

Article

# Sustainability: A Regional Australian Experience of Educating Secondary Geography Teachers

Michael Danaher \*, Jiaping Wu and Michael Hewson 

Department of Humanities, School of Education and the Arts, Central Queensland University, Rockhampton 4701, Australia; j.wu@cqu.edu.au (J.W.); m.hewson@cqu.edu.au (M.H.)

\* Correspondence: m.danaher@cqu.edu.au

**Abstract:** The United Nations Sustainable Development Goal (SDG) number four seeks an equitable and widespread education that enables an outcome of sustainable development by 2030. Intersecting the studies of society and earth processes, a geographical education is well placed to make cohesive sense of all the individual knowledge silos that contribute to achieving sustainability. Geography education is compulsory for the first three years of the secondary education curriculum in Australia; however, research has shown that many geography teachers are underprepared and report limitations in their teaching of sustainability. This article engages with this research problem to provide a critical reflection, using experiential knowledge as an analytical lens, on how tertiary level geography training at one Australian regional university can equip undergraduate teacher education students with the values, knowledge, and skills needed to develop their future students' understanding and appreciation of the principles of sustainability. The authors unpacked a geography minor for a Bachelor of Secondary Education degree at Central Queensland University and, deploying content analysis, explain how three units in that minor can develop these students' values, knowledge, and skills through fostering initiatives and activities. The analysis was framed by elements of pedagogy that offer learners a context for developing active, global citizenship and participation to understand the interdependencies of ecological, societal, and economic systems including a multisided view of sustainability and sustainable development. The study concluded that the three geography units engage student teachers in sustainable thinking in a variety of ways, which can have a wider application in the geography curricula in other teacher education courses. More importantly, however, the study found that there is a critical need for collaboration between university teachers of sustainability content and university teachers of school-based pedagogy in order to maximise the efficacy of sustainability education in schools.



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## 1. Introduction

The broad objective of this article is to show how tertiary level geography training meets the challenge of equipping undergraduate education students with the values, knowledge, and skills needed to teach about sustainability that is embedded in geography in the Australia school curriculum. Research has shown that many geography teachers are underprepared and report limitations in their teaching of sustainability. Sustainability is one of the three cross-curricular priorities in the Australian school curriculum [1]. In this context, sustainability has been developed around the three key concepts of systems, world views, and futures. The first key concept explores the interdependent and dynamic nature of systems that support all life on Earth and our collective well-being. The second concept enables a diversity of world views on ecosystems, values, and social justice to be discussed and recognised when determining individual and community actions for

sustainability. The third concept is aimed at building capacities for thinking and acting in ways that are necessary to create a more sustainable future. The concept seeks to promote reflective thinking processes in young people and empower them to design action that will lead to a more equitable and sustainable future [1]. Accordingly, sustainability education has elements that are embedded in broad teaching fields including English, mathematics, science, the humanities and social sciences, the arts, technologies, health and physical education, languages, and work studies in schools. As a consequence, teacher education courses in universities must prepare graduates with the knowledge about both the individual subject matter and the competencies for education for sustainability (EfS) [2].

EfS is defined in the Australian curriculum as “to develop the knowledge, skills, values, and world views necessary for people to act in ways that contribute to more sustainable patterns of living” [1]. It is more than knowing about sustainability and cannot be attained by simply adding more units to an already crowded and often incoherent teacher education curriculum [3]. EfS involves an entire reorientation of educational systems and goals that empower everyone “to make decisions and act in ways that are culturally appropriate and locally relevant to address the problems threatening our common future” [4] (p. 29). Although the teaching of sustainability is a cross-curricular priority in Australian schools, there are no mandated policies for the inclusion of EfS “as a key requirement in pre-service teacher education”, at least not in Queensland, Australia [5] (p. 27). Therefore, there is a need to reduce the “quality” gap between tertiary and secondary level sustainability education and, in that way, to build up the capability of teacher graduates for implementing EfS in schools. Geography “is fundamentally interdisciplinary and deeply integrative” [6]. Many education policymakers saw that geography could offer a highly appropriate home for sustainability studies, but “the geographical community itself had so far been relatively slow to take a leading role” [7]. This article presents a case study that explores a content-based analysis of three geography units in Central Queensland University’s (CQU’s) secondary teacher education course and makes a contribution to the literature in the emerging field of embedding EfS in teacher education courses [8].

Bosevska and Kriewaldt [9] cite Capra [10], Orr [11], and Sterling [12,13] in arguing that the state of the global environment and the perceived estrangement of humanity from the natural world has caused a growing number of educational scholars to call for a reorientation to sustainability in the school curriculum and school communities. Education is considered to be the greatest of all our resources and is heralded as a major strategy for developing the skills, knowledge, and values needed to build a more sustainable world [14,15]. Central Queensland University (CQU) recognises the importance of the education-sustainability nexus and has been offering environmental geography units since the early 2000s. Geography education has a critical educative role to play in focusing our attention on serious sustainability issues, and arguably plays a central role in integrating the related aspects of science, technology, engineering, and mathematics (STEM) as well as other disciplines.

Geography is a mandatory subject in Australian schools from prep level to year 8. It may be taught as a specified sub-strand in a combined humanities subject in primary schools, while in secondary schools, geography is generally a separate subject and is compulsory up to year 10. Geography is offered as an elective subject in years 11 and 12. The Australian Curriculum Assessment and Reporting Authority (ACARA) [1] explains that the concept of sustainability in geography is used as a way to evaluate decisions and proposals as well as to measure the capacity of something to be maintained indefinitely into the future. It is used to frame questions, evaluate the findings of investigations, guide decisions, and plan actions about environments, places, and communities. Though sustainability is a widely used concept, it is no real surprise that the main student preconception around it is a vague understanding of what it means and how it can be achieved when there is so much evidence of non-sustainable practices [16]. As [17] (p. 2) aptly puts it, “given [the] reality, the international community has come to recognise that sustainability is essentially an on-going learning [change] process”. Common notions around the concept

of sustainability tend to be framed within the values and principles that the world's natural environments need to be used and managed in such a way as to make them available for future generations [18]. The features of a geographical approach to enquiry provide a much more effective means of developing an environmental education that is more cognisant of the deeper aspects of sustainability than a standard scientific approach to enquiry-based learning [18].

## 2. Background to CQU Geography Units

CQU has its main campus in Rockhampton (Central Queensland), though there are several campuses throughout Australia, including in most of the capital cities. Most students enrolled at CQU are online students and use the Moodle learning platform to access and engage with their units. Historically, CQU has been a large provider of distance education because of its regional location, and over time, this distance education has evolved into online learning. This was the case long before the emergence of the COVID-19 pandemic. CQU's Bachelor of Education (Secondary) degree is popular, with 515 enrolled students in 2020 (CQU Handbook 2020). Students of this degree are required to complete 2 discipline teaching areas from a choice of 11, with each discipline teaching area comprising 6 units. The geography minor comprises 1 of those 11 discipline teaching areas. The three units from the geography minor that are the focus for this study are "Sustainable Regions and Cities", "Remote Sensing of Environment", and "Environmental Management Systems". They are similar to other units in the geography education minor through which we teach the core knowledge and skills of aspects of geography with a focus on local applications. In the three cases, we take diverse and complementary approaches to EfS. The three units can be considered as representative cases to explain and exemplify the integration of EfS in geography education at CQU.

## 3. Limitations of Geography Teachers in Australian Schools

Sustainability education competes for curricular space, both in schools and in university teacher education. However, ultimately, the emerging prominence of sustainability issues will need the support of all, or at least the vast majority of, teachers and teacher educators [19]. Fullan [20] places teacher educators first and foremost in their role as local change agents. Teacher competence is crucial to effective implementation of sustainability education [19]. However, many schoolteachers are underprepared and report limitations in their teaching of sustainability. In Australia, a survey shows only about one-third of teachers who are aware of EfS know how to integrate it into their teaching practices. More than half of those who know what it is are not teaching it to a standard that meets ACARA guidelines [21]. The under-preparedness of teachers relates largely to their lack of deep subject-matter knowledge around sustainable development as well as around the pedagogy for sustainable development. Furthermore, there are other shortcomings for realising effective teachers of sustainability education in Australian schools. The National Committee for Geographical Sciences (NCGS) of the Australian Academy of Science notes that secondary school teachers are under-prepared for teaching geography. Some 39.8% of geography teachers are doing so "out of field", that is, teaching geography without any geography training themselves [22]. This figure is the highest percentage of any secondary school discipline. The NCGS opinion is that, "this is a serious problem for the subject, and for the education of young people in general, because research shows that unqualified teachers may devote less time to the subject, skip topics they find difficult, and fail to engage the interest of students" [22] (p. 85). The NCGS further observed that only 9 of Australia's 37 public universities retained a full-time specialist geography educator.

This article considers how we can build up the EfS teaching skills of teachers. As previously mentioned, sustainability is one of the three cross-curriculum priorities of Australia's national curriculum, the other two being Aboriginal and Torres Strait Islander Histories and Cultures and Asia and Australia's Engagement with Asia [1]. Geography teachers and pre-service teachers have identified more facets of sustainable development

than their counterparts do in science [23]. The task of promoting sustainability education in Australian schools falls on the geography discipline more than any other and therefore serves to both advantage and challenge the position of geography teachers in teaching sustainability in schools.

The implementation of the sustainability cross-curricular priority (CCP) is a major transformation in school education in Australia. To teach the sustainability CCP, schoolteachers must be sustainability-literate so they can integrate sustainability into their teaching. Therefore, the embedding of EfS in teacher education is clearly compelling, but it remains “a patchy or neglected area of practice”. The literature around this is ad hoc [8,24]. The existing studies are mostly contributed by education experts and focus on pedagogies of how to engage EfS [25] and program or department-wide approaches for EfS [8]. However, students can indeed learn EfS through one or two dedicated units, like in a model taken by many primary education programs in Australian universities, including CQU. Students who undertake the secondary education degree, however, must take six units in the discipline area that they will teach. Their EfS training will be through the study of these discipline subjects. Therefore, before teaching them how to teach sustainability, education experts should know what kind of sustainability knowledge the students have learnt in their discipline areas. The embedding of EfS in the units in education courses is therefore fundamental for preparing sustainability-literate teachers. However, what kind of sustainability knowledge and skills has been embedded in these units and how sustainability has been taught in these units remains unknown. This study provides a detailed discussion on embedding EfS in geography units in teacher education. This includes not only what kind of sustainability knowledge students will learn in these units, but also how we teach them. The study makes a critical contribution to the literature on pedagogies that support EfS and embed sustainability “as part of the core focus of teacher education policies and practices” for education programs [8] (p. 406).

#### 4. Materials and Methods

In the context of a reported under-preparedness of geography teachers in schools to integrate sustainability into their teaching practices because of a lack of deep subject-matter knowledge around both sustainable development and pedagogy for sustainable development [22], this article provides a regional Australian focus on how tertiary level geography training meets the challenge of equipping undergraduate education students with the values, knowledge, and skills needed to teach about sustainability that is embedded in geography in the Australia curriculum. The article deploys an exploratory case study design, augmented by a qualitative content analysis of academics’ and students’ experiences across three geography units at Central Queensland University.

There are many ways to evaluate the effective implementation of sustainability education, and this article analyses some specific forms of teaching and learning at the university level for future school geography teachers. Specifically, the deployed content analysis method [26] was framed by selected elements of pedagogy—unit content, learning activities, assessment tasks, and student feedback—and is benchmarked against units of study in the Australian geography curriculum that relate to the sustainability CCP.

Each of these three case studies, according to Stake’s [27] framework of case study design, can be seen as an *intrinsic* case study as they each provide insights into the development of student’s knowledge, skills, and understanding of sustainability pertaining to the specific subject matter. They each have developed into an *instrumental* case study through seeking to understand EfS in geography education more generally. Together they are a *collective* case study with a single goal of integrating EfS into geography education, but each has specific aims and objectives and teaching and learning perspectives. They each would have different impacts on the teacher education students and may also generate different findings that are potentially universally transferable to other geography subjects in other teacher education courses.

For each case unit analysed, we followed the same structure to ensure consistency in the case study approach: overview, aims and objectives, teaching and learning, and impact and challenges. The aim of the content analysis was to focus on one aspect of the three units, which was how they contribute to sustainability education. To analyse the overview of each unit, we explained the broad summary of what the unit is about and how it is structured. This provides information about the extent to which principles of sustainability and sustainable thinking are incorporated into the unit's learning activities. To analyse the aims and objectives of each unit, we referred to the official learning outcomes of the unit and related those learning outcomes to knowledge and skills development that are specifically related to understanding sustainability and being able to realise sustainable practices. To analyse the teaching and learning in each unit, we explained the methods of teaching with a focus on learning resources, learning activities, assessment types, and student feedback. This analysis provides information that relates these teaching strategies to what can be learned by the student in terms of enhancing their knowledge and skills about sustainability. Finally, to analyse the impact and challenges, we synthesised the information from the previous analyses to explain the potential of the unit to offer the student teacher knowledge and skills to be prepared to integrate the units of study in the school geography curriculum as a teacher of sustainability education. Likewise, we analysed the limitations of the units to achieve this preparedness and pointed out any challenges to improving teacher education geography courses.

Overall, this method allowed us to use our experiential knowledge as an analytical concept to reflect on how these units incorporate sustainability education, to explain how we link our teaching of sustainability to the Australian geography school curriculum that concerns sustainability education, and to make informed suggestions around EfS pedagogy for teacher education [28]. Compared to less experienced individuals, experts have acquired extensive knowledge through their experiences, which affects what they notice and how they organise, represent, and interpret information [28]. Two key limitations of this study are that, firstly, only three geography units were analysed and, secondly, the study does not extend to providing an impact of the teaching strategies on future teachers' competence and behavioural change. Consequently, future research might analyse data on such an impact, building on this study.

## 5. Sustainable Regions and Cities

### 5.1. Overview

This unit is one of the core subjects in the geography education minor at CQU. It is the only unit that has the term "sustainable" in its title with designated sustainable learning goals and outcomes, which are to "identify, analyse, and evaluate key trends of change, challenges, and opportunities of sustainability in regional Australia". The unit's content is structured into three integral parts. The first part introduces students to the concept and principles of sustainability, as well as relevant frameworks for analysis, such as carrying capacity, ecological footprint, the IPAT equation, strong and weak sustainability, and methodologies for measuring and assessing sustainability. The second part applies the sustainability knowledge and skills developed in the first part to examine urban and regional sustainability in Australia. It recognises that the challenge of sustainability is heterogeneous and complex, reflecting the diversity of human societies and physical environments at different scales, and the differences between a metropolitan area and regional settlements. The topics covered include "Place Matters: Defining Cities and Regions", "Australia's Regional Settlement System", "How Do Regions Develop and Change?", "A Changing Regional Environment: Climate Change and Natural Hazards", and "Whose Regions? Population, Health and Liveability in Regional Context". Students are expected to investigate what metropolitan, regional, rural, and remote places mean in Australia in terms of policymaking, and to determine what are the key drivers and processes of their transformations towards sustainability. These involve not only an understanding of the broad changes in regional Australia, and especially its settlement systems, but also an

appreciation of how these changes are experienced differently by places and communities in terms of sustainability.

Students will learn about the on-going challenges of sustainability transformation and what is necessary to meet these challenges. The unit focuses mainly on settlements outside of capital cities where most of our students come from and will continue living. The third part of the unit consists of cases studies. Topics cover “Planning as a Sustainability Instrument”, “Sustainability Regions by Planning: A Case Study of Central Queensland”, and “Sustainability Place by Design: A Case Study of Rockhampton”. The learning covers sustainability planning in Queensland, and sustainable design for neighbours, regional towns, and regional areas. The unit concludes by highlighting the interconnected and interdependent sustainability between cities and the countryside. It extends to discuss the sustainability transformation of the urbanisation in Asia and calls for value changes and actions.

### 5.2. Aims and Objectives

This unit is unique in the sense that it aims to fully integrate sustainability literacy “into the warp and weft” [3] (p. 431) of geography teacher education. It aims to shed light on how a geography unit can contribute to developing a student’s sustainability literacy and enable an education student to teach sustainability as designated in the geography section of the Australian curriculum, and particularly, “the human characteristics of places” [29]. These include (but are not limited to) the “place and liveability” unit in year 7, which involves understanding the nature of place, the pattern of communities, and the liveability of places and the ways it is measured; additionally, this includes the “sustainable places” unit in the senior years. In teaching this unit, schoolteachers guide students to investigate challenges facing different places and how these challenges are being addressed. These include identifying and discussing “the extent to which the strategies adopted have been or could be informed by the concept of sustainability” and “the strategies adopted and an assessment of how these have enhanced the sustainability and liveability of the place” [1].

The sustainability literacy here is to “recognise and reward other people’s decisions and actions that favour sustainable development” [30] (p. 9). Once teachers are equipped with sustainability literacy, “they become empowered to: (a) approach society with a critical lens; (b) teach sustainability topics and ways of thinking to their students; (c) make informed decisions; (d) contribute to rethinking intrapersonal, interpersonal, intragroup, and intergroup conceptions of society and the environment. Along with other key literacies, teachers should be able to infuse sustainability literacy into their daily instruction and across the curriculum” [31] (p. 4).

Among the geography education themes at universities, regional geography has long been used as “a pedagogic device for organising information for the most effective presentation, comprehension, and retention” [32] (p. 21). For many geographers, region is the best link between academic geography and their communities. As commented by Wade [33] (p. 188): “Why should we bother being geographers if we cannot effectively and intelligibly convey this connection to the public and convince them of geography’s applicability to their lives?” We can argue that the same is true for sustainability education as it should be specialised on the basis of the transformation needs of particular regions and communities.

### 5.3. Teaching and Learning

The unit’s teaching and learning are organised around “key concepts and concerns” in a weekly format. There are two typical types of weekly readings, which are carefully selected book chapters and/or journal articles about the topics. One source of readings considers the classic studies that elaborate on the “key concepts” like “Sustainable Cities or Cities that Contribute to Sustainable Development”? [34], “Sustaining human carrying capacity: a tool for regional sustainability assessment” [35], and “Are we planning for sustainable development? An evaluation of 30 comprehensive plans” [36]. The second

source of readings is the studies of Australia's regional transformation and sustainability including the lecturer's publications, like "Specialisation and growth: evidence from Australia's regional cities" [37], "Population dynamics in regional Australia" [38], and "The peri-urbanisation of Shanghai: Planning, growth pattern and sustainable development" [39]. These are just a few examples. A comprehensive weekly study guide is provided and explains how to complete the readings, and highlights examples and case studies, projects, and other explanations of the "key concepts and concerns" of the week. These allow students to have both the time and the opportunity to investigate their studied phenomena and situations on the basis of each student's personal interests. Students take a lot of the responsibility for their learning as they construct knowledge through completing the activities and through discovery.

Except for the readings, there are two other in-class activities that are designed to inspire the students' creativity and encourage them to apply the relevant knowledge and skills to their practices. One of these in-class activities is a weekly online discussion forum that serves as traditional tutorials. Students discuss their learning about the topic and the application of the knowledge and skills to the real-world issues they know. For example, after completing the study of "Measuring and Assessing Sustainability", students are asked to imagine and discuss: if you were an environmental consultant and asked to provide a set of sustainability indicators to guide the sustainable development of your local area, list six potential indicators and give your reasons, and provide what data you will need for developing these indicators and where these data can be found.

Some of these learning activities involve undertaking comparisons of sustainability transformation between different places. For example, one of the activities is designed to ask students to use an online tool about ecological footprints [40] to calculate the ecological footprints of their households and post their calculation results in the discussion forum. They are then guided to compare the results of the students who are from a regional area or remote community with those from a big city or metropolitan area. The class interestingly found that those from regional areas often consumed more natural resources than their urban counterparts. They are further guided to discuss what factors determine the ecological footprint of a household and to debate whether or not a big city is more sustainable than a small one, and whether or not urbanisation would make a contribution to sustainability transformation in general. This exercise and debate not only help students to understand ecological footprint tool, but also assists them to critically analyse their lifestyles and think about their actions to achieve community sustainability. These are essential components of EfS in schools that teacher graduates can bring with them [41].

To transform to a more sustainable future, teaching and learning at all levels must be able to encourage students to imagine what an ideal place should look like. Imagination also "helps to make knowledge applicable in solving problems" [42] (p. 688). Sustainability imagination plays a growing role in EfS in schools. Some of the in-class activities in this unit are designed to deploy "sustainability imagination" by helping students to discover their visions of an ideal place. For example, in teaching "Whose Regions? Population, Health and Liveability in Regional Context", students are encouraged to imagine and discuss what additional social and environmental attributes they want to have in their current neighbourhoods and why. They also discuss what kind of neighbourhoods they want to create for their children to live in and why.

In addition to the online discussion forum, there are two pieces of written assessment. The second type of in-class learning activity is designed to help students to complete the written assessments. The two pieces of assessment were broken into weekly tasks. Students complete the tasks by process of learning by doing, actively engaging in discovery, and constructing the assessments. The first piece of the assessment is to write a sustainability report about a place of their choice, and the second piece is a term research paper that uses sustainability frameworks and principles to evaluate an existing spatial plan of the same place. The two assessments are interrelated. Students are encouraged to choose a place from their local area or one that they want to know more about.

Assessments play a central role in accomplishing the unit learning outcomes. In terms of assessment, online discussion forums and authentic assessments investigating “real-world” problems with clearly defined rubrics are often viewed as the best practices from the online learning literature [43]. Many students already have some environmental awareness when they come to take this geography unit; however, this awareness does not necessarily give them the ability to assess sustainability issues and teach them in schools. To complete the sustainability report, students can learn about the nature of different places and the sustainability challenges that places face. Students need to organise their report on the basis of sustainability frameworks and apply the approaches and tools to identify sustainability challenges.

An assessment forum is designed to monitor students’ progress, identify problems in specific stages or areas, and provide on-going and meaningful feedback. A comprehensive guide for structuring the report and the evaluation is also provided. Because students investigate their local environments, they can use this familiarity to their advantage. Many students include their own experiences and observations such as lack of local employment in regional towns, urban expansion and habitat loss, and poor waste management infrastructure. Some students include photos they take in support of their discussion. Using the words of one student, the assessment “offers a chance for them to organise something they see and hear almost every day and investigate them.” The assessments become personally meaningful, and therefore, authentic.

Students adopt a similar approach to completing the term research paper that draws on the sustainability frameworks, principles, and tools to evaluate a local government’s spatial plan. This assessment involves an introduction of the spatial plan, a summary of sustainability challenges emanating from the sustainability report, and an evaluation of the plan against established sustainability frameworks and principles. This includes a critical analysis of how the plan would support the sustainability transformation of the place, including whether the sustainability challenges identified in the first assessment were dealt with or not and why. The assessment rubric indicates that the evaluation should reflect local social, economic, and environmental changes and should be supported by literature and data. It offers an opportunity for students to demonstrate their geography and sustainability competencies.

After completing the two pieces of assessment, students should attain a deep knowledge of places and their sustainability, which will enable them to teach the relevant units in the Australian curriculum, including the frameworks and skills to guide their own students to examine sustainability challenges. The students’ term papers for the past few years covered spatial plans or strategies for various local governments across Australia. To motivate students to actively engage with sustainability, students are encouraged to send their term papers to the relevant local governments after they have been marked and feedback has been provided.

#### *5.4. Impact and Challenges*

With the global imperative of meaningfully realising sustainability, more “sustainably-literate teachers” need to be trained. Geography “is one of the few disciplines that encompasses different ways of knowing, from the natural, physical, and social sciences to the humanities” [6]. It is a discipline that can play a central role in teaching the cross-curricular priority and take “the major responsibility for” doing it [44] (p. 6). This particular unit case study has shown that sustainability can be well integrated into the study of urban and regional geography. Students can concurrently gain knowledge and skills of both geography and sustainability from studying this unit. While the pathways of Australian cities and regions towards sustainability are diverse, so too is sustainability education in schools of different cities and regions. Embedding sustainability in this unit is essential for education students, who mostly live in these cities and remote communities. This can enable them as both citizens and teachers to play their part in teaching sustainability and in community sustainability engagement projects. Compared to geography in schools,



geography in tertiary education is divided between physical and human geography and into several units. Each division has its established themes and issues, which are often overcrowded. The scope of sustainability coverage in one unit is limited to its content. For example, this unit has not significantly touched on poverty in the developing world nor peace in the world. If we need to engage in EfS, every geography unit, and especially those in university education courses, should contribute. As noted by Robert Harper [45] (p. 178) half a century ago, the need for taking new opportunities to strengthen geography is “not simply for more geography, but for better geography. The new geography is essentially a search for a new perspective that meaningfully comes to grips with the real world of today and presents insights into the pressing problems that concern all citizens.”

## 6. Remote Sensing of Environment

### 6.1. Overview

Sustainability is, for all the right environmental and ethical reasons, a critical geographical “big issues” concept in this era of the Anthropocene. So why geographical? Suppose one accepts that “the challenges of the Anthropocene are the challenges of a world in which humanity must learn to accommodate itself to the limits of the Earth system” [46]. In that case, one will note the keywords of geographical enquiry in that statement, “human” and “Earth”. Assuming one accepts such an epistemological concept, a practical question around methodology then becomes: how does geography quantify the state of sustaining the Earth system? Furthermore, since sustainability also means transferring knowledge through succeeding human generations, a second question follows: how do tertiary level geography educators engage secondary education undergraduate students to teach these Earth monitoring skills? This second unit case study discusses how satellite remote sensing is one way to visually engage secondary school students with cost-effective monitoring of earth processes on the way to gaining a personal environmental and sustainability consciousness.

Mulligan [47] notes that the critical challenges towards addressing sustainability at a societal level are the conditions of water, food and agriculture, and the urban footprint challenge. Appropriately designed satellite remotely sensed image-derived time-series maps quantify the rates of change for many of the related biophysical parameters within these applications. Kavvada et al. [48] argue that earth observation (EO) using satellite remote sensing is contributing to the realisation of the United Nations Sustainable Development Goals (SDGs). In particular, EO images provide data for the change detection analysis towards Goals 6 (Clean Water and Sanitation), 14 (Life Below Water) and 15 (Life on Land). SDG Goal 13 (Climate Action) can also be progressed using satellite image-derived atmospheric constituent maps [49]. Chirici [50] (p. 1) notes that EO technology “offers the ability to generate spatial information, which can be used to determine indicator baselines and to track progress towards meeting targets, thereby making an important contribution to informing planning and decision-making for sustainable development”.

In the last 40 years, EO technology, in the form of satellite imagers, have been making giant capability leaps, and yet, the European Space Agency (ESA) estimates that less than 5% of collected EO satellite data is purposefully used [51]. Clearly, what is needed is more useful “end-user” sustainability monitoring applications and educated secondary school graduates to utilise this underused EO data-mine.

Since 2018 at CQU, students taking the geography minor of the Bachelor of Education (Secondary) course can select “Remote Sensing of Environment” as one of their units of study. The spatial science (and thus geographical) activity known as remote sensing engages students, primarily because environmental data as maps and pictures convey a visual narrative beyond tabulated data. There is something about image processing that engages students. Further, processing pictures of biophysical parameters is a creative and artistic activity that is intrinsically engaging for some. In short, who does not like making pictures with meaning? Here the word “making” is a deliberate choice, one does not “take” pictures with satellites, rather, one makes them given the skills required to convert

digital photographs to biophysical parameters that are suitable for EO and the monitoring of sustainability. There is a direct correlation between the kind of knowledge and skills development in this unit and unit 3 in the senior year school geography curriculum, titled “Land-cover transformations”, where teachers assist students to identify and classify land-cover change using remotely sensed images and aerial photographs [29].

### 6.2. Aims and Objectives

The aim of the unit “Remote Sensing of Environment” is for secondary school teacher undergraduates to acquire practical skills in producing EO maps derived from satellite images. The expected downstream outcome is that these teachers will use such skills to teach EO in secondary schools for monitoring sustainability because it is an engaging activity. Secondly, EO skills are an emerging career option for environmental management employment. For that reason, the unit learning objectives include planning and implementing a satellite image processing project related to quantifying land-use change.

The establishment of the Australian Space Agency in 2018 aimed at encouraging the use of satellite data for EO in Australian industry and government [52]. Post-secondary school employment of spatial imagery analysts is expected to increase in Australia. EO is mainly used to quantitatively monitor adherence to environmental management legislative requirements, for public service natural resource and land-clearing monitoring, and for health assessments of agricultural activity. These employment roles consist of directly monitoring issues associated with sustainability.

### 6.3. Teaching and Learning

In Australian secondary schools, sustainability is one of the seven concepts in the geography curriculum [53]. In an assessment of the Australian secondary school “Education for Sustainability” curriculum, Kennelly et al. [54] encourage teachers to incorporate sustainability as a cross-curriculum priority into their teaching. While the production of maps and the analysis of images suit many applications, the geographical line of enquiry lends itself to the use of imaging technology to explore the human impact on the Earth system. Satellite image processing, being a spatial science, can be a creative outlet fully aligned with the geography curriculum.

A plethora of satellite platforms and a range of software programs to process EO images exist. While ultra- or very-high spatial resolution and commercial satellite imagery can be expensive, the ESA Copernicus program provides educators (and anyone else) with free high spatial resolution imagery [55]. Sentinel-2 (S2) high spatial resolution (10 and 20-metre pixel resolution), multispectral (13 bands) optical satellite images, available around every five days, are mainly designed for Earth system monitoring. The sensor design characteristics are particularly suitable for a time-series assessment of many biophysical parameters for monitoring the sustainability of natural resource utilisation.

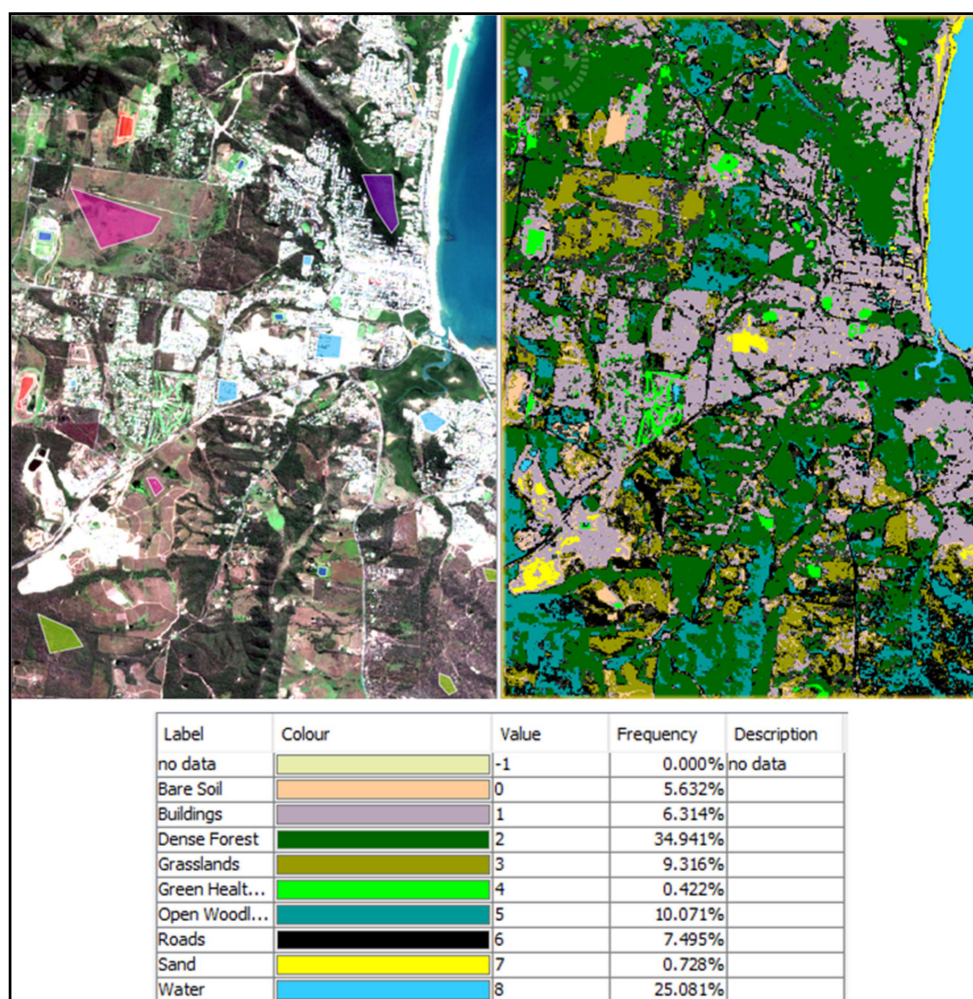
Further, the ESA makes the Sentinel Application Platform (SNAP) satellite image processing software freely available [55]. The several, off-the-shelf image processing software systems that are commercially available tend to be prohibitively expensive. SNAP is surprisingly feature-rich and contains all the functionality needed to teach satellite remote sensing.

Taken together, free software and free imagery mean that geography teachers have cost-effective access to earth monitoring utilities to enhance the engaged teaching of monitoring some activities of sustainability. The extent to which such tuition imparts a positive learning experience depends on how a teacher selects topical case studies and how they emphasise the creative activity, rather than the technical intricacies. Image processing can be a technical challenge, but the ESA SNAP system can produce quality and meaningful mapping products without delving into the technical details too much. Such is the experience in this unit. A range of Earth ‘pictures’ can be readily achieved.

The first two weeks of the unit delve into the theoretical basis for using the ESA S2 satellite and for using electromagnetic radiation as photographic lighting constructs.

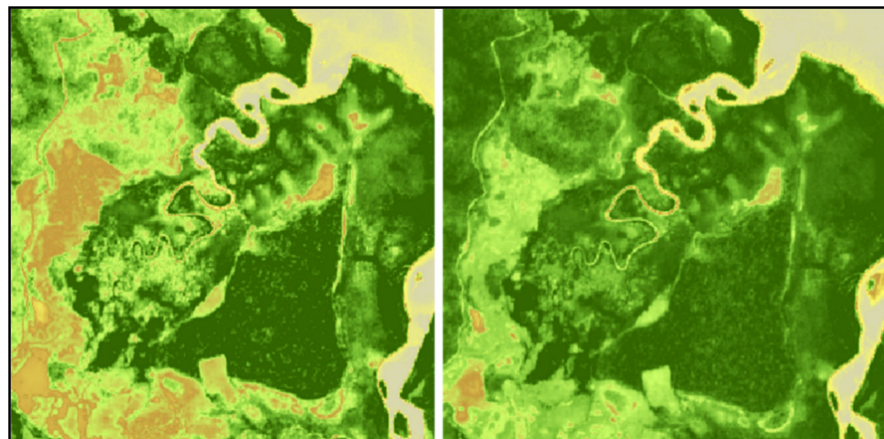
Only the necessary theoretical basics of satellite image processing are explained in these weeks, while the students continue to acquire a range of practical and essential image pre-processing skills. Students are then taught how to download both the satellite images and the SNAP software.

In the following weeks, students exercise simple image enhancement functions highlighting urban and natural environments so that the creative aspects of picture processing can be enjoyed as early as possible. In the middle teaching weeks, students spend considerable time learning to map and quantify land-cover change detection and a time-series of vegetation health biophysical proxies. The time-series maps quantify the temporal and spatial extent rates of change. An assessed exercise builds skills in applying machine learning algorithms to produce land-cover classified images (shown in Figure 1).



**Figure 1.** “Remote Sensing of Environment” student conversion of a European Space Agency Sentinel-2 true colour (left) image (with training polygons) into a nine-class machine learning supervised classification (right and legend) of land-cover for a regional town of Australia in 2018.

After learning how to assess the accuracy of the resultant maps, students quantitatively compare the land-cover classification change over time for a range of geographically related sustainability questions. In the weeks leading up to the end-of-term, students derive vegetation health response rate maps by comparing season impacts on the vegetative cover of the landscape (shown in Figure 2).



**Figure 2.** “Remote Sensing of Environment” student conversion of two European Space Agency Sentinel-2 true colour images into a normalised difference vegetation index (a proxy for photosynthetic health) for the dry season 2017 (left) and the wet season 2018 (right) of a region of rural Australia.

The output maps are the visual representations of the balance of environmental, economic, and social considerations and provide unique graphical evidence of the impact of the Anthropocene. In the process, students are asked to reflect on the conversion of land-use between natural, agricultural, and urban landscape categories using quantitative map-based metrics. Consistent with the pedagogical aims of advanced-level learning and the acquisition of critical thinking skills, budding geography teachers are encouraged to reflect on sustainability concepts related to carrying capacity, food security, and ecosystem services during a reflective assessment of the map-making process. Accordingly, some of the “big issues” associated with sustainability are addressed.

Students are required to submit portfolios of the results of image processing as well as to answer a range of reflective questions designed to encourage a cognitive connection between the acquisition of image processing skills and the mapping of quantified sustainability indicators. The assessment is therefore tuned to assess skill acquisition as well as critical thinking skills. That means students construct their learning of how satellite image processing measures the progress of sustainability.

Each week, the unit contains a website or video highlighting the use of satellite remote sensing for broader sustainability quantification monitoring. For example, radar satellite’s ability to monitor waterborne oil pollution plumes, threatened fauna species and related habitat vegetation health, threatened flora species clearing by mining companies, urban landscape expansion, water storage spatial extent change, as well as water quality time-series analysis for both algae and sediment plume lifecycles.

Students are further asked to critically analyse the image processing results with an image accuracy assessment that is considered to be a standard scientific remote sensing professional practice. Students are also assessed on their workflow by maintaining a processing log of input, processing, and output tasks. In part, this requirement teaches students to ensure they can repeat their process as a practice quality assurance mechanism as well as to assure results for potential customer benefit.

In 2021, the unit content is to be extended to consider the impact of climate mode (and climate change) on biophysical parameters. The particular case study utilises the outcomes of research projects by the lecturer about vegetation response rates for koala (*Phascolarctos cinereus*) habitats. The koala is an iconic species in Australia. At the time of writing this report, the conservation status of the koala is listed as *vulnerable* with a declining population trend as indicated by the International Union for Conservation of Nature. This determination is based primarily on the occurrence of several recent severe droughts and continued habitat fragmentation due to vegetation clearing [56]. Discussed by Hewson et al. [57]; “long-term koala conservation is founded on the persistence of habitat of appropriate composition, structure, and quality. However, the Eucalyptus communities

upon which koalas depend change over time in response to environmental, successional, and anthropogenic influences, often working together as a set of complex interacting pressures. Effective conservation management of this species requires an understanding that, over most of the koala's range, habitat pressures are acting at a landscape or regional scale. Consequently, habitat condition assessments can be logistically challenging and expensive" [57] (p. 6). The use of remote sensing for quantitative habitat assessment is aimed at providing habitat managers with a cheap, repeatable, and spatially widespread tool for pinpointing habitat issues for later habitat management intervention. In this "real-world" application, teachers can then impress on secondary students how easy and cheap satellite remote sensing can be when applied to quantifying issues of threatened species sustainability.

The students are encouraged to retain and reuse the tutorial guides as well as the source locations for ESA images, processing software, and a range of ESA-provided tutorial videos. The intention is that, even when software updates are made, students can refresh their skills prior to their lesson preparation.

#### *6.4. Impact and Challenges*

Student feedback since 2018 suggests that they enjoy the opportunity to explore earth observation creatively and that the "instant gratification" of biophysical map-making is a satisfying activity. The pedagogical approach is aligned to the principals of constructivism, where students construct their knowledge building on their previous and on-going learning experiences [58]. Further, deep student learning is guided by the teaching principles espoused by Meyers and Nulty [59], that is; the learning activities are authentic and experiential, allow for constructive learning, provide challenges, and engender both student interest and learning motivation. Video clips and graphical diagrams are used to explain concepts in learning activities.

The limitations of the educative experience include the use of sophisticated (perhaps complex) software platforms. The image processing chain was simplified in more recent offerings of the unit, since the ESA have provided what is known as "atmospherically corrected" images. While the ESA atmospheric corrections may not suit all scientific uses, the algorithms are entirely suited to an educative objective.

In recent years the proliferation of drones, or uncrewed aerial vehicles (UAV), has become a secondary school educator's imperative. The main reason is that the use of drone technology is an engaging activity, and not just for boys [60]. However, the cost of the hardware and suitable payloads to emulate the earth monitoring capability of satellites (for example, a multispectral instrument) is not cheap. If one adds further expenses associated with operator training, government aviation registration, image processing software to the equipment cost, as well as the need for extensive operator time depending on the spatial extent of image capture required, the costs become prohibitive.

Colloff [61] hypothesises that one secret to attaining sustainability in the Anthropocene is a human reconciliation with the landscape. In some ways, listening to first nation peoples and their concept of "country"; the visceral and physiological connection to the earth's surface [62] and reliance on what environmental science now calls Earth system services [63], indicates what it will take for some students to acquire an environmental consciousness. The visual presentation and creative activity of EO provides an educative toolkit to enhance the empathy of emerging human generations towards their earthly home.

## **7. Environmental Management Systems**

### *7.1. Overview*

As developed by the International Organisation for Standards (ISO) and by Standards Australia, this unit examines the nature of environmental management systems (ISO 14001). In year 10 of the Australian curriculum for geography, there is a unit section titled "Environmental change and management" [1]. CQU's "Environmental Management Systems" (EMS) unit has a direct correlation with this curriculum unit section and can enable education students to

better teach sustainability in schools and engage with communities. CQU education students learn about the concepts of EMS, auditing and certification, relationships with environmental impact assessment, and about how to develop an EMS for a hypothetical organisation. Both this unit and the school curricular unit explore human-induced environmental changes that challenge sustainable practices and behaviours.

The secondary education students are given the following short explanatory note about the significance and relevance of this unit to their future career as geography teachers. They are told this unit will help them to develop important geographical skills and knowledge that they will be able to impart to school students. According to the ACARA document titled “Shape of the Australian Curriculum: Geography (2011)”, there are three geographical perspectives. They are place-based, spatial, and environmental. The environmental perspective has close links with this EMS unit and with sustainability education. This environmental perspective involves the study of the processes and interrelationships that form and change the biophysical environment, looking back in time as well as forward into the future. It also includes the important theme of the reciprocal relationships between the environment and human activities. Students explore the opportunities and constraints that the environment provides for human life and economic activity; they examine the different ways people have perceived, managed, used, and altered earth’s environmental resources and learn about the importance of environmental sustainability for humanity’s future. The concept of a system and its interdependencies may be used to help in the analysis of many of these processes and interrelationships. Students also learn about how humans share the earth’s environment with plants and animals and consider their responsibilities towards these other forms of life [29].

### 7.2. Aims and Objectives

The unit has the broad aim of introducing students to the concepts of “standards” and their world-wide growth and implementation. The unit then drills down to explain the origins of EMS and their linkages to environmental impact assessment processes and other mechanisms of environmental protection. It identifies key documents in the ISO 14000 series and describes their functions. It lists the key features of ISO 14001 and ISO 14004 and describes the key concepts and principles of EMS. It further discusses approaches to implementing an EMS. There are two key skills that are developed in this unit, which arguably enhance the ability to think sustainably. Firstly, students learn how to conceptualise an EMS as an innovation and learn how to become a change-maker. Secondly, they learn about systems thinking, which is also a component in the geography school curriculum. Innovation is critical for the sustainability agenda [64].

### 7.3. Teaching and Learning

The unit is taught using a textbook titled *ISO 14000 Environmental Management* [65], a weekly study guide, and reference to the two main standard publications from Standards Australia (Standards Australia 2016, “Australian/New Zealand Standard: Environmental management systems—Requirements with guidance for use (AS/NZS 14001:2016)” and Standards Australia 2018, “Australian standard: environmental management systems—general guidelines on implementation (AS ISO 14004-2018)”). The unit content also uses case studies and example documents from real organisations that have been certified with ISO 14001, and identifies lessons that have been learned from those experiences.

The main assessment piece of this unit tasks students with designing and creating a draft EMS for a small hypothetical organisation. In doing so, students learn to see how an environmental management system, which is essentially a management tool, highlights the triple bottom line with a focus on “profit, people, and planet”. An EMS is designed to save money for the business by streamlining processes, to improve the image of the business, to identify environmental impacts of the organisation, and to show how it can mitigate these impacts; students learn how to look at the operation of the business iteratively and build in the concept of continual improvement [65]. All of this involves

the application of systems thinking to understand the connections, complexities, causes, and likely consequences of environmental change. The application of systems thinking is also a facet of the “Environmental change and management” unit in the Australian curriculum for geography, so an ideal synergy exists [1]. Starting from the fourth week of the unit, students are encouraged to work on their draft EMS, which becomes about a 50-page document when completed. This assignment is due at the end of the term.

To make this assessment task more manageable, students are encouraged to select a small organisation, and they commonly select a hypothetical dine in/takeaway café, a petrol station, or some other small business. When students sit down to plan and develop an EMS for a hypothetical organisation, they need to think about the whole organisation and all of its environmental aspects: which of the organisations’ activities or products or services interact or can interact with the natural environment (Standards Australia, 2016). This process helps to develop a holistic approach to problem-solving. The assessment piece also helps the student to recognise that sustainability is a major and growing driver of business change or innovation [64]. Continual improvement is a critical aspect of an EMS, and carrying out continual improvement can lead to best practice innovation [64]. Through this unit’s content, learning activities, and assessment, students develop a deeper understanding of how an organisation’s financial viability is linked to its interaction with the natural environment, both directly and indirectly. This exercise, in turn, encourages the students to be more responsible corporate citizens.

The other assessment piece in the unit includes online workbook activities. These activities are a type of learning exercise rather than a ‘testing’ one. Each of the online workbook activities is meant to deal with one week’s work in the term. Each online workbook activity has 10 questions with multiple choice answers; about half of these questions come from the online study material for that week and the rest come from the textbook or other readings from that week. The questions are designed to make the student read the material more thoroughly and to integrate, apply, or reflect upon their learning for that week. There is considerable feedback given for each answer, which is a learning resource in itself.

One of the great advantages of EMSs is that they offer a means of extending the principle of good environmental management over the lifetime of a project, and not just in its construction and early operational stages. EMSs can also be a tool that can be used to help organisations adjust to changing external environments, such as the challenges that face the world community due to global warming. As part of developing their draft EMS plan, students have to develop an environmental policy for the organisation. ISO 14004 [66] indicates that an environmental policy should include statements about the following:

- The organisation’s mission, vision, core values, and beliefs;
- Requirements and communication with interested parties;
- Continual improvement;
- Prevention of pollution;
- Specific local or regional conditions;
- Compliance with relevant environmental regulations, laws, and other criteria to which the organisation subscribes.

Developing environmental policy skills is associated with systems thinking, taking a holistic view to understand how an organisation can adopt a sustainable mission, and interacting in a more environmentally responsible manner with the local community. ISO 14001 is a standard used in many countries and in many kinds of organisations, both large and small, and some organisations that have an international reach. These students are therefore acquiring skills that are transferrable globally and are learning to be environmentally responsible global citizens.

ISO 14001 is still relatively new, and therefore is an innovation, which continues to spread rapidly both geographically, and more importantly, in terms of the numbers and types of organisations that are establishing EMSs based on ISO 14001. Within organisations that already have an EMS in place, the process of continual improvement (which is a key

feature of ISO 14001-based EMSs) means that innovations (which is what “improvements” are) are likely to occur frequently within those organisations. Arguably, it will take considerable innovation in order to achieve meaningful, sustainable practices locally and globally. Part of this means having the knowledge and skills to be able to implement social change no matter how big or small. This unit aims to develop a social innovation mindset in the learner, which articulates the potential for positive social change and impact in students’ discipline and career futures. An EMS is a tool for organisations to consider and measure their environmental impact. In this unit, students develop a draft EMS, which is by nature an innovative approach that seeks to improve operational sustainability. For a business to achieve international ISO 14001 accreditation, it must demonstrate continual improvement on its environmental performance.

Innovation theory, which had its origins in the 1930s, is covered in week 6 of the unit, including a short quiz, and this content enables students to better prepare their EMSs. The EMS development requires students to ask broad, open-ended questions about environmental issues within an organisation, and design solutions that address these issues. These solutions require many different insights and perspectives and broadly align with social innovation and human-centred design processes. Another component of the unit is the “five Ps”: power, pay, prestige, perks, and privileges. Students explore how to influence people to change using these key levers. Although the traditional approach to learning EMS processes does not focus on innovation theory, nor is it part of the unit’s learning outcomes, the argument is that the theory makes students more aware of how to innovate and what may prevent them from innovating when they are faced with a given issue. A student who develops an EMS for an organisation is trying to improve both the environmental and social outcomes. Through this unit, we are encouraging them to do this by innovating and iterating new ideas. In this regard, they could start to see themselves as change-makers, informed by a social innovation mindset.

There are a number of attributes of a social innovation mindset [67] that this unit helps to foster:

- Empathy and self-awareness: Students are exposed to diverse perspectives and reflect on their world views. Students focus on understanding organisational elements and stakeholders’ needs and contexts;
- Deep curiosity: Students encouraged to seek out information, ask questions, and develop lifelong learning attitudes. Students are encouraged to seek out new information and perspectives;
- Systems perception: Students explore and address both micro and macro root causes of social challenges. Students need to think about issues from both a macro and micro perspective;
- Outcomes focused: Students work on tasks with a shared goal in mind. Students are focused on achieving improvements through EMS;
- Creativity and imagination: Students are given permission, space, and resources to approach challenges in new and different ways. Students identify potential improvements and are challenged to be creative and use their imagination;
- Risk-taking and resilience: Students are encouraged to and rewarded for pushing their ideas, understanding that initial success is not guaranteed. Students are encouraged to test new ways or approaches to problem-solving, even though some may not be effective.

#### 7.4. Impact and Challenges

While students find the task of developing their own draft EMS challenging because of the volume of work involved, in the end, their feedback indicates general satisfaction that they have learned how to deploy a management tool that improves environmental outcomes. Figure 3 illustrates the kind of work students do in their draft EMS plans.



APPENDIX D: Register of Environmental Objectives and Targets					
Aspect No.	Aspect Description	Objective	Target & Date	Action Plan, Improvement Program or Control	Key Performance Indicator (KPI)
1	Use of electricity for lights, fans and food preparation and storage appliances.	Reduce annual energy consumption.	5% reduction by 31/12/2020√	Replacement of old appliances (including lights and fans) with energy efficient counterparts such as LED bulbs once originals are no longer working. Continual improvement through development of Restaurant Utility Use policy. Possible installation of renewable energy sources.	kWh
2	Generation of organic waste.	Reduce organic waste sent to landfill.	25% reduction by 31/12/2020	Development of a food waste inventory. Efficient ordering and stock rotation. √ Offer coffee grinds for public interest for free (to use as fertiliser etc.). Monitor consumption patterns to avoid overproduction. Offer food wastage to local farms for compost or animal feed.	No. of bags sent to landfill – organic waste specific.
3	Disposal of single use plastic packaging.	Reduce plastic waste sent to landfill.	All identified alternatives	Replacement of straws, plastic cutlery, takeaway food containers and bags with	Food packaging invoices + kgs.

Revision	Issue date	Revised by	Approved by	Reason for change
1.0	06/05/2020	Environmental Representative	General Manager	Issue for approval.

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**Figure 3.** An example of a “Register of Environmental Objectives and Targets” from a 2020 student assignment.

To take what is learned in this unit further into the school environment, a future teacher might entice and facilitate the adoption of the essential elements of an EMS into the school. This would indeed be a powerful transformation for a school community [9]. This unit case study shows that sustainability education resonates with environmental management systems through the learner developing the capacity to think innovatively and systemically.

## 8. Discussion and Conclusions

The new Australian school curriculum with the three CCPs has transformed the landscape of teacher education in Australia. Unlike traditional disciplines, the CCPs do not have a dedicated subject in the school curricula. To successfully deliver the CCPs, teacher students now must learn not only subject content, but also how to teach the themes of the three CCPs including sustainability. These CCPs will reshape teacher education programs in Australian universities if they are taken seriously. In terms of delivering the sustainability CCP, embedding EfS in teacher education is beyond just the scope of teacher education academics. It requires academics who teach a discipline subject in education courses, like geography, to be aware of and actively engage in preparing EfS for teacher students. This article reported some details around embedding EfS in three “non-education” subjects as well as some critical reflections on how we engage sustainability education in the units. The units studied were geography units, which serve the broader interests of Bachelor of Arts and Bachelor of Environmental Science students as well, but we purposefully embedded EfS in the context of these courses. As shown, EfS was integrated into the content and teaching practice of these three units, which involve, to varying extents, the four (social, economic, environmental, and technological) dimensions of sustainability. The effective integration of EfS in geography units is in part due to the interdisciplinary nature of geography.

The analysis found that the three geography units engaged student teachers in sustainable thinking in a variety of ways through their unit content, learning activities, and assessment tasks, which was also indicated from student feedback. All three units correlated with units of study in the Australian geography curriculum, which is critical. This suggests that students can apply what they learn from the units to what they teach at school. The units do address the lack of deep subject-matter knowledge, which was reported in the literature as a limitation of many geography schoolteachers. The case study

of “Sustainable Regions and Cities” raised the importance of teaching sustainable literacy so that we might have more sustainably-literate teachers. This unit also teaches principles of sustainability and frameworks for analysing sustainability and provides students with the tools to measure and evaluate sustainability plans. The unit discusses the importance of sustainability imagination, which is growing in importance in schools. The unit “Remote Sensing of Environment” teaches skills in creatively quantifying earth monitoring in order to measure sustainability. The discussion of the koala case in “Remote Sensing of Environment” demonstrates the application of satellite imagery interpretation skills to a key sustainability issue, that of conserving biodiversity. This unit also explains how other affordable applications of technology can enhance the skill sets of future teachers. The unit “Environmental Management Systems” contributes to EfS by building the capacity of student teachers to develop a social innovation mindset and a systems-thinking approach in order to promote and realise sustainable practices and transform unsustainable collective social practices.

This study presents evidence on how teacher education students are taught sustainability in these geography units. As we can see, the three units are quite different, involving broad sustainability concepts, but with each unit having its own foci. In Australia, secondary education students need to learn to teach two subjects in school, and they would need to study 12 units (two 6-unit minors) at university in these two subject areas. This study implies that the complexity and diversity of sustainability would be covered in these units. More importantly, the teacher education students not only need to learn about sustainability, but also need to learn how to teach it. Underpinning this is the need for collaboration between the pedagogy experts and the subject experts. The need to build up the knowledge and skills capability as well as the pedagogical expertise of graduate teachers in EfS is crucial. We argue that the strategies explained in this collective case study for improving knowledge, skills, and attitudes would have universal application in other teacher education geography units, though local applications would differ.

The article calls for a more strategic embedding of EfS, including pedagogical strategies, in geography units in the Australian tertiary sector, where, at the moment, the approach seems to be ad hoc. Now is an opportune time for thinking more strategically about sustainability education in the university sector, and especially in teacher education courses, so that future teachers can be better prepared for making the most of the sustainability priority in the Australian geography curriculum. Thus, we reflect on a comment from a contemporary geography luminary, Nicholas Crane [68] (p. 109): “today, anyone with a primary or secondary school grasp of geography knows enough about the planet’s major challenges to recognise that action is desperately urgent. The Earth system is in trouble”.

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