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Student and Staff Engagement: Developing an Engagement Framework in a Faculty of Education

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Abstract: Student engagement is emerging as a key focus in higher education, as engagement is increasingly understood as a prerequisite for effective learning. This paper reports on the development of an Engagement Framework that provides a practical understanding of student (and staff) engagement which can be applied to any discipline, year level or course. The Engagement Framework proposes five non-hierarchical elements: personal engagement, academic engagement, intellectual engagement, social engagement, and professional engagement. As well as describing these elements, the paper also explores the theoretical foundations of the Engagement Framework, including a recognition of the importance of conation as one of three faculties of the mind alongside cognition and affect. By adopting this Framework, the Faculty aims to enhance unit design and development, teaching practice, and student support practices.

Introduction

This paper describes the development of an Engagement Framework that is designed to be used as an underpinning tool to support a range of initiatives to enhance both staff and student engagement within a Faculty of Education in a regional Australian university. Many students engage actively in their own learning and are passionate about and committed to their studies. This is particularly the case in pre-service teacher education where the goal of becoming a teacher acts as a motivator for many students. This is not to say that all students who are engaged are all engaged equally, or remain fully engaged across the course of their studies. The Engagement Framework described in this paper was designed as a means of breaking apart the concept of engagement in order to more explicitly explore the question of 'how' students engage.

A range of courses is offered within the Faculty – including a number of 4-year Bachelor of Education courses (Early Childhood, Primary, and Secondary Specialisations) and 2-year Master of Teaching courses (Primary and Secondary). The majority of courses are offered online as well as on-campus. Over half the student population studies in the wholly online mode and many of these students live in other Australian states or in other countries. The wholly online courses have no residential component and it is possible that students will not physically meet lecturers, tutors, professional staff or their peers during their course of study. Online students interact through the University's learning management system (currently Blackboard) and use a range of other technologies to communicate and develop learning communities. The online nature of much of the teaching and learning presents other challenges for students and staff – being engaged in a virtual space is different from being engaged as an on-campus student, where the support of peers and staff can appear more 'real'. The Engagement Framework described below can be applied to both modes of study, and can be used by staff, students and Faculty leadership to determine various aspects of engagement and how these might be enhanced.

Upon taking on the role of Director of Student Engagement in June 2011, I considered questions such as who and what pre-service teachers engage with while undertaking their study, whether engagement is the sole responsibility of students, the role staff play in enhancing/developing/fostering engagement through teaching and support practices and in unit design and the development of online learning environments. I also closely considered *how* students engage, in an effort to develop a deeper understanding of how engagement is manifest in pre-service teachers and how staff can distinguish between attendance, participation and engagement. These questions, while not new or original, were instrumental in the development of the Engagement Framework. What emerged from posing these questions, and from reflecting on my experience of teaching in the Faculty, were five distinctive yet intersecting, non-hierarchical elements of engagement: personal, academic, intellectual, social and professional. These are described in some detail later in the paper.

While this paper provides a brief review of the engagement literature, its primary purpose is to describe the Engagement Framework and its theoretical underpinnings. Within the Faculty of Education a range of activities, including staff professional learning workshops and the Faculty's Orientation program, have been designed around the elements of the Engagement Framework. In addition, some staff members have used this Framework to undertake reviews of their unit content and documentation, leading to unit re-development and a more explicit focus being placed on enhancing engagement strategies and articulating expectations. This Framework therefore, while still being developed theoretically and practically, is already proving to be a useful tool for staff in their teaching practice.

Literature Review

According to Krause (2005) engagement “emerged as a cornerstone of the higher education lexicon over the last decade” (p. 3), and defined engagement as “the time, energy and resources students devote to activities designed to enhance learning at university” (p. 3). The importance of engagement is highlighted by Chen, Gonyea and Kuh (2008) who argue that “by being engaged, students develop habits of the mind and heart that promise to stand them in good stead for a lifetime of continuous learning” (p. 1). Engagement is not only an action or a set of behaviours in which students are active. Staff too must be actively engaged as, according to Middlecamp (2005), “if [academics] do not engage we are unlikely to engage our students” (p. 17). In Australia, the ACER report, published in June 2011, highlights the role institutions and staff play in student engagement: “while students are seen to be responsible for constructing their knowledge, learning is also seen to depend on institutions and staff generating conditions that stimulate and encourage involvement” (p. 4). Engagement is also a key focus of the University. One of the principles underpinning the draft Strategic Plan for Learning and Teaching 2012-2014 is the “importance of student engagement in their own learning” (p. 1).

Engagement, as described in the literature, is often linked to particular behaviours or outcomes. For instance, Bowen (2005) claims that “engaged learners are those who complement and interpret what they learn from others with direct knowledge based on personal experience, who develop appropriately complex understandings situated in relevant contexts, and who recognise learning's moral implications and consequences” (p. 7). Brady (2004) notes that “when students are more active in their learning, they are more likely to be engaged” (p. 3). ‘Active learning’ involves “increasing student autonomy, interaction and exploration” (Brady, 2004) which is particularly important for pre-service teachers in coming to understand the complexity of teaching. Chen, Gonyea and Kuh (2008) state that “engagement is positively related to a host of desired outcomes, including high grades,

student satisfaction, and persistence” (p. 1). Stanford-Bowers (2008) describes engaged learning in some detail, claiming that it includes:

students establishing their own learning goals, working together in groups, and exploring appropriate resources to answer meaningful questions; tasks that are multidisciplinary and authentic, with connections to the real world; assessment that is ongoing and performance-based; and products that are shared with an audience beyond the classroom. (p. 39)

Stated more simply, the Australasian Survey of Student Engagement defines engagement as “students’ involvement with activities and conditions likely to generate high-quality learning” (ACER, 2011, p. 3). While much is made of the positive aspects of engagement, Krause (2005) claims that “for some it is a battle when they encounter university teaching practices which are foreign to them, procedures which are difficult to understand, and a ‘language’ which is alien” (p. 11). The importance of engagement and the behaviours associated with it are clearly established; the challenge is coming to a practical understanding of student (and staff) engagement that actively involves staff and students making deliberate decisions to engage in learning and teaching.

In developing an engagement framework, a fundamental starting point is determining how engagement manifests within student learning and staff teaching and support practices. It is important to view engagement as distinct from, and broader than, attendance or participation in learning activities, and to include students studying in all modes (on campus as well as wholly online) and on all three state-based campuses. While the University has proposed a First Year Framework (Brown & Adam, 2010), which includes a model outlining ‘Elements of success at university’, the focus of the Framework is on first year students. Recent evidence suggests that the number of students in their first year of study who have seriously considered withdrawing from university is declining (from 35 to 28% between 2008 and 2010), while the number of students in their third year of study who have seriously considered withdrawing is increasing – from 31 to 34% between 2008 and 2010 (ACER, 2011). Thus the development of the Engagement Framework reported in this paper was undertaken for the purposes of enhancing support for students across all courses, year groups and modes of delivery within the Faculty of Education and is underpinned by understandings derived from the AUSSE, the wider engagement literature, and research conducted within the Faculty (for example Dowden, Pittaway & Yost, 2009; Moss & Pittaway, 2010; Moss, Pittaway & McCarthy, 2007; Pittaway & Moss, 2006).

The Engagement Framework

All teaching is undertaken within an environment, or context. Teaching staff are responsible for the environment they construct, whether that environment is online or on-campus. Staff have a sphere of influence, within their units and their teaching spaces, in which they make deliberate decisions to create an environment conducive to learning. This environment will be different for different academics: not all teachers will teach in the same way or have the same expectations of themselves and their students but, allowing for differences, the importance of a safe, respectful and supportive environment in which to teach and learn is fundamental to student engagement. As such, the environment has a significant role to play in shaping each element of the Engagement Framework, and the elements cannot be divorced from these environmental factors (see Figure 1 below). Four key principles, emerging from the engagement literature and the literature on teaching and learning in higher education, underpin the Engagement Framework. These four principles are:

1. To engage students, staff must also be engaged (Middlecamp, 2005; ACER, 2011).
2. The development of respectful and supportive relationships is paramount for learning and teaching (Allodi, 2010).
3. Students are given – and take – responsibility for their learning (Allen & Clarke, 2007; Scevak & Cantwell, 2007; UTAS Strategic Plan for Learning and Teaching 2012-2014).
4. Students develop knowledge, understandings, skills and capacities when their learning is scaffolded, high standards are set, and expectations are clearly communicated (Krause, 2005; University of Melbourne, 2007; Dunn & Rakes, 2011).

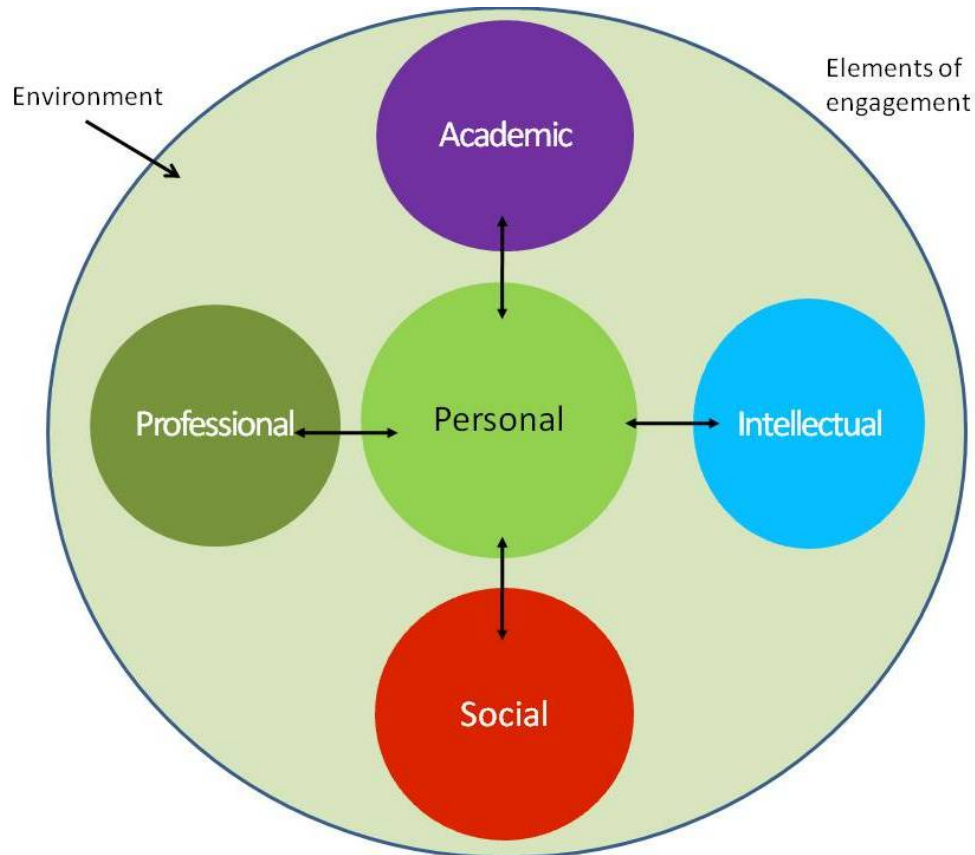


Figure 1: The Engagement Framework.

Elements of the Framework

As can be seen in Figure 1, which is my attempt to visually represent the Engagement Framework, the Framework is comprised of five generic elements which can be applied to any discipline, year level or course. These elements can be used by unit coordinators when designing and developing a unit, by tutors when considering the teaching practices they might employ to engage students in on-campus and/or online tutorials, by students in taking responsibility for their own learning and making decisions about what, when and how they will engage in their studies, and by professional staff in the design of materials to support marketing, recruitment, orientation, induction, transition and student support initiatives.

The Framework is not designed to be a hierarchy; rather the elements intersect with each other. None is more important than another, although some are necessary to support other elements of engagement. For instance, personal engagement – making the decision to

enrol in a university degree, having a level of confidence that a university education is achievable, being aware of intentions of and motivation for enrolling, and having, or developing perseverance – is important for students to then engage academically, intellectually, socially and professionally. For some students one element of the Framework will be more or less important than others; for example, some students will be highly engaged with the profession they intend to enter during their studies (an aspect of professional engagement), while for others social engagement is vital for success.

The personal element of the Engagement Framework is the most fully-developed at this stage and thus will be the element of major focus in this paper. Each of the other elements is introduced in the paper but continue to be both theorised and applied in online and on-campus learning contexts.

Personal Engagement

The theoretical underpinnings of this element are informed by two key concepts: conation and Dweck's (2006) work on mindsets. Conation, along with cognition and affect, make up the three faculties of the mind through which we think, feel and act. Conation, defined as "action derived from instinct, purposeful striving, or volition, has fallen out of common parlance partly because of modern psychologists' focus on [cognition and affect]" (Kolbe, 2009). Despite its lack of use in modern times, conation is still to be found in psychological and philosophical writing. For instance, Ernest Hilgard published a paper in 1980 titled 'The trilogy of mind: Cognition, affection, and conation' in which he cited many philosophers (including Aristotle and Kant) and psychologists (including William McDougall and Sigmund Freud) who had written about conation. According to Hilgard, McDougall "assumed that his reader was familiar with the classification of cognitive, affective and conative as common-sensical and noncontroversial" (p. 114). Centuries earlier Moses Mendelssohn wrote that the fundamental faculties of the soul are understanding, feeling and will (1750, cited in Kolbe). Likewise, in 1790 Kant wrote about the "three absolutely irreducible faculties of the mind: knowledge, feeling and desire" (cited in Hilgard, 1980, p. 107). Writing much more recently, Riggs and Gholar (2009) claim that conation is vital if learning is to take place.

When education is seen as a commodity, a necessary means of gaining employment, then 'learning' can be overlooked if at the forefront of students' thinking is the ultimate goal (of becoming a teacher, in the case of Education students). Without this awareness of taking on the role of learner a student's expectations of university study may be unrealistic or not able to be realised. This is significant as, according to Krause (2005), students "who enter the university environment with unrealistic expectations also tend to have greater difficulty engaging successfully" (p. 10). Personal engagement begins with the decision to enrol in a university course. This decision is informed by the information students receive before commencing study, which plays an important role in shaping students' expectations and their beliefs about their capacity to succeed at university. Information provided at the time of enrolment, through Orientation and induction activities, and the unit-specific information students receive is also an important aspect of personal engagement.

The implications of this are clear. Students have a responsibility in this regard and can be described as being personally engaged in their own learning; but the importance of others within this element of engagement and the responsibilities of others cannot be disregarded (ACER, 2011). Professional staff, when preparing materials to send to students (such as enrolment advice), also have a role to play as do unit coordinators, in designing unit outcomes, assessment tasks and study materials, and in designing learning environments, both physical

and online. Similarly, tutors, through their teaching practices, are also involved in enhancing personal engagement and hence learning.

The second theory underpinning the element of personal engagement is Carol Dweck's work on mindsets. Dweck, a psychologist, was "obsessed with understanding how people cope with failures" (2006, p. 3) and began her research career studying children as they grappled with 'hard problems'. The reactions of some of the children to these hard problems suggested that they had a view that "intellectual skills could be cultivated through effort ... not only weren't they discouraged by failure, they didn't even think they were failing. They thought they were learning" (p. 4). This came to be known as a growth mindset, or incremental theory: "stretching yourself to learn something new. Developing yourself" (p. 15). At that time Dweck held a different view: she thought that "human qualities were carved in stone. You were smart or you weren't, and failure meant you weren't ... struggles, mistakes, perseverance were just not part of this picture" (p. 4). This is described as a fixed mindset, or entity theory, and characterised by a view that to be successful a person must prove themselves to be "smart or talented. [It's about] validating yourself" (p. 15). In one study, Dweck investigated university students' reactions to feedback that was "quite critical, but also helpful. Those with a fixed mindset viewed it as a threat, an insult, or an attack ... the students with a growth mindset viewed the marker as a dinosaur [he sounded arrogant, intimidating and condescending], but as a dinosaur who could teach them something" (pp. 75-76).

If students enter university with a fixed, or 'entity' view of intelligence then they may disengage when things become difficult. When students with a fixed view of intelligence, and who have been praised throughout their early school years for being 'smart' or 'good', they may have developed a "helpless pattern of responses when asked to solve challenging problems" (Marzano & Pickering, 2011, p. 17). The students in Dweck's studies blamed their lack of success on their abilities [I'm not smart enough]. On the other hand, students who have a 'growth' view of intelligence know that "the more effort they put in, the more they will learn and the better their ability will be" (Dweck & Master, 2009, cited in Marzano & Pickering, p. 17). A student's beliefs about intelligence have important implications for their level of engagement. So too do academic staff awareness of their own beliefs about intelligence. A person's view of intelligence, whether intelligence is fixed or has the potential to grow, can be changed; therefore an important question to consider is how unit coordinators and tutors might foster a growth view in their students.

Personal engagement is the necessary first element of the Framework. Students bring expectations, experiences, assumptions, knowledge, skill and dispositions with them to university. They have a reason for enrolling at university, have made a choice to enrol and to complete a degree, and have specific intentions for choosing a course within a particular Faculty. This element of the Framework is therefore primarily about awareness: of intentions, expectations, assumptions, level of skill, and the responsibilities associated with their choice of enrolling in university. It also encompasses a student's awareness of their approaches to learning, and an awareness that others may have different intentions, expectations, assumptions that might not fit with their own. These are just some of the issues around personal engagement that staff could bring to the attention of their students, and questions they could ask of themselves when designing materials for student learning, support or advice.

As previously noted the Engagement Framework is in development and while preliminary thinking has allowed for the identification of the elements, more needs to be done to expand each category. The remaining four elements of the Framework are briefly described below.

Academic Engagement

Along with engaging personally, students also engage *academically*. They have particular academic attributes and skills that they bring, and others that they actively develop as they learn (Marshall & Rowland, 2006; Scevak & Cantwell, 2007; Clarke, 2008). In order to be successful, students need to engage academically with their learning, including taking “active control” of their learning “by planning, monitoring and evaluating their learning” (Scevak & Cantwell, p. 37); becoming effective note-takers, readers, listeners and problem solvers and becoming familiar with other aspects of academic culture including academic writing, and information and computer literacy (Brick, 2006; Scevak & Cantwell; Clarke). Staff who develop and coordinate units and courses must ensure that there are opportunities for the development of these skills and attributes over the course of a degree program. Academic engagement allows students to engage in other ways, one of which is intellectual.

Intellectual Engagement

Intellectual engagement comprises students’ engagement with the ideas, concepts, disciplinary thinking associated with education, and the social, political, civic, moral, and ethical issues that are part of teaching and formal education (Bowen, 2005; University of Melbourne, 2007). According to the University of Melbourne’s *Nine principles for guiding teaching and learning* “intellectual excitement is probably the most powerful motivating force for students and teachers alike. Effective university teachers are passionate about ideas. They stimulate the curiosity of their students, channel it within structured frameworks, and reveal their own intellectual interests” (p. 5). In the case of students studying within the Faculty of Education, if students are intellectually engaged they are more likely to think critically about education and educational issues, take an interest in current debates about education and schooling, read widely, discuss ideas with others, be aware of their existing beliefs, values and attitudes in relation to teaching and education and the disciplines to which they are exposed, and will develop confidence when their ideas are challenged. Students will ask questions, recognise the strengths and weaknesses of their own thinking and be open-minded to the views of others (Judge, Jones, & McCreery, 2009).

Social Engagement

The diversity of students enrolling in university extends to a diversity of views, perspectives, knowledge, understanding, and level of skill, confidence and competence. While becoming an independent learner is an important aspect of university life, it is also important to recognise the place this diversity has in enhancing individual students’ learning. Social interaction allows students to confront other ways of seeing the world and can deepen and extend their own views, beliefs and perspectives. Krause (2005) contends that social engagement is vital for success in university and is “equally as important as intellectual pursuits” (2005, p. 9), particularly for first-year students. Similarly, Masters and Donnison (2010) claim that success at university is “dependent upon the social networks that [first year students] have formed” (p. 88).

The University’s (draft) *Strategic plan for learning and teaching* highlights this social aspect of learning within strategy 4.1.2: Provide an optimum learning environment which “recognises the value of social interaction” and encourages learners to “incorporate into their learning perspectives that transcend the boundaries of a single nation, society or culture” (p. 3). Being engaged *socially* is about getting to know other students in class, whether that is an

online or physical class; making friends with fellow students, and engaging in social activities with them. Social engagement also includes forming positive relationships with tutors and unit coordinators (Pascarella & Terenzini, 2005, cited in Vaughan, 2010), and involves being proactive in becoming part of a learning community (Stanford-Bowers, 2008). Social engagement also happens through formal groups and societies organised and run by students, which help connect to others and which provide opportunities for networking and professional learning. In this way social engagement is also connected to all other elements of engagement.

Professional Engagement

The final element of the Framework is ***professional*** engagement. In the context of Education this is partly about Professional Experience (PE) and the connections pre-service teachers make with teachers, principals and others within the settings in which those experiences are undertaken. These connections go beyond PE, however, as professional engagement is also about involvement in classroom life on a more regular and sustained basis than professional experience allows for, and also includes joining professional and subject associations, attending professional learning opportunities, workshops and conferences, sharing experiences of placement with other students and learning from each other about varied educational contexts. Once students graduate these networks can help sustain them as beginning teachers and the skills developed through establishing these networks and through taking advantage of professional learning opportunities will allow graduates to develop into highly effective teachers.

Conclusion

The Engagement Framework, currently being developed within the Faculty of Education, is being used to underpin initiatives related to teaching and learning. It has been used as a starting point for professional conversations with staff in the development of course, unit and support material for students. These conversations provide opportunities for lecturers and tutors to share the teaching practices they currently employ to enhance engagement, and ways in which they make the elements of engagement explicit to their students. However, the Framework does not only apply to students: it is designed to enable staff to ask questions such as ‘how am I personally, academically, intellectually, socially and professionally engaged in my work?’ and ‘which of these elements are important to me in my work and how can I foster them to ensure that I am engaged?’. The Engagement Framework is therefore able to be applied to both staff and students, across disciplinary boundaries, in a developmental way across and within year levels, across modes of delivery, as a frame for unit design and development, and beyond university to include graduates, employers, and other stakeholders.

References

- ACER. (2011). Dropout DNA, and the genetics of effective support. *Research briefing, Australasian Survey of Student Engagement*, 11, 1-18. Retrieved from www.acer.edu.au
- Allan, J., & Clarke, K. (2007). Nurturing supportive learning environments in higher education through the teaching of study skills: To embed or not to embed? *International Journal of Teaching and Learning in Higher Education*, 19, 64-76. Retrieved from <http://www.isetl.org/ijtlhe/articleView.cfm?id=164>
- Allodi, M. (2010). The meaning of social climate of learning environments: Some reasons why we do not care enough about it. *Learning Environments Research*, 13, 89-104. doi: 10.1007/s10984-010-9072-9

- Brady, L. (2004). Towards optimal student engagement in teacher education. *Australian Journal of Teacher Education*, 29(2). Retrieved from <http://ro.ecu.edu.au/ajte/vol29/iss2/3/>
- Brick, J. (2006). *Academic culture: A student's guide to studying at university*. Sydney, NSW: Macquarie University.
- Brown, N., & Adam, A. (2010). *UTAS first year framework – proposal: Report to the UTAS Student Transition and Retention Taskforce*. Hobart, Australia. Centre for the Advancement of Learning and Teaching, University of Tasmania.
- Chen, P., Gonyea, R., & Kuh, G. (2008). Learning at a distance: Engaged or not? *Innovate*, 4(3). Retrieved <http://www.innovateonline.info>
- Clarke, A. (2008). *e-Learning skills* (2nd ed.). Hampshire, UK: Palgrave Macmillan.
- Dowden, T., Pittaway, S., & Yost, H. (2009). Enhancing written feedback: Partnering with students to find out the type of feedback they like best. *Partnerships for learning on campus and beyond*. Hobart, TAS.
- Dunn, K., & Rakes, G. (2011). Teaching teachers: An investigation of beliefs in teacher education students. *Learning Environments Research*, 14, 39-58. doi: 10.1007/s10984-011-9083-1
- Dweck, C. (2006). *Mindset: The new psychology of success*. New York: Random House.
- Hilgard, E. (1980). The trilogy of mind: Cognition, affection, and conation. *Journal of the History of the Behavioural Sciences*, 16, 107-117. doi: 10.1002/1520-6696.
- Judge, B., Jones, P., & McCreery, E. (2009). *Critical thinking skills for Education students*. Exeter, UK: Learning Matters.
- Kolbe, K. (2009). Kolbe Wisdom: Theory, history, research. Retrieved from <http://www.kolbe.com/theKolbeConcept/what-is-conation.cfm>
- Krause, K. (2005). *Understanding and promoting student engagement in university learning communities*. Centre for the Study of Higher Education. Retrieved September 4, 2011, from http://www.cshe.unimelb.edu.au/resources_teach/teaching_in_practice/.
- Marshall, L., & Rowland, F. (2006). *A guide to learning independently* (4th ed.). Frenchs Forest, NSW: Pearson Longman.
- Marzano, R., & Pickering, D. (2011). *The highly engaged classroom*. Bloomington, IN: Marzano Research Laboratory.
- Masters, J. & Donnison, S. (2010). First-year transition in teacher education: The Pod experience. *Australian Journal of Teacher Education*, 35(2). Retrieved from <http://ro.ecu.edu.au/ajte/vol35/iss2/6/>
- Middlecamp, C. (2005). The art of engagement. *Peer Review*, 7, 17-20. Retrieved from ProQuest.
- Moss, T., Pittaway, S., & McCarthy, R. (2007). The first year experience: Transition and integration into teacher education, *Proceedings of the AARE 2006 International Education Research Conference*. Adelaide, SA.
- Moss, T., & Pittaway, S. (2010). Changing lives, changing selves: Negotiating the world of online teacher education. *2nd International Conference on Academic Identities*. Glasgow, Scotland.
- Pittaway, S., & Moss, T. (2006). Contextualising student engagement: Orientation and beyond in teacher education. *Proceedings of the FYHE Conference*. Gold Coast, QLD.
- Scevak, J., & Cantwell, R. (2007). *Stepping stones: A guide for mature-aged students at university*. Camberwell, VIC: ACER Press.
- Stanford-Bowers, D. (2008). Persistence in online classes: A study of perceptions among community college stakeholders. *Journal of Online Learning and Teaching*, 4, 37-50. Retrieved from <http://www.webcitation.org/5cZeDTQS8>
- University of Melbourne. (2007). Nine principles guiding teaching and learning: The framework for a first-class university teaching and learning environment. Retrieved from <http://www.unimelb.com.au>
- University of Tasmania. (2011). Draft Strategic plan for learning and teaching 2012-2014.
- Vaughan, N. (2010). A blended community of inquiry approach: Linking student engagement and course redesign. *Internet and Higher Education*, 13, 60-65. Retrieved from Science Direct.