Exploring Effective Pedagogies in Environmental and Sustainability Education for Teachers: A Story of New Zealand Pre-Service Teachers' Learning Experiences

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Abstract

Although teachers have been identified as key change agents in the shift towards a flourishing planet for all, research into effective pedagogies for embedding environmental and sustainability education (ESE) into teacher education courses is an emerging area. Understandings about the most effective approaches and activities are needed, along with theories that could underpin teachers' learning. This study explores 21 pre-service primary school teachers' learning following their engagement in an elective course designed to help them embed ESE into their future practice. Qualitative data were gathered using reflections as well as peer and individual interviews. An analysis showed that the activities considered most valuable for learning were those that gave pre-service teachers space and time to think more deeply and in different ways. Mezirow's transformative learning theory was used to explore their learning. The use of its three elements and six components identified that transformative learning took place for about half of these pre-service teachers. While it seems this theory has potential to underpin ESE teacher education courses, further research is needed to explore how transformation can occur for more teachers.

Keywords: transformative learning, environmental and sustainability education, pedagogy, pre-service teacher education

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Positioning the Key Role of Teacher Education

The detrimental effects of humans exceeding our planet's capacity to sustain life are becoming increasingly apparent. To counter these effects, environmental educators believe that education is a vehicle that can be used to teach people how to care for our planet (Reid et al., 2021; Wals & Benavot, 2017). Some environmental educators believe that along with other elements such as knowledge and action-taking, teaching to develop stewardship is key. It is further argued that the teaching of stewardship involves the re-orientation of people's values because people do not inherently possess the necessary values (Reid et al., 2021). Such teaching is at the heart of environmental and sustainability education (ESE) programs. This belief is not new and can be traced back to the Stockholm Conference of 1972, one of three seminal environmental education conferences held in the 1970s by the United Nations (Palmer, 1998). It is echoed in Tilbury's (1995) article where she includes the component of values education, one of six components needed to achieve the goals of ESE. When including this component, Tilbury argues for ESE that aims to develop positive "environmental awareness and concern" in order that a "personal environmental ethic" is acquired (p. 201). Wals and Benavot (2017) argue similarly, stating that ESE needs to develop learners who are self-reflective and can alter their values and consequential behaviour to build societies that are more sustainable and equitable for all.

Over the last 10 years, the United Nations has issued many declarations and agreements about the importance of integrating environmental education into both formal and informal education. Some of these include the United Nations' Global Action Plan on Education for Sustainable Development that followed its Decade of Education for Sustainable Development (2004-2014), and then UNESCO's Education Strategy (2014-2021). The most recent is the United Nations' Sustainable Development Goal 4 Target 4.7, which states, "By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development" (SDG-Education Steering Committee Secretariat, n.d.). It has been followed by the *Incheon Declaration and Framework for Action for the Implementation of Sustainable Development Goal 4* (UNESCO, 2015), which sets out a plan for enacting SDG 4 to 2030 internationally.

In the *Incheon Declaration*, ministers of education from around the world endorsed ESE as fundamental in teaching and learning programs across all sectors of learning (UNESCO, 2015). Universities, in particular, are identified as having a crucial role to play to bring about the necessary changes to shift towards more sustainable societies through their research and teaching activities. Teachers are also regarded as key change agents and the *Incheon Declaration* states that through teacher training, ESE can be mainstreamed into formal and nonformal education systems worldwide. Charged with this responsibility, ESE needs to be at the centre of teacher education programs, for both pre-service and practising teachers (Reid et al., 2021).

However, there is a paucity of evidence about the efficacy of pedagogies that facilitate ESE learning in teacher education programs (Evans & Ferreira, 2020). There is also a lack of consensus about the types of pedagogies that can promote pre-service teachers' abilities to embed ESE into their practice and a gap in our understanding about the theoretical frameworks that could underpin such pedagogies (Evans et al., 2017; Wals & Dillon, 2012). This lack is illustrated in Evans and Ferreira's (2020) systematic literature that sought evidence of the pedagogical strategies being used and their impact on pre-service teachers' learning. Out of 509 publications found in the initial search, 17 informed the entire review's conclusions and 10 provided evidence about impact. Furthermore, according to Karrow and DiGiuseppe (2019), there are only a handful of countries where this type of research is occurring. Researchers in Australia and Canada seem to be leading the way, with some contributions from Scotland, the United Kingdom, the United States, Latvia, Israel, and Spain. Consequently, a broader base of research is necessary to identify and theorize pedagogies that will result in effective education for pre-service teachers, enabling them to integrate ESE into their professional practice. This paper aims to add to this research base by exploring Aotearoa-New Zealand pre-service teachers' learning during an elective course about teaching ESE. The pedagogies employed are critically evaluated and transformative learning theory used to analyze learning that took place.

ESE Learning in Pre-Service Teacher Education

While it is acknowledged that all teachers need access to education about how to embed ESE into their practice, pre-service teachers especially need opportunities to engage in such learning (Karrow & DiGiuseppe, 2019). What ESE learning involves has changed over time in ways that align with environmental concerns and problems (Tilbury, 1995). A current point of agreement is that ESE should be transformative for learners (Reid et al., 2021; Sterling, 2010; Wals & Benavot, 2017). Transformative learning in ESE involves fundamental changes in one's values and beliefs (Burns et al., 2019; Sterling, 2010), leading to having an environmental ethic of stewardship for both the planet and other people (Reid et al., 2021). In order for such change to occur, learning must be at a deep level and involve critical thinking skills such as reflection. Sterling (2010) likens transformative learning to epistemic learning where a change occurs in the way a person understands the world, and he argues that it can lead to "heightened relational sensibility and a sense of ethical responsibility" (p. 512). Wals and Benavot (2017) concur, asserting that transformative learning will enable people to connect with their communities and the non-human world by developing a relational worldview.

Under this umbrella of transformative learning, there is general agreement that pre-service teachers need to acquire holistic knowledge and understanding about environmental issues (Burns et al., 2019; Frisk & Larson, 2011), using a range of different disciplines to embed ESE into their own teaching once in their educational settings (Evans et al., 2017; Reid et al., 2021; Tilbury, 1995). Alongside knowledge is learning in the affective domain, where pre-

service teachers need to develop awareness and sensitivity towards environmental problems and the differing perspectives of people who are involved and affected by those problems (Reid et al., 2021). Pre-service teachers' attitudes and values need to be nurtured and shifted towards developing a personal environmental ethic (Tilbury, 1995; Wals & Benavot, 2017). Skills such as reflection, systems thinking, resilience, building capacity for individual and collective action taking (Reid et al., 2021; Sterling, 2010) are also needed, as well as accepting responsibility to be a lifelong learner (Wals & Benavot, 2017).

In order to achieve these outcomes, appropriate pedagogies are needed. A wide range of pedagogies are used in ESE and it is agreed that they should be student-centred (Evans et al., 2016; Walshe & Tait, 2019), experiential, active, and employ different methodologies (Redman, 2013). Examples of pedagogies found in the ESE literature include: role-plays and simulations to gain an appreciation of different perspectives (Walshe & Tait, 2019); using case studies to develop debates and to envision possible and probable futures (Frisk & Larsen, 2011); using images as a basis for analyzing and discussing environmental issues (Evans et al., 2016); literacy activities (reading, writing, viewing media, and discussions) where issues are critically examined (Tomas et al., 2017); and experiential activities outdoors that strengthen connections between learners and nature, such as fieldwork and restoration projects (Wals & Benavot, 2017), which can also influence emotions.

However, the term "pedagogy" is difficult to define (Walshe & Tait, 2019). While generally regarded as the "art" of teaching and how a teacher facilitates learning, this term also has social and cultural processes and practices inherent within it. Therefore, in this paper the term pedagogy will refer to the "conscious activity by one person designed to enhance learning in another" (Walshe & Tait, 2019, p. 1732).

There is a further problem in that research determining the impact of ESE pedagogies is sparse (Evans & Ferreira, 2020). When they were able to discern impact in their review, these authors found that learning aligned with Sterling's (2010) first-order thinking was the most common type, with only four studies out of 10 discussing second-order thinking. This finding is of concern because first-order learning involves developing knowledge or awareness of environmental issues, rather than third-order thinking that Sterling likens to an epistemic type where transformation occurs.

Ideally, ESE pedagogies are mainstreamed into pre-service teacher education curriculum in ways that are authentic, rather than tokenistic to enable pre-service teachers to implement effective ESE in their practice (Reid et al., 2021). Evans et al. (2017) go further and promote the ideal of ESE being embedded not only in curriculum, but also having sustainability as a foundational principle in the policies and practices of the institution—a systemic approach. However, this systemic approach is rarely adopted. Instead, ESE is usually offered as a core subject; included as part of a core subject (e.g., science) or else offered as an elective (Evans et al., 2017).

Theoretical Framework

Due to the lack of theorizing about pre-service teachers' learning about ESE (Evans et al., 2017), and the lack of theorizing in ESE in general (Wals & Dillon, 2012), this paper explores the potential of Mezirow's (1990) transformative learning theory to analyze pre-service teachers' learning. This theory proposes that learning occurs when a person encounters information or actions that result in dilemmas or distortions that challenge their assumptions, values, or beliefs. This challenge can either be ignored, or it can lead to a person questioning and thinking about their assumptions, beliefs, and values. This questioning has the potential for transformative learning but it is not until change in behaviour or practice is evident that transformative learning can be said to have taken place (Cranton & Taylor, 2012).

In many ways transformative learning theory is similar to constructivist learning where the learner plays an active role and new knowledge is built upon one's experiences. Also, both of these learning theories have a variety of conceptions, mainly due to the changing levels of analysis, namely individual and social. Like the different views of constructivist learning, three broad groupings of transformative learning theory have evolved: rational, extrarational, and social perspectives (Cranton & Taylor, 2012). This paper will focus on the rational perspective as it targets individual change because it was individual pre-service teachers' learning that was analyzed and interpreted.

The rational perspective of transformative learning theory is predicated on the notion that people have an innate drive to derive meaning from their experiences. Assuming a relativist position where truth is not fixed and change is unremitting, it proposes that people are continually striving to improve their understanding of the world and can develop a more critical view of the world. This "psycho-critical process" of interpreting or re-interpreting one's experiences (Cranton & Taylor, 2012, p. 196) is based on three elements: construing of meaning; critical reflection; and rational discourse (Mezirow, 1990, 2003).

The element of construing of meaning is central to this theory because it is seen as the construction of a new or revised interpretation of the meaning of an experience that then guides subsequent understanding, appreciation, or action (Mezirow, 1990). These interpretations are filtered by a set of assumptions, or habits of mind. Habits of mind are formed in childhood through cultural assimilation and socialization. They are the habitual ways that people think, feel, and act in their world and are expressed as a point of view particular to a person (Cranton & Taylor, 2012). Over time, habits of mind and points of view, or what are referred to as frames of reference, are reified and become the way that people rationalize and evaluate their world. When people encounter new ideas that present a dilemma or distortion, they either strengthen these frames of reference or else extend their boundaries. However, if the new idea or experience is so markedly dissimilar and cannot be assimilated, it is either rejected or else a new frame of reference is formed, which results in transformation of one's perspective (Cranton & Taylor, 2012).

The second element of critical reflection plays an integral role in the construction of a new frame of reference. It is when engaging in critical reflection that people can question their frames of reference and challenge the validity of presuppositions in prior learning. Mezirow (1990) and Taylor (2007) assert that people need time to reflect on their frames of reference and, if necessary, transform them. Hence teaching about critical reflection is not about how or how to; it is about providing opportunities for learners to reflect why—the reasons for and consequences of what we do. It is about challenging frames of reference and exploring alternative perspectives, which might lead to the transformation of former ways of framing the world and perhaps action being taken based on these new perspectives.

The third element of transformative learning theory is rational discourse. It is an important element because transformative learning can be regarded as "communicative learning," a type of learning where one needs to be able to understand what someone else means when they are communicating with others; in other words, their frame of reference (Mezirow, 2003, p. 59). As this type of communication or rational discourse occurs, one is assessing the authenticity, appropriateness, and beliefs of others to arrive at a judgment of some kind. This process is referred to as "critical-dialectic discourse" and this dialogue with others is an essential part of critical reflection (Mezirow, 2003, p. 59; Taylor, 2007), grounding transformative learning in the nature of human communication.

Consequently, transformative learning is synonomous with teaching for change as it aims to change a learner's frame of reference. In terms of ESE, this means that a learner changes their frame a reference to one where they see themselves as part of their environment and develop a personal environmental ethic (Reid et al., 2020; Tilbury, 1995). This type of learning aligns with Sterling's (2010) epistemic learning and also his third order of learning where changes in a learner's epistemology takes place. Six integrated components have been identified to nurture this change. These components can assist in shifting learners' simple awareness of experiences, to a process of reflecting on the conditions for their experience, then beyond to an awareness of why they experience things in this way and the consequent action that can be taken (Cranton & Taylor, 2012). These six components are: the experiences and knowledge learners bring to the classroom; use of critical reflection; the role of dialogue; having authentic and supportive relationships; using a holistic orientation; and having an awareness of context.

Given the paucity of research about ESE pedagogies in pre-service teacher education (Evans & Ferreira, 2020), this study aimed to explore pre-service teachers' learning during an ESE course designed to help them embed ESE into their future professional practice. An evaluation of the strategies used was undertaken and their learning theorized using the framework of transformative learning theory.

Research Design

This research adopted a qualitative-interpretive approach. The participants were 21 pre-service teachers in the final year of a 3-year Bachelor of Education degree specializing in

primary education (children 5–12 years of age). All but one were females. In terms of ages, 13 of these pre-service teachers were between ages 20–29, three were between 30–39, and five were aged 40 years and over.

A cohort of about 200 pre-service teachers were invited to take part in an elective course consisting of three workshops where they would learn about teaching ESE as it was not offered in any other course. Twenty-one pre-service teachers chose to participate. Only one of these teachers had previously engaged in ESE professional learning.[1]

A series of three workshops was held once a week with each lasting about one and a half hours. During the workshops, the pre-service teachers engaged in activities that modelled ways in which they could teach about the concept of sustainability and ESE, an approach commonly employed in teacher education courses (Evans et al., 2017) and simultaneously learn about sustainability and issues involved in ESE. The activities in the workshops were underpinned by the concept of sustainability because sustainability is integral to ESE (Reid et al., 2021; Tilbury, 1995). The activities were also linked to Mezirow's (1990, 2003) transformative learning theory. Table 1 provides details of each activity used along with the links between the activity and intended targeted elements and components of this theory.

Table 1

Sequence of Activities and Their Links to Transformative Learning Theory's Elements and Components

Activity	Description	Link to transformative learning theory	
		Element	Component
Picture sorting cards	Pictures to sort into instances and non-instances of sustainability.	Construing of meaning	Experiences and knowledge
Presentation about sustainability	Introduction to 4 aspects of sustainability (environmental, social, economic, and cultural) and their interrelationships along with tensions involved with any definition.	– Construing of meaning – Critical reflection – Rational discourse	– Critical reflection – Role of dialogue
Re-sort of picture sorting cards	Following presentation, making changes to grouping of cards Discussion of each other's groupings.	– Construing of meaning – Critical reflection – Rational discourse	– Use of critical reflection – Role of dialogue

[1] In Aotearoa-New Zealand, professional learning refers to situations where practising teachers engage in courses or programs that further develop their understandings and skills about their practice, usually in a particular curriculum area.

Table 1 (cont'd)

Sequence of Activities and Their Links to Transformative Learning Theory's Elements and Components

Activity	Description	Link to transformative learning theory	
		Element	Component
Jigsaw	In a group of 4, assemble a jigsaw showing examples of 4 interrelated aspects of sustainability.	– Construing of meaning – Critical reflection – Rational discourse	– Use of critical reflection – Role of dialogue
Consequence wheel	Opportunity to consider future consequences of implementing a waste reduction program in a school context (e.g., see Education for Sustainability TKI, n.d.).	– Construing of meaning – Critical reflection	– Experiences and knowledge – Use of critical reflection – Awareness of context
Diamond ranking	Opportunity to clarify values by ranking images of instances and non-instances of sustainability within a set structure and decision-making Discussion about each other's placement (e.g., see World Vision Australia, 2012).	– Construing of meaning – Critical reflection – Rational discourse	– Experiences and knowledge – Use of critical reflection – Role of dialogue
Newspaper article	Selection of a newspaper article about a sustainability related issue and discussion of how aspects of sustainability are represented in that issue.	– Construing of meaning – Critical thinking – Rational discourse	– Experiences and knowledge – Use of critical reflection – Role of dialogue – Awareness of context
Peer and individual interviews	Opportunity to discuss newspaper article, ideas about sustainability and future practice with a peer and then with the researcher.	– Construing of meaning – Critical reflection – Rational discourse	– Critical reflection – Role of dialogue

Note. Component of having supportive relationships was present throughout workshops.

At the end of each activity, the pre-service teachers reflected on their learning, recording their thoughts using an audio-recorder. They also engaged in peer interviews where they discussed their ideas about sustainability, ESE, and their future practice. Individual interviews were held with the researcher 1 to 2 weeks following the elective course to reflect on their experiences. These recordings were transcribed and formed the dataset.

As shown in Table 1, a range of pedagogies was selected. The first activity involved the pre-service teachers sorting images into what illustrated sustainability and what did not. The images were of instances of sustainability, such as a regional park which consists of a native forest, people riding bicycles, and solar panels. Images of non-instances of sustainability were also included, for example a congested motorway, monoculture planting of crops, and a shanty town. When sorting these images into two categories, the pre-service teachers were *construing meaning* as they had to interpret these images in terms of their understanding of sustainability, which was their frames of reference. Their interpretation was guided by their *experiences and knowledge*.

In the next activity, the researcher gave a presentation about the generally accepted definition of sustainability. It was hoped the ideas would challenge the pre-service teachers' understandings, presenting them with a dilemma that could result in them beginning to form a new frame of reference about sustainability (*construing of meaning*) as they reflected on their current understanding and compared it with the new ideas they were encountering (*critical reflection*). Discussion about the presentation enabled the pre-service teachers to consider each others' ideas (*rational discourse*). When construing meaning, the component of *critical reflection* could have been employed and *dialogue* was used during the discussion.

Next the pre-service teachers were given the opportunity to re-sort their images to accommodate their new ideas, in a manner similar to constructivist learning theory. Each pre-service teacher discussed any changes they had or had not made (and why) with the group. This activity presented further opportunities for *construing of meaning* as the pre-service teachers had to decide whether to make changes or not. The use of *critical reflection* related to their own ideas and those of their peers presented through *rational discourse* (*dialogue*) could have assisted in their decisions.

The jigsaw activity consisted of images that depicted the environment, society, culture, and the economy. It was based on the model of strong sustainability where the importance of the environment is paramount as all human life and activities (society, culture, and the economy) occur within its limits (Phase2, 2010). The environment images were arranged on the outside and the others in the centre. The jigsaw was completed in groups of four and when assembled, the pre-service teachers discussed what the jigsaw showed about sustainability, providing opportunities for *rational discourse* (*dialogue*). As the pre-service teachers worked together, there was the opportunity to continue reflecting (*critical reflection*) on their understanding of sustainability, possibly constructing a new frame of reference about this concept (*construing of meaning*).

Completing a consequence wheel gave the pre-service teachers an opportunity to consider their understanding of sustainability in the context of waste reduction in a school. Using their *experiences and knowledge* about waste reduction in the *context* of a school, they considered the consequences of, for example, implementing a compost system at a school.

Again the pre-service teachers could have been *construing meaning* by *critically reflecting* on their understanding of composting, how they manage organic waste in their own households and its link to sustainability.

The diamond ranking activity consisted of nine images showing instances of sustainability, such as a futuristic city with green buildings, a ferry powered by solar panels, and instances of un-sustainability, such as a forest area being cleared and a desert area converted into suburbia. The pre-service teachers had to sort these images into a diamond shape with one at the top being the most sustainable, one at the bottom the least sustainable, and the others in three lines a graduated order (see World Vision Australia, 2012). They then discussed the reasoning they used. Yet again there was an opportunity for *construing of meaning* as they used their *experiences and knowledge* to *critically reflect* on the images and interpret them in terms of their frame of reference about sustainability. The images and *rational discourse* (*dialogue*) might have presented the pre-service teachers with a dilemma, leading to a change in their frame of reference.

The newspaper activity was an opportunity for pre-service teachers to select a media article about an issue that they thought illustrated components of sustainability. They discussed their reasoning with the researcher, which was use of *rational discourse* (*dialogue*). Once more, through *critically reflecting* on their *experiences and knowledge* about the issue, which was of interest to them (*awareness of context*), further *construing of meaning* could have occurred.

The final activity, the peer and individual interviews, gave the pre-service teachers the opportunity to *critically reflect* on their experiences throughout the elective course. As they discussed their experiences using *rational discourse* (*dialogue*), once more it was possible that further *construing of meaning* occurred and they considered their experiences holistically.

Data from the interviews were analyzed inductively using thematic analysis (Braun & Clark, 2006). The pre-service teachers' analyzed responses were then deductively analyzed in terms of evidence of construing of meaning, the central element of transformative learning, to ascertain if any changes in their behaviour had occurred. The majority of the dataset were multiple response data.

Findings

At the start of the elective course, the pre-service teachers were asked to record their understandings of the concept of sustainability. Their responses were analyzed using a definition of sustainability that included five components: environmental; socio-cultural; economy; interrelationship between these three components; and time (temporal) (Birdsall, 2014). Seven pre-service teachers recorded uncontextualized definitions that did not relate to the definition with responses such as "Keeping things the same" (PT13). Eight pre-service teachers' responses illustrated one component of sustainability, usually the environmental

component and related to resources and their use, for example "conserving resources, reducing use of natural material" (PT9).

Five gave responses that included two components. PT19's definition was an example and she stated that sustainability was "man's attempt/activity to find alternative options to use our resources efficiently and effectively [environmental component] to achieve/last for a lifetime [*temporal*]." The one pre-service teacher who had previously engaged in professional learning about ESE had a sophisticated understanding containing three components and she defined sustainability as:

> how we ensure the good use of resources to conserve the environment and our resources [*environmental component*]. We need to preserve our world for future generations [*temporal*] in a way which is economically viable, socially acceptable and environmentally sound [*interrelationships*]. (PT18)

At the conclusion of the course, pre-service teachers recorded their understanding of sustainability again. On this occasion, four pre-service teachers' definitions comprised of one component, 15 included two components, and two pre-service teachers had three components in their definitions. However, although six of these teachers' definitions did not change in terms of the number of components, they did seem to become more detailed. For example, in her initial definition PT12 wrote that sustainability meant, "Looking after the environment [*environmental component*] to sustain it over time" [*temporal*]. But at the conclusion she wrote that sustainability is "based around environmental, economic and societal aspects of the world *[interrelationships component*] with the creation of systems that contribute to the continuation of life that is sustainable long term [*temporal*]." The growth in their understandings seemed indicative of learning having occurred.

Four categories of data from the interviews were developed from related themes. These categories are now presented: Identification of most important idea learnt; identification of the most effective activity; Ideas about their future practice; and changes to their lifestyle choices. These categories of analyzed data were chosen to illustrate both what these pre-service teachers learnt and how they used (or intended to use) their learning in their personal and professional lives. Data were then collated and further analyzed to explore the possibility of transformative learning having occurred.

Identification of the Most Important Idea Learnt

In the peer interviews, pre-service teachers were asked to identify the most important idea they had learnt. Although asked to identify one idea, 25 responses were given. Two inductively analyzed themes were identified in this category: Effects on people's actions (11 responses) and Knowledge/understanding (10 responses). Four responses were not able to be themed.

In the Effects on people's actions theme, six pre-service teachers identified the way in which people's decisions and actions have impacts on the environment as the most important and

this response is indicative of this theme: "it's everything that impacts on the environment and just being aware of that and trying to make positive changes" (PT1). This response shows PT1's belief that people need to be aware of their actions and work towards making changes that lessen their impact on the planet as most important.

Three pre-service teachers' responses placed in this theme related to the consequences of people's actions today on the future being most important. PT2's response illustates this idea: "The consequences, if we don't look at sustainability and doing things for our environment, like the future impacts it's going to have."

Two pre-service teachers' responses placed in this theme were linked to the idea that people's actions can make a difference to the quality of our environment. For example, PT3 opined, "how we can action things to make our world more sustainable."

Knowledge/understanding was the other theme and all 10 responses placed in this theme related to learning about the interrelationship between the four sustainability components being the most important idea learnt. For example, PT4 said: "you need to consider the aspects of lifestyle, the cultural, the social, the economic and the environmental, and how they're interrelated. And if one changes, it affects basically all of the rest of them."

Identification of the Most Effective Activity

In the peer interviews, the pre-service teachers were asked to identify the activity that had the most impact on their learning and why. Twenty-seven responses were given. Nine identified the consequence wheel activity, eight the jigsaw activity, and five the picture sorting activity. The diamond ranking activity received three responses and the researcher's presentation two responses.

The reasons given for an activity's impact were analyzed. Twenty-eight reasons were given that either related to their learning (24 responses) or else an activity's suitability for use in their practice (four responses). Thirteen of the reasons that related to learning were themed as Encouraging thinking. Responses placed in this theme related to ideas such as the activity fostering thinking more deeply or in a different way. For example, when talking about the consequence wheel activity, PT5 said that she had to "seriously think through what affected what ... and that ... evokes thinking that I didn't have before." A similar response was given by PT6 when speaking about the jigsaw activity when she said, "it got me to think about how important the environment is."

The jigsaw activity also encouraged thinking because it enabled the pre-service teachers to see the interrelationships between the components of sustainability due to the way that the environmental component formed the jigsaw's borders and the other three components (economic, social, and cultural) were in the jigsaw's body. Four gave this type of reason and PT7's response is indicative; she said: "I liked the way it was set out ... the environment ... around the edge ... see everything link into each other and ... the environment link into

everything so it shows that the environment is the most important."

Two pre-service teachers found the discussions that accompanied the activities most valuable for their learning. PT8's comments illustrate this reasoning:

> ... it wasn't just doing the activity. It was going round and looking at everybody else'sideas and talking to them about how they looked at it. ... I actually learnt probably more hearing other people's perceptions than I did just doing the activity.

Lastly, five pre-service teachers' reasons for the efficacy of activities related to them being able to use a visual mode of learning and manipulate concrete materials. For example, PT9 commented: "organising the pictures into diamond shapes and the big jigsaw ... quite important as it's a visual aid ... personally for me I enjoy practical activities so this really helped."

Four reasons given for the activity being the most significant for their learning related to it being able to be used in their future practice. PT10 gave such a reason when she discussed the consequence wheel activity saying, "I would definitely use that in my classroom."

Ideas About Their Future Practice

In the peer interview, another question was asking their peer how their participation in the workshops would impact on their future practice. Forty responses were given and placed in three different themes: Classroom resource management; Intent to teach sustainability; and Philosophical reasons.

The majority of responses (23) were placed in the Classroom resource management theme as they related to ideas that reflected the intent to implement sustainable practices into a classroom or school grounds such as recycling systems, setting up composting/worm farming systems, planting vegetable gardens, and reducing energy usage in the classroom. For example, PT6 thought she would "get involved with school recycling, vegetable gardens, having worm farms." PT14 also spoke about the importance of having a recycling system but also said she would focus on teaching about sustainability through "just simple things like always turning off the lights."

Eleven responses were themed as Intent to teach sustainability as they expressed ideas about including ESE in their future classroom learning programs in a general way. Responses such as "I'll be able to teach it now from what I've learnt" (PT11) and PT12's more expansive reasoning were examples: "now that I know a bit about sustainability ... I definitely want to incorporate sustainability programmes into my classroom."

The last theme (Philosophical reasons) had six responses. This type of response related to ideas about a teacher's role in bringing about change in learners' ideas that would affect their behaviours through the culture they develop in their classroom and programs they implement. PT15's response exemplifies this theme:

> I think it's [sustainability] going to be just part of what my class does. It's about

> training your class and that's just what you do ... train your class to be able to do that [make sustainable decisions], then that should carry on into all aspects of their lives ... into their future. ... Hopefully I can be a catalyst in that creation.

Changes to TheirCifestyle choices

During the individual interview with the researcher, each pre-service teacher was asked if their participation in the workshops had brought about any changes in their lifestyle choices. This question was posed because action-taking is central to ESE (Reid et al., 2021; Tilbury, 1995) but the format of the workshops did not allow for this opportunity. It was hoped that these pre-service teachers might use what they had learnt during the workshops to make changes in their personal lives, directly applying their knowledge and possibly providing evidence of transformative learning (Frisk & Larsen, 2011).

Thirteen pre-service teachers reported making changes to make their personal lives more sustainable. Seven of this group of 13 said that they already incorporated sustainable practices such as recycling or energy saving in their households but had increased the number of such practices as a result of engaging in the workshops. An example of this type of response was given by PT1. She said that she was already "hyper on recycling and ... energy efficient ... always switch[ing] everything off." PT1 was moving to a country residence where her boyfriend already had a vegetable garden that she planned to continue and she had "been talking to him about getting a worm farm ... so I can do the whole compost and worm farm thing."

Another pre-service teacher who had made further changes was PT16. She had begun recycling at her rented house and had now "got a scrap bucket" to collect her household's organic waste to take to her parents' place for their flock of hens. In addition, she "got a worm farm for my brother for his birthday."

Not all of these pre-service teachers reported making changes. Four of them said that they already implemented sustainable practices in their lives and had not changed anything. Another four discussed the way that they had become more aware of potential sustainable practices but had not implemented any changes.

Occurrence of Transformative Learning

Another aim of this study was to explore the potential for transformative learning theory for explaining learning in ESE. This theory postulates that transformation has occurred if behaviour change has occurred (Cranton & Taylor, 2012), possibly due to the forming of a new frame of reference about sustainability. In this study, change was deemed as occurring if pre-service teachers articulated notions about incorporating ESE into their future practice and had made sustainable lifestyle decisions as a result of engagement in the course.

Data analysis showed that three loose groupings of pre-service teachers could be determined. One group seemed to be more aware of sustainability as a concept and about

possibilities of making sustainable decisions in their lives. The second group noted the value of the activities in the elective course and their potential use in their future practice. This group also discussed current sustainable practices in their lives, evidence that they were making connections between what they had learnt about ESE and their lives. The third group identified ways that they would incorporate ESE into their future practice, identified sustainable practices in their lives, and also ways in which they had extended these. A vignette that characterizes each of these groups was developed and is now presented.

Four of these pre-service teachers demonstrated a greater awareness of ESE and the possibilities for sustainable practices in their lives, demonstrating that they had thought about the activities and knowledge presented, but their engagement had not resulted in any articulated changes. PT17's responses exemplified this grouping, demonstrating a raising of her awareness about sustainability and its implications for her personal and professional life. For example, when asked about the value of the course, she opined that "just this little time ... makes me think about things a lot differently." When asked about the impact on her future practice, she replied that it "just makes me more aware"—a response that gave no commitment to ESE's future inclusion. Her heightened awareness of ways she could make sustainable lifestyle decisions was apparent when she discussed her household's use of energy, but again, there was no commitment to making change:

> ... we have a pool and we didn't put solar heating in. We put electricity in ... how stupid is that, but I wouldn't have thought about it before. ... It's a freezing cold pool because we never put the heating on but those sorts of things will affect my future. ... The course will affect my future experiences. (PT17)

Consequently, in terms of Mezirow's theory, transformation did not seem to occur for this grouping.

Eight pre-service teachers' responses could be placed in a second grouping. This group's responses showed that they valued the ESE activities presented during the course and were considering its incorporation into their future practice. They also discussed their existing sustainable lifestyle decisions. The teachers in this grouping seemed to have reflected on the activities and realized the potential for impact on both their professional and personal lives, but similarly to the first grouping, did not articulate a commitment to any demonstrable change. PT9's responses were indicative of this grouping. For PT9, the value of the course was in the "resources we can use in the classroom " but she never said she would implement ESE in her future practice. However, she was enthusiastic about belonging to a environmental club in her professional future and being "part of whatever the school system has ... a nature group"—suggesting that although she was prepared to be involved, she was not considering a role leading ESE. PT9 mentioned that she had "energy saving bulbs at home ... a compost bin ... and to reduce our petrol costs ... we walk if we just need to go down the road" but did not mention any further changes to her lifestyle decisions. Her comment about her learning was apparent when she said that the course had "opened my

eyes to a lot of the issues in society and how I can ... make an impact ... make it a more healthy environment." However, despite this sentiment, like the other seven pre-service teachers in this grouping, no intended change was stated and therefore, transformation did not seem to occur.

The remaining nine pre-service teachers articulated changes in their thinking about their lives, a commitment to incorporate ESE into their practice and identified changes they had made in their lifestyles in order to be come more sustainable. PT10's responses were indicative of those placed in this grouping. Changes in PT10's thinking about the environment were evident in her expression of feelings of responsibility and stewardship, especially for her local community: "We do really need to look after what we've got. ... My place in the world is ... where I can change things ... taking responsibility ... demonstrating to my children and those around me that I need to be responsible." She also expressed a firm commitment to incorporate ESE into her professional life with her responses showing her understanding of how her ideas and beliefs would impact on her teaching: "The sustainability classes have made me think, my ideas have changed and will ... come out in my teaching because ... you teach what you know and what you believe in."

In addition, PT10 was looking forward to "all the cool stuff I can do with kids" with her goal of being to "put them [the children] towards having a sustainable life and environment." Furthermore, PT10 discussed the changes she had made in her personal life, such as waste minimization where she now bought "one big box of the crackers and we divide it up ... [into] little tubs ... so we've not got the rubbish." Her household now had a flock of hens and she had purchased a scooter "as opposed to having a second car" and she was encouraging her children to "walk at least twice a week [to school] as opposed to going in the car." In these ways, it seemed that transformative learning had occurred for these pre-service teachers.

Discussion

This research aimed to evaluate the strategies used in an elective course designed to help pre-service teachers embed ESE in their future practice. It also aimed to use Mezirow's transformative learning theory as a framework to explain any changes that occurred.

Over the duration of the course, the pre-service teachers' understandings of sustainability became either more detailed or developed in complexity. This change could have been due to their learning during the course. Pedagogical approaches identified as having most impact on their learning were the consequence wheel and jigsaw activities. Five identified the picture sorting activity as being the most efficacious. Their responses suggested that it was the capacity for these activities to stimulate thinking, either to think more deeply or to think in different ways that made them valuable. Another reason was the capacity of the jigsaw activity to illustrate interrelationships between aspects of sustainability. The final

reason related to being able to physically manipulate visual learning materials to assist learning.

It appeared that engaging in these types of activities gave the pre-service teachers space to think about environmental issues and realize the effects of people's impacts on the environment, both now and in the future. They were also able to consider the many aspects involved in an environmental issue (e.g., social, cultural, economic aspects) and understand how these aspects are interrelated and can change over time. Consequently, not only were their understandings of sustainability and environmental knowledge enhanced, but their environmental awareness was heightened too. Furthermore, many of them were developing systems thinking skills in that they now understood sustainability consisted of interrelated environmental, social, cultural, economic, and temporal components, rather than just meaning the environment and/or resource conservation. These are desired outcomes of ESE according to Reid et al. (2021). Consequently, these findings suggest that when planning courses about ESE for pre-service teachers, activities that give space and time to encourage critical thinking as well as illustrating interrelationships are important considerations. The findings also corroborate Evans and Ferreira's (2020) argument that no one ESE pedagogy can bring about transformative learning and hence a variety of pedagogies are necessary.

The analysis showed that transformative learning seemed to occur for nine pre-service teachers, but not for the other 12 participants. Transformative learning theory's three elements and six components will now be used to interpret these findings.

These pre-service teachers would have started construing of meaning, the first element of transformative learning theory, when they engaged in the initial picture sorting activity and continued using it throughout the course. They used their frames of reference to complete this initial activity but during the presentation about sustainability, they were presented with dilemmas and distortions related to their ideas about sustainability. During the other activities, the pre-service teachers continued to be confronted by these dilemmas and distortions and as a result, for some (the 12 who did not commit to change), boundaries of their frames of reference could have been extended. It could be argued that this extension was evident in their deeper environmental awareness and definitions of sustainability. However, for the nine who did report change, it could be said that they formed new frames of reference about sustainability, possibly evidence of Sterling's (2010) epistemic learning, which was apparent in their intention to incorporate ESE in their future practice and make sustainable choices in their lives.

The second element, critical reflection, is regarded as central to transformation (Taylor, 2007) and is also a component that assists in transformative learning. As shown in Table 1, there were opportunities for critical reflection throughout the course. Both during and at the conclusion of activities, the pre-service teachers had such opportunities, which gave them space to question their frames of reference and consider the reasons for doing and thinking the way they did, or how they could do things in the future—an exploration of alternative

ideas. These reflections could have led to an extension of the boundaries of their frames of reference and to the formation of new ones.

Rational discourse, the third element, also occurred throughout the course as the researcher and pre-service teachers discussed ideas and engaged in the activities, particularly the activities in pairs (peer interview) or as a group (diamond ranking). Also, after the picture sorting and diamond ranking, the pre-service teachers did a "walk and gawk," where they walked around, looking at the way others had sorted their cards, and discussed their justification for sorting with each other. This discourse gave the pre-service teachers an opportunity to assess other people's ideas in relation to their own, and arrive at a judgment about their ideas and those of others. Similarly to critical reflection, engaging in rational discourse could have also led to either an extension of existing frames or formation of new frames of reference and links to the component of the crucial role of dialogue in transformative learning.

The remaining four components that nurture transformative learning could have also contributed to understanding these findings, for example the component of employing a holistic orientation. By presenting a holistic definition of sustainability that included environmental, social, economic, and cultural components, the pre-service teachers were able to apply this knowledge to environmental issues and their sustainability definitions, showing a deeper level of thinking and seeming to have developed systems thinking skills. This was apparent when they discussed the interrelationships between these components. Some went further and were able to reflect on issues in a temporal manner when they discussed the effects of people's actions on the future of our planet.

Having genuine relationships is another component that assisted these pre-service teachers' learning. Having studied together for nearly 3 years as a cohort, these pre-service teachers knew each other and had worked together on many other occasions. Also, they had developed a relationship with the researcher during another semester-long course. Consequently, the discussion of ideas was more open, building shared understandings as a community of learners who were focused on learning about the teaching of ESE. Similarly to Walshe and Tait's (2019) findings, being part of this community could have made these pre-service teachers feel they were participating in a valued event, further supporting transformative learning.

When designing the course, materials and activities were selected that were relevant to the pre-service teachers' professional and personal lives, such as the consequence wheel activity. Being aware of the context for learning is another component. Because of the relevance of the activities, these teachers were able to make connections between their existing understandings, both personal and professional, and the new ideas presented during the pedagogical strategies. Being able to build on the familiar could have helped in the extension of their frames of reference or the building of new ones, as they reflected on

how the new ideas either fit within their current frames or else realizing the need to build new ones (construing of meaning).

The final component is that of experiences and knowledge. The intial picture sorting provided a starting point, enabling pre-service teachers to mobilize their prior experiences and knowledge. During the presentation and subsequent activities, they began to critically examine assumptions underlying their experiences and beliefs. Through critical reflection and rational discourse, they could carefully consider the effects of their experiences and beliefs on their frames of reference, possibly leading to extension of, or changes in, their frames.

While transformative learning seemed to occur for nine of these teachers, four other teachers appeared to only increase their environmental awareness, while eight others reflected on their experiences and made connections about sustainability to their lives but did not articulate any change. This finding concurs with Evans and Ferreira's (2020) assertion that the use of ESE pedagogies does not necessarily result in transformative learning. The question remains of how to nurture transformative learning for all.

Limitations

Despite the growth in the pre-service teachers' understandings of the concept of sustainability and the transformative learning that seemed to occur for some, this elective course had its limitations. One limitation is that this course was an elective offering of short duration (four and a half hours in total), which is a frequent choice for delivery of ESE teacher education (Evans et al., 2017). Its delivery was driven by the "passions and concerns" (Evans et al., 2017, p. 413) of an individual and only enacted change at a micro level. Moreover, the course provided few opportunities for affective learning where values and attitudes could have been discussed and critically examined. Also, there was no overt action-taking included; instead it was hoped that these pre-service teachers might be inspired to make change as a result of their engagement.

Furthermore, there was an emphasis on knowledge in the course, for example the presentation and the mobilization of their personal knowledge and experiences. While their understandings of sustainability deepened, it is accepted that knowledge alone is insufficient for behaviour change (Kollmuss & Agyeman, 2002). However, it seemed that these pre-service teachers did need to use and build knowledge about sustainability and environmental issues and they then used their knowledge to inform their deeper environmental awareness and changes they made. This finding, which is similar to that of Evans et al. (2016) and Walshe and Tait (2019), suggests that knowledge plays an important part in ESE teacher education and is possibly a pre-cursor to change.

However, because this study is a small scale one and the pre-service teachers chose to participate, its findings must be interpreted with care. Research that involves self-reporting of change is fraught (Guskey, 2002) and the findings of this study are highly nuanced and

contextually based in one short course. These pre-service teachers had yet to begin their professional careers and enact their intentions and beliefs in the complexity of a classroom and school context. Factors such as rigid timetables and the requirement for teachers to cover large volumes of knowledge impact on the implementation of ESE pedagogies (Frisk & Larsen, 2011; Stevenson, 2007) and could prevent them from teaching ESE. This limitation points to the complicated nature of teaching and learning in general, along with the contexts in which teaching and learning take place (Evans & Ferreira, 2020). In addition, the effects of learning can fade over time, bringing into question for how long these pre-service teachers would embed ESE pedagogies into their practice and continue their espoused behaviour changes.

Furthermore, despite the vast number of studies that have been done, no one theory can explain why people choose to change their behaviour (Kollmuss & Agyeman, 2002). While transformative learning theory seems to have some potential to explain change in behaviour, it has its limitations. Firstly, these findings were analyzed using Mezirow's original conception (1978) and as a theory, it has since evolved. There are currently at least seven quite different conceptions (DeSapio, 2017) ranging widely from a cultural-spiritual conception, to a race-centred and a social emancipatory conception. Consequently, as a theory it lacks a central concept and formal organization, preventing consistent description and explanation (Romano, 2018).

Another issue lies in the question of identifying the domain that needs to be targeted in learners in order for transformation to occur. Without identification of a domain, it is hard to separate transformative learning from non-transformative learning (DeSapio, 2017). This is an issue particularly problematic for ESE learning, which involves the learning of knowledge (cognitive domain), development of pro-environmental values and attitudes (affective domain), along with action-taking skills (kinaesthetic domain). This critique could explain why some of these pre-service teachers' understandings of sustainabiity and environmental awareness developed, but no behaviour change was reported. They were learning but it was not transformative.

A further issue is what is termed the "inbetween problem" (DeSapio, 2017, p. 58), that of bridging the gap between theory and practice. There is no doubt that transformative learning does occur and is observable, as was seen in this study. However, the learning process that results in this transformation needs to be studied and described in order to develop a consistent and replicable process for transformative learning in particular contexts (DeSapio, 2017). This need echoes Evans and Ferreira's (2020) recommendations for further long-term research into the efficacy of ESE pedagogies.

While this project has provided some empirical evidence about the efficacy of ESE pedagogies, given the issues with self-reporting of behaviour change and the continuing development of transformative learning theory, long-term research with larger cohorts of pre-service teachers is needed. Such research could follow them into their professional

careers to explore their practice and the stability of any change. Continued exploration of the utility of transformative learning theory to study change is also warranted with the aim of possibly developing an ESE-specific form of this theory of learning.

In summary, this research has provided a snapshot of the effects of 21 pre-service teachers' engagement in an elective course designed to help them teach ESE. Findings suggest that activities that provide space for and encourage pre-service teachers to think more deeply and to see interrelationships can assist in their learning about sustainability. Transformative learning theory did have potential to explain the learning of these pre-service teachers and how change could have come about. However, further research is needed to evaluate ESE pedagogies using this theory. Exploring ways to enable all teachers to embed ESE into their practice is also needed, so that all learners develop the environmental ethic needed to work towards a flourishing planet for all.

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