ACTIVE LEARNING — FROM LECTURE THEATRE TO FIELD-WORK

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Introduction

Much of the literature (Bligh 1998; Gibbs and Jenkins 1992; Ramsden 1992) on active and deep learning – as opposed to passive and surface approaches to learning – suggests that most students do not internalise and cannot understand nor apply learning, unless they are actively involved in it. In the traditional approach to lectures, learning is seen as unproblematic: the lecturer's role is that of expert, the student's that of passive note-taker. The authors find that fieldwork can be an equally passive experience. Activity does not necessarily equate to learning. Fieldwork can simply be a 'lecture in the field'.

The lecture format is highly favoured by institutions. One lecturer teaches many students, and this is seen as cost effective. From analysis of 91 studies by various investigators, Bligh (1998) concludes that the lecture format is appropriate for information dissemination. Butler (1992) accepts that the perceived efficiency of the lecture will result in the continuation of this mode of study, but argues that educationalists must change their use of the lecture time in order to improve student learning, and achieve learning objectives. The lecture must be used in conjunction with other methods and techniques.

Occasionally a great speaker can expound, with very little class interaction, and we can all be motivated and inspired. Although this is teacher-focused transmission (Approach A of Trigwell et al. (1994)), great speakers may be student-focused in the sense that they are aware of passing on enthusiasm – they want to motivate and inspire. In this situation students may be motivated to read and reflect on the subject outside of class. Is this active learning, or 'incitement' to active learning?

Taking mathematical education as an example, Bligh (1998) concludes that the function of the lecture should be to guide students as to how to explore the problems later in private study. Copying equations from the board, two lines behind the lecturer, apart from introducing errors, causes students to experience lack of confidence and despondency. This teacher-focused transmission of information is still commonplace. Students can memorise the symbols of an equation without too much difficulty, but this is not understanding. To understand such an equation you have to read it with a flow of other words and symbols, as part of a whole framework of ideas. This is active learning.

Research in the cognitive sciences indicates that knowledge gained through activity is more useful than knowledge gained through memorisation (Moran 1997). Although teachers are aware of this, teaching methods still encourage and reward rote-learning and algorithmic performance. Why? Teachers may be constructivists at heart, but in the reality of the teaching session they

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act like behaviourists. Practicalities mean that transmission is the most effective way of getting through course content, and the reality of higher education is that many teachers have undeveloped or unexplored theories of teaching and learning.

Behaviourists view the mind as a static receptacle with its limits stamped on from conception. The student listens and should 'get it' if they are good enough. This view, known as eugenics, is very different from the theory of mind being developed by Greenfield (2000). Greenfield has studied the functioning of the brain, and introduces the notion of neuronal plasticity. The important point to note is that Greenfield's work suggests there is an intervening mental process between the stimulus and response. To learn, connections between neurons are made. This raises one dilemma. 'Passive learner' is a contradiction in terms. By definition, learning is an active process, with the student playing a key role. The concern should be about the *level* of activity that takes place. Greenfield says we do not receive signals passively as neuronal connections intercept what is relayed, and 'we see the world in terms of what we have already seen'. So a key implication of Greenfield's work is that 'the understanding of the world will be different for each individual'. Constructivist theories of learning, based on the belief that knowledge is built by the learner, and is not transmitted from the teacher to the student, are supported by Greenfield's work.

Our own view is that we are all born with high learning potential. Some of that potential is developed through experience and stimuli. Much is not developed. We agree with Brown (1997) whose work has provided evidence that problems in children's learning are not related to a mental capacity, but rather to children's inability to make use of what capacity they have. Interestingly Greenfield says 'the more ramifying and multiple the associations, the more meaning or relevance an object will have'. With more associations we can begin to see patterns, and themes, to relate these things into ideas. So as teachers we must help students' 'capacity to learn'. This may involve students learning *how* to learn (Hodson 1998). This suggests that teachers have a role in metacognition, that is, helping the students to understand their own learning.

What do the students think of the lecture format? Given 5 different formats for teaching sessions the students in Butler's experiment decided that the didactic lecture was the least effective. Other formats included students being set tasks and reporting back. In a study by Ross in 1989 (in Bligh 1998) clarity, organisation and student involvement emerged as important stylistic factors for students. However, these studies included only student *perceptions* of what was effective, and student understanding was not assessed. The introduction of performances of understanding (Wiske 1998) would enhance such studies.

In experiments carried out in UCC a short experiential task, introduced towards the end of the lecture is used to encourage communication between pairs or small groups. Natural 'buzz-groups' seem to form. The exercises are designed to encourage active review of notes just taken, and to build concepts. In these experiments the students can ask the teacher any questions they consider relevant. Work has to be handed in before the student leaves the class. Informed by this work, the teacher holds a debriefing of the exercise at the beginning of the next session. Students will usually have appropriate answers, but sometimes all members of a group will demonstrate a misconception. For example, in one session I described sediment as poorly sorted, and later discovered students had written 'pearly-sorted' in their notes. Students relate new information to what they already know, and generate new meaning. What meaning were they constructing in their minds to fit this description? Students may be influenced (or not) in intended or unintended ways. However, students learn through the course not to take the word of someone in the group but to think for themselves. They learn to question their peers, and eventually to produce counter arguments. This is active learning, and leads from peer to independent mode of study and articulation of ideas. This is important for student development. Interestingly this teaching strategy has encouraged greater attendance at lectures, since contributions from non-attendees are not accepted. This teaching method is similar to Bonwell and Eisson (1991) for improving active learning within the lecture format.

We would agree with Butler's conclusions that the traditional didactic lecture can be transformed into an exciting mechanism for fulfilling the objectives of higher education. Butler stresses that it is our duty as facilitators to make the lecture inspiring, exciting, provoking, and an effective learning mechanism. The benefits of the enhanced lecture as a teaching method are now recognised. Teachers are encouraged to employ a range of teaching methods within the 'lecture'. This provides a greater equality of learning opportunity. Carrying out learning style questionnaires in UCC, and revealing the findings to the students, helps them to be more aware of their own learning, and broaden their strategies. Multiple Intelligences theory (Gardner 1999b;a)is potent in highlighting that students learn in different ways.

In science education a lecture may be linked to some practical activity, and act as a briefing, so that the time for 'activity' focuses on what is important for conceptual development. Procedural skills can be rehearsed so that they do not present a problem to distract from the understanding taking place in, for example, the fieldwork learning time. Claims abound from staff and students, regarding the learning that does take place in practical fieldwork (Sanders 2004). But is this always true? Students enjoy the social dimension of fieldwork but is the learning effective? Questioning students after a day in the field can indicate that their understanding of what they have seen is not high. This often does not match with the claims of the teacher. Field trip leaders often enjoy telling the story! They may pay little attention to what the students know at the end of the session...except that they can tell the same story. The transmission model is certainly alive and well in the geological field trip. We can transfer the learning site, but not necessarily the mindset (Zilbersztain and Gilbert 1981). Undoubtedly some learning takes place, but what is it? How can we release more of the learning potential of practical fieldwork? This natural laboratory should maximise active learning, encouraging communities of learners and creating a collaborative culture (Brown 1997). How can we achieve this?

In a study, one lecturer reported 'Reflection on my own experiences in higher education led me to realise that I learned because I had questions I wanted answered. My curiosity was heightened during some practical activities, but not all. As a first year geology student, on my first field trip, the teacher spoke 'over my head'. I tried to write down everything he said. Only when I was asked to do something did I become an active learner. Key to my learning was small group work, and an assistant teacher who I could communicate with on my level. Now, I recognise the above characteristics in my own students'.

Social constructivists, and socio-culturists believe that we learn by social and communal activities. All agree that learning is an active process of construction of meaning. Meaning is shaped, and knowledge constructed, through discussion with peers and teachers, and through reflection. This social constructivism is observed in groups of mature students, in UCC, who continuously interact with each other as they learn. This demonstrates a link between the constructivist view of learning, and the way we should teach. Teachers must be concerned with knowledge construction, and have well designed activities that appropriately challenge, and draw upon, student's prior learning. Allowing students to develop the narrative, as advocated by Bruner (1996), guided by an expert, is a way of teaching, and appears to work well. The teacher has responsibility for guiding students' development of shared meaning. Vygotsky (1978) introduced the term 'Zone of Proximal Development' to define the gap between the individual's unaided achievement and their potential achievement with the help of a skilled partner. For successful scaffolding, directing students to significant and timely aspects of the task, teachers need to know when to give support and when to withdraw it.

Teachers can engage with students in simple ways initially, taking account of students' existing views and making the subject relevant to encourage engagement. They can introduce new structures into the personal engagement as the need arises (Driver et al. 1994), and have on-going performances of understanding, to find out what the student's know and understand. An interplay of social and personal experience should be fostered in the process of learning. Social interaction and discourse can give effective feedback. This is feedback that learners can give to each other as well as to the teacher.

A diverse group of mature students talked of a lecturer who was 'very good in the field'. In 2001 I had the opportunity to assist in one of his field classes. The lecturer talked for two hours, telling the students the geological history of the area. He pointed out some features, not all of which were correct. There was no opportunity for the students to question him. However, the students were entertained, impressed with his knowledge, and had enjoyed the experience.

So, what learning went on in this activity? The lecturer did not demonstrate how a question should be formulated in the field, or how he would go about answering it. Acceptance of information by students, without argument, can contribute to learning helplessness. A more inclusive session would have provided students with time to discover evidence and discuss this in groups. This would allow students to pose questions, and to answer some of their own questions. Tobin (2004) calls this a 'co-participation model'. What is the role of the teacher in this situation? Tobin (2004) believes students must be primed to look for certain types of evidence before they will see it for themselves. Students can be shown a plant fossil in sandstone, but must be allowed to discover examples for themselves. Tobin found that when students worked in groups, prior knowledge was shared. Those who understood were able to explain to those that did not. He observed that peer teaching was occurring and 'all students had chances to co-participate in the learning activities'. Increased inclusivity resulted.

During this field class, two experienced teaching assistants were available, but not called on by the leader. Kuhn (1993 in Tobin 2004) sees science as a form of argument. When field assistants are used well, students are able to listen to the discourse between teachers and assistants. If assistants remain silent and are not invited to join in, opportunities to hear the discourse of science are missed.

Practical fieldwork can help students to consolidate knowledge gained during the year in the classroom. It can be used to feel how it is to be a scientist in the real world, and help to develop practical and procedural understanding. In the work place accurate following of procedures are necessary, so for authentic science procedural understanding is important (McGlinn and Roth 1999). This contradicts Hodson (1998) who would like students to have total 'freedom' to be individuals in their investigations. We agree with Hodson that students appear to value cognitive challenge, combined with a handover of control from teacher to student. Practical fieldwork can, if correctly designed, offer these challenges and opportunities for learning, and lead to a deeper understanding –as opposed to shallow learning. It can be an authentic experience. Real scientists observe, discuss, persuade, negotiate, argue, disagree, and agree.

The context of learning is important. In fieldwork there is a unique opportunity to design activities that communicate the nature of science itself. In the geosciences there is rarely only one viewpoint. This is real, authentic, evidence-based science. Getting the right answer should be a lesser goal, since very often the experts disagree, or the answer cannot be proved.

Students learn that science is about thinking, guessing, predicting, measuring, testing, describing, reporting, defending, in appropriate scientific language. Science does not always work, or turn out as you expected. 'Conjuring' is unlikely to take place during fieldwork. It is difficult to rig the investigation. Students feel the work is honest. They do not blame their lack of understanding on poor apparatus. What is there is what is there, and needs explanation. However 'talking your way out of it' (Hodson 1998) is frequently practiced, instead of saying 'how could we go about finding that out?'.

An example of practice

A field course for first year undergraduate students.

The learning activities form one day of a three-day field course. A carefully sequenced programme of investigative activities has been constructed " the event by which the teacher assists students in learning science" (Leach and Scott 2000). The scientific story develops over the 3 days, with students creating much of the narrative.

Student Learning Goals

- *To carry out an investigation in the natural world.*
- *To view rocks as a 3-D physical entity, surface and subsurface.*

- *To increase knowledge and understanding of strategies for scientific inquiry.*
- *To understand the role and status of evidence in scientific knowledge building.*
- *To think, plan and reflect, and oversee own learning.*

Teacher Learning Goals

- *To address the learning demand*
- *To encourage student-student communication, as well as student-teacher communication.*
- *To motivate, arouse curiosity, pose questions, be a role model, get students to think about how to answer questions.*

Learning outcomes:

- *The student will be able to demonstrate geological understanding by drawing a vertical geological cross-section through the area investigated.*
- *The student will be able to observe and record geological evidence, and discuss and defend their interpretation of evidence.*
- *The student will have experience and understanding of different learning strategies.*

This activity is informed by observation of a previous class, where the transmission method was dominant. The structure of the subsurface was not emphasised. Students were assessed on the day's work, and asked to draw a vertical cross-section. None of the students showed understanding of what was happening beneath the surface, and so failed in this activity. The 'internalisation' concept of Vygotsky (1978) suggests there is a difference between making the story available, and having individual students make sense of the story.

Leach and Scott (2000) identify authoritative discourse (presenting ideas) and dialogic (making meaning) discourse. These can be used to make the story intelligible to the students.

However, to do this the leaders needs to be aware of the existing understanding the students are bringing with them, so that they can develop lines of argument to engage with their existing understanding.

So, the teaching method has been modified to address the perceived 'learning demand'. Learning goals are made explicit, and engaging in dialogue with students is encouraged, to identify areas of confusion. Authoritative discourse is reduced, and more guidance given. The opportunity for dialogic discourse is increased, to allow students to develop their own narrative, and to improve scientific literacy (McGlinn and Roth 1999).

> ***Activity (am)***.
>
> *The Fieldwork leader introduces the activity and briefly reminds students of the purpose and relevance of this activity.*
>
> *Groups: Work in 4s Resources: Expert learning facilitators are available*

An introduction to important aspects of the task requires authoritative discourse. The way the teacher approaches an investigation in the field is part of the authoritative discourse. A balance with dialogic discourse must be achieved.

> ***Instructions to students***
>
> *From a vantage point, look at the rock outcrops on the foreshore. Note the layers of rock stacked one on top of the other. Note the direction of the boundaries between these layers of rock. Make an estimate of this direction, and indicate it on your map.*
>
> *Go down to the foreshore and look closely. Using a handlens, note colour, texture, thickness, and any special characteristics. Record this information systematically in your notebook. Measure dip. Mark this information on your map. Discuss with your group what you think happens to these rock layers beneath the ground, and make a 3-D sketch. (Essentially build a hypothesis you can test). Discuss the economic potential of these rocks?*

Here instructions are a guide, scaffolding, not a recipe to follow. Work is doable, but with some degree of independence. Challenge is at the core of motivational activities. If relevance to society is signposted, it enhances any routine procedural tasks. Asking students 'how would you extract the coal?' has students going through the same mental processes as 'construct a cross-section'.

Activity (pm)

Groups: Work in 4s. Resources available: expert learning facilitators.

Instructions to students

Currently, in the literature, there are at least 2 differing views on what these rocks represent We want you to investigate and come up with your own view on what the evidence is suggesting. After 30 minutes the whole group will congregate; each group can report a piece of evidence they think is significant.

The groups try to persuade each other of their case, creating a more authentic learning experience. Teachers act as facilitators of the discussion, guiding it if necessary. Students develop the narrative. This is authentic science.

Activity (evening)

Follow-up: Debriefing with students negotiating, defending, discussing, persuading.

The resources available for this fieldwork are the whole group, the small working group, the teacher, and assistants. Brown (1997) quoting Bruner calls this ' the mix of human beings involved in teaching and learning', a rich resource, uniquely available almost 24 hours a day in the fieldwork environment! Students work in groups and are responsible for their own learning and that of the group. The group reports and defends their findings, citing evidence, to the whole class. Students develop their own narrative and share expertise with their classmates, so that they may all have access to the entire topic. Their investigations lead to performances of consequential tasks, such as debating and defending. This metacognitive environment encourages 'do I understand?' and 'that doesn't make sense!'. In this way Hodson (1998) says 'conceptual understanding is necessarily articulated, tested and challenged', encouraging robust learning. Reflection and discussion are essential and through time become the 'norm' for the group. Over time it becomes second nature to appreciate good questions and to critically evaluate answers that are themselves partially correct and in need of revision. What is important is that the students have good reasons for their interpretations, and can establish a chain of arguments from their current understanding to the interpretation (McNairy 1985; Hodson 1998). Teachers should be open, and willing to accept a student's point of view. Entirely authoritative discourse is not the most effective for learning (Brown 1997). Teachers can then lead the class in setting new learning goals. As the work progresses, the teacher can hand over control, in recognition of the student's increased capabilities for unassisted performance.

A key skill in fieldwork is observation, but the demarcation between objective observation and theoretical inference depends on prior experience. Hodson (1998) points out that 'where particular individuals 'draw the line' depends on their knowledge, level of experience, and familiarity with the phenomena or events being studied.' For example using terms such as bedding, cleavage, and joints all carry with them some prior theoretical framework. We need to be aware (and the students need to be made aware) of the ways in which there own observational skills change and develop as their theoretical understanding becomes more sophisticated. At the end of a field course, a shift in the language employed since the start can be pointed out to students to demonstrate their progress. Hodson (1998) calls this 'the conceptual-linguistic shift that can be readily demonstrated'. Shuell (1990) says 'meaningful, cognitive, learning is an active constructive and cumulative process that occurs gradually over a period of time'. On the residential field course it is possible to introduce key topics 'in a drip-feed fashion' over several days.

We must avoid tasks that promote performance orientation, where maximum marks are gained by reproducing material in exactly the form in which the teacher presented it. These tasks do not require the student to think very deeply about the material, or to re-order or re-structure any ideas. We see this learning helplessness in the field. If a student does not realise how superficial his/her understanding is, he/she will not take steps to improve it. Positive attitude/inclination of students must be encouraged. Tasks should be a challenge not a threat.

Teachers who promote good habits assist students to become learning orientated. These students will use feedback to progress their understanding and re-double their efforts. Without this attitude students may believe they are unable to surmount negative outcomes. They view failure as predictive of their own potential, and discount any successes ('I'm no good at sketching what I see; I could never imagine structures in 3D'). Can we get the student beyond this conditioned belief system? This can be done by judicious design and selection of learning activities to maximise intrinsic motivation. Learning orientated students who do take steps to restructure in order to personalise their understanding should be rewarded for having done so. Design of field course assessment should take this into account. Self- directed effort should not be wasted as far as tangible reward is concerned?

Conclusions

In this brief discussion we have questioned the traditional roles of teacher and learner in undergraduate education. We, like others, have concluded that new models of teaching and learning are needed to avoid didactic lectures and passive approaches to learning. All activity does not equate to learning. Undeveloped and unexplored theories of learning in higher education must be addressed so that the potential of the learning environment can be maximised. For the teacher in UCC it can be unsettling to give up the 'power' of the lecturer, and become the facilitator. For the students it can be uncomfortable to take responsibility and control of their own learning. These are still relatively new roles, and constructivism is present more in discourse than in practice. However, experiments in UCC are helping teachers to find ways to transform the lecture theatre into an active learning environment, and analysis of the 'field lecture' indicates that by giving up some 'control' the teacher can facilitate a movement from activity to active learning.

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