victorian' manner. Students are lectured to, take notes, read books, do problems, laboratory work and, perhaps, go to the library. Civil engineers and engineering geologists may also go on site visits and get their boots muddy. For the most part this is passive, information transfer mode. Students may sit a class test and almost certainly will do examinations at the end of the term (or semester). However, we take little regard for advances in pedagogy theory and practice and use technologies now available. This paper is concerned with building upon recent thinking and research in pedagogy, cognitive sciences and technological innovation in an adaptive manner, for institutions, lecturers and students. It places 'active lecturing' in a developing higher educational evolutionary system that includes information transmission but encourages 'thinking like an engineer' by designing active learning sessions into lecture periods.

2. LECTURES AND THEIR VALIDITY

In most Higher Education (HE) systems lecturers/lektors give ‘lectures’. From medieval universities onwards, lectures to students have been given by ‘the sage on the stage’. This is what institutions, students, and frequently their parents, expect. The Wikipedia entry ‘Lecture’ gives several examples and from where:

> Though lectures are much criticised as a teaching method, universities have not yet found practical alternative teaching methods for the large majority of their courses. Critics point out that lecturing is mainly a one-way method of communication that does not involve significant audience participation. Therefore, lecturing is often contrasted to active learning. …. lectures have survived in academia as a quick, cheap and efficient way of introducing large numbers of students to a particular field of study.

This tradition has been continued through J.H. Newman’s view of the university in 1858 to the present day and into MOOCs. For the most part, information is transmitted; ‘College is a place where a professor’s lecture notes go straight to the students’ lecture notes, without passing through the brains of either’ (variously attributed to Mark Twain, Edwin Slosson or Hamilton Holt). Although this might raise a laugh, and with comments that this could never occur in my lectures, it does identify the issue of student inactivity within an hour-long (50 minute) lecture. Underlying this Victorian approach lies a conception, of ‘transfer’ that;

> lies at the heart of our educational system. Most educators want learning activities to have positive effects that extend beyond the exact conditions of initial learning. They are hopeful that students will show evidence of transfer in a variety of situations: from one problem to another within a course, from one course to another, ….. to their years in the workplace. Bransford and Schwartz (1999 p. 61).

There is no specific mention of ‘lecture’ here but is implicit in procedures at most institutions. At various times there have been questions posed about ‘the lecture’, before and after Bligh’s influential, ‘What’s the use of lectures?’ (Bligh, 2000). Occasionally, large lecture classes have given way to smaller meetings and the use information and communication technology (ICT), e.g. personal response systems (‘clickers’). This was influenced by Mazur’s (1997) promotion of ‘Peer Instruction’ (PI) of in-class problem solving. A widely promoted graph, apparently showing lack of student brain activity when compared with sleeping, has been used to show the need for active learning in lectures. Whilst the validity of this graph has been questioned (Masters, 2014), a drop off in student attention after about 25 minutes has long been recognised (Bligh, 2000 p. 49-53; Lloyd, 1968). This paper promotes active learning and ‘transfer’ where appropriate within a lecture-based system such as still operates in most institutions.

3. AN ECOLOGY OF UNIVERSITY EDUCATION

At most institutions, students experience linear education (Figure 1). Students arrive, attend lectures, take examinations and graduate three or four years later. This is the way most students view university, with lectures as the main point of contact with lecturers. With the advent of mass higher education, universities have added structures and related staff; student services, ICT, employment and disabilities as well as expanded library and examination systems. Formalised

Virtual Learning Environments (VLE) or Learning Management Systems (LMS) of increasing sophistication and complexity, 'manage' students' learning. Notwithstanding these systems, interaction between lecturers and students is still that of directed and linear progression by learning and examining. Active learning opportunities in lectures are rare.

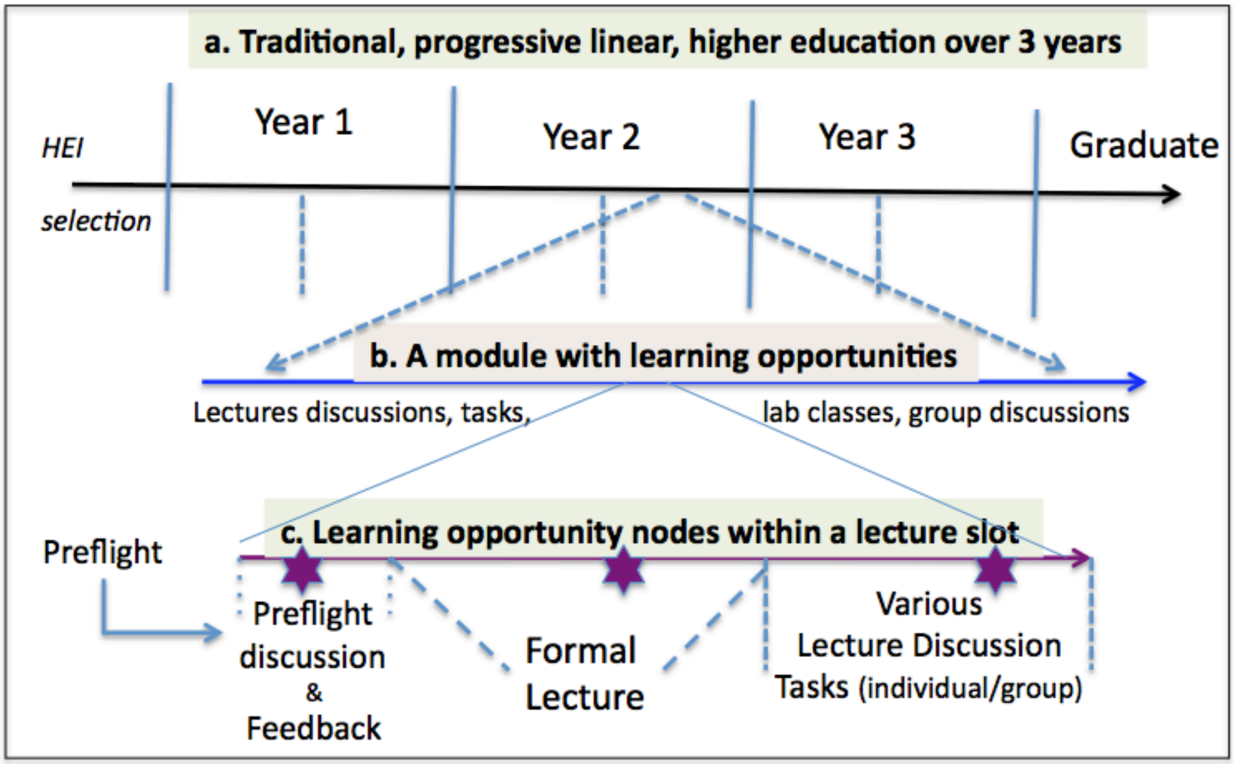

Figure 1. Linear University. a. Usual progression to graduate. b. Module designed with learning opportunities, c. Lecture with nodes of interactions and Lecture Discussion Tasks.

However, it is possible to consider ecological processes to examine the interactions of organisms and environments in degree programmes. A recent approach to pedagogy is 'rhizomatic' learning (Cormier, 2008) as being especially suited to the 'net generation'. After Deleuze and Guattari (1988), this suggests that 'the community is the curriculum' and subverts traditional instructional design. However, vascular plants, whether with roots or rhizomes, commonly have associated mycorrrhizal systems. It is via these mutualistic fungal systems that plants actually gain nutrition via aqueous solution. Students can gain information of any kind in the university linear approach where they require it; student services, library or lecture. Here is one way of making lectures active to benefit students by making better use of contacts between lecturer and student at mycorrrhizal nodes of interaction, problem solving or dialogue in lecture slots (Figure 1b, c).

4. COMPETENCIES IN HIGHER EDUCATION

In competence-based learning, the unit of learning is fine grained. A competence needs to be mastered before moving on to the next. Partial differential equations might be considered as a competence that should be 'mastered' but to what extent should an instructionist view be followed? Is it better rather to have a range of related tasks as a competence? The medical sciences have had a general approach to competencies for some time (Leung and Diwaker, 2002). In engineering, Goel (2006) lists several nationally-expected competencies for graduates including (Engineering Council UK, 2003); use, application and demonstration of:

a. a combination of general and specialist knowledge to apply existing and emerging technology;
b. appropriate methods to design, develop, manufacture, construct, commission, operate and maintain engineering products, processes, systems, and services;
c. technical and commercial management;
d. effective interpersonal skills; and
e. personal commitment to professional standards, recognizing obligations to society, the profession and the environment.

The above constitute competencies needed to think like an engineer. Furthermore, they require active learning, such as could be achieved the competence of 'communication', of engineering practice in terms of numbers, graphics, written and spoken forms. None of these are covered easily by the one-way experience of being lectured to. Winberg et al. (2016) have recently argued that, 'engineering is hard' and;

> 'Students difficulties when encountering engineering knowledge is well documented… Much of the knowledge in engineering is conceptually complex and specialised, thus very different from the mathematics or science learned at school' (Winberg et al. p. 400).

These authors are concerned with developing an engineering curriculum via the social relativistic methodologies and the sociology of knowledge (Maton, 2013). Here, more practically, we are developing a means to fulfil curricula that are tackled as student-centred enterprises and within 'mycorrhizal learning' at points of active ecological contact. We need to determine competencies deemed appropriate for a given curriculum and to make engineering less 'hard'.

5. **MICRO-LEARNING**

Microlearning (en.wikipedia.org/wiki/Microlearning) deals with relatively small learning units and short-term learning activities. Generally, the term 'micro-learning' refers to perspectives in the context of learning, education and training and is used in e-learning and related fields in the sense of a new perspective on learning processes in computer-mediated environments. An example might be, selecting an answer to a multiple-choice quiz. In large classes, personal response devices may be used. Micro-learning can be used to cover aspects of the fine-grained competence learning approach. One would hope that micro-learning activities associated with understanding the difference between stress and strain has been accomplished before tackling von Mises and Tresca criteria but all need to be accomplished within a wider competence of analysing stress fields. Visiting, and perhaps criticising, appropriate pages of Wikipedia or see an event on YouTube could be micro-learning events. Alternatively, devise a problem and put it to the class for discussion with reporting back in ten minutes. Competence in stress analysis (or circuit design etc.) could be built upon an understanding of basic concepts of theory and practice aided by micro-learning events. Such events can be extended in various ways, for example, before, during and after a lecture. Flipped classes reverse the ordinary/normal schedule by having what would be considered 'homework' (or out of class activity) done in the formal lecture theatre. Instructional/didactic material is delivered outside the class, by video watching or a piece of reading. Although there are advantages in the approach (O'Flaherty and Phillips, 2015) it does require a substantial shift of mind-set for both tutor and students. A less challenging methodology of just-in-time teaching (jitt) with the idea of 'preflights' (Whalley, 2013). The active micro-learning entity can be a question, a calculation to do or a piece of code to write. The preflights need not be of the same type but rather related to a piece of 'troublesome knowledge' (e.g. Perkins, 2006). Such knowledge could be dealt with in class or as concept that needs to be understood before a practical laboratory. E-mailing the tutor with the answer provides a convenient way of checking that all have done it. It does not matter if any or all get it wrong. A quick scan of the results will give an indication of what feedback is needed and this can be done in the next class or by a mass e-mail. Not only does this save time but students also feel part of the educational system rather than as objects to be lectured at. Events or learning nodes, such as Mazur's PI, in a lecture are 'lecture discussion tasks' (LDTs) Figure 1c.

6. SCHEMATA FOR EDUCATION IN AN EVOLUTIONARY APPROACH

The advantages of having discussions in lectures has been identified with improvement in test scores (Freeman et al., 2014; Waldrop, 2015). Once we have agreed that there is merit in moving away from a totally lecture-based system and to use approaches such as jitt and micro-learning opportunities, PI and group discussions of various kinds, it becomes possible to provide a more personal education. Students, as observed above, arrive in HE with a wide variety of backgrounds; cultural, educational as well as perhaps having predispositions to individual difficulties. The latter may include traits such as dyslexia and ADHD that are commonly called special learning difficulties (SpLD). Students may know about these before they arrive at university, or they may not. But most of us feel anxieties (class tests) and worries (e.g. financial, social) even before some major event, such as examinations, where anxiety could be extreme. For people with SpLDs especially their individual needs are a problem for teachers. Mortimore (2008) investigates how students might respond to these pressures and supplies strategies that can accommodate them. Group interactions and problem solving, even in lectures, can alleviate individual stress as well as enhance soft skills and competencies in which students' own reflections may be valuable (Wismath et al., 2013). Recent work on 'wise interventions' in education (Walton, 2014) shows that even small interventions can assist in improving some students' confidence. These events or nodes of interaction might include motivational processes, as for example stemming from the work of Carol Dweck (Dweck, 1986) within lecture discussion tasks.

These are part of a general movement towards exploring 'pedagogies for diversity' (Haggis, 2006). Linn (2000) has suggested a number of principles in which knowledge Integration environments can be viewed. Her list, modified and slightly shortened, below, has science rather than engineering but in fact any academic discipline might be considered here:

Making engineering accessible
- Encourage students to build upon their developing ideas into sound principles
- Encourage students to investigate personally relevant problems
- Scaffold engineering activities so students participate in the enquiry process

Making thinking visible

- Model the process and consider alternative explanations and diagnosis of mistakes
- Scaffold students to explain their ideas
- Provide multiple, visual implementations from varied media

Helping students learn from each other

- Encourage students to listen and learn from each other
- Design social activities to promote productive and repeated interactions
- Scaffold groups to design criteria and standards
- Employ multiple social activity structures

Promote lifelong engineering learning

- Encourage students in reflecting on their own scientific information
- Engage students as critics of diverse scientific information
- Engage students in varied sustained engineering project experiences
- Establish a generalizable inquiry processes suitable for diverse engineering projects

The above provide a good way of identifying lecture discussion tasks that will be of value to all students at appropriate stages in all students' university paths (Fig. 1b)

7. DELIVERING INDIVIDUAL COMPETENCE AND CONFIDENCE

Traditionally, the Victorian system of Figure 1a has the main student 'contact time' as lectures with passive information transfer. With some planning and imagination, the lecture slot can be divided up by various devices such as just-in-time teaching, preflights, peer instruction, giving feedback and group interaction and problem solving in different ways (Figure 1c). Lecture Discussion Tasks (LDTs) are nodes of interactions (as in mycorrhizal learning). These nodes are occasions when students can interact with their peers and lecturer, admittedly at the expense of 'content'. The lists above showing competencies (Goel, 2006) and knowledge integrating environments (Linn, 2000) are aspects that could be covered in LDTs. A lecturer might cover some theory then ask class to draw, say, an equivalent circuit, to help understanding, competence and to provide the confidence that is especially important when students enter university. Thus lectures *and* LDTs help students reduce the amount of processing to be done for a topic. This can be developed into 'schema theory' where a schema is a general representation of a typical structure of an experience. Schemas (or schemata) help organize, retrieve and encode chunks of information such that, once a schema is developed, it tends to be stable over time and can be associated with other accumulated schemata. The idea of schema theory and schemata can be linked to active-interactive learning and computer-based instruction (Gholson and Craig, 2006).

8. TABLET AND CLOUD TECHNOLOGY

Most students have laptops and frequently use these in formal lectures to record notes (although see Mueller and Oppenheimer, 2014). Students may really take notes and listen to the lecture; this is reasonable use of lecture time and computer use. However, students transcribing lectures takes us back towards transmission mode education and the notion of students' and professors' brains. Tablets, iPads, iPhones and similar, whether or not linked to a local WiFi system or the cloud, constitute a disruptive technology. Tablets and smartphones enable people in ways that are not possible otherwise. A circuit design task could be run on app such as *iCircuit* and be used to try ideas in real time. Tablets and smartphones make separate ‘clickers’ redundant. Images can be downloaded, annotated, shared between students and returned to the lecturer as part of problem-based learning exercises. They also allow communication between individuals and the lecturer, using Twitter for example, as a simple informal example of question and answer mode. There are specific apps for this purpose (e.g. *Socrative* or *Explain Everything*) but ‘chatbots’ (eg. *Slack*) could be useful for group or class use to provide the scaffolding or support that is particularly important for students making the transition from school to HE. Research over the last four years has shown how iPads can be used in a variety of student-staff participations in fieldwork (France et al., 2015) such that apps can be used in many lecture class situations; limited more by lecturers’ imaginations than deficiencies of the device (Whalley et al., 2016).

9. SOME CONCLUSIONS

Although the death of the lecture has long been mooted, adaptations can promote active learning with student involvement by short interventions, or longer lecture discussion tasks. Discussion of material can be used to overcome difficulties students might have with particular concepts or methods. LDTs aid communication between student groups, with or without tablet-cloud technologies, when the lecturer can act as a local tutor. This strategy embodies a change from ‘sage on the stage’ to ‘friend on the side’. Instead of content, interventions require wider regard for competencies and theory and problem-solving. Tablet-cloud technologies enhance students’ learning opportunities via apps and virtual reality opportunities. It is for the lecturer to lecture less and participate more and use student time in a lecture room in an enaged and active manner for both individuals and groups. Deliver ‘less content but more context’ might be a better way to increase students’ capabilities and develop their confidence in being engineers. Further, this is an opportunity to develop learning within an evolving ecology of education.

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