RESTRAINING THE URGE TO ENLIGHTEN STUDENTS IN ORDER TO CHALLENGE THEM TO DISCOVER AND LEARN

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Abstract

This paper looks at the link between what educators understand about learning and the putting of that knowledge into practice when designing learning experiences for their students. The focus of the paper is the structuring and execution of a farm tour for farm management students to achieve higher order learning outcomes. The design involves focussing student attention by embedding the student assessment process entirely within the tour itinerary. More provocatively, it involves teaching staff and farmer cooperators initially restricting their responses to aspects of student questioning in order to help rouse students to sharpen their observational abilities and skilfully share and draw on their own collective prior learning and knowledge.

Keywords: Farm management education, student tours, constructivism

Introduction

There is no shortage of advice in the educational literature regarding the preferred roles for students and their instructors in the teaching and learning process. Much favours the constructivist approach which purports that students learn best through a process of personal discovery. With this process students are confronted with complex situations and challenged to learn what is needed to resolve them. The role of the teacher is to provide the learning environment and support to assist the students to learn under these circumstances at a deep level.

At the same time, a feature of farm management education in Australia has been the practice of taking students onto commercial properties to learn about their management. Generally this has proven to be informative, enjoyable and successful. But have these occasions been planned from an educational perspective to achieve a level of learning by students of the highest order? This paper will review some educational underpinnings then discuss one case where an understanding of learning processes has been applied for students participating in farm tours in an attempt to reach a level of learning not normally achieved.

Views about learning

When we take students onto farms to learn about management then it is helpful if we understand how it is that students learn. While students have their individual styles and differences, if instructors have an understanding of the learning process they are more likely to be able to structure the farm visit to best educational advantage.

Many theories of learning exist and coexist. Cranton (1992) credits Dewey with promoting interest in the area of adult learning, the place of interest for those engaged with tertiary students. While Dewey does not write about adult learning specifically many of his ideas of learning are based on the notion that *experience* is a critical component. Behavioural psychologists such as Skinner, Thorndike and Watson used experience through a stimulus recall approach to describe an approach to learning. Gagné (1975, 1977) builds on these ideas and with others (Gagné, Briggs & Wager 1988) describes an approach to teaching based on behaviourist learning theory. Interest in behaviourist approaches however has waned and Vygotsky (1962), among others, criticised behaviourism as failing to consider the person and having a narrow view of learning that fails to take into account the sociological context in which the learning takes place.

A different view of learning is addressed by those often labelled as humanists. Where behaviourists essentially focus on content, humanists focus on people. Rogers (1969) describes learning in terms of self actualisation and Maslow (1968) presents a hierarchy of needs that learners work through in order to achieve this self actualisation. Knowles (1980, 1990) in his theory of andragogy takes essentially a humanist view - a theory that picks up on other views as well. This focus on the learner has resulted in the identification of learning styles typified by the work done by Kolb (1976). Developmental psychologists and critical theorists are among many others who have been principal contributors to further building our understanding of the learning process.

It has however been the constructivists who have emerged from these earlier debates on the nature of learning with widespread acceptance. Constructivism represents a radical departure in thought about the nature of knowing, hence of learning, thus of teaching. Some have suggested shortfalls (for example Phillips 1995 and Fox 2001) but constructivism has attracted general support as it holds that knowledge is not mechanically acquired through information processing but is actively constructed within the constraints and offerings of the learning environment (Liu & Matthews 2005). It perceives learning as a change in meaning constructed from experience. Constructivists view learning as being something very personal. Von Glaserfeld (1984) explained that learners do not simply mirror and reflect what they are told or what they read, they look for meaning. Much of today's thinking about this has developed from the work of Bruner (1966) who points to learners constructing new ideas or concepts based upon their current/past knowledge. The learner selects and transforms information, constructs hypotheses, and makes decisions allowing the provision of meaning and organisation to experiences and allows the individual to, as Bruner (1973) explains, go beyond the information given.

Central to the tenet of constructivism is that the construction of knowledge by individuals needs to be an *active process*. While information may be imposed on students, understanding and therefore knowledge cannot be imposed as it must come from within. This is a critical point – knowledge is not directly transmittable from person to person. Constructivism requires a lecturer/teacher to act as a facilitator with a primary function of helping students become active participants in their learning and to make meaningful connections between prior knowledge, new knowledge, and the processes involved in learning. This is not always applied in practice by those planning student learning experiences such as farm tours where the student is often *told* information by either the farmer cooperators or the lecturer/teacher and somehow this is expected to translate into learning. Those taking a constructivist approach will structure the tour somewhat differently by devising learning experiences and providing mentoring and guidance in a way whereby their students will *discover* knowledge and develop skills which lead to the achievement of worthwhile learning outcomes.

Implications for Teachers

The foregoing discussion about learning processes suggests that as far as instruction is concerned, there is general acceptance among educators that the instructor should encourage students to discover knowledge

for themselves. This contradicts the approach frequently taken with conventional student tours where they often reduced to merely information gathering exercises where the answers are provided by the farm staff or the teachers.

Bruner (1973) has given the guidance that the task of the instructor is to translate information to be learned into a format appropriate to the learner's current state of understanding with curriculum organised in a spiral manner so that the student continually builds upon what they have already learned. While there are differing perspectives, most educators appear to agree that learning involves a synthesis of cognitive and social perspectives (Windschitl 2002). For the most part learning occurs in an *interactive* social environment and is considered to be largely a situation-specific and *context bound* activity (McInerney & McInerney 2002, Woolfolk 2001). So while meaning making is regarded as something to be personally constructed, it is most effectively achieved when there is social mediation.

Given the above, potential barriers to student learning on a farm tour are a lack of appreciation of the importance of context and an absence of opportunity for social mediation. If students do not sufficiently appreciate the importance of making management decisions according to context then they could well default to a narrow right/wrong, one-size-fits-all viewpoint. There is some research described next which gives this credence.

It has been argued that students themselves need to shift from a credo that knowledge is certain and comes from some external authority, such as the cooperating farm manager or their teacher (Morgan 2006). Individuals have to define their own beliefs, identity and relationship with the world – attaining this is termed self-authorship (Baxter Magolda & King 2004). Self-authorship means actively understanding the basis and the limitations of our own knowledge and accepting that knowledge is relative and personal. Pizzolato (2003) points out that many entering university students see the world in binaries of right or wrong, good or bad, and anticipate being given single right answers. There is a progressive transition away from expecting sets of single right answers to be accepted uncritically and towards realising that determining what is right requires analysis of relevant evidence according to the context (Belenky et al. 1997, Chickering & Reisser 1993, King & Kitchener 1994).

Research by Baxter Magolda (1992) clearly showed this process of transition unfortunately provides no guarantee that most students develop contextual ways of knowing by the time of their graduation. When she followed her students beyond their graduation and into the workforce, Baxter Magolda (2001) found a sharp rise in their ability to consider context when interpreting situations. However, she also found that they lacked self-authorship; that is, they did not construct their knowledge through interactions driven by their own perspectives and goals balanced with their understanding of the contextual nature of knowledge. She concluded *that universities failed to trigger the necessary development of self-authorship by* ***too readily supplying students with information and answers***. Students were not being confronted with sufficiently provocative experiences that disrupted their equilibrium in such a way that they would develop complex, reflective ways of knowing.

Morgan (2006) feels this beckons university educators to devise approaches that will assist the development of self-authorship in students. He suggests employing processes that provoke students to engage with others in critical thinking and knowledge applications. It bids us to immerse our students in challenging experiences from which they can make meaning. He asserts that as academics our role is not necessarily to provide answers but instead to pose questions that guide our students as they explore ideas and test and refresh their current knowledge through new contexts and experiences. Student excursions are opportunities for employing such active learning designs and the remainder of this paper will report on a case situation where such a learning design was used.

A Constructivist Farm Tour Design

Morgan and Cox (2006) have detailed a farm tour structure used at an Australian campus that appears to align well with the learning considerations outlined above. Their final year Farm Management degree students undertake a three day tour looking at beef cattle properties. Earlier these students will have had a preparatory series of lectures and practical classes and they will previously have successfully completed other studies in the livestock field providing them with a relevant knowledge base. Many also will have gained a familiarity with livestock systems through their own farm experiences [this fits with Bruner's principle for the spiral organisation of curriculum where students build upon their earlier knowledge base].

Students visit three properties and while there they work in groups do devise management plans for each property's beef cattle enterprises. These are significant challenges [this fits Baxter Magolda's maxim to disrupt the equilibrium of students] and group members have to be incisive with their observations and interrogations and utilise the knowledge and abilities of each member to the group's best advantage [this fits with the social mediation aspect of knowledge construction by facilitating an interactive social environment]. This is an approach also advocated by Pizzolato (2003) whose research highlighted the importance of interactions with others in managing provocative experiences and building self-authorship, as it is others who guide the establishment of procedural, conceptual and relational schemas associated with their personal goal or task achievement.

The benefits to students from successfully working in groups is widely acknowledged (for example Jacques 1984 and Michaelson 1992) and it is not surprising that capabilities arising from this such as interpersonal and teamwork skills commonly appear on university graduate attribute lists and are highly valued by employers seeking graduates (Harvey & Green 1994). Incorporating group activity within this tour design provides both staff and student benefit. For teaching staff, the activity would be logistically more difficult, if not impossible, if individual rather than group plans were to be presented while on the tour and also an unreasonable imposition on cooperating farm staff to participate in the far more extended assessment process that would result. For students, by working in groups they have the enhanced opportunity of learning from and with each other. Through utilising the strengths within their group the students will likely collectively analyse and evaluate the situations they encounter in a more comprehensive and refined manner than they would as individuals, a laudable management capability.

Not all students will of their own accord devote themselves to achieving group tasks. It is widely recognised (for example Isaacs 2002) that assessment can be a driving force motivating students to participate in a committed manner in group tasks. This tour design incorporates the assigned tour tasks into the subject's assessment with peer assessment by the students included in the task alongside the evaluation conducted by tour staff and cooperating property managers [this fits Bruner's guidance to heighten the students' predisposition for learning]. The tour design involves an evaluation of both individual and group performance and the combination of tutor and peer assessment, and possibly utilising independent judges as is the case on this tour design, is commonly advocated in the literature concerned with the assessment of group tasks (see, for example, Isaacs 2002 and Spronken-Smith 2003).

On this tour the students are allocated by staff into groups of six with a three part requirement. Each group is to propose

- a livestock management calendar for the property,
- product specifications for the livestock enterprises on the property, and
- a marketing strategy for the livestock products.

The groups who do this well tend to be those where they quickly discern and manage the expertise and attributes of their team members to best advantage, a foundation of good management generally. Understandably students approach the task in part by utilising their current knowledge base formed from

preparatory class work, learning gained in earlier livestock subjects studied and from their previous farm experiences. The major contributor to completing these tasks to a high standard, however, needs to be through their understanding of the context of that farm – the precision of their observations about the property being examined and its livestock plus knowledge specific to the property they glean from farm staff.

The logistics of the exercise are described by Morgan and Cox (2006) in some detail but basically a full day is spent at each property with each visit commencing with preliminary discussions involving the farm manager and other farm staff with the full tour party. An overview of the farm business and broad details of the current livestock enterprises are provided. However, where this differs from a more conventional tour design is that it is stressed to these presenters to refrain from giving any details directly related to the three particular contextual tasks that the students have to complete [this fits with Baxter Magnolia's views on self-authorship discussed earlier where universities were criticised for too readily supplying students with information]. Similarly, while students have the opportunity to ask questions to help them clarify the business environment, there is a constraint on their questioning as they are instructed not to seek details of the current management calendar, product specifications or marketing strategies being used – the areas where they are to propose plans.

Following the briefing the tour party look over the property and view its livestock. Typically the stock are in several groups located on different parts of the property either grazing, in a feedlot or in the cattle yards. While students do have the opportunity to quiz the farm staff within the set parameters, again the hosts are under instruction not to volunteer any information on the livestock being viewed. Instead, while the students are looking at the livestock the lecturer in charge challenges their observational and deductive skills by putting some questions to them which serve to provide a platform for them to go about their assessable tasks. The teaching and farm staff restrain themselves at this time from making any comment as to the accuracy or otherwise of the responses students make to such questions as the students are expected to reach agreement within their groups on these matters [this fits the guidance from Brooks and Brooks (1993) to encourage student enquiry by asking thoughtful, open-ended questions and encouraging students to ask questions of each other. It is also supports the approach advocated by Schön (1991) who encouraged educators to replicate conditions that reflect realities professional practitioners face trying to contend with unique problems as they "think on their feet" using a collection of theories, processes and experiences].

After this property inspection, the students work in their well-separated groups on their assigned tasks with their teachers and the cooperating farm staff acting as itinerant facilitators. The first group ready to do so orally presents their findings to an audience of the teaching staff on the tour, the farm manager and other cooperating farm staff. Meanwhile the other groups remain apart and continue with their preparations until the assessors are ready to hear them. The students are expected to share duties fairly among themselves and generally divide the presentation into different segments, assigning each member a particular responsibility. Once each student completes his or her contribution the other group members provide supplementary commentary. During the presentation, each student is asked by the audience at least two individual questions with others in the group invited to add to the reply of the individual respondent. This process is repeated for each of the two subsequent properties visited with group membership changed each time.

The cooperating farm staff and the teachers respond to the students once they have completed their presentations. They discuss the merits or otherwise of the observations, thoughts and suggestions that were raised. It is at this time that they reveal the actual farm management approaches and explain the constraints and rationale behind these approaches [this fits with the need to emphasise the contextual relevance of the decision making].

It is at this point that the evaluations occur of both the overall group performance and that of each group member [this fits the widely held view that it is important to assess student understandings through task application and performance (Brooks & Brooks 1993)]. All parties are involved in doing the assessing – the teachers, the farm manager/staff, and the students doing peer assessment. Earl (1986) notes that giving students such a responsibility mirrors aspects of the professional environment and tour staff felt this contributes to their development as managers. Again the details are discussed by Morgan and Cox (2006) but there are weighting differentials with all parties making judgements against pre-determined marking criteria with the first visit used as a non-assessable 'trial run'. The students individually are told their mark before visiting the next property and going through the process once again. The assessment design largely follows the guidance and format explained in detail by Healy and Addis (2004) who refined their approach from one presented by Conway et al. (1993). It is a design that makes it necessary to be an active participant in the group processes if an individual student wishes to score well. Unlike some other forms of assessment (Alam 2004, Marsden, Carroll & Neill 2005), it would be difficult for a student with a low learning orientation to score well through heavy reliance on others. This design also is one where it is in every student's interest for their particular group to score well overall and it overcomes a criticism of category-based peer-assessment made by Lejk and Wyvill (2001) when individual marks are calculated on a 'zero-sum' basis leading to competition within the group.

Conclusions

The farm tour approach described here fits well with principles advocated in the educational literature:

- it involves engaging students actively in their learning (e.g. Brockbank & McGill 2003, Marquardt 2004),
- it has a strong process orientation involving the nurturing and improvement of student communication, observation and enquiry skills (e.g. Athman & Monroe 2002),
- it gives students leadership opportunities and the challenges of managing group situations and taking responsibility for others (Gold et al. 1991, Watson et al. 1998),
- it involves intense group discussions intended to lead to a greater depth of understanding of the issues and independence as students need to learn from each other and not be cognitively dependent on their lecturer (Kremer & McGuiness 1998),
- it demands students utilise effective communication and teamwork skills to generate logical, creative ideas and exhibit a capacity to apply their learning (Duch, Allen & White 1998, Kremer & McGuiness 1998, McIlveen, Greenan & Humphreys 1997), and
- it requires students to pursue, collect, analyse, synthesise and evaluate information, a process consistent with the building of the above higher order skills (Powis 1999, McKinney 1998).

Excursions to farms can be occasions where students look and listen and not necessarily enquire and analyse. Students invariably return from farm tours reporting that they have learned a great deal, but what is it have they learned? How well have they constructed meaning from the authentic context they have experienced?

The design of the farm tour reported in this paper effectively demands a high level of participation from all the students. As Mossa (1995) found, motivating students to participate actively in field excursions leads to outcomes such as the acquisition of self-esteem, something we associate with self-authorship. This tour design, which includes providing feedback while they are on the tour, has been effective in provoking students to contribute conscientiously to their group output. Perhaps more importantly, its focus on demanding students to be self-reliant and link their observations with their prior learning, to probe each other and industry cooperators purposefully, and to work productively under pressure with their colleagues to analyse the situation and solve problems all intertwine holistically to build self-authorship. From a constructivist's perspective, the design fulfils the primary responsibility of teachers to create and maintain a collaborative problem solving environment, where students are allowed to construct their own knowledge with their teacher acting as facilitator and guide.

In summary, there is considerable potential for many student excursions to farms to better achieve valuable educational outcomes through teachers rethinking and reframing their approach and structuring student participation around constructivist learning principles. For farm management educators, there needs to be a connection between how they design their student tours and what is understood about the learning process. That linkage is not always apparent.

References

Alam, L S 2004, 'Is plagiarism more prevalent in some form of assessment than others?', *Proceedings of the 21st ASCILITE Conference*, Australasian Society for Computers in Learning in Tertiary Education, Perth, pp. 48-57.

Athman, J & Monroe, M C 2002, *Enhancing natural resource programs with field trips*, FOR 105, School of Forest Resources and Conservation, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

Baxter Magolda, M B 1992, *Knowing and reasoning in college: gender-related patterns in students intellectual development*, Jossey-Bass, San Francisco.

Baxter Magolda, M B 2001, *Making their own way: narratives for transforming higher education to promote self-authorship*, Stylus Publishing, Sterling, Virginia.

Baxter Magolda, M B & King, P M (eds.) 2004, *Learning partnerships: theory and models of practice to educate for self-authorship*, Stylus Publishing Sterling, Virginia.

Belenky, M R, Clinchy, B M, Goldberger, N R & Tarule, J M 1997, *Women's ways of knowing*, Basic Books, New York.

Brockbank, A & McGill, I 2003, *Action learning handbook: powerful techniques for education, training and professional development*, (RoutledgeFalmer, London.

Brooks, J G & Brooks, M G 1993, *In search of understanding: the case for constructivist classrooms*, American Society for Curriculum Development, Alexandria VA.

Bruner, J 1966, *Toward a theory of instruction*, Harvard University Press, Cambridge, MA.

Bruner, J 1973, *Going beyond the information given*, Norton, New York.

Conway, R, Kember, D, Sivah, A & Wu, M 1993, 'Peer assessment of an individual's contribution to a group project', *Assessment and Evaluation in Higher Education,* vol.18, no. 1, pp. 45-56.

Chickering, A W & Reisser, L 1993, *Education and identity*, 2nd edn, Jossey-Bass, San Francisco.

Cranton, P 1992, *Working with adult learners*, Wall and Emerson, Toronto.

Duch, B J, Allen, D E & White, H B 1998, 'Problem-based learning: preparing students to succeed in the 21st century', *The Catalyst*, Center for Advancement of Teaching, Illinois State University. Retrieved: March 11, 2005, from http://www.cat.ilstu.edu/publications/catalyst.shtml.

Earl, S E 1986, 'Staff and peer-assessment: measuring an individual's contribution to group performance', *Assessment and Evaluation in Higher Education*, vol. 11, no. 1, pp. 60-69.

Fox, R 2001 'Constructivism examined', *Oxford Review of Education*, vol. 21, no. 1, pp. 23-35.

Gagné, R 1975, *Essentials of learning for instruction*, Dryden Press, Hinsdale, Ill.

Gagné, R 1977, *The conditions of learning*, Holt, Rinehart and Winston, New York.

Gagné, R, Briggs, L & Wager, W. 1988, *Principles of instructional design*, 3rd edn, Holt, Rinehart and Winston, New York.

Gold, G R, Jenkins, A, Lee, R, Monk, J, Riley, J, Shepherd, I & Unwin, D 1991 'Fieldwork', *Teaching geography in higher education: a manual of good practice,* Geography Discipline Network. Retrieved: February 10, 2007 from http://www2.glos.ac.uk/gdn/gold/ch3.htm.

Harvey, L & Green, D 1994, *Employer satisfaction*, University of Central England, Birmingham.

Healey, M & Addis, M 2004, 'Use of peer and self-assessment to distribute group marks among individual team members: ten years' experience', in Healey M & Roberts J (eds.), *Engaging students in active learning: case studies in geography, environment and related disciplines*, School of Environment, University of Gloucestershire.

Isaacs, G 2002, 'Assessing group tasks', *Teaching & Learning in Higher Education Series*, Teaching & Educational Development Institute, The University of Queensland.

Jacques, D 1984, *Learning in groups*, Croom Helm, London.

King, P M & Kitchener, K S 1994, *Developing reflective judgement*, Jossey-Bass, San Francisco.

Knowles, M 1980, *The modern practice of adult education*, Associated Press/Follett, Chicago.

Knowles, M 1990, *The adult learner: a neglected species*, Gulf Publishing, Houston.

Kolb, D A 1976, *The learning style inventory: technical manual and self-scoring test and interpretation booklet*, McBer, Boston.

Kremer, J & McGuinness, C 1998, 'Cutting the cord: student-led discussion groups in higher education', *Education & Training*, vol. 40, no. 2, pp. 44-49.

Lejk, M & Wyvill, M 2001, 'Peer assessment of contributions to a group project: a comparison of holistic and category-based approaches', *Assessment and Evaluation in Higher Education*, vol. 26, no. 1, pp. 61-72.

Liu, CH & Matthews, R 2005, 'Vygotsky's philosophy: constructivism and its criticisms examined', *International Education Journal*, vol. 6, no. 3, pp. 386-399.

McIlveen, H, Greenan, K & Humphreys, P 1997, 'Involving students in teaching and learning: a necessary evil?', *Quality Assurance in Education*, vol. 5, no. 4, pp. 231-238.

McInerney DM & McInerney, V 2002 *Educational psychology: constructing Learning*, 3rd edn, Prentice Hall Australia, Sydney.

McKinney, K 1998, 'Engaging students through active learning', *The Catalyst*, Center for Advancement of Teaching, Illinois State University. Retrieved: March 11, 2005, from http://www.cat.ilstu.edu/publications/catalyst.shtml.

Marquardt, M J 2004, *Optimising the power of action learning: solving problems and building leaders in real time*, Davies-Black Publishing, Palo Alto, California.

Marsden, H, Carroll, M, & Neill, J 2005, 'Who cheats at university? A self-report study of dishonest academic behaviours in a sample of Australian university students', *Australian Journal of Psychology*, vol. 7, no. 1, pp. 1-10.

Maslow, A H 1968, *Towards a psychology of being*, Van Nostrand, New York.

Michaelsen, L K 1992, 'Team learning: a comprehensive approach for harnessing the power of small groups in higher education', *To Improve the Academy*, vol. 11, pp. 107-122.

Morgan, C K 2006, 'Exploiting farm tours to provoke exceptional student learning and development', *Extension Farming Systems Journal*, vol. 2, no. 1, pp.117-123.

Morgan, C K & Cox, R 2006, 'An authentic learning design for farm tours', *Journal of Learning Design*, vol.1, no. 2, pp. 65-71.

Mossa, J 1995, 'Participatory student field guides and excursions, *Journal of Geography in Higher Education*, vol. 19, no. 1, pp. 83-90.

Phillips, D C 1995, 'The good, the bad, and the ugly: the many faces of constructivism', *Educational Researcher*, vol. 24, no. 7, pp. 5-12.

Pizzolato, J E 2003, 'Developing self-authorship: exploring the experiences of high-risk college students', *Journal of College Student Development*, vol. 44, no. 6, pp. 797-813.

Powis, K 1999, 'The field trip as an active learning strategy', *Teaching Options*, Center for University Teaching, University of Ottawa, vol. 3 no. 1. Retrieved: February 8, 2007, from http://www.uottawa.ca/academic/cut/options/Feb_99/FieldTrip_en.htm.

Rogers, C 1969, *Freedom to learn*, Merrill Publishing Co., Columbus, Ohio.

Schön, D A 1991, *The reflective turn: case studies in and on educational practice*, Teachers Press Columbia University, New York.

Spronken-Smith, R 2003, 'Implementing a problem-based learning approach to teaching research methods in geography', paper presented at Higher Education & Research & Development Society of Australasia Conference, Auckland.

Von Glaserfeld, E 1984, 'Radical constructivism', in Watzlawick, P (ed.), *The Invented Reality*, Harvard University Press, Cambridge MA.

Vygotsky, L S 1962, *Thought and language*, MIT Press, Massachusetts Institute of Technology and John Wiley and Sons, Cambridge MA.

Watson, P, Dawes, L A, Mathieson, W & Shanableh, A 1998, 'Putting environmental engineering into perspective: a field study', *Proceedings of the 10th Australasian Conference on Engineering Education*, James Goldston Faculty of Engineering and Physical Systems, Central Queensland University, Rockhampton, Australia, pp. 179-183.

Windshitl, M 2002, 'Framing constructivism in practice as the negotiation of dilemmas: an analysis of the conceptual, pedagogical, cultural, and political challenges facing teachers', *Review of Educational Research*, vol. 72, no. 2, pp. 131-175.

Woolfolk, A 2001, *Educational psychology*, 8th edn, Allyn and Bacon, Boston.