Designing an online lecture in the discipline of soil science

Joginder Kaur Gill and Zed Rengel
The University of Western Australia
gillj03@student.uwa.edu.au

Technological developments have not only been introduced to support traditional face to face education, but also to facilitate the spread of distance education programs and online learning. This paper contributes to the development of online lectures based on the foundations provided by learning theories (behaviourism, cognitivism, constructivism and connectivism). Using this approach, the author has developed an online lecture in the discipline of soil science on the topic ‘crop residue management and phosphorus cycling’. Different aspects of designing an online lecture in terms of the content of lecture and its organisation, learner preparation, a couple of activities to engage students, and strategies to promote interaction have been discussed in detail. This lecture is designed for use in future and the feedback received by authors would be effectively utilised to improve upon this practice.

*Keywords*: online learning, soil science education, online lecture, technology use in education

**Rationale**

Soil science has broad holistic importance in society. It is integral to many ecological and social systems and holds the potential solutions for many of the world’s economic and scientific problems (Flannery, 2010; Hartemink, 2008). Soil science is a discipline concerned with a material that has unique features and behaviour (Churchman, 2010) and has been recognised as a natural science in its own right (Ruellan, 1997). Field (2011) proposed that its curriculum needs to be integrated with many of the related sciences, prepare graduates for applications in environmental, agricultural, land resources and related sciences; and be developed in cooperation with employers and industry partners to ensure practical relevance.

As teachers, we have broadened our presentation of soil from the traditional edaphic and pedagogical approaches to include a range of other aspects such as soil engineering, pollution and waste management and land use planning (Lockwood, 1997). Traditional soil science courses, especially with a hands-on laboratory component, used to be face to face events (Reuter, 2007). However, with the advances in Internet technologies and the impact of changing academic programs, many web-based applications have been developed in the discipline of soil science as well. These web-based applications are aimed at enhancing student comprehension and accommodating the multiple learning styles of students. An instructional multimedia program called ‘Oz Soils’ was developed at the University of New England and has been used by the students of an introductory soil science unit (Soil Science 211) as an additional learning aid (Lockwood, 1997). Eick (2000) developed a web-based clay mineralogy tutorial to assist students learning clay structures and cation exchange capacity. At the University of Florida, faculty have developed virtual field laboratories using 3-D imaging programs (Ramasundaram, 2004). Students were able to run a spectrometer using the Internet to analyse unknown chemicals (Scanlon, 2004). Stout (2004) designed a GIS and soil survey exercise to introduce students to GIS technology and the land use information available in digital soil surveys. Thus, e-learning tools such as video-recording of lectures, online lectures and computer-based trainings or tutorials should be developed to meet students’ changed expectations and to create new possibilities for the use of electronic learning in education.
Significance of paper

Rapid developments in science and technology are affecting all fields including education and are encouraging academics to stay abreast of new strategies and approaches in teaching. As the use of technology is increasing in education, there is a shift occurring from traditional face to face learning systems to online learning systems. Within this context, The University of Western Australia is launching free online courses in the disciplines of arts and science from early 2013 as part of a collaboration with the Stanford University of United States (Glance & Sinclair-Jones, 2012). This paper outlines the strategies used to design an effective online lecture which can be used as a guide for developing online lectures, not only in the discipline of soil science but for other disciplines as well.

Literature review

People who have earned their college degrees through traditional, on campus courses are often suspicious of distance learning (Fowler, 2005). But, a weakness of traditional university courses is their lack of time flexibility, requiring learners to be present in the class as per the schedule every week. This disadvantages part time students, adults returning to study after or during the child rearing periods and traditional full time students, many of whom may now require part time jobs to survive. Thus greater schedule flexibility in the online or hybrid course than learning face to face, allowing students to fit school work asynchronously into their schedules becomes a major motivational factor in taking online or hybrid courses (Connolly, 2007; Wuensch, 2008). In some cases, the additional flexibility provided by online learning may help meet the needs of non-traditional students with family responsibilities or off campus employment, additionally helping them to avoid time spent dealing with traffic (Daugherty, 1998; O'Malley, 1999; Sun, 2008; Young, 2006); however, they may suffer from limited face to face interaction in terms of verbal (e.g. giving praise, soliciting the viewpoints, humour) and non-verbal (e.g. eye contact, facial expressions, gestures, physical proximity) immediacy behaviours of teachers and peers (Swan, 2001).

As the use of computer technology is becoming widespread in the college and university classrooms, e-learning tools such as video recordings of lectures, computer-based trainings, tutor-guided online discussions and virtual document sharing systems have become an integral part of the undergraduate and graduate programs worldwide (Mohr, 2012).

In the literature, different terminologies have been used for the explanation of online learning. The most commonly used terms are e-learning, Internet learning, distributed learning, networked learning, tele-learning, virtual learning, computer-assisted learning, web-based learning and distance teaching (Ally, 2008). More specifically, online learning can be defined as “the use of the Internet to access learning materials; to interact with the content, instructor, and other learners; and to obtain support during the learning process, in order to acquire knowledge, to construct personal meaning, and to grow from the learning experience” (Ally, 2008).

Comparison of online and face to face learning

The research based on student evaluations comparing online and face to face learning environments has been focused on several aspects of study, such as student perceptions of effective teaching, by assessing the overall quality or student satisfaction of learning via multiple formats (Rovai, 2006; Sun, 2008); student motivation for taking online courses (Wuensch, 2008; Young, 2006); communication with peers or the instructor (Lieblein, 2000; Mullen, 2006) and other support issues specific to online learning (Lieblein, 2000; Young, 2006). Most of the research work has been focussed on the relationship between online learning and learning styles (Dag, 2009).

In terms of teaching practices and student outcomes, results have indicated very small (Gunawardena, 2004; Zhao, 2005) or non-significant differences between face to face and online learning formats (Bata-Jones, 2004; Horspool, 2012; Summers, 2005; Swan, 2000; Topper, 2007). In fact, Kassop (2003) outlined ten ways, (student-centred learning, writing intensity, highly interactive discussions,
geared to lifelong learning, enriched course material, on-demand interaction and support services, immediate feedback, flexibility, an intimate community of learners and faculty development and rejuvenation) in which online education either matches or surpasses face-to-face learning.

**Approach**

The goal of any instructional system, whether online or face to face, is to promote learning. Therefore, before designing or developing any learning material, teachers must understand the principles of learning and how students learn. The development of effective online learning material should be based on proven and sound learning theories (Ally, 2008).

Relevant learning theories include behaviourism (Skinner, 1974), cognitivism, constructivism (Duffy, 1996) and connectivism (Siemens, 2004). Behaviourism, cognitivism and constructivism are the main, broad learning theories which most often inform instructional environments. However, they were developed in a time when learning was not impacted by technology (Siemens, 2004).

**Behaviourist theory of learning**

Behaviourist theory of learning postulates that learning is a change in observable behaviour caused by external stimuli in the environment (Skinner, 1974). On the basis of this theory, the implications for online learning include that the learner should be explicitly told about the outcomes of the lecture; learners must be tested to determine whether or not they have achieved the learning outcomes; learning material should be sequenced; and feedback should be provided to learners (Ally, 2008).

**Cognitivist theory of learning**

Cognitivists see learning as an internal process that involves memory, thinking, reflection, abstraction, motivation, and metacognition (Ally, 2008). This theory underlines all the guidelines and the strategies needed for the preparation of an effective online lecture.

Cognitive psychology suggests that a teacher/educator should use the strategies that promote perception and attention for online learners. It can be achieved by placing the important information in the centre of the screen for reading and by highlighting the critical information to focus learners’ attention. Information should be chunked to prevent overload during processing in working memory. To facilitate efficient processing in working memory, the online material should present between five and nine items on the screen (Miller, 1956).

Conceptual models should be used to allow online learners to retrieve existing information from long-term memory to help make sense of the new information. Pre-instructional questions to set up the expectations or pre-requisite test questions can be used to activate the prior acquired knowledge of the learners (Ally, 2008).

A variety of learning strategies should be included in the online instruction to accommodate individual differences and learning styles (Cassidy, 2004). The information should be presented in different modes such as textual, verbal and visual, to facilitate processing and transferring to long-term memory (Ally, 2008).

Learners should be motivated to learn. The ARCS (Attention, Relevance, Confidence, Satisfaction) motivation model proposed by Keller is an appropriate one to follow to motivate students (Keller, 1983; Keller, 1988).

**Constructivist theory of learning**

Constructivists see learners as active rather than passive. The learner is the centre of learning, with the instructor playing an advising and facilitating role (Ally, 2008). Here, learners should be allowed to
construct knowledge rather than being given knowledge through instruction (Duffy, 1996). Constructivism assumes that learners are not empty vessels to be filled with knowledge; instead learners are actively attempting to create meaning (Siemens, 2004). So, in an online environment, it becomes essential to assess the prior learning level of the students.

The implications for online learning include that learning should be an active and interactive process. Learners should be able to construct their own knowledge; they should be given time and opportunity to reflect and also they should be given some control of the learning process. Real-life examples should be included to make the learning material more meaningful (Ally, 2008).

**Connectivist theory of learning**

Connectivist theory is relevant for the digital age, where individuals learn and work in a networked environment. This theory is driven by the understanding that decisions are based on rapidly altering foundations, new information is continually being acquired and it is vital to be able to draw distinctions between important and unimportant information (Siemens, 2004). Principles of connectivist theory include that learning and knowledge rests in diversity of opinions. According to this theory, learning can reside outside of ourselves (within an organisation or a database), is focused on connecting specialised nodes or information sources that enable us to learn more, and are more important than our current state of knowing (Siemens, 2004).

Apart from that, the guidelines for the development of online learning material include that the learners must be allowed to connect with others around the world to share and review information. The learning material should be taken from different sources to reflect the networked world and diversity of thinking (Ally, 2008). Because of globalisation, information is not location-specific and the learners should be given the opportunity to research and locate new information. Learners must network with other students and experts to make sure that they are continually learning and updating their knowledge (Ally, 2008).

Therefore, for the development of effective online materials, strategies should be used to motivate learners, facilitate their deep learning, cater for individual differences, promote interaction, provide relevant feedback, facilitate contextual learning, and provide support throughout the learning process. As discussed above, there are different learning theories, but no one is used exclusively to design online learning materials. Instead all of these theories can contribute to the design of online learning materials. Behaviourist strategies can be used to teach the facts ('what'); cognitivist strategies to teach principles and processes ('how'); and constructivist strategies to introduce real-life and personal applications and contextual learning (Ally, 2008). In addition to this, connectivism principles can be used to guide the development of effective online materials.

**Process**

Using this approach, I designed an online lecture on the topic ‘Crop residue management and phosphorus cycling’. This lecture is planned for students in the third year of an agriculture honours degree. It is planned as an asynchronous event.

**Creating a supportive environment for online learners**

For ensuring success and promoting persistence, it is crucial to create a supportive environment for online learners (Moisey, 2008). To build trust and a sense of safety, I shall post a few introductory comments about myself, my interests in the subject matter and my personal experiences in the research so far and the learners will be asked to do the same in a week prior to the lecture. This will help to develop connections with the learning community.

The ARCS (Attention, Relevance, Confidence and Satisfaction) model proposed by Keller (1988) is used to motivate the learners. To capture the attention of learners, a small activity is included after
introducing the topic and discussing the outcomes of the lecture. The learners are asked to think/make a note about the crop residue management strategies they are familiar with, and the underlying reasons for the popularity of those management strategies.

The learners are informed about the relevance of the lecture in the broader context, for example the implications of different crop residue management strategies in term of immobilisation/mineralisation of nutrients or losses of nutrients with burning of crop residues and thus related pollution problems, etc. Examples from all over the world are included to show them the bigger picture of the context.

Strategies are followed to develop the confidence of learners by structuring the lecture from simple to complex. The lecture starts from simple information regarding what crop residues are, what are their different uses, how much residues are produced and then carried on to more complex information regarding effects of different management strategies on soil properties and phosphorus content in the soil. To support learners, feedback will be provided on their queries and during the follow-up discussion of their own experience with crop management.

Lecture content and organisation of the material

All the content of the lecture is taken from refereed journals. In-text referencing is done within each slide and a complete references list is provided at the end of the lecture for further reading and exploration by the learners. The lecture slides are prepared carefully by not putting too much text on them. Appropriate pictures are also included to meet the requirement of learners with different preferred styles of learning.

Learner preparation

I included a variety of pre-learning activities for the online learners to motivate them and to connect with them. A conceptual map (Figure 1) is included at the start and in the middle of the lecture to effectively deliver the details of the lecture, to show them the structure of the lecture and to establish the existing cognitive structure. Learners are also informed of the learning outcomes of the lecture so that they know what is expected from them and also, so they can judge themselves whether they have achieved the outcomes or not.

Outline of the lecture

![Conceptual Map](image)

**Figure 1:** A conceptual map used at the start of lecture to present a detailed outline

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A self-assessment is provided at the start of the lesson to allow learners to check whether they are ready for the lecture, i.e. they have the pre-requisite knowledge. Also, it will help the learners to build on their prior knowledge and thus will help to bridge the gap between what learners already know and what they need to know.

**Learning activities**

To accommodate individual differences and different learning styles of the learners, various learning activities (self-assessment at the start of lecture, textual reading material, use of different formats to present data, photographs and follow-up discussion exercises) have been included in the lecture. Along with the textual reading material, photographs regarding the management of crop residues are also being provided. Data showing the effect of different management strategies is presented in different formats such as tables, line graphs and bar charts. To encourage learners to conduct further research on the topic, a list of reading materials and links to the online journals is also provided.

A follow-up discussion exercise has also been included in the lecture, in which learners are asked to share their own experience of management of crop residues. This discussion exercise will be an asynchronous discussion using the discussion forum after the delivery of lecture. This will not only help to promote high-level knowledge and application in learners, but also personalise the content in terms of real life applications.

**Learner interaction**

Learning should be interactive to promote higher-level learning and to develop personal meaning (Ally, 2008). For online learners, interaction is critical to create a sense of presence and a sense of community. It helps to promote transformational learning (Murphy, 2001). The lecture is being designed to promote a number of interactions such as learner-interface interaction (while accessing information using computer), learner-content interaction (while learners navigate through contents of lecture), learner-learner interaction and learner-educator interaction (while working on the follow-up discussion exercise of the lecture). The follow-up discussion exercise will also promote learner-context interaction as it will allow the learners to apply information in real-life and thus will help to develop their personal knowledge and construction of personal meaning for the information.

Four aspects of a teaching/learning environment which foster deep learning include: 1) the environment is enjoyable and students are motivated to learn, 2) students engage in a variety of activities and sensory experiences related to the learning tasks, 3) there is interaction between the students and a responsive expert and interaction between peers, 4) the content is well-structured rather than piecemeal, with an emphasis on connections and relationships between different facets of the knowledge base (Biggs, 1991, as cited in Lockwood, 1997).

I have tried to accommodate all of these aspects while preparing this lecture. A couple of learner activities (self-evaluating questionnaire and follow-up discussion exercise) are included in the lecture to engage students. To promote peer interaction and expert-learner interaction, the follow up discussion exercise has been incorporated. The ARCS model proposed by Keller (1988) to motivate the learners and other strategies like organisation of lecture content from simple to complex and use of conceptual maps to make connections are used in the lecture. All these efforts are done to make the teaching and learning experience enjoyable for the learners.

**Implications**

The focus of this paper has been on strategies for designing an online lecture in the discipline of soil science. I have tried to develop it in a broader sense so that educators or teachers from other disciplines can also use these strategies, if found useful. As there is still neither an ideal approach to pedagogy of online learning nor an ideal online learning environment, online educators/ teachers must be aware that some strategies might not be useful for their discipline and may need to be adapted to their own requirements.
This online lecture was developed for use in the future and is based on the assumption that the students do have the pre-requisite knowledge regarding phosphorus cycling in soil, some aspects of management of crop residues, and that their level of knowledge may be varied, thereby affecting their learning. Reflective practice and student feedback are the important aspects to determine the success of a teaching or learning practice.

Conclusions

Online learning has recently become one of the fastest moving trends in education. It is aimed at creating and delivering the training or educational content quickly, effectively, and economically. However, some environments and pedagogical approaches that can facilitate online learning in one discipline may or may not work for other disciplines. Based on the guidelines provided by different theories of learning, I developed an online lecture on ‘Crop residue management and phosphorus cycling’ in the discipline of soil science. To determine the success and to improve upon this practice, feedback from learners in terms of feelings of isolation and engagement, learning preferences, motivation, support (peer and expert), clarity of lecture material and the overall experience of the lecture will be most valuable.

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