Professional Preparation for Science Teachers in Environmental Education

James T. McDonald and Lynn A. Dominguez

Introduction

The ability of a new science teacher to incorporate and teach environmental concepts in their classroom requires content knowledge but also the skills of *how* to teach the concepts. The use and integration of environmental education (EE) pedagogy into teacher preparation programs assists with the skills of "how to teach." EE resources developed to assist current teachers in integrating environmental concepts into their science classrooms are also appropriate for the professional preparation of preservice teachers. These resources may include national EE *Project* curricula such as Project WILD (2000), Project Learning Tree (2006), and Project WET (1995). Additional resources are available from the North American Alliance for Environmental Education (NAAEE), the Environmental Protection Agency (EPA), the National Wildlife Foundation (NWF), the Leopold Education Project (LEP), the World Wildlife Fund (WWF), and many others. However, simply having resources available is not enough; EE methods and skills need to be purposefully integrated into preservice teacher preparation programs. Thoughtful integration of concepts, ideas, pedagogy, and skills for EE should reach beyond subject area barriers to include the rich scope of knowledge included in many areas of study. The purpose of this chapter is to introduce: background literature about preservice teacher preparation in EE; challenges of EE preparation; National Science Education Standards (NRC 1996) for professional development and the Guidelines for the Initial Preparation of Environmental Educators (NAAEE 2000); development of knowledge, skills, and pedagogy for EE; mentoring preservice teachers; and a section on recommendations.

J.T. McDonald (✉)
Department of Teacher Education and Professional Development, Central Michigan University, EHS 134C, Mt. Pleasant, MI 48859, USA
e-mail: jim.mcdonald@cmich.edu

L.A. Dominguez
Department of Recreation, Parks, and Leisure Servises Administration, Central Michigan University, 103 Finch, Mt. Pleasant, MI 48859, USA
e-mail: domin1la@cmich.edu

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The process of "doing" EE is intended to be interdisciplinary and supplemental throughout the K-12 curriculum, not confined to one subject area. Unfortunately, most higher education institutions are not set up to work across departments and subjects areas. Consequently, preservice teachers may learn content knowledge in one specific subject and teaching methods from different departments. The state certification process will usually only recognize certification in a specific subject area. Because of the interdisciplinary nature of EE it tends not to fit neatly with one subject area. How then do we manage to adequately prepare future teachers in EE?

To teach quality EE, there is a definite need for appropriate pedagogies to deliver effective EE in schools. There is also a need for teacher education institutions to address the specific teacher competencies for EE and provide adequate training and preparation for beginning teachers. A wide range of essential skills is required by individuals or groups to effectively participate in dealing with environmental issues. This is one reason that teachers, teacher educators, and education administrators have not adequately addressed the reality of exploring effective pedagogies for delivering EE within the context of the current *National Science Education Standards* (NRC 1996).

Theoretical Framework

The notion that knowledge is constructed from the interaction of prior and new experience is the basis of contemporary approaches to experiential education. John Dewey (1966, p. 140) suggested that to "learn from experience" was to use prior knowledge and present experience to develop connections between things in order to move forward. Dewey (1966) stated that the "nature of experience can be understood only by noting that it includes an active and a passive element peculiarly combined. On the one hand, experience is *trying*" (p. 139) – a meaning which is made explicit in the connected term experiment. "On the passive, it is *undergoing*" meaning that when we experience something, "we act upon it, we do something with it; then we suffer or undergo the consequences" (Dewey 1966, p. 139).

Dewey made the point that if experience involved being affected by something, then it embraced the concept of thinking about our actions. If our actions shift and become a change in behavior, then Dewey believed that true learning had occurred. However, it is the connection of what Dewey calls the passive and active elements of experience that determines the true value of an experience. Therefore, he argued that the activity by itself "does not constitute experience" (1966, p. 139).

Multiple research studies in EE have demonstrated the truth of Dewey's words. Research into the effectiveness of EE has demonstrated that simply having knowledge of an issue does not result in behavioral change (Hungerford and Volk 1990). Instead, for students to accept responsibility for the environment they need to take ownership for issues and feel empowered to do something about those issues (Hungerford 1996). Although EE programs are common to

nonformal educational settings, many studies have also shown the need for the inclusion of EE in formal education venues.

Since the early 1970s numerous studies have been completed concerning the need for EE to be infused throughout schools and around the world. The frequently cited Belgrade Charter (UNESCO-UNEP 1976) provides a goal statement that is the generally accepted definition of EE. This statement goes beyond cognitive knowledge about the environment and encompasses education whereby learners develop responsible environmental behaviors. The Tiblisi Declaration (UNESCO 1978) was adopted in 1978 and provided three objectives for EE that build upon the Belgrade Charter (Disinger and Howe 1990; Stone 1989). A comprehensive framework for the delivery of EE was conceptualized and included elements of informal and formal educational settings. Early on, competencies needed by both formal and nonformal teachers for EE instruction were identified. These included the ability to select, utilize, and implement EE curricular programs; an understanding of the goals of EE; the ability to infuse EE into the curriculum; knowledge in environmental issues and concepts; the ability to investigate and evaluate environmental issues; and the knowledge and skill in taking environmental action (Stone 1989; Wilke et al. 1987).

EE is perceived by many teacher educators in the world (NIER 1993, 1996) as not part of the mainstream school curriculum. It is not a specific learning area in its own right, and therefore has low status. The lack of policy guidelines and a national framework for effective teaching and learning of EE in the USA (prior to 2002) has resulted in ad hoc delivery that was superficial and primarily focused on delivering information about the state of the environment (Powers 2004). It was often characterized by gathering information *about* local and global issues and presenting hypothetical solutions. There are few examples in formal education of quality EE programs that require individuals to reflect on their own behavior and explore the range of skills that produce solutions resulting in a change of attitudes and values, either "*for*" or "*with*" the environment. In most cases, the teaching and learning strategies are inappropriate and reflect a lack of commitment to EE by administrators (Plevyak et al. 2001).

However, the willingness of inservice teachers to engage in EE has been well-documented (Disinger and Howe 1990; Simmons 1998; Stone 1989). Unfortunately, these same teachers identify many barriers to the implementation of EE methods in their classrooms. These include a lack of content and pedagogical knowledge, a lack of skills in taking children into outdoor settings, an overcrowded curriculum, a lack of perceived preparation time, a lack of adequate resources, and a lack of personal commitment to EE (Kim and Fortner 2006; Samuel 1993; Simmons 1998; Stone 1989). In an effort to increase the impact of EE professional development and employ the "multiplier effect" – whereby teachers are taught and the knowledge is multiplied by their students being taught – preparing preservice teachers in EE may be the answer (Powers 2004).

The North Carolina Department of Public Instruction's Division of Science Education (1973) stated that preservice teachers represent "the most effective, long-range means of diffusing EE throughout the general curriculum" (p. 2).

Consequently, centering the focus of preparation for EE on the professional development of preservice teachers, in particular the development of new science teachers, would be effective (Heimlich et al. 2004; McKeown-Ice 2000; Stone 1989; Westing 1993).

The challenges of preparing preservice teachers to bring EE methods and environmental issues into the classroom are well-known (Heimlich et al. 2004; McKeown-Ice 2000; Powers 2004). These begin with the concept of EE itself as interdisciplinary and supplemental to a wide range of school subject areas. In the USA, new teachers are prepared to teach within specific disciplines. If a preservice teacher identifies that they are preparing to be a biology, social studies, or mathematics teacher everyone can conceptualize a basic framework of what they will be prepared to teach. Identifying oneself as an EE teacher is a conflict in terms. Will you teach an "environmental education course"? Will you be certified by your state to teach "environmental education"? Even many teachers certified for elementary education have specialty areas such as science, reading, language arts, or mathematics in which they are certified to teach. The concept of EE as a *method* of teaching is foreign to many State Departments of Education along with the issues of interdisciplinary and cross-curricular methodologies (Disinger and Howe 1990).

Currently, preservice teacher education programs have been tasked with including numerous general and professional education courses in their preparation programs. Finding room for EE is difficult, especially when its interdisciplinary nature is taken into account. Consequently, very few universities have any type of required EE coursework or fieldwork. In general, preservice teachers have very limited access to EE content or teaching methods in their course work (McKeown-Ice 2000; Mastrilli 2005). If EE is included in a teacher preparation program, science or social studies methods classes are usually used rather than an interdisciplinary approach (Plevyak et al. 2001).

Key research findings for the preparation of effective teachers have found that both the knowledge of the subject being taught and the "knowledge and skill in *how to teach* that subject" (NCATE 2006, p. 4) are critical to classroom success. Managing students in an outdoor classroom setting, using methods designed to increase their environmental awareness, and being able to successfully critique and evaluate appropriate EE resources are all skills related to teaching about the environment. Preparing preservice teachers to successfully use EE methods and resources requires exposure to appropriate teaching materials that are non-biased and based on science.

The best methods are based on inquiry techniques that allow preservice teachers to be learners, encourage active engagement, and model appropriate teaching methods for use in their own classrooms (Bell et al. 2003). The advantage of incorporating professional development early and often into teacher preparation programs is to expose preservice teachers to best professional practices early in their career. As they enter the classroom, new teachers are then better equipped and have resources ready for curriculum planning, development, and use (Van Petegem et al. 2005).

Preservice Science Teachers as Environmental Educators

Two documents have been developed to guide the professional development of science teachers. These documents are also important to guide the professional preparation of preservice teachers in both science and EE. The *National Science Education Standards* (NSES) (NRC 1996) contains a section on professional development for inservice teachers and provides a description of professional development:

> Professional development for teachers should be analogous to professional development for other professionals. Becoming an effective science teacher is a continuous process that stretches from preservice experiences in undergraduate years to the end of a professional career. Science has a rapidly changing knowledge base and expanding relevance to societal issues, and teachers will need ongoing opportunities to build their understanding and ability. Teachers also must have opportunities to develop understanding of how students with diverse interest, abilities, and experiences make sense of scientific ideas and what a teacher does to support and guide all students. And teachers require the opportunity to study and engage in research on science teaching and learning, and to share with colleagues what they have learned (p. 55).

The second document, *The Guidelines for the Initial Preparation of Environmental Educators* (*The Guidelines*) (NAAEE 2000) was developed by the North American Association for Environmental Education (NAAEE). *The Guidelines* contains "a set of recommendations about the basic knowledge and abilities educators need to provide high-quality environmental education" (NAAEE 2000, p. 1). Emphasized within *The Guidelines* is the need for all teachers to pursue ongoing professional development opportunities. Also important is the development of relationships with mentors and advisors who can model teaching methods, provide different ideas about environmental issues, and assist in expanding the skill base of beginning teachers. These professional development frameworks from these two documents (see Fig. 1) will guide our discussion of professional preparation for preservice teachers in the field of EE.

There is some agreement between these two documents when it comes to how teachers should obtain professional development in EE. Standard A of the NSES (NRC 1996) states that professional development should be a lifelong process. This aligns with guideline 3.3 of *The Guidelines* (NAAEE 2000) that states that professional development should be ongoing. It takes time to learn all of the EE curricula that have been developed for use in the USA. Therefore, it is critical to prepare preservice teachers for the need to pursue professional development in new and emerging EE projects, programs, and curricula. These projects in EE continue to be developed by a variety of agencies. Ultimately, it becomes the teacher's responsibility to determine which EE resources best fit their curriculum.

Professional development needs to go beyond familiarity with the various EE *Project* curricula and resources. Familiarity with the content of the curricula does not mean that preservice teachers or experienced teachers possess the proper skills to create positive learning environments for their students in science or EE.

National Science Education Standards for Professional Development	Guidelines for the Initial Preparation of Environmental Educators: Professional Responsibilities of Environmental Educator
A. Professional development for a teacher of science is a continuous, lifelong process.	3.1 Exemplary environmental education practice.
B. The traditional distinctions between "targets," "sources," and "supporters" of teacher development activities are artificial.	3.2 Emphasis on education, not advocacy.
C. The conventional view of professional development for teachers needs to shift from technical training for specific skills to opportunities for intellectual professional growth.	3.3 Ongoing learning and professional development.
D. The process of transforming schools requires that professional development opportunities be clearly and appropriately connected to teachers' work in the context of the school.	

Fig. 1 The standards for professional development from the *National Science Education Standards* (NRC 1996) and the professional responsibilities section of *The Guidelines for Initial Preparation of Environmental Educators* (NAAEE 2000)

Standards C and D of the NSES (NRC 1996) pertain to the need to go beyond acquiring knowledge about a variety of activities to use in the classroom. The "intellectual professional growth" that it talks about is in accordance with *The Guidelines* (NAAEE 2000) standard 3.2 to emphasize education and not advocacy.

The emphasis on opportunities for professional growth states that professional development should be continuous. In addition, professional development should be connected to the context of school as an area related to acquiring pedagogical content knowledge and relevant science and EE content knowledge by preservice teachers and practicing teachers.

Pedagogical Content Knowledge

Shulman (1986, 1987) developed a framework for teacher education by introducing the term "pedagogical content knowledge" (PCK). Rather than considering the knowledge of teaching from the perspective of either content or pedagogy, Shulman

(1986, 1987) believed that elements should be combined of these two knowledge domains. Various scholars have further developed conceptualizations of PCK (e.g., Appleton 2003; Gess-Newsome 1999; Loughran et al. 2006; Van Driel et al. 1998). PCK has become a way of understanding the complex relationship between teaching and content through the use of specific teaching approaches. Understanding of this relationship is developed through an integrated process rooted in classroom practice (Van Driel et al. 1998). Preservice teachers who have only an awareness of the science content studied in the academic discipline are not necessarily prepared with the understandings needed to teach that content. Their academic knowledge must be transformed into instructional activities appropriate for classroom instruction. Encouraging preservice teachers to reflect on their own teaching may well allow them to develop insights into their thinking about science subject matter, science teaching, and their own professional development. However, in so doing, there is a need to explicate the knowledge used for teaching and to establish ways of thinking about science teaching beyond the accumulation of pedagogical strategies.

The NSTA Standards for Science Teacher Preparation (NSTA 2003) help address issues of PCK and are based on a review of the professional science education literature and on the goals set forth in the National Science Education Standards. These standards outline the knowledge that teachers ought to have about specific content in four areas of scientific study: biology, chemistry, earth sciences, and physics. Within each of these domains, numerous objectives describe the most important ideas teachers ought to understand and demonstrate throughout their preservice experiences.

A Call for Strong Science Content Knowledge

Since the science education movement began in the 1960s, the study of student misconceptions about scientific phenomena has been prolific in the literature. Students develop these misconceptions as a result of either personal experience, from other people, or through the media (Ausubel 1978; Driver et al. 1985). Driver (1985) reported that different people have different misconceptions in different areas of science. In teacher education, it is critical to evaluate the conceptions of preservice teachers. If they have misconceptions, it is likely they will pass the incorrect content on to their future students. The result of persistent wrong conceptions about scientific phenomena is an ill-informed citizenry and a reduced possibility of appropriate preventive actions by these citizens against future problems (Boyes, Chamber, & Stanisstreet 1995).

This is a cascading effect that has not been widely addressed. For example, an analysis of survey data indicated that many high-school preservice teachers possess an array of misconceptions about the causes and effects of the greenhouse effect, ozone depletion, (Boyes, Chamber, & Stanisstreet 1995) and acid rain (Khalid 2003). The problem grows more complex due to mismatched concept and student

developmental levels. Inaccuracies in textbooks, incorrect information provided by instructors, and student memorization of prior concepts without meaningful understanding of the basic concepts compound the problem. Ultimately, a lineage of confused science concepts – and confused students – is created (Westbrook and Marek 1992). Both preservice and practicing teachers need to know the potential misconceptions that students can have in examining EE concepts and topics.

Call for Quality EE Teacher Preparation

Research points to the urgent need for teacher education to embrace teaching and learning approaches that support and complement the aims and objectives of EE. Beginning teachers must also be assisted with reflecting on their own teaching practices. The global significance of this issue is illustrated by the importance placed on teacher education for EE in the 1975 International Belgrade workshop (UNESCO-UNEP 1976), the ministerial-level Tbilisi Conference of 1977 (UNESCO 1978), the 1987 Moscow Congress (UNESCO-UNEP 1990), the Brundtland Report (WCED 1987), the "Earth Summit" in 1992 (UNESCO-UNEP 1992) and the UNESCO-ACEID conference on "Environmental Education in Teacher Education in Asia and the Pacific" (NIER 1993).

More recently, an Asia-Pacific UNESCO-ACEID project "Learning for a Sustainable Environment" (UNESCO 1997) addressed the issue of quality teacher education for EE by implementing a region-wide action research project that focused on enhancing professional practice (Fien et al. 1997). Independent researchers have also emphasized the need to develop pedagogical practices in preservice teacher education programs for EE (Fien 1993; Hart 1990; Robottom 1987c; Stapp et al. 1980; Tilbury 1995).

Robottom (1987a, b, c, d) posits that teacher education for EE involves a dual pedagogical challenge. The first challenge is the need to address the social change objectives of EE that seek to transform the "business as usual" mind-set to ecological sustainable approaches. The second challenge addresses the need for professional preparation experiences in EE that assist preservice teachers to become critically reflective practitioners.

Robottom (1987a) has proposed five principles in order to address his dual challenge. Teacher preparation in EE should:

- Be participatory and practice-based
- Be enquiry-based
- Involve ideological critique
- Be community-based
- Be collaborative

These are the approaches that have guided a mentoring program in EE developed at Central Michigan University.

Mentoring Preservice Science Teachers

In order to develop a notion of PCK and how to know when to use appropriate teaching techniques in EE, a mentoring program has been developed for several preservice teachers to help them become exemplary science teachers. In this program, preservice teachers work as "facilitators in training" with a mentor faculty member to assist with professional development workshops. These experiences provide intensive, hands-on opportunities for skill development. Preservice teachers first take part in four EE *Project* curriculum workshops: Project Wild (2000), Aquatic Wild (2001), Water Education for Teachers (Project WET) (1995), and Project Learning Tree (PLT) (2006).

In Michigan, coordinators for the various EE *Project* curricula report a predominance of preservice teacher participants in the majority of workshops (D. Elshoff, K. Fischer, and J. Vail, personal communication, 2008). At Central Michigan University, we have found this participation trend to hold true in each of the two annual workshops in EE that we offer. Of the participants 95% are our own preservice teachers or students studying for careers in outdoor education. In order to develop project facilitators for tomorrow, we are "growing" our own facilitators for the four EE *Projects*.

After students have completed the four EE *Project* workshops as participants, interested preservice teachers can become facilitators in training. This addresses Robottom's (1987b) principle that teacher education should be participatory and practice-based. If preservice teachers have been recent participants in EE classes, they can apply that experience to becoming an effective facilitator when they have to lead their own workshop.

Two faculty mentors, a science educator and an outdoor educator, work with the selected preservice teachers as they plan and implement their own EE professional development. Preservice teachers learn to be an EE facilitator and combine that experience with their previous participant experience to plan effective EE professional development. The experience is collaborative since the preservice teachers work and team with the mentors.

The preservice teachers must plan three EE professional development experiences before they become facilitators. After each is planned and implemented, reflective meetings are held with mentors to evaluate the effectiveness of the experience. Evaluations from participants are reviewed and a discussion ensues as to how the next professional development session can be enhanced. The preservice teachers also reflect on how they can become better facilitators, and by association, better science teachers or outdoor educators.

Preservice teachers also work to mentor local alternative high-school students who then provide EE programs for elementary school children. This process of teaching others helps students to develop their own PCK. This local collaboration addresses Robottom's (1987b) principle that teacher preparation in EE needs to be community-based.

Preservice teachers have been encouraged to present EE activities at state and national conferences. This assists them in practicing their teaching skills and connects them to professional networks. Many of the preservice teacher mentees that we have worked with at Central Michigan University have presented at area conferences of the National Science Teachers Association (NSTA) and at the Michigan Science Teacher Association annual conference. Many of these preservice teachers are members of the NSTA preservice chapter NSTA-CMU. Working with this organization has given us access to a committed group of students who wish to actively engage in professional development activities. Many of the above preservice-teachers-turned-EE-facilitators are among the mentees that have presented EE activities at conferences.

The above example addresses several of Robottom's (1987a) principles. The presentations that the preservice teacher mentees gave at the science education conferences were participatory and practice-based. The activities presented were from the four main EE *Project* curricula mentioned above. Preservice teachers worked in collaborative teams to present in a share-a-thon format with activities that were enquiry-based.

Recommendations and Conclusion

Our experiences with the professional preparation of preservice teachers in EE have led to the following recommendations.

1. Faculty involved in the preparation of preservice teachers in EE should be familiar with and incorporate the *NAAEE Guidelines for the Initial Preparation of Environmental Educators* (NAAEE 2000) in their methods courses. *The Guidelines* (NAAEE 2000) provides science methods instructors with a framework with which to integrate EE into a science methods course. The instructional strategies, methods, and skills applied during EE activities are particularly applicable to science processes.
2. EE should be a part of science methods courses in teacher preparation programs since many of these programs do not have a separate EE methods course. Although the basic premise of EE calls for an interdisciplinary approach, the reality of resource availability for preservice preparation may mandate a single subject approach. Therefore, the most reasonable alternative would be the use of science methods courses for EE preparation delivery.
3. Examples of EE curriculum (for example, *Project* curricula) should be introduced to preservice teachers as a way to promote the use of science process skills, the integration of EE with science and other subjects, and as a way to introduce hands-on, minds-on instructional strategies that encourage active learning. Student participation in the EE *Project* curriculum workshops provides preservice teachers with a toolbox of exemplary activities appropriate for immediate use in their science classroom. At the elementary level, the EE activities

promote integration with science and other subjects. These activities contain multiple opportunities for teachers to develop and enhance their students' process skills.

4. EE can be used as a way to promote environmental literacy for preservice teachers and an interdisciplinary, multicultural, and global approach to instruction. Environmental perspectives can also be used along with indigenous ways of knowing to present global issues. Using an EE perspective in science promotes global thinking because of its interdisciplinary approach. A global approach is needed for preservice teachers to be prepared to educate the next generation of global citizens.
5. Global and local issues related to the environment are a way for preservice teachers to think critically, while examining both sides of an issue, and how they can be involved in providing a solution for a problem. Environmental issues need to be presented in a balanced, nonbiased manner so that students can see both sides of an issue. Examples of issues that need to be presented in a balanced manner include the harvesting of the Redwood groves in northern California, whaling, the rainforest, energy use and policy, global warming, and endangered species.
6. EE can serve as a way to introduce the use of appropriate technologies to preservice teachers. Outdoor environmental data collection experience can provide preservice teachers with opportunities to learn how to use technologies such as GPS and probeware for environmental investigations. The use of these technological tools can promote higher-order thinking skills for students and allow them to apply science to their own lives.

In conclusion, preservice teachers need opportunities to practice instructional strategies for EE. Instructional strategies as outlined by NAAEE (2000) include hands-on observation and discovery in the environment, inquiry, cooperative learning, service learning, problem-based learning, and other methods. Preservice teachers must also develop their own environmental awareness and an attitude toward environmental responsibility and stewardship to be effective environmental educators. Preparation in EE methods and strategies at the preservice level gives new teachers a variety of resources, skills, and knowledge to assist them with implementation of environmental lessons in their science classrooms.

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