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Promoting Online Students' Engagement and Learning in Science and Sustainability Preservice Teacher Education

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Abstract: At James Cook University, a core first-year subject within the Bachelor of Education, Foundations of Sustainability in Education (FSE), sees students investigate the underlying science and complexity of socioecological challenges through inquiry, place-based learning, experimentation and consideration of classroom practice. Given that this subject is delivered across modes, a blended learning approach that encompasses an innovative use of learning technologies and careful consideration of pedagogy provides opportunity for both on-campus and online students to engage in active, learner-centred, collaborative, experiential and praxis-oriented learning experiences (Wals & Jickling, 2002). In this paper, we draw upon Pittaway's (2012) engagement framework and Herrington, Herrington, Oliver, Stoney and Willis's (2001) guidelines for quality online courses to explore students' perceptions and experiences of FSE. We investigate how a blended learning design can support the development of a robust foundational knowledge base in science and sustainability education, and engagement in active, experiential and praxis-oriented learning experiences for first year online students. This paper furthers the discussion around best pedagogical practice and blended learning design for science and sustainability education in online preservice teacher education, and in other disciplines in teacher education that call for hands-on learning experiences in an online environment.

Introduction

Research indicates that the current generation of school leavers entering university is more technically competent and confident than any previous student intake and, as such, has high expectations of universities to provide robust and engaging online learning environments and technologies (Jeffries & Hyde, 2010). However, generalisations about 'digital natives' (Prensky, 2001) are likely to mask complexities related to differences in, and the potential impact of socio-economic and cultural factors on, young people's technology uses and skills (Bennett, Maton, & Kervin, 2008). For instance, underprepared students and those who are the first in their families to attend university are likely to differ from their young peers in regard to their capacity to adapt to university study, the level of monitoring and support that they need for successful participation, and prior experience with online

learning and learning management systems (Brinthaupt, Fisher, Gardner, Raffo, & Woodward, 2011).

In Australia, it is worth noting that the widening participation agenda in higher education is not only reflected in a doubling of the participation rate (1982–2010) for school leavers but also for students in their twenties (Norton, 2013). Jeffries and Hyde's (2010) study revealed a changing landscape for learning, especially for those 'mature' aged students (i.e. over 21 upon entry) who have had no prior experience of using technology for learning and yet, on account of busy lives involving employment and family responsibilities, are dependent on accessing technology to undertake their studies. Indeed, for many higher education students in the second decade of the 21st century, "the existence of all day, every day online access" is an essential requirement and support for study (Jeffries & Hyde, 2010, p. 134).

While research shows that learners are likely to assume greater responsibility for their learning in online learning environments (Jeffries & Hyde, 2010), there are also heightened expectations on their part for the provision of adequate learning support (Kawka & Larkin, 2011). According to Kawka and Larkin (2011), the support that is required by online students "relates both to authentic learning and assessment experiences, as well as assistance in communicating with lecturers, tutors and peers" (p. 40).

In terms of online delivery, research efforts have tended to focus generally on the effectiveness of the medium itself (Reeves, Herrington, & Oliver, 2005), and, more specifically, on the utilisation of particular tools or strategies (Brinthaupt et al., 2011). The literature now calls for greater attention to aspects of curriculum and content organisation, pedagogy, assessment, communication, support strategies and resources that promote student engagement and learning (Brinthaupt et al., 2011; Green et al., 2010). According to Fan and Lê (2011), in order to cater better to students' learning needs in online environments, research is needed that privileges "the views of both staff and students, particularly their evaluative judgements" (p. 367).

The need for determining and ensuring quality in the process of designing and delivering online learning is an increasingly important issue for higher education institutions worldwide (Herrington et al., 2001). The past five years have seen a substantial expansion in the number of universities offering preservice teacher education courses in an online or 'blended' mode (i.e. technology-enhanced instructional design that draws together physical and online learning environments) (Fasso, Knight, & Knight, 2013; Green et al., 2010; Kawka & Larkin, 2011; Keppell & Riddle, 2011). At James Cook University (JCU), we offer preservice teacher education courses in early childhood, primary and secondary majors across multiple modes of delivery and campuses. A Bachelor of Education (B.Ed.) in early childhood education is delivered wholly online, of which the student cohorts typically comprise females in their twenties and thirties, with family and work responsibilities, from rural and regional contexts in Queensland and interstate. While these mature students are likely to have acquired a range of learning experiences, both formal and informal (often within the early childhood care and education sector), many are the first in their families to undertake higher education. Responding to diverse student needs and delivery contexts has substantially impacted the pedagogical and technological knowledge of the Education academic staff within our College (Kennedy et al., 2008).

At JCU, *Foundations of Sustainability in Education* (FSE) is a compulsory subject (or 'unit') for first-year preservice teachers that engages them in the underlying science and complexity of socioecological challenges, such as global climate change and premature species extinction, through inquiry, place-based learning, experimentation and consideration of classroom pedagogy. Given that FSE is undertaken by students studying on-campus and wholly online, a key consideration in the development of the subject was how to address the challenge of engaging students in an online context, with a view to develop foundational

knowledge in science and sustainability education, and to engage students in active, experiential and praxis-orientated learning. In this paper, we investigate how a blended learning design can support online students' learning and engagement by exploring the perceptions and experiences of a cohort of students who studied FSE in the online mode. We utilise two lenses – Herrington and colleagues' (2001) framework for evaluating online learning settings and Pittaway's (2012) engagement framework – to analyse students' perceptions regarding their engagement and learning vis-à-vis the subject's content modules and resources, scaffolded learning experiences, assessment tasks, and communication and support strategies. As reflexive practitioners, this focus is important as we are interested in the extent to which the blended learning approach adopted in the subject successfully engages our online students in active, learner-centred, collaborative, experiential and praxis-oriented learning experiences (Wals & Jickling, 2002), while developing a foundational knowledge base in an intellectually rigorous subject. While these aspects underpin science and sustainability education, they are potentially challenging to facilitate in an online learning environment. We aim to inform best practice regarding the design and development of online and blended learning environments in science and sustainability preservice teacher education, and believe that our findings have relevance to other learning areas in teacher education that also call for active learning approaches in an online environment.

In the sections that follow, we begin by reviewing the literature on online learning in both higher and teacher education, before outlining the aim of the current study and our chosen interpretative frameworks.

Online Learning in Higher and Teacher Education: Challenges and Opportunities

Online learning presents both challenges and opportunities to promote student engagement and learning. There is evidence in the literature that online learning environments can provide different affordances than physical learning spaces (Johnson, Adams Becker, Estrada, & Freeman, 2014) and, hence, more creative learning opportunities (Salysers, Carter, Barrett, & Williams, 2010). The literature is also suggestive that online learning environments can be more responsive to different learning styles and rhythms (Pombo, Smith, Abelha, Caixinha, & Costa, 2012). Fan and Lê (2011) proposed that:

Due to its adaptability to various learning styles, paces and contents, web-based learning has a stronger potential than the face-to-face learning mode to satisfy students with varied learning needs and preferences. This adaptability is desired by Australian universities as it fits with a high level of diversity in student populations, backgrounds and preferred learning styles. (p. 373)

According to Brinthaupt et al. (2011), a “productive and transformational approach” to online teaching entertains no notions of it being less demanding or time consuming than face-to-face teaching “or something that can be put on autopilot” (p. 522). Instead, it recognises that, on account of a well-designed online learning environment, the teacher is free to shift their attention from transmitting content to fostering student engagement, stimulating intellectual development and building rapport with students. In this way, online and blended learning environments can facilitate a shift from didactic teaching to constructivist, collaborative and student-centred learning approaches (Beldarrin, 2006; Fan & Lê, 2011) – approaches that are conducive to sustainability and science education.

It is important to note that our paper informs a scant literature on facilitating sustainability education in online teacher education environments. Having delivered an environmental education elective for preservice teachers online at JCU since 2001, which has

sustained high levels of student enrolments and satisfaction over time, Whitehouse (2008) concluded that, “well-conceived, web-based delivery is certainly no barrier to teaching and learning environmental education in the tertiary sector” (p. 11). Initially concerned with “how to engage students meaningfully with place-based learning through the no-place of cyberspace”, Whitehouse (2008, p. 11) reflected on learning and pedagogical design aspects of the fourth-year elective, as follows:

Students enrolled in e-learning subjects have to learn how to learn online as well as offline and make effective use of information communication technologies ... I deliberately designed learning and assessment options that require my students to shut down their computers and go offline and outdoors to undertake activities of their choosing ... Online delivery can realise quality outcomes if the principles of participatory inquiry are kept firmly in mind. (pp. 12, 15, & 17)

The assessment requirements of her online subject saw students undertake self-guided field visits to local environmental education facilities; ‘learning investigations’ that could be replicated with school age children (e.g. *Plant a Garbage Garden, Mapping my Place*); a research/curriculum assessment project (e.g. ‘*Learnsapes*’ analysis of a school ground, designing a web-quest); and reflective posts on the discussion board. In contrast with Whitehouse’s (2008) emphasis on self-directed and largely individual, place-based inquiry, Briano, Midor and Trentin (1997), in much earlier work, highlighted the potential of online environments to facilitate collaborative, interdisciplinary, project-based learning in environmental education, for Italian teachers and their students. While the article reported significant logistical challenges in the structuring and facilitation of the project groups, which needed to be addressed, the authors concluded that the pedagogical approach allowed the teachers who engaged in all phases of the projects to develop skills in environmental education project planning and implementation, problem solving and working in interdisciplinary teams.

More recently, in the context of online teacher professional development, Pombo and colleagues (2012) investigated the efficacy of a blended e-module in enhancing Portuguese primary school teachers’ assessment practices in science education, through group-based and reflective learning experiences. While participant teachers reported that their new learnings extended their classroom repertoire of science assessment and teaching strategies and tools, the authors concluded that participant teachers would benefit from a further blending of strategies in the e-module in order to enhance opportunities for *inter*-group sharing, possibly through peer assessment activities utilising asynchronous online tools, as well as face-to-face interaction with module facilitators (Pombo et al., 2012).

Sinha, Khreisat and Sharma (2009) identified four key interactions that shape learning processes in the online environment: (1) learner–content interaction; (2) learner–instructor interaction; (3) learner–learner interaction; and (4) learner–interface interaction (i.e. the interaction between learner and tools in order to perform requisite tasks). Online learners have reported on the benefits of both asynchronous and synchronous strategies to support such interactions (Beldarrin, 2006). There is broad consensus in the literature that, for effective online learning to occur, it is ultimately important to create a ‘community of learners’, wherein the quantity and quality of interactions promote student engagement (Abedin, Daneshgar, & D’Ambra, 2010; Oliveira, Tinoca, & Pereira, 2011).

Fasso et al. (2013) proposed an online learning design framework, in the context of teacher education, which aligns Dettmer’s (2006) phases of learning and doing with learner-centred pedagogies enabled by Learning Management System (LMS) and Web 2.0 tools. The framework enables preservice teachers to engage in the sociocultural practices of an online community as knowledge creators, rather than knowledge consumers, and, positioned as

such, to achieve higher order learning outcomes. In a similar vein, Green et al. (2010) evaluated a design approach to online early childhood teacher education, underpinned by notions of “learning as knowledge creation” and “teaching through assessment with technologies” (p. 270). These authors reported on an assessment schedule that built on the experiential bases and sociocultural contexts of their online students – many of whom were working in education and child care settings in addition to studying, as is the case for our online cohort – by way of tasks that called for resource sharing, co-creation of documents and personal reflection. Green and colleagues (2010) observed an evolving shift in their pedagogical emphases from knowledge acquisition to student-centred and self-directed engagement in “knowledge-creating communities” (Hong & Sullivan, 2009, cited in Green et al., 2010, p. 270).

Aim, Research Question and Interpretative Frameworks

Student engagement is increasingly understood as a prerequisite for learning and, hence, an emerging priority in preservice teacher education (Pittaway, 2012). Engagement is particularly important for online students given their need for often greater responsibility and self-discipline than on-campus students (Brinthaupt et al., 2011; Jeffries & Hyde, 2010) – who interact face-to-face in class settings where peer and staff support “can appear more *real*” (Pittaway, 2012, p. 37) – to actively engage themselves in meaningful tasks for effective learning to occur (Simon, 2002). Our study aims to investigate how blended learning design can promote online preservice teacher engagement and learning in science and sustainability education. Within this context, the research question that guided the development of the research design was:

In what ways does a blended learning design promote the development of a robust foundational knowledge base within a discipline or field of study in teacher education, and engage first year online university students in active, experiential and praxis-oriented learning experiences?

This research question reflects our view that the findings reported in this paper have applicability in other university areas of learning apart from science and sustainability education. The frameworks we use to interpret the findings, and hence respond to this research question, also enhance this study’s transferability to other areas.

We utilise Pittaway’s (2012) engagement framework to investigate the ways in which the first-year students of this study engaged or disengaged in the online delivery of FSE. Pittaway’s (2012) framework was developed as a tool for academics “to enhance unit design and development, teaching practice and student support” in both online and face-to-face modes of delivery (p. 37). It comprises “five distinctive yet intersecting, non-hierarchical elements” of engagement (Pittaway, 2012, p. 38), as follows: (1) personal, (2) academic, (3) intellectual, (4) social, and (5) professional elements (see Tab. 1). We saw utility in the framework given that it was developed for Faculty of Education academics in a regional Australian University, as is true of the authors’ context, and is applicable to online contexts as well.

Personal	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.
Academic	Planning, monitoring and evaluating learning, 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.
Intellectual	Engaging with ideas, concepts and disciplinary thinking associated with education and the social, political, civic, moral and ethical issues that are part of formal education.
Social	Forming positive relationships with tutors and unit coordinators, and being proactive in becoming part of a learning community.
Professional	Connecting with teachers, principals and others within professional experience settings, being involved in classroom life, joining professional associations, and attending professional learning opportunities, workshops and conferences.

Table 1: Pittaway’s (2012) elements of engagement and engagement behaviours. Source: Pittaway, 2012, pp. 39-44.

The second analytical lens that we employ in this paper – Herrington and colleagues’ (2001) quality guidelines for online courses – is a framework that was developed at an Australian university in order to provide a university-wide tool for “instructional design and consistent assessment and evaluation of online learning materials” (p. 266). It identifies three main areas of focus (pedagogy, resources and delivery strategies) and, what are deemed to be, critical elements of effective learning environments related to these areas (see Tab. 2). According to Herrington et al. (2001), the framework is intended to provide academics with the capacity to evaluate the potential effectiveness of online units through “a determination of the scope and extent of these critical elements” (p. 266). While we acknowledge other more recent guidelines for evaluating online education within the literature (e.g. Parsell, 2014) we found that our chosen framework resonated strongly with our data, and provided a powerful frame to investigate student perceptions of what elements supported their engagement and learning in the online subject under review.

Pedagogies	Authentic tasks; Opportunities for collaboration; Learner-centred environments; Engaging; Meaningful assessments.
Resources	Accessibility; Currency; Richness; Purposeful use of media; Inclusivity.
Delivery strategies	Reliable and robust interface; Clear goals, directions and learning plans; Communication; Equity and accessibility; Appropriate corporate style.

Table 2: Herrington and colleagues’ (2001) three main areas and associated critical elements of effective online learning environments. Source: Herrington et al., 2001, pp. 267-269.

Research Context

In response to JCU’s Curriculum Refresh Project, *Australia’s University for the Tropics* (Australian Department of Education, Employment and Workplace Relations, 2009–2011), and recognition of sustainability as a cross-curriculum priority in the Australian Curriculum (Australian Curriculum, Assessment and Reporting Authority, n.d.), the School of Education adopted a whole-of-program approach to embedding sustainability in its B.Ed.. Academic staff engaged in collaborative projects in order to design two new dedicated sustainability subjects (FSE, the focus of this paper, and a fourth-year capstone, *Service Learning for Sustainable Futures*); revise aspects of content in a longstanding elective (Whitehouse, 2008); and embed sustainability principles, concepts and issues in other early childhood and primary subjects in the B.Ed. (see Lasen et al., 2015; Simoncini, Lasen, & Rocco, 2014).

FSE was designed collaboratively by three academics (including the first and second authors) with disciplinary and curriculum expertise in science, science education and social science. Input was also sought from an online designer and academics from other universities, who facilitated sustainability subjects in preservice teacher education programs. An internal teaching and learning fellowship funded the fourth author, an academic with extensive expertise in environmental and science education including online delivery, to conduct an external evaluation of teaching and learning in the newly developed sustainability subjects. The external evaluation generated one of the data sources for this study. FSE seeks to develop students’ foundational knowledge of science, through exploration of the underlying science of key socioecological challenges – such as climate change, renewable and non-renewable energy, water availability and quality, and biodiversity conservation – and to model classroom pedagogies, involving experiential activities and hands-on experimentation, relating to sustainability and science education. Table 3 presents a summary of the blended learning design utilised in the online mode of FSE. The subject’s content is organised within six online modules hosted by Google Sites™ (Tab. 3) that adopt an overarching inquiry framework (with ‘tuning in’, ‘preparing to find out’, ‘finding out’, ‘sorting out’ and ‘reflecting and taking action’ phases [Hamston & Murdoch, 1996]), in order to engage students in a weekly, scaffolded journey of learning and discovery. While this study focuses on the early childhood online cohort, student cohorts are enrolled in FSE across multiple modes, including on-campus offerings at JCU’s three major campuses, and a community-based delivery for Indigenous students. Cohorts share the one platform in the university’s online LMS (*LearnJCU*) that hosts all learning materials (Tab. 3), and interact differently with teaching staff, activities, resources and technologies to achieve the subject’s learning outcomes through comparable learning experiences.

Aspect of subject delivery for online cohort	Engagement with learning environments
Modules hosted by Google Sites™ and linked to LMS	Online learning environment
Lecture vodcasts	Online learning environment
Other subject materials (e.g. readings, assessment support documents) hosted by LearnJCU	Online learning environment
Tutorials facilitated using wikis (e.g. scaffolded online tutorials support simple science experiments)	Online and physical learning environments
Assessment task 1: Solar still investigation and report (i.e. conducting a science inquiry and communicating findings)	Online and physical learning environments
Assessment task 2: Sustainability inquiry and web story (i.e. investigation, photographing and communicating aspects of local sustainability issue)	Online and physical learning environments

Table 3: A summary of the blended learning design adopted for the online delivery of FSE.

Intentional, student-centred blended learning design is recognised within the JCU (2014) *Access, Participation and Success Plan, 2015-2017* as a key strategy to engage diverse learners. The blended learning approach in FSE involves deliberate pedagogical choices that are responsive to both the diversity of student cohorts and the nature of the subject matter itself. It may be described as an ‘enabling’ and ‘enhancing’ blend (Keppell, 2010) in that it *enables* students’ participation by providing flexibility and overcoming issues of access and equity (e.g. through weekly lectures that are vodcasted for online students; Tab. 3) and *enhances* learning and the student experience through engagement with online and physical learning environments (e.g. through hands-on activities and experiments that are scaffolded by online tutorials; Tab. 3). Through this blend, students develop a foundational

knowledge base in key science and sustainability concepts and engage in authentic learning opportunities appropriate for classroom practice. For the online cohort, the innovative use of learning technologies and purposeful assessment task design facilitates achievement of the subject's intended learning outcomes, arguably providing students with a learning experience that is as rich and engaging as that of their on-campus peers. The assurance of "equivalent student learning outcomes regardless of a student's place or mode of study" is a recognised priority in the current Australian higher education threshold standards (Department of Industry, Innovation, Science, Research and Tertiary Education, 2011, Ch. 3.1.9).

The intended learning outcomes of FSE emphasise the development of a foundational knowledge base in science and sustainability education, as well as sustainability competencies and capabilities, such as critical, creative and systemic thinking and values clarification, as follows:

- *Recall, apply and communicate concepts and procedures of science and sustainability through multiple modes and genres to local and global contexts;*
- *Explore how the design and implementation of engaging and intellectually challenging learning experiences promotes the development of scientific literacy;*
- *Develop evidence-informed values and positions relating to sustainability through active citizenship, critical and systemic thinking, and reflection (JCU, 2015a, para. 2)*

These learning outcomes reflect Fien and Maclean's (2000) definition of education for sustainability as:

... a new paradigm for a lifelong learning process that leads to an informed and involved citizenry having the creative problem solving skills, scientific, technological and social literacy and commitment to engage in responsible actions to ensure an environmentally sound, socially just and economically prosperous future for all. (p. 37)

At the same time, science education is foregrounded in the subject given that an understanding of the Earth's systems and systems thinking are essential in empowering students to engage critically with the complex sustainability issues explored during the semester (Morse, 2000). Given that experiential learning is inherent to science and sustainability education – and the importance of place-based learning is increasingly recognised (i.e. connecting students with the resources, issues and values of their local community and environment) (Buxton, 2010; Green, 2012; Semken & Freeman, 2008; Smith & Sobel, 2012) – learning and assessment experiences in the subject are designed to get students 'out and into' their environment and working in active, hands-on ways.

Weekly tutorials provide opportunities for experiential learning and modelling of classroom pedagogies for science and sustainability education (Tab. 3). For example, students perform simple science experiments and activities involving the simulation of the greenhouse effect in a jar, the identification of soil samples and the use of dichotomous keys to classify plants and animals. All of the activities and experiments are designed such that they can be performed with simple everyday materials, making them accessible to online students. At the same time, they are supported online by wikis hosted within the LMS that guide students through the activities.

Experiential learning is also a key feature of the assessment schedule (Tab. 3). With a focus on the development of scientific literacy, all students are required to plan, conduct and report upon a solar still investigation that engages the principles and processes of a fair test,

the water cycle and sustainable ways of purifying water. Students also collaboratively investigate a local sustainability issue, through application of the strategic questioning framework (Peavey, 1994; United Nations Educational, Scientific and Cultural Organisation, 2010), and communicate findings to a children's audience through the creation of a digital web story. The focus here is on place-based learning and consideration of actions for a more sustainable future. The assessment schedule also includes a written examination wherein students are required to demonstrate foundational science and sustainability conceptual and pedagogical knowledge.

In light of the nature of the content and the diversity of the student cohorts, we deemed it essential to design and deliver a subject that was learner-centred, supportive of deep and meaningful learning and praxis-oriented. In the design phase of the subject, we carefully considered what online technologies, within and outside of the university's LMS, could support these pedagogical emphases and student achievement of learning outcomes.

Methods

Utilising a multi-method case study research design (Yin, 2009), we draw upon two sources of data (a student survey and student interviews) to explore the perceptions and experiences of a cohort of students who studied FSE online as part of the B.Ed. (Early Childhood Education) at JCU in 2012, with a view to understand better *how* they engaged in the subject's online environment, and *what* elements of the subject supported their engagement and learning. In reviewing the literature for this study, we found that research papers concerned with online pedagogies tended to focus on a specific technological platform or tool in a specific context, demonstrate the tool's effectiveness and then seek to generalise the tool's effectiveness in all contexts – a kind of 'one-size-fits-all' approach (Knight & Gandomi, 2010). For example, there are numerous studies on the benefits and limitations of blogs for teaching and learning (see Koschman, Kelson, Feltovich, & Barrows, 1996; Oravec, 2002; Saeed, Yang, & Sinnappan, 2009; Williams & Jacobs, 2004). However, within the LMS used for FSE, there are multiple tools that students engage with. Instead of focusing on the technological affordances of each tool or design feature, we have chosen to focus on students' perceptions of their learning processes and levels of engagement in an online delivery that draws upon a variety of learning technologies. This approach allowed us to privilege the students' voice so as to understand their learning experience while avoiding technological determinism wherein learning is tied to a specific technological platform or tool.

Data Sources

Within all sectors of education, student views of teaching and learning are becoming increasingly common as a perspective to be seriously considered (Baumfield, Hall, & Wall, 2008; Flutter & Rudduck, 2004; Jenkins, 2006). In this study, we draw upon two sources of data that privilege the students' voice. In order to understand better which elements of FSE, including the online environment, supported student engagement and learning, we canvassed the students' voice through: (1) an online survey that was completed once at the end of the semester; and (2) interview data from the aforementioned external evaluation of FSE that was completed in December, 2012.

Surveys are a reliable and valid tool for researchers and subject developers to evaluate web-based learning (Fan & Lê, 2011). The online survey was developed specifically for this study, comprising eight questions that generated evaluative data about the subject through

rating scales (including Likert-style scales), dichotomous questions and open-ended questions allowing for free response. Specifically, the survey explored the design and delivery of the subject (Question 1); aspects of the subject's online delivery that supported students' learning (e.g. their understanding of content knowledge, and the development of teaching strategies for science and sustainability education) (Question 2); students' ratings of the extent to which the hands-on activities and experiments embedded in the subject were engaging (Question 3); students' perceptions of the most and least effective aspects of the subject for their learning (Questions 4 and 5, respectively); students' views as to whether they would have liked additional/alternative learning materials and other approaches to online learning and teaching (Questions 6 and 7, respectively); and students' views on whether they had sufficient information communication technology (ICT) skills to undertake the subject online (Question 8).

Students were invited to participate in the research via a group email to the cohort. Twenty-seven participants (55% response rate) consented to completing the survey online and accessed the instrument through the LMS. Approximately 80 per cent of the respondents (n=22) were aged in their twenties and thirties; five respondents were aged in their forties; and one respondent was less than 20 years old. One respondent was male. Given that this profile is quite typical of the student demographic within the online cohort, it is likely that student survey responses reflect the views of the cohort, overall.

As part of the external evaluation, the fourth author conducted individual semi-structured interviews with a small group of volunteer students in December 2012, after they had completed the subject. Five female mature age students were interviewed. All interviewees were mothers, and two were employed as teachers' aides at the time of interview. Four of the students were in the first year of their degree, and one had almost completed two years of her degree.

Given students' varied geographical locations, the interviews were conducted by telephone and ranged from approximately 30 to 47 minutes in duration. Students were asked a range of questions about the learning processes, online pedagogies and assessment tasks that they engaged in during the subject. While they were not explicitly asked what they learned or acquired (e.g. content, processes, skills, attitudes, values), some of what they had learned emerged through the interviews. The interviews were audio recorded and fully transcribed, and the transcripts analysed in this study to provide a deeper insight into students' experiences and perceptions of FSE, than provided by the survey alone. While we acknowledge that generalisations may not be drawn from such a small sample of students, their responses could be interpreted as an indicator of possible typical responses, especially if all five interviewees mentioned particular issues. In the reporting of results, the participants are identified as Student 1 through to Student 5.

Data Analysis

Students' responses to the rating scales and dichotomous questions of the survey (Questions 1-3, and Questions 6-8) were analysed quantitatively using univariate analysis (frequencies, percentages and means). The results of this analysis are presented and discussed according to our analytical frames: Pittaway's (2012) elements of engagement (Tab. 1) and Herrington and colleagues' (2001) critical elements of effective online learning environments (Tab. 2). A deductive approach was employed to qualitatively analyse students' free responses to Questions 5, 6 and 7 according to elements of one or both of the analytical frames, as appropriate. For example, a student's comment that he/she would have liked the provision of additional videos to explain key science concepts more effectively (Question 6) would be coded as follows: *intellectual engagement* (Pittaway, 2012) and *resources* –

purposeful use of media (Herrington et al., 2001). The first and second authors undertook this process, discussing and refining their coding of the survey data until they were in agreement.

Students' free responses to Question 4 of the survey (i.e. the most effective aspects of the subject that supported their learning) and the transcripts from the five student interviews were analysed qualitatively using Nvivo 10 (QSR International, 2012). These data were also coded according to one or both of the analytical frames, as appropriate, in order to analyse students' perceptions of engagement and learning based on the online subject's modules, resources, scaffolded learning experiences, assessment tasks and support strategies. For example, a student's comment that referred to the opportunity or value of learning something new about a local sustainability issue through the sustainability inquiry assessment task would be coded as follows: *intellectual engagement* (Pittaway, 2012) and *pedagogies – meaningful assessment* (Herrington et al., 2001). The coding for this part of the analysis was discussed and refined by the first and third authors until they were in agreement. The coded data derived from the Nvivo analysis were also used to generate a word cloud (see word cloud software, for example, at <http://tagcrowd.com/> or <http://www.wordle.net/>) to provide a visual representation of the prominent themes to emerge from the findings and to guide the discussion of the results.

Findings and Discussion

In the following section, we present the findings of our analyses according to each of Pittaway's (2012) five categories of engagement, and outline students' perceptions of what elements of the subject supported their engagement and learning, drawing upon Herrington et al.'s (2001) quality guidelines for online courses. In this way, we seek to illuminate how the pedagogies, resources and delivery strategies adopted in FSE shaped students' personal, academic, intellectual, social and professional engagement. Figure 1 presents the word cloud highlighting the prominent themes regarding student engagement and learning to emerge from the analysis of the open-ended responses of Question 4 of the student survey and the interview data. It is broadly evident that 'intellectual engagement' (Pittaway, 2012; see Tab. 1) and 'authentic tasks', 'communication', 'clear goals, directions and learning plans', and 'purposeful use of media' (Herrington et al., 2001; see Tab. 2) are the most prominent themes to emerge from students' perceptions of the subject. We will now present and explore these findings, and others, in closer detail.



Figure 1: A word cloud representing the most prominent themes regarding student engagement and learning that emerged from the analysis of the coded open-ended responses of the student survey and the interview data.

Personal Engagement

Being personally engaged in university study requires an awareness of one’s own “expectations, experiences, assumptions, knowledge, skill and dispositions” (Pittaway, 2012, p. 42). In the context of a first year subject – when students are transitioning into higher education – feeling enabled to successfully undertake university study through accessible and inclusive approaches to teaching and learning is critical to student retention and success (Kift, 2009). When FSE was first conceptualised, a key consideration was providing ‘equivalence of experience’ for on-campus and online students. This immediate challenge was driven by our university’s *Learning, Teaching and Assessment* policy which requires that “the design of course content and learning experiences across different campuses and/or modes ... will ensure equivalent opportunity for students to achieve the stated learning outcomes” (JCU, 2015b). While we acknowledge that equivalence of experience does not guarantee quality provision of online or blended learning, in this case, this requirement provided the impetus to think creatively about how all students could be enabled to be successful in the subject through a purposeful selection of learning technologies that provide equitable access to learning that is participatory and experiential. Equity and accessibility (i.e. ensuring that all subject materials and activities are accessible to all students, irrespective of their geographical location) are critical elements in the delivery of online courses (Herrington et al., 2001). In the context of FSE, equivalence of experience is achieved, in part, by having a shared LearnJCU site for all student cohorts to access (noting that the university’s LMS automatically generates separate sites for each mode and that a request for a merged site is required) (see also, *Social engagement*).

Equivalence of experience is also achieved by using a range of learning technologies that enable lecturers and tutors to deliver the subject effectively in an online environment (see Tab. 4). Online modules and weekly lectures are the primary mode for content delivery. As previously discussed, the online modules (hosted by Google Sites™) are framed by an inquiry approach that navigates students through the weekly learning by way of a scaffolded narrative supported by readings and activities. The modules are linked into LearnJCU for all

students to access at any time, while the on-campus lectures are video-recorded (‘vodcasted’) so that online students can listen to their lecturer’s explanation of the subject matter, watch demonstrations and videos, and listen to questions asked during the lecture:

Being an online student I really, really appreciated being able to watch the lectures because they videotaped them and then put them online a few days later. I found that very helpful for my particular learning style to actually listen to the lecture and be able to watch the lecture online. *I felt like I was in the classroom* as well so it proved beneficial for me. (Student 3, emphasis added)

In the student survey, the majority of respondents (92.6%) agreed or strongly agreed that the subject materials and online delivery of FSE (including online modules, lecture vodcasts, online tutorials and Collaborate™ sessions) enabled them to have an experience of the subject comparable to that of on-campus students. As one student explained in the survey, “By having lecture vodcasts and online tutorials I felt like I was getting a similar experience to that of internal [*on-campus*] students”. This is significant because providing online students with equitable opportunities to achieve the same learning outcomes as their on-campus peers – particularly in the context of challenging subject content and underprepared first-year students – supports their personal engagement by empowering them to be motivated and successful learners.

On-campus provision	Equivalent online provision
LearnJCU site hosts all subject materials – accessed by all students	
Online modules hosted by Google Sites™ – accessed by all students	
On-campus lectures	Lecture vodcasts
On-campus tutorials	Online tutorials facilitated using wikis
Additional assessment support provided in lectures and tutorials at students’ request	Real-time assessment support provided via Blackboard Collaborate™ (virtual classroom) sessions
Interactive discussion and question-and-answer time provided in lectures and tutorials	Online discussion board, including prompts to use the discussion board in online tutorials

Table 4: A summary of the approaches to on-campus subject delivery employed in FSE and equivalent online provisions, facilitated via a range of learning technologies.

On-campus tutorials, in which students engage in hands-on and experiential learning activities, extend the concepts examined in the modules and lectures, and model teaching strategies for science and sustainability education. For online students, the tutorials are facilitated using wikis that, like the online modules, provide a scaffolded narrative that guides them through the weekly activities and simple experiments performed with everyday materials. The wikis include task instructions, links to resources, model responses and opportunities to respond to the activities via a discussion board.

Academic Engagement

Academic engagement supports students’ success through the employment of a range of academic skills and attributes that they bring to their university studies, and the active development of others while they learn (Pittaway, 2012). In a blended learning environment, students’ computer literacy skills, including the ability to navigate and engage successfully with the online learning environment, is as important to academic success as other academic

skills and attributes, such as the ability to read critically, evaluate and synthesise information, solve problems and communicate.

Question 8 of the survey asked students whether they had sufficient ICT skills to successfully undertake FSE online. While 25 respondents indicated that they did, two students (7.4%) responded in the negative. For instance, one student explained that she did not know what a hyperlink was or how to create one – a necessary requirement for the web story assessment. While this may not seem like a significant proportion of students, it does challenge the assumption that students who enrol in online courses possess the necessary computer literacy skills required to complete their studies successfully (cf. Bennett, Maton, & Kervin, 2008). Not possessing the necessary skills is likely to impede students' intellectual engagement in online study, as it makes navigating the online learning environment, accessing information and completing activities difficult. Furthermore, it is likely to impede students' personal engagement by eroding their confidence in their ability to successfully complete their university studies. It is also important to note that even students with advanced computer literacy skills benefit from guidance on how to use technologies in learning.

Aside from computer literacy, FSE explicitly teaches, models and assesses a range of other academic literacy skills that are necessary to complete the subject (and first-year university studies) successfully, such as written communication and numeracy skills. At interview, a student recognised the importance of her own academic engagement, valuing the emphasis placed upon the development of academic literacy in FSE, in addition to skills that she perceived as essential to future classroom practice:

I think the emphasis upon academic literacy is very valuable ... it's only a first year subject so you need to be able to learn from these things ... [*assessment*] feedback [*indicated*] that referencing across the board was pretty poor ... so, covering a whole range of different skills from academic literacy to some of the skills that will become vital in a classroom environment down the track. (Student 5)

Another interviewee explained how the online modules fostered important academic skills, including self-directed learning:

I felt we were encouraged to do the online modules of work, where you had to read, answer questions. That was self-directed learning, structured self-directed learning ... (Student 4)

Indeed, a blended learning approach can introduce opportunities for self-directed, self-paced learning (JISC, 2009). Beyond fulfilling 'content delivery' requirements of teaching, the modules were purposefully designed to create compelling and personally relevant weekly learning journeys for students. It is important to note though that six students (22.2%) indicated that technical difficulties associated with accessing the learning materials impeded their learning in the subject. A reliable and robust interface that is error free in its operation is an important consideration in the online environment (Herrington et al., 2001).

Intellectual Engagement

Intellectual engagement concerns students' engagement with the ideas, concepts and thinking associated with their chosen discipline. Students who are intellectually engaged ask questions, are critical about their own thinking and are open to multiple perspectives (Pittaway, 2012). Given that FSE is a first-year subject, it is foundational in the sense that it develops a knowledge base for students' curriculum studies in science and social science

education later in their degree. As such, the development, communication and application of science and sustainability concepts are important learning outcomes in the subject. Achievement of these outcomes is promoted through a purposeful choice of pedagogies and enabled through quality resources and media (Herrington et al., 2001).

As shown in Figure 1, intellectual engagement was the most significant theme to emerge from analysis of the student survey and interview data. A number of aspects of FSE engaged students intellectually; namely, the nature of the subject matter, the organisation of the subject matter (i.e. the modularised structure and the use of an overarching pedagogical framework), the assessment tasks, and the purposeful choice of online pedagogies and resources that supported students' learning (i.e. their conceptual understanding, scientific literacy and personal actions for sustainability). The findings pertaining to each of these aspects are presented below.

The Nature of the Subject Matter

It was clear from interview data that the nature of the subject matter explored in FSE played a critical role in engaging students intellectually. Students explained that new and diverse content and perspectives, which served to enhance their awareness and understanding of sustainability and sustainability issues both locally and globally, was engaging:

I really do enjoy the content of this unit. I found it very interesting and there's a lot of things that I didn't know and I've learnt for the first time. (Student 1)

I went to a commercial school when I was in school so we did practical subjects like typing, accounting and business economics and stuff like that so I haven't had a science-based schooling. I was really captivated by the subject content. I found it really interesting. I learnt heaps about the environment. I knew, but didn't really want to look at the bigger picture. (Student 3)

From a personal perspective, it gave me the opportunity to look at a lot of different issues ... that previously I haven't had time or the motivation to do. So, I gained a lot, lots and lots of knowledge about the environment, sustainability, about it being more than just a piece of land outside, that there is so much more to all of it, to the whole subject, and to sustainability. (Student 4)

The Organisation of Subject Matter

With regards to engaging students with the key ideas and ways of thinking in science and sustainability education, the conceptual organisation of the subject and an overarching pedagogical framework were key design considerations. The foci of the six modules (*Education for Sustainability, Water, Energy, Land, Air and Sustainable Futures*) serve as conceptual organisers for the key science and sustainability concepts and issues explored in the subject. With a view to foster independent learning, the modules themselves are framed by an inquiry pedagogical framework that prompts students to explore their prior knowledge, learn new knowledge by engaging with the weekly concepts and readings, reflect on and synthesise their learning, and consider implications for classroom practice and personal sustainability actions. The inquiry framework provides explicit guidance, scaffolding and structure, conveying clear expectations to students – as is necessary in the first-year experience (Kift, 2009). It also helps to structure clear learning goals and directions

(Herrington et al., 2001), which, for the students in our study, was a prominent theme to emerge from the data (Fig. 1).

As shown in Table 5, all students indicated in the survey that the modules effectively organised subject content. Approximately 92 per cent of students agreed that the inquiry framework was an effective way to organise the weekly learning materials. Thirty-seven per cent of respondents ($n=10$) indicated in Question 4 of the survey that the online modules, including their organisation, best supported their learning. As two students explained, the modules provided a “structured learning environment” and were “very helpful in developing an understanding of the content especially, the way they were structured e.g. drawing on our previous knowledge before learning new concepts and sorting out the new knowledge and how it can be used in classroom practice”.

Items	Agree and Strongly agree, n (%)	Mean
The six module organisation (i.e. <i>Education for Sustainability, Water, Energy, Land, Air and Sustainable Futures</i>) was an effective way to organise subject content	27 (100.0)	1.3
The inquiry framework of online modules (<i>Tuning in, Finding out, Sorting out</i> , etc.) was an effective way to organise the weekly materials	25 (92.6)	1.5
Assessment Task 2 (Sustainability inquiry and web story) provided a valuable opportunity to use my imagination and creativity in designing a web story	25 (92.6)	1.6
Assessment Task 2 (Sustainability inquiry and web story) provided a valuable opportunity to consider actions for sustainability	25 (92.6)	1.6
Assessment Task 1 (Solar still investigation) was valuable for developing my scientific literacy	26 (96.3)	1.7

Table 5: A summary of students’ responses regarding the conceptual organisation and assessment tasks in FSE ($n=27$). Mean represents the average score for each item, on a scale of 1 (strongly agree) to 4 (strongly disagree).

Choice of Online Pedagogies and Resources to Support Student Learning

According to Herrington et al. (2001), effective online learning environments use technology and media purposefully and appropriately, “according to strengths and affordances” (p. 7). The purposeful use of media was a prominent theme to emerge from the data, as shown in Figure 1. With regards to the online pedagogies and resources that engaged students intellectually, the online modules and lecture vodcasts and accompanying lecture notes (in the form of PowerPoint™ slideshows) were most frequently cited by students as supporting their understanding of content knowledge, development of scientific literacy and personal actions for sustainability (Tab. 6; see *Professional engagement* for a discussion of science and sustainability teaching strategies). Approximately 56 per cent of students ($n=15$) also reported that the hands-on activities and experiments embedded in the online modules, which were designed to consolidate students’ disciplinary knowledge, were highly engaging (Tab. 7).

As shown in Table 6, all students who responded to the survey engaged with the lecture vodcasts and accompanying notes in the subject. The lecture vodcasts were also cited most frequently in Question 4 of the survey ($n=12$, 44.4%) as being the most effective aspect of the subject that supported students’ learning and intellectual engagement because, for

example, they “really, really helped in my understanding of the content”. A student explained at interview that “being able to watch the lecture online [*was*] very beneficial because the stuff that I had read, my modules that I had worked through by myself, made more sense when I listened to the lecture” (Student 3). In this way, bringing students ‘into’ the lecture is important to support their personal engagement and learning. Further, unlike face-to-face lectures, vodcasts can be paused and replayed as necessary, from any location. Evidence suggests that students spend longer with content of pod/vodcasts than that of the scheduled lecture by, for example, replaying parts and researching recommended resources or links (JISC, 2009).

Aspect of learning	Responses, n (%)					
	Online modules	Lecture vodcasts and accompanying PowerPoints™	Weekly online tutorials	Assessment preparation sessions delivered via Collaborate™	Additional Camtasia™ recordings	Discussion board
Supported understanding of content knowledge	23 (85.2)	24 (88.9)	16 (59.3)	11 (40.7)	14 (51.9)	13 (48.1)
Supported development of scientific literacy	23 (85.2)	22 (81.5)	17 (63.0)	10 (37.0)	16 (59.3)	12 (44.4)
Supported personal actions for sustainability	23 (85.2)	20 (74.1)	15 (55.6)	9 (33.3)	11 (40.7)	12 (44.4)
Supported development of science and sustainability teaching strategies	22 (81.5)	21 (77.8)	15 (55.6)	9 (33.3)	10 (37.0)	10 (37.0)
I didn't participate in this aspect of the subject	1 (3.7)	0	2 (7.4)	8 (29.6)	4 (14.8)	1 (3.7)

Table 6: Students' views regarding the online pedagogies and resources that supported different aspects of their learning in FSE (n=27). The mode for each item is shaded. Students could select more than one response in each row.

Students most frequently cited the online modules and lecture vodcasts as supporting personal actions for sustainability (Tab. 6). At interview, students explained how studying FSE was an “eye-opening” experience that motivated them to consider their own actions for sustainability, as well as how to influence those of their family and colleagues:

It has been a real eye opening subject ... It has made me more conscious, more aware of personal issues, of community issues, and the world as a whole, and the issues that the world is facing going forth ... It has made me more aware, and I want to share it with people at school. I want to turn off the fridge on the weekend, and get the other staff that I am working with involved and share what I am learning with them so that they can also, especially the teachers, which are more in a position to share and motivate the kids, and incorporate some of the things that I am learning in what they're doing. (Student 4)

It [*the subject*] has made me think what can I do as one little person on my own or one little family, what we can do to make things better. (Student 3)

Responses to the online tutorials were mixed. While only two survey respondents reported that they did not participate in the online tutorials (Tab. 6), five students (18.5%) indicated in Question 5 that the tutorials were least effective for their learning. Similarly, the majority of students reported that the hands-on activities and experiments embedded in the online tutorials were only somewhat engaging (Tab. 7). One student explained that she could not complete all of the experiments as she worked through the tutorials at night. For example, in one activity, students are required to calculate the carbon content of a tree by measuring the circumference and shadow of a tree: “[I] couldn’t do the shadow test [*because*] I did that tute at night!” This student also explained the uncertainty she experienced doing the activities on her own: “Getting the resources together to do the experiments then wondering if I had done it right was disheartening”. The model tutorial responses provided, however, were helpful for this student: “Embedding response data to experiments was valuable”. In this case, studying online was an isolating experience that impeded this student’s intellectual and personal engagement.

Items	Responses, n (%)			Mean
	Highly engaging 1	Somewhat engaging 2	Not engaging at all 3	
Online modules	15 (55.6)	12 (44.4)	0	1.4
Weekly online tutorials*	2 (7.7)	20 (76.9)	3 (11.5)	1.8
Assessment Task 1 (Solar still investigation)	14 (51.9)	12 (44.4)	1 (3.7)	1.5
Assessment Task 2 (Sustainability inquiry and web story)	19 (70.4)	6 (22.2)	2 (7.4)	1.4

Table 7: Students’ views regarding the extent to which the hands-on activities and experiments embedded in particular aspects of FSE were engaging (n=27). The mode for each item is shaded. Mean represents the average score for each item, on a scale of 1-3. *n=25.

It can also be seen from Table 6 that approximately 30 per cent of students did not participate in the assessment preparation sessions delivered via Blackboard Collaborate™. Student feedback indicated that ‘real time’ or synchronous teaching and learning opportunities like these are difficult to accommodate given their personal commitments. A small number of students did not engage with the Camtasia™ recordings, developed by their tutor as ‘additional’ resources to support selected topics relevant to assessment, such as how to design a fair test and how to reference their work appropriately. Only one student indicated that she did not engage with the discussion board. Perhaps this is not surprising because, while optional, it presents the only ongoing opportunity for students to connect with their peers in the subject.

Twenty-one survey respondents (77.8%) indicated that they were satisfied with the range of the pedagogies employed and resources provided in FSE (Questions 6 and 7 of the survey). Four students offered the following suggestions to better support their intellectual engagement with the key concepts in the subject: more YouTube™ clips (“I found some YouTube clips on areas where I lacked understanding [*that*] really helped”); optional Collaborate™ sessions each week (“to consolidate weekly information”); and “more examples” (presumably of applied concepts). Interestingly, one student indicated that she would have preferred that *less* resources and activities were provided, explaining that it “was

a lot to get through per week. I could only work at night, so for me it was heavy going”. This highlights an interesting tension between providing a rich and stimulating online learning environment for students and them managing the realities of online study when often time-poor.

The Assessment Tasks

The two key assessment tasks also played an important role in engaging students intellectually. Assessment lies arguably at the heart of the learning experience in higher education, shaping how learners understand the most valued aspects and intent of the curriculum (JISC, 2010). Ninety-six per cent of students surveyed felt that the solar still investigation was valuable for developing their scientific literacy (Tab. 5). With regards to the sustainability inquiry and web story, 25 respondents (92.6%) felt that this assessment task enabled them to use their imagination and creativity, and to consider actions for sustainability (Tab. 5). Approximately one-quarter of respondents indicated in Question 4 of the survey that the assessment tasks were the most effective aspects of the subject for their learning ($n=7$, 25.9%).

The majority of students also reported high levels of engagement arising from the hands-on activities and experiments embedded in the assessment tasks (Tab. 7). Some students explained that they found the “hands-on learning” beneficial in the solar still investigation, while the place-based nature of the sustainability inquiry and web story was valuable as “it bought home the reality of sustainability”. At interview, a student explained how playing an active role in completing the assessment engaged her intellectually:

I don't know if interactive is the right word, but it [*the assessment*] kind of made you get out there and do things, like the solar still assessment, you had to make a solar still and watch it and write up about it, and the web story we had to go out there and take photographs of our chosen web story and research the sustainable issues around it, so it made you get out there and do stuff. I found being interactive with our assessments was beneficial. It made it interesting and not just reading vast amounts of literature and regurgitating it in an essay. (Student 3)

Social Engagement

For first-year students, social engagement (including social interaction and communication, getting to know other students, the development of strong social networks, and being part of a learning community) is particularly important for success at university (Kift, 2009; Pittaway, 2012). Social engagement also involves the development of positive relationships and open communication with university teaching staff. As shown in Figure 1, ‘communication’ arose as a dominant theme in this study.

In the student survey, 22 respondents (81.5%) either agreed or strongly agreed that they felt part of a community of learners in the FSE online environment (Tab. 8). At the same time, it must be recognised though that nearly one-fifth of students surveyed responded in the negative to this statement. Opportunities for dialogue with other students and university teaching staff are an important part of the delivery of quality online courses (Herrington et al., 2001). In FSE, the discussion board is the only tool within the LMS that facilitates student-student communication for online students; however, contributions are not compulsory or assessed. This was a deliberate choice in the design of the subject, so as not to overburden students’ workloads in what is already a rigorous subject. Instead, students are

prompted to contribute to the discussion board in the online tutorials to share their learning and experiences of the activities, and to ask questions. Three students indicated in the survey that the discussion board was least effective for their learning (Question 7). One survey respondent, on reflecting on a tutorial activity that was intended to culminate in students debating renewable energy on the discussion board, commented that: “I actually debated myself as no one else participated. [I] felt like I was doing the subject alone”. Another student explained at interview that contributing to the discussion board was onerous in light of the volume of reading that she had to do as an online student, and that she preferred the real-time verbal communication that came by way of the Collaborate™ sessions to support the assessment:

I am studying externally [*online*] so I have to read and I have to write an awful lot but just the general communication, to also have to sit and write that and then read responses, I find really tiring. And it’s like a chore, where being able to verbally just listen and talk about things is quick, it’s immediate. That’s what appealed to me.
(Student 4)

Item	Agree and Strongly agree, n (%)	Disagree and Strongly disagree, n (%)	Mean
There was benefit in sharing the one LearnJCU site with all modes of delivery in the subject (on-campus and online)	23 (85.2)	4 (14.8)	1.7
I felt part of a community of learners in the online environment	22 (81.5)	5 (18.5)	1.9

Table 8: A summary of students’ responses in regards to feeling part of a community of learners and accessing a shared LearnJCU site in FSE (n=27). Mean represents the average score for each item, on a scale of 1 (strongly agree) to 4 (strongly disagree).

Another opportunity for student–student communication and collaboration comes by way of the assessment tasks. For on-campus students, the solar still experiment and the web story task is completed in small groups so that students can collaborate on their experimental design, and on their inquiry into a local sustainability issue. For external students, working collaboratively is optional, acknowledging that not all students will have peers in their own geographic location to work with. For one online student who could take up the opportunity, collaborating on the assessment tasks was useful for their learning:

With our assessment tasks, we had the opportunity to work in a group, so I was working alongside other students, and I think, yeah, that did help me to learn and consolidate and talk with other students seeing what they thought or what their understanding is with the content. (Student 1)

High levels of student–staff communication are fostered throughout the subject in relation to weekly learning and the assessment tasks (e.g. via email, the discussion board, announcements on LearnJCU and assessment preparation sessions). While this is reflected in consistently high levels of student satisfaction in subject and teaching evaluation surveys (administered by the university), it is not clear whether students considered their communication with teaching staff when deciding whether they felt part of a community of learners. Students did, however, acknowledge the importance of timely communication and feedback from teaching staff at interview:

I think they [*the tutor and lecturer*] have done a really good job, in like, they're constantly sending out emails and reminders and letting us know when information has been posted and I think that's sort of been a good motivation for myself. (Student 1)

My tutor was outstanding because any questions that anyone had, he would respond to very promptly and there was no silly question. It was safe to ask a question. (Student 2)

As discussed earlier, a deliberate decision was made to develop one integrated LearnJCU site for all student cohorts in FSE. Aside from contributing to students' personal engagement, there is evidence that this approach also supports their social engagement. Although students are not actively required to interact with peers across different modes of delivery (on-campus and online), the provision of one LearnJCU site does appear to provide students with a sense that they are part of a larger cohort and community of learners. In the student survey, 23 respondents (85.2%) felt that there was benefit in sharing the one LMS site with all modes of delivery in the subject (Tab. 8).

Professional Engagement

Professional engagement involves students engaging with their chosen profession during their university study. In the context of our study and Pittaway's (2012) framework (i.e. preservice teacher education), it is about students connecting with teachers, principals, schools and other educational contexts; engaging in professional experience; participating in professional learning opportunities; and sharing and reflecting on their professional experience with other students. We have also extended this category of engagement to include the development of a professional identity and the skills and knowledge necessary to teach in the classroom. As teacher educators, we understand the importance of modelling and engaging students in authentic learning experiences that also can be effectively implemented in classrooms. We recognise that "teacher education represents a unique form of teaching in which both the content of the teaching and the practice of the teaching form the basis of what is being taught" (Edwards, 2010, p. 10).

Indeed, it is the purposeful choice of authentic pedagogies in FSE that engages students professionally (Herrington et al., 2001); see the prominence of 'authentic tasks' in Figure 1. Through the online modules, lectures, tutorials and assessment tasks, FSE makes connections to early childhood and primary curricula and pedagogies for science and sustainability education, in order to develop students' professional identity and competence. As shown in Table 9, 89-96 per cent of respondents agreed that the online modules made effective links to classroom practice, and that the online tutorials and assessment tasks modelled classroom strategies for science and sustainability education effectively. Students most frequently cited the online modules and the lecture vodcasts in terms of supporting their development of science and sustainability teaching strategies (Tab. 6).

Item	Agree and Strongly agree, n (%)	Mean
The assessment tasks (Tasks 1 and 2) effectively modelled classroom strategies for science and sustainability education	26 (96.3)	1.7
The online module activities made effective links to classroom practice	26 (96.3)	1.8
The weekly online tutorials effectively modelled classroom strategies for science and sustainability education	24 (88.9)	1.9

Table 9: A summary of students' responses regarding whether the online modules, online tutorials and assessment tasks in FSE made effective links to classroom practice and effectively modelled classroom strategies for science and sustainability education (n=27). Mean represents the average score for each item, on a scale of 1 (strongly agree) to 4 (strongly disagree).

Student perceptions of authenticity of assessment tasks and consideration of the implications for real-world practice have been shown in the literature to influence student learning (Gulikers, Kester, Kirschner, & Bastiaens, 2008). In this study, one student explained at interview how the solar still investigation engaged her professionally as a future teacher:

Actually doing the experiment and as a prospective teacher going through the process of doing a basic experiment and writing it up and going into a little bit of depth was quite useful. (Student 2)

Similarly, for another student, the sustainability inquiry and web story was professionally engaging as it modelled an authentic pedagogical process:

I think it was a very good exercise for preservice teachers to be able to work on developing something that was age appropriate, something that was meaningful in terms of being a sustainability issue, something that was informed by the process of inquiry and too, I suppose, to have a bit of an idea of what it's like if you were to be able to present it on a real issue in the world around us and to be able to deliver it in an educational environment. (Student 5)

This student also explained that the provision of authentic examples of education for sustainability by way of case studies was engaging and motivating, and helped her to consider her role as a future teacher:

Of interest to me was some of the examples where schools have taken on engaging sustainability and garden projects and things like that. Reading about some of the different schools, you know, like the ones that were the trial for the Stephanie Alexander garden project. Case studies like that. And I suppose for me as I'm starting to envisage myself as a teacher ... it's really quite motivating, I suppose, to see that on a national scale there are a lot of things that we can learn ... The value of seeing a case study, the successes, the failures that people have had in the past and being able to learn from that to be able to draw from that. (Student 5)

In the context of preservice teacher education, and our own subject, authenticity serves to promote learning through "a more challenging content of diverse practices and for diverse learners" (Iverson, Lewis, & Talbot, 2007, p. 291).

Summary and Conclusions: Implications for Practice

This research sought to investigate the ways a blended learning design can promote the development of a robust foundational knowledge base in science and sustainability education, and engage first year online university students in active, experiential and praxis-oriented learning experiences. While this study was conducted in a science and sustainability context, we believe its findings are of value to a range of learning areas in teacher education that call for quality online and blended learning design.

In answering the first component of our research question, our findings revealed that intellectual engagement was fostered through the provision of online modules that effectively organise the subject's content and structure the weekly learning through an overarching inquiry pedagogical frame. Together, these aspects most strongly supported the development of students' foundational knowledge base by supporting them to engage with the learning material in a structured way and providing them with clear learning goals and directions. Far from privileging knowledge acquisition, student-centred, self-directed engagement with the learning material is supported through the explicit scaffolding (cf. Green et al., 2010). Such scaffolding is critical in an online environment – and even more so in the context of the first-year experience for diverse student cohorts.

The appropriate use of media and the assessment tasks also played a critical role in engaging students intellectually and developing their knowledge base. Students frequently cited the lecture vodcasts as being important for engaging with the subject's content. Indeed, it was the nature of the subject matter itself that students found stimulating and engaging. Intellectual engagement was also fostered through the assessment tasks that support the development of students' scientific literacy, exercise their imagination and creativity, and prompt them to consider actions for sustainability.

In answering the second component of our research question, our findings revealed that students engaged in active, experiential and praxis-oriented learning experiences through scaffolded hands-on activities and experiments embedded in the online modules and tutorials. These aspects were also integral to the assessment task design. Both assessment tasks engage students meaningfully with place-based learning by mobilising them in their local environment through inquiry. This finding has applicability to other learning areas in teacher education that call for active, learner-centred, experiential and praxis-orientated pedagogies in an online or blended learning environment, such as the Arts, Technology, and Health and Physical Education. A powerful blended learning design can be achieved by using online affordances to facilitate students' learning in their physical environment; for example, by thoughtfully selecting experiential activities that students can perform themselves with readily accessible materials; by scaffolding and structuring such activities in the LMS so that students feel supported and enabled; and by considering how a subject's assessment tasks can offer opportunities to engage meaningfully with their local environment. Although not employed in FSE, learning technologies can also encourage students to share their hands-on experiences through, for example, video blogs, which themselves become shared artefacts for learning. In this way, a blended learning environment can support active, student-centred learning approaches, as suggested by Beldarrin (2006) and Fan and Lê (2011).

Although the online tutorials included opportunities for experiential learning, the majority of survey respondents found that these activities were only 'somewhat engaging', which may be a reflection of the activities' requirements (e.g. to source materials to complete the experiments, or to conduct some activities outdoors). Where possible, the tutorials provide secondary data or scenarios if students cannot perform the activities themselves. In 2014, the first author led a project to develop a suite of short videos to accompany the online tutorials that show on-campus students performing the activities and manipulating materials and equipment, with a view to support students' engagement with the tutorials and prevent

the “disheartening” experience of wondering whether they have “done it right”, as described by one of the survey respondents. These videos will be employed for the first time and evaluated when the subject is delivered in 2015.

In a professional degree like the B.Ed., we found that students valued opportunities for praxis-orientated learning, which, in turn, fostered professional engagement as a way to develop both their professional identity as teachers, and the skills and knowledge required for classroom practice. Authentic tasks emerged as a dominant theme in our study; links to the curriculum and classroom strategies for teaching science and sustainability education are evidenced in the online modules, the lecture vodcasts and PowerPoint™ slideshows, online tutorials and assessment tasks.

Academic engagement was found to be fostered through the effective use of a range of ICTs that enable students’ access to the learning materials, as well as an explicit focus on academic skills such as self-directed learning (which can be supported through well-designed and scaffolded learning modules). At the same time, we are reminded of the importance of understanding the ICT proficiency of our students, as not having adequate skills can impede students’ academic, intellectual and personal engagement.

As students are transitioning into higher education, an enabling learning environment that supports personal engagement is critical. We found that providing online students with a clear sense that they are receiving a comparable learning experience to that of their on-campus peers to be important in this context. The need to provide equivalent learning opportunities, as required by our university, led us to consider how we might leverage the strengths of a range of learning technologies to deliver subject content and experiential learning opportunities for *all* cohorts, through purposeful pedagogical design. In this way, the online modules became an integral component of subject delivery for both online and on-campus students, while learning technologies offer tailored solutions to enable online students to access tutorials and lectures.

With regards to promoting students’ social engagement in the online environment, we found that student–staff communication was another prominent theme to emerge in our study, as students valued timely feedback and support from teaching staff. In our review of the literature regarding what constitutes quality online teacher education, there is broad consensus on the value of creating a community of learners that positions students as knowledge creators through collaborative, learner-centred pedagogies (Abedin et al., 2010; Fasso et al., 2013; Green et al., 2010; Oliveira et al., 2011). It is interesting to note, however, as we reflect on the design of FSE, strategies that promote social engagement and the development of an online community were not a key consideration. Nonetheless, our findings indicate that more than 80 per cent of the students who were surveyed felt part of a learning community (Table 8). This raises interesting questions about the extent to which online student–student interactions and collaboration are important in a successful blending learning design. In FSE, online students predominantly learn individually through carefully scaffolded learning experiences, guided inquiry and place-based learning. While engagement and learning may be enhanced through greater opportunities for student–student interaction, the challenge is to find a balance between an intellectually rigorous and stimulating subject (and the associated student workload) and building connections between learners in such a way that is not onerous (cf. Student 4, who found the discussion board ‘tiring’). We continue to reflect on how to embed purposeful opportunities for online student collaboration as the subject evolves, particularly given that building connections between learners is important in supporting first-year students’ personal engagement and success.

Our journey through this research reminds us that promoting student engagement with a view to best support learning must be purposefully planned during the subject development phase. In this study, Pittaway’s (2012) engagement framework and Herrington et al.’s (2001) quality guidelines for online courses offered real utility in reflecting on our instructional

design to understand how students engage in the online environment personally, academically, intellectually, professionally and socially, and how this is facilitated by our choice of pedagogies, resources and delivery strategies. In doing so, we believe that this study furthers our understanding of what constitutes quality preservice teacher education in an online environment, particularly within the under-researched field of science and sustainability education. We encourage other university educators developing or enhancing online or blended courses to share their experiences of using quality frameworks to inform their instructional design and pedagogical choices, to further the discussion on best practice for student engagement and learning across a range of disciplines, particularly those that call for place-based and experiential learning.

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