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The development of environmental awareness through school science: Problems and possibilities

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This paper focuses upon the problem of raising environmental awareness in the context of school science. By focusing, as it does, on the relationship between the self and the natural environment, the paper discusses the difficulties that exist, such as the students' involvement with the natural world, as their object of study, the empirical treatment and the modeling of the natural world, and the purpose of learning science, as well as the possibilities for promoting the development of such relationship by keeping the natural world, as an object of study, in the foreground of the teaching-learning process. Such possibilities refer to the awareness of the personal and wider significance of science ideas and socio-scientific issues, the wonder evoked by science ideas and by natural forms and phenomena, the aesthetic appreciation of the natural world, and the 'story of the universe', as a story that addresses the interconnection of science and human life. The educational importance of 'awareness' is also discussed in the paper.

Key words: environmental awareness, environmental education, school science, problems, possibilities, wonder, aesthetics, storytelling

Introduction

Promoting environmental awareness is considered a crucial goal in the context of contemporary education (Slattery, 2003; Slattery & Rapp, 2003). The importance of this goal lies in the interdependence between humankind and the natural world (Richards, 2001; Orr, 2003). If Bonnett (2004a) is right in arguing that Nature defines both our existence and our relationship with the world at large, then the development of environmental awareness can help change our relationship with Nature, and thus promote a more responsible behaviour toward, and even respect for, it. However, fostering the development of that relationship can also promote environmental awareness.

Although young students' direct, "first-hand" experiences in Nature are considered crucial for the development of an emotional bond with it (Kahn, 1997; Hinds & Sparks, 2008; Kellert, 2002), indirect learning experiences should also be considered. Why? Children, according to Wilson (1994), who are close to the natural environment, tend to relate to it as a source of joy, wonder and awe. This relationship, as the "biophilia hypothesis" suggests, is still strong, since our technological development has been so rapid that our evolutionary adaptation to new environments has yet to develop (Wilson, 1993; see also Kahn, 1997). Wilson (1993) argues that human beings have an "innately emotional affiliation to other living organisms" (p. 31) and therefore there is still a need to be in Nature. However, some advocates of the "biophilia hypothesis" believe that this genetic bond behind such a hypothesis may very well be a weak one, thus requiring additional learning experiences (Kahn, 1997; Kellert, 2002). The fact that children grow up in a highly technological environment and, more often than not, away and literally cut off from the natural environment, makes learning experiences and knowledge about the latter imperative. The question though is whether science education can provide such learning experiences, and whether such experiences can raise environmental awareness. This is a crucial question given the contested relationship between science education and environmental education (Ashley, 2000; Gough, 2002, 2008; Lucas, 1980; Robottom, 1983; Robottom & Hart, 1993).

Yet what should be acknowledged is that the incompatibilities, in general, between science, science education, and environmental education made more sense in the past when science was insensitive, or even inhospitable, to social issues. The same holds for the view that environmental education is more appropriate for areas or disciplines other than science. Postmodern perspectives on science and science education (Bencze, 2000; Hodson, 1993, 2003, 2004; Jenkins, 2009; Littledyke, 1996, 2008; Roth & Desaultes, 2002; Roth & Lees, 2004; Sauve, 1999), in providing "opportunities for students to engage in a wide range of personal, social, economic or political issues that stem from the role the sciences have come to play in society" (Jenkins, 2007), make the relationship between science education and environmental education more compatible, and therefore it makes sense to pursue the development of environmental awareness through science.

It has been pointed out that science education, despite its limitations, can offer several opportunities for fostering environmental awareness (Littledyke, 1996, 2008). In fact, over the last two decades, several science educators have addressed, explicitly or implicitly, the need for environmental awareness (Bybee, 1993; 1997, 2005; Hodson, 2003, 2004; Hurd, 1998; Roth & Lee, 2004; Pedretti, 2005; Yager, 2007). Notwithstanding the limitations and the problems inherent in the STS movement in science education (see Hadzigeorgiou, 2008; Hodson, 2004), one has to acknowledge its contribution toward paving the way for the inclusion of social issues and problems in the science curriculum (see Kumar & Chubin, 2000; Solomon & Aikenhead, 1994; Yager, 1996, 2007), and also note the pedagogical advantages resulting from such inclusion (i.e., issues/problems can provide a context for learning, can provide students with a purpose, can discourage a "spectator theory" of knowledge, can facilitate the development of planetary consciousness). However, the recent emphasis on socio-scientific issues (SSI) appears to be more promising, compared with the traditional STS approach, in the sense that it offers more opportunities for raising environmental awareness. The reason is that the SSI approach, focuses on empowering students to reflect upon the interrelationship between the physical and the social world, and their own life, and also upon the moral principles that guide their decision-making in regard to socio-scientific issues.(Dolan, Nichols, & Zeidler, 2009; Sadler & Zeidler, 2005; Zeidler, Sadler, Simmons, & Howes, 2005; Zidler & Nichols, 2009).

Of course, it is not only through socio-scientific issues that environmental awareness can be raised. Science ideas can also help raise environmental awareness. The problem though is whether the natural world is, or is perceived by the students as, an object of study. While some alternative approaches to education (e.g., Judson, 2010; Noddings, 1992) give primacy to the natural world as an object of study, thus providing students with opportunities to develop environmental awareness (see Slingsby, 2006), in science education there is a question whether the natural world is students' object of study. The question, in fact, concerning the degree to which science education can help raise environmental awareness is a question about the degree to which nature is perceived by the students as their object of study.

If school science is to help foster environmental awareness, an appreciation of the natural world through the learning of school science should be an important instructional goal. At present, as Bonnett (2011) points out, much official educational policy in England – including that which relates to the natural environment - makes scant reference to Nature. What dominates the National Curriculum concerning science education, especially for students of the age range 5 to 11 years, is the learning of science process skills, and an analytic/intrumental rationality. In the United States, inquiry science, conceptual change, and standards are considered paradigms that drive current science education (Pugh & Girod, 2007). These conditions do not provide a fertile ground for the development of environmental awareness through school science.

On the other hand, although science educators and science teachers can use issues, problems and science ideas, with an explicit or implicit environmental dimension, to foster environmental awareness (Slattery 2003; Wals 2011; see also Littledyke, 2008), there are certain difficulties or obstacles that need to be considered. For it is one thing to use issues and even certain science ideas with an environmental dimension for teaching science and another to expect that such issues and ideas necessarily help develop environmental awareness, even when such awareness is an explicit goal.

It is the purpose of this paper to discuss these difficulties but also the possibilities that exist within science education for the development of environmental awareness. A discussion, however, of the importance of raising "awareness", especially in the context of education, is imperative. This paper aims to further the dialogue concerning the contribution of science education toward raising environmental awareness (see Littledyke, 1996, 2008). At the same time, it should be made clear that even though the difficulties and possibilities we discuss have educational merits, there can be many others that can be scrutinized.

The Educational Importance of 'Awareness'

No doubt students learn, both formally and informally, many things, including those concerning the natural environment. An assessment, in fact, of students' representations of the various concepts, that they have supposedly learned, can be a measure of their knowledge. Doubt, however, could be raised in regard to their awareness of what they really know. For there is a delicate distinction between knowledge, as representations of the world, that students are either presented with – that is the traditional representational pedagogy - or construct through personal experience – that is the constructivist pedagogy (Biesta & Osberg, 2007), and awareness, as one's ability to notice things, as a state of being fully conscious of what one knows or what one has learned. The educational philosopher Maxine Greene, in talking about "shocks of awareness", makes this point quite clear:

> A great part of our everyday life is not lived consciously, and since nothing makes an impression, the world seems bland, muffled, and vague. Now and then, however, there are exceptional moments, moments of response to 'shocks of awareness'. (Greene, 1978, p. 185)

It is after those shocks, according to Greene, that one perceives abruptly something and sees connections that were not seen before. For many students the world of science and education in general may very well appear bland, muffled, and even vague. And there may be students who have learnt science but are not really conscious of what they have learned. Of course, in cases in which knowledge is created through situated, authentic learning experiences, students' awareness of the ‘local significance’ of certain issues and ideas, due to the authenticity of the learning situations they participate in,.can be raised (when compared with traditional constructivist approaches). However, it is debatable whether a wider awareness of the significance of those issues or ideas is raised (see Biesta & Osberg, 2007).

The idea, of “shock of awareness” in the context of science education has been central to the process of cognitive conflict since the aim of the instructional process is to challenge existing misconceptions (Limon, 2001). However, the development of awareness goes well beyond the cognitive conflict approach, and encompasses science learning in general. Thus awareness, in the context of teaching and learning, is about noticing things, about being fully conscious of what is being taught. For example, although a student knew all about gravity and about being the weakest of all forces in Nature (since the class had been provided with the numbers concerning the relative strength of all fundamental forces in Nature), it was after a demonstration experiment that she became aware of the weakness of the force of gravity. Similarly, a student knew that molecules are very-very small. But it was after calculating the number of molecules contained in a glass of water that he became aware how tiny they really are (Hadzigeorgiou, 2011). It is therefore apparent that awareness has a metacognitive dimension, which may very well be totally absent from knowledge.

However, as empirical evidence suggests (Hadzigeorgiou, 2012), awareness also facilitates a shift or change in perspective, which is a prerequisite for significant learning. There are both philosophers of education and educators who have argued that the value in teaching any subject should be sought in the possibilities it offers to students for developing a different outlook on the world (e.g., Hirst, 1972, p. 401; (Jardine, Clifford & Friesen, 2003, p. 102; Peters, 1973, p. 20; Schank, 2004, p. 37). This change in perspective is certainly important when the natural environment is an object of study.

It is quite interesting to note that the notion of awareness is akin to the notion of “cognitive perspective”, as was put forward by British philosopher of education Richard Peters. “Cognitive perspective”, according to Peters (1977, p.29), is about the acquisition of "differentiated modes of awareness" (i.e., mathematical, scientific, moral, interpersonal, historical, aesthetic, religious, philosophical), leading to a kind of understanding that is related to the students ability to see the place of knowledge "in a coherent pattern of life" (Peters, 1966, p. 45). However, seeing knowledge in that pattern of everyday life does not simply mean that students perceive the relevance of knowledge to their own life. It also means that students change their "general view of the world" (Peters 1967, p. 9). This point is made quite explicit elsewhere: "To be educated is not to have arrived at a destination; it is to travel with a different view" (Peters, 1973, p. 20).

In light of the notion of “cognitive perspective”, as awareness that enables one to see the place of knowledge in relation to one’s life, the difference between ‘knowledge’, as representations of reality, and ‘awareness’, as the ability that enables one to think about how knowledge affect one’s own life, can be more easily understood. For example, knowledge of trees, as taxonomies, classification schemes, and even as ideas concerning the utility of trees, is different from one’s awareness of how trees affect one’s life. Although one can know many things about trees, it is likely that such knowledge does not make any difference to one’s life. Apparently it is the awareness, and not just knowledge, that enables one to change one’s perception of trees and also do something about trees. There is empirical evidence that even very young children can change the way they think about trees if their awareness of trees is raised (Hadzigeorgiou et al. 2010).

It is unfortunate that the term "cognitive” may lead one to take “cognitive perspective” as representing a limited view of knowledge. But if cognitive perspective, as was pointed out, is about the ability of the learner to see the place of knowledge in a coherent pattern of life, then cognitive perspective is closely related to emotions, aesthetics and ethical conduct. Therefore it is a holistic notion. Scheffler (1996) has pointed that out: "the notion of cognitive perspective is related to the idea of wholeness" (Scheffler 1996, p. 84). In this respect, it makes sense to relate "cognitive perspective" to “holistic awareness”, which, in fact is used by Richards (2001), as discussed later in the section concerning the wonder of science.

In line with the above analysis, environmental awareness is directly linked to environmental knowledge, attitudes, and actions (Menze, 2010), or to knowledge, which can have an effect on students’ attitudes (Dimopoulos, Paraskevopoulos, & Pantis, 2009). Critical thinking also appears to be linked to environmental awareness (see Wals, 2011). The fact that environmental awareness is broadly defined as knowledge, critical thinking, and attitudes can be justified by the concept of awareness per se, since it is awareness that leads to a change in perception, necessary for a change in attitude, which, in turn, is a prerequisite for a change in behaviour and action.

For the purpose of the present paper environmental awareness is taken to mean knowledge of the interrelationships between issues/problems and human life, which (knowledge) though has an effect on one’s life (i.e., how one feels, thinks, behaves and acts). And, as such, environmental awareness can be seen as a prerequisite for environmental literacy (i.e., the contextualized and detailed understanding of issues and problems, which allow one to evaluate and make decisions as a citizen). The importance of helping students develop their environmental awareness, through an awareness of the relationship between environmental and socioscientific issues/problems and human life acquires a special significance given the critique of the notion of sustainability or sustainable development, which is based upon a conception of nature as a resource and reflects anthropomorphic and even economic motives (see Bonnett, 2004a, 2004b and Sauve, 1999).

Difficulties and Problems in Raising Environmental Awareness

Starting from the fact that the natural world is an object of study, there is a question concerning the significance students attach to this object. Whether we are talking about a natural phenomenon (i.e., a flash of lightning, the water cycle, photosynthesis, aurora borealis), an object or entity from the natural world (i.e., a piece of rock, a flower, a glass of water), a socio-scientific issue (i.e., genetically modified food, transportation, overpopulation) or an environmental issue (i.e., water pollution, global warming, acid rain), the natural environment, directly or indirectly, becomes an object of study. The question though to be raised is whether this object is in the ‘foreground’ or simply remains in the ‘background’ of the teaching-learning process.

Keeping the natural environment in the foreground means that, regardless of the teaching strategy we use and the concept we introduce, the natural environment is ‘present’ during the teaching/learning process (Hadzigeorgiou, 2005). This, in turn, means that both the word ‘nature’ and the appreciation of the natural environment in general (i.e. appreciation of its beauty, of the extraordinary power hidden in the natural phenomena) are ubiquitous during the learning process. Although this might be easier in the case, in which a concept is directly and explicitly linked to a natural phenomenon (e.g., the water cycle), there is difficulty in the case, in which there is no direct linking (e.g., electric current). Regardless, however, of this degree of difficulty, environmental awareness cannot be promoted if the natural environment is in the background. This is a crucial issue and concerns not only phenomena and issues that have an implicit environmental dimension, but also those with an explicit one. There appear to be four specific reasons that can explain the difficulties and the problems one faces in bringing and keeping the natural world in the foreground of the teaching-learning process.

In talking, of course, about using the natural environment as an object of the study, its place as foreground or background may sound like the different dimensions of environmental education, that is, "education about the environment" (i.e., learning about how natural systems work), "education in the environment" (i.e., direct experiences in the environment necessary for emotional involvement) and "education for the environment" (i.e., the political dimension and the actions necessary to bring about change) (Davies, 1998). One may even associate "education in the environment" with "keeping the natural world in the foreground" of the teaching/learning process. However, what should be pointed out is that awareness, in order to be raised and developed, requires an "education about the environment". Learning opportunities for students to make connections among environmental knowledge, socioscientific issues and their life, require more than what an "education in the environment" can offer. It requires explicit teaching, and, in this sense, environmental awareness can involve the first two dimensions of environmental education, and can also be a prerequisite for the third one (i.e., "education for the environment").

Involvement with the natural world as an object of study

There is an argument to be raised in regard to the difficulty for students to develop environmental awareness, due to the difficulty they have to become involved with the natural world, as their object of study, in the first place. In distinguishing between participation in a learning activity and involvement with the object of study itself (Hadzigeorgiou, 1997; Hadzigeorgiou & Stivaktakis, 2008), or between peripheral things (e.g., humor, interaction with peers, flashy demonstrations) and engagement with science content (see Pugh, 2004), it becomes apparent that environmental awareness is more likely to be raised and developed when students become involved with the natural world, as their object of study. This means that students will more likely raise their awareness of the natural environment if they perceive the latter as an object of study, which, at the same time, motivates them to study it.

Thus the emotional significance students attach to the natural world may be considered as one of the most important reasons for the difficulty the have to become involved with it as their object of study. Although the problem of involvement with science, in general, is a complex one (Hadzigeorgiou & Stivaktakis, 2008), the issue of worldview is an important one to consider when dealing with the natural world as an object of study. More specifically, a clash between the students' worldviews and the scientific worldview, or between their worldview and their science teacher's worldview is an issue that needs some attention. Such a clash between worldviews can happen if a student's metaphysical frame is in conflict either with the teacher's metaphysical frame or with that of school science. For example, a student may experience a sense of beauty, which though derives from his/her own metaphysical frame and not from that of school science. Another student, who feels inspired by a sense of wonder and by aesthetic factors in general, may very well find that a teacher's approach to teaching science is rooted in mechanistic, reductionist, and "scientistic" view of science. Certainly, these aesthetic experiences are desirable in the context of science education and they should be encouraged (see Pugh & Girod, 2007). The point though that is being made here is that they may very well clash with the way science is conceived and presented to them.

In considering the issue of the incompatibility between the teacher's personalized worldview and that of a student (see Cobern, 1991, 1996, 2000), one can see how involvement with the object of study becomes problematic. Of course, there might be some engagement, a "playing of the game", but it is debatable whether such engagement leads to involvement of the self and therefore to integration of affective and cognitive factors, which is considered crucial for the development of environmental awareness (Littledyke, 2008).

The modeling of Nature

A third problem concerns the "deliberate modeling" of Nature. Whether we study a natural phenomenon, like, for example, the water cycle and photosynthesis, or an entity from the natural world, like, for example, water in its various phases, a piece of rock, and a tree, understanding of a phenomenon and of an entity involved in the same or another phenomenon, presupposes some kind of modeling. And herein lies a problem, or a paradox, one might say, namely, the placing of the actual natural phenomenon or natural entity in the background, since the focus of our study becomes the model that we create and use in order to understand that phenomenon or entity. One may very well say that it is very likely for the means (i.e., the constructed model) not to replace the end (i.e., our understanding of a natural phenomenon), but to acquire more significance than the actual phenomenon. For example, a model for photosynthesis (i.e., iconic, mathematical), and the learning of it – which will be assessed in the near future - may very well acquire a higher status and therefore higher significance, than a tree-leaf, which is in fact responsible for photosynthesis. The same holds true for all natural entities and phenomena.

The point that is being made here is not that modeling is not important. On the contrary, modeling is an excellent tool for approaching and studying Nature. But although of crucial importance, it has become, consciously or unconsciously, more significant for young students, who, in their attempt to describe, explain and predict during their science classes, place the actual phenomenon of study in the background. Students, like scientists, may become enamored of their models and their possibilities (by manipulating these models), and thus forget about their actual object of study, that is, the natural world (see Witz, 1996). Harvey (1989), makes a similar point in talking about "an ontological reversal", that is a process whereby mathematical abstractions take on a higher ontological status than the experience itself.

That mathematical abstractions and modeling can easily attain a higher ontological status can be explained by the fact that young children, due to the contemporary way of living, have very few experiences within Nature, and that some children grow up in an environment that is literally cut-off from the natural world. This fact, coupled with the effect that technology has had on human life, and with the higher status of mathematics and science in the school curriculum, can make young children learn about how Nature works and that She is in peril, but not fully aware of the significance of their learning. This point I will take up in the next section when I will discuss the notion of significance of issues and science ideas.

The empirical treatment of Nature

Just like modeling, the empirical treatment of Nature – a fundamental element of the scientific worldview – may very well encourage loss of focus on Nature as our larger object of study. Apparently, the focus is on the specific object or phenomenon.

This may, in turn, promote a dualism between student and Nature, which conflicts with the idea of self-as-part-of-Nature, and it may also conflict with the idea of respect for Nature.
But if the empirical treatment of the natural world perpetuates the dichotomy between self and Nature, then, one might argue, the development of environmental awareness is discouraged. Students may very well understand an environmental issue or problem, but it is also likely that they do not become aware that they are part of these (Hadzigeorgiou & Stivaktakis, 2008).

Empirical treatment, by use of science process skills, is usually an end in itself, especially with young children. This is quite reasonable since an inquiry approach to science education is based on the use of those process skills. Like modeling, these process skills are of paramount importance but in and by themselves do not and cannot help develop environmental awareness. The study of a leaf or a piece of rock, with the use of a magnifying glass, for example, may be indispensable in observing and describing these objects, but such study does not promote an awareness of being part of the natural world. Nor does it help them “see the bigger picture”, that is, Nature as a larger object of study.

The purpose for studying science

In discussing the empirical treatment of Nature, one may raise an issue of purpose: why do students treat Nature empirically? This question, in fact, can be posed by students themselves in the case they try to find a purpose for studying science. This purpose is quite crucial, since it can encourage involvement with the object of study, and, in the end, determine the actual learning outcome (Hadzigeorgiou, 2005). As philosopher Maxine Greene pointed out, “all learning entails a commitment to human freedom […] the power to act to attain one’s purposes” (1988, p. 3). In science education, of course, questions of purpose are not raised at all. The questions that are commonly and explicitly asked are the following (see Osborne, 1996): (a) What do we know? (the ontological question), (b) How do we know? (the procedural question), (c) What can do we with what we know? (the technological question), and (d) How can we communicate what we know? (the communicative question). An important question, namely, "Why should we know?" is missing from this list. Forshay’s (1970) view that “If a student cannot give a good answer to the question why he is studying what he is studying, he probably should not be studying it” (p.34) should provide food for thought to science teachers and science educators. In the context of education for sustainability, Arjen Wals does point out that education is useful only when one reflects upon what kind of education one receives and for what purpose (Jickling & Wals, 2012).

No doubt, the above four questions are fundamental and should certainly be considered in planning curriculum and teaching, but they should neither obscure nor downplay the importance of purpose. Postman’s (1995) view, that the greatest problem in education is metaphysical and not technological, should be given more serious thought by the science education community, especially when the development of environmental awareness is an implicit or explicit goal of school science education. So if Postman’s (1995) view that the “why learn” question is more important that the “how to learn” question is seriously considered, then helping students find a purpose for studying science, or any other school subject, is of utmost importance, despite the fact that purposeful learning in general is a problematic notion, especially in the context of compulsory education (Hadzigeorgiou, 2001, 2005).

A justification of science in terms of the scientists' attempt to study and understand the world or even in terms of the various rationales developed and put forward by science educators (see Hadzigeorgiou 2005) is, apparently, insufficient, to help students find a purpose for studying the natural world. What Weinberg (1977, p.54) has pointed out we should certainly consider: “The more the universe seems comprehensible, the more it seems pointless”. Why should people be interested in studying and understanding the natural world? Why should a student closely observe a natural object or a natural phenomenon? Why should he or she try to understand them? These are important questions to be raised granted that the recent science education reform agenda, which, although emphasizing what is referred to as “citizen science” and science “education as sociopolitical action” (see Jenkins, 2002, 2007; Hadzigeorgiou, 2008; Roth & Desaultes, 2002; Roth & Lee, 2004), explicitly or implicitly, addresses the need for understanding science: An understanding of science and technology is central to the personal, social, professional and cultural lives of the individuals (OECD, 2000). But this is what the policy makers are putting forward. The question is why should science, as a discipline, be central to the lives of people and particularly to the lives of students? Why should scientific knowledge be part of everybody's general knowledge? This is an extremely difficult question for a student to answer.

One, of course, can find, as has already been pointed out, coherent justifications for science learning. However, it is crucial that a distinction be made between a rationale, as proposed by a philosopher, a science educator, or a science teacher, and a personal purpose. For it is the latter that gives personal meaning to, and thus facilitates, the learning process. In the context of school science education, the view that “Without hope there is no incentive for learning, for the impulse to learn presupposes confidence in the possibility of improving one’s existence” (Phenix, 1971, p. 275), may very well shed some light on the relationship between purpose and learning. Such learning, of course, cannot simply be the outcome of the empirical treatment of Nature, or the study of science in general, but the outcome of the awareness that such treatment and such study may help us improve human life and indeed our own existence. And this can happen when there is curricular and instructional emphasis on issues and problems, and on those science ideas, which help promote a sense of relationship with the natural world. This brings me to the existing possibilities for developing environmental awareness within science education.

Existing Possibilities

Given the contested relationship between science education and environmental education (see Ashley, 2000; Gough, 2002, 2008), promoting environmental awareness is a real challenge for science education. One, however, should consider the fact that that both natural phenomena and natural entities, on the one hand, and socio-scientific issues/problems on the other, have the potential to foster the relationship between human beings and the natural world, by making this relationship explicit. Starting from the distinction between learning or knowing about science ideas, and about socio-scientific issues and problems, and being aware of their personal and wider significance, is considered a fruitful approach to developing a sense of relationship with the natural world and therefore opportunities for the development of environmental awareness. What follows can be considered a complement to the features of postmodern science (i.e., personalization, politicization of science, use of narrative) that Littledyke (1996) had outlined, and which support the development of environmental awareness. The discussion makes sense in the context of both postmodern science education and environmental education, which, in line with postmodern education (Aronowitz & Giroux, 1991; Slattery & Rapp, 2003), adopt a contextual, socio-constructivist, and critical approach to learning and also an ethical stance towards socioscientific issues and knowledge in general (Sauve, 1999).

Awareness of the significance of science ideas

No doubt the argument against decontextualized scientific understanding is a valid one (see Jenkins, 2002). Apparently, the natural environment can provide the context which is necessary for such understanding. For example, the concepts of conservation and recycling can become understood through a number of natural processes and phenomena (i.e., the water cycle). However it is doubtful whether such context is in and by itself enough to promote the development of environmental awareness. Although necessary, environmental context is insufficient, if environmental awareness is a goal. Environmental awareness presupposes an awareness of the significance of certain science facts and ideas. For example, it is the awareness of the personal and wider significance of the fact that the earth cannot make more water or air, and therefore the water we drink and the air we breathe have been around for a very long time, that is more likely to foster environmental awareness than simply knowing about and applying the concepts of conservation and recycling in a variety of contexts. By the same token, awareness of the significance of the idea that plants, of all living organisms, are responsible for maintaining life on the planet, is more likely to promote environmental awareness than simply knowing about the process of photosynthesis (i.e., knowing the chemical reaction that describes such process, making a concept map with links between relevant concepts), in the same way that being aware that the resistance of one's own skin will determine in certain circumstances one's chances to be alive is very different from knowing and applying Ohm's law (i.e., understanding technological applications, solving problems involving batteries and resistors).

It is quite crucial, as these examples suggest, that a distinction be made between 'understanding an idea' (i.e., conservation, recycling) or a natural phenomenon like the water cycle (i.e., understanding the processes of evaporation and rain or precipitation in general, or even other phenomena involved, such as transpiration, infiltration and sublimation) and 'being aware of the personal and also the wider significance of it'. Although understanding involves the ability on ones' part to apply a concept/an idea to a wide variety of contexts, this ability does not necessarily translate into an awareness of the personal significance of that concept or idea (see (Hadzigeorgiou, 2005; Hadzigeorgiou & Stivaktakis, 2008). A 'psychologization' of the concept or idea (i.e., restoring a concept or idea to the experience in which it had its origin and significance) is a good way to foster awareness, since, as Pugh and Girod (2007) suggest, such 'psychologization' of subject matter can lead to transformative experiences. Apparently such experiences, by facilitating a change of outlook, will have an effect on personal identity, which, in fact, determines the development of ecological self, thus strengthening the students' biophilic tendencies (see Clayton & Opotow, 2003)

It is apparent that the awareness of the significance of certain science facts and ideas stems from the awareness of the explicit connection between self and the environment, which is necessary for the development of environmental awareness. Littledyke (2008) points out that the so-called 'big ideas' of science, apart from offering the most interesting and important contributions of science, and hence the bigger picture of it, help integrate science concepts with real life experiences linked with environmental consequences. Given that these ideas help integrate the cognitive and the affective domain, their potential in fostering environmental awareness should be seriously taken into account. Attention, of course, should be paid so that the integration of science concepts with real environmental experiences makes the connection between self and Nature explicit.

Awareness of the significance of socio-scientific issues and problems

Socioscientific issues (SSI), whether with an explicit or implicit environmental dimension, not only help contextualize science and provide opportunities for students to become aware of the interdependence and relatedness of such issues and human life, but also help promote argumentation and socio-moral discourse (Dolan, Nichols, & Zeigler, 2009; Sadler & Zeidler, 2005; Zeidler, & Nichols, 2009). Given that environmental awareness is directly linked to a change in perception, which is a prerequisite for changes in behaviour and action, moral/ethical considerations, in the context of SSI-based activities, are crucial.

Dolan, Nichols and Zeidler (2009) provide an excellent example of an SSI activity, whose goal was to provide opportunities for students to apply what they have learned about erosion and weathering to a debate regarding beach erosion on a local Florida beach. The students were faced with a question: Should the county continue to purchase beach sand to fix the beaches or use crushed glass as a new alternative? The discussion within the various groups of students, aimed to produce arguments for one of the two positions (i.e., sand vs crushed glass) in order for them to determine the most just solution concerning how to protect and restore the beach, helped foster critical and ethical/moral reasoning. Although some students asked questions, such as, "what happens if I bury someone in the sand?" and "what happens if it gets in my eyes?", thus exploring the legal ramifications, in the case someone were to get hurt because of the glass on the beach, questions concerning sea turtles and the impact the glass may have on them and their ability to lay their eggs, and how the shape of the sand in comparison with glass might adversely affect the sea turtle nests, were also raised.

The message form the above example is quite straightforward: in one way or another, environmental awareness is raised, since reflection and ethical/moral discourse help students to notice things, particularly interrelationships and implications which, otherwise, would have remained unnoticed. In other words, it is reflection and ethical/moral discourse that helps students become aware of the personal and the wider significance of an issue.

The recent emphasis on SSI can be justified by the fact that they offer a space, in which ideas can be explored from multiple perspectives and by integrating cognitive, affective, ethical, and aesthetic elements. It is this multiplicity of perspectives and these elements, along with the complex interplay of ideas taking place in such space, and not just the context, that enables students to become aware of the significance of a certain issue, which (significance), in turn, will help raise environmental awareness. It is important therefore to stress here that, although a SSI provides a context for teaching and learning, it is doubtful whether such context is in and by itself enough to foster environmental awareness.

If fostering environmental awareness is equivalent to helping students become conscious of the various interrelationships between issues/problems and human life, the teaching goals should be based upon a rationale that includes cognitive, emotional, socio-political, and ecological arguments. For example, the four pedagogical arguments for learning about biodiversity, namely the emotional argument (i.e., (re)connecting with nature through discovery and sensitization, and experiencing biodiversity to create personal meaning), the ecological argument (i.e., understanding relationships, functions and (global) interdependencies), the ethical argument (i.e., dealing with values, taking a moral position, raising critical) and the political argument (i.e., dealing with controversial issues, making choices, developing action competence) (Van Weelie & Wals, 2002), need to be considered if students are to become aware of the 'full significance' of the concept of biodiversity. Van Weelie and Wals (2002) do point out that all four arguments have to be addressed if learning about biodiversity is an instructional goal.

A point also that needs to be stressed concerns students' awareness of being part of a SSI or problem. Recognizing that mere participation in project work on a SSI or problem, with an implicit or explicit environmental dimension, is no guarantee for the development of an awareness of the significance of the issue or problem (Hadzigeorgiou, 1997, 2005), it is imperative that students be helped to experience what Michel Polanyi (1959, p.66) had called "indwelling and association". In other words, students should be helped to develop an awareness of being part of an issue/problem, and thus develop a sense of relationship with the natural world. Given that local issues and problems can have some personal significance, starting from students' own locality and helping them become aware that they are themselves part of certain issues and problems, can be a good strategy to promote environmental awareness.

But although participation in community projects (Roth & Desaultes, 2002; Roth & Lee, 2004) can be a starting point, there is always a question concerning students' involvement with problems and issues that transcend their own locality. Given that environmental awareness can be promoted if students are helped to become aware of the larger significance of their local issues and problems, the development of the "big picture", of a global awareness, should become an important goal of science education (Hadzigeorgiou, 2005). This is important to stress, for it is through global awareness that young students feel and become aware that they are part of a larger environment, which, apparently, includes the natural environment. Oliver and Gershman (1989), in making a distinction between "technical" and "ontological" knowing, pointed out the importance of the latter in the process of meaning construction. Its central quality, as they argued, is "one's feeling for tentative connection. to the larger world" (p.14). In short, if we are to educate for environmental awareness, the larger significance of what is being studied in the classroom should be an important goal. The "Great Story of the Universe" (see last section) can facilitate the awareness of the larger significance of local issues and problems. This, however, is crucial for science education in general. As Pekarsky (1982, p. 351) put it, "if the 'little scientists' of the classroom were encouraged to reflect on the larger human significance of what they were studying, the adult scientists of the future would be more likely to do the same".

The wonder of science

Related to the awareness of the significance of science ideas and issues is the development of a sense of wonder at and about these ideas and issues. As Verhoven (1972) had argued, it is wonder that gives things their infinite significance. And this awareness of significance can be a potent stimulus for learning (Hove, 1996). One, for example, can start to wonder about the idea that the water we drink is the same water that dinosaurs drank thousands of years ago, or about the fact/issue that the corn used to produce ethanol used by an SUV in one day can feed as many as a hundred people for more than a week. It is this wonder which can help foster an awareness of the significance of these ideas and issues. But this point needs to be explained further.

In making a delicate distinction between curiosity, as the drive to investigate or study something, and wonder, as a state of mind or feeling, one has to consider the aesthetic dimension of the latter. This aesthetic dimension includes astonishment and admiration, as both a conceptual analysis of wonder and empirical evidence suggest (Hadzigeorgiou, 2012; Hadzigeorgiou, Kodakos, & Garganourakis, 2010). Given that during the state of astonishment "the mind is so entirely filled with its object that it cannot entertain any other" (Burke, 1990, p. 53), a sense of wonder can help develop awareness of the significance of issues and ideas, through the opportunities it offers students for noticing things and ideas. Moreover, it can help counter what curiosity does, along with the empirical treatment of Nature, to which it leads, namely, to take things apart, in order to investigate them closely, and thus lose the 'bigger picture' (H2005).

Taylor (1998), in associating admiration with wonder, talks of the "poetic" nature of the latter. For Taylor (1998) the emotional response to what is being perceived stems primarily from the wholeness of the object of perception. While curiosity, according to him, is a scientific impulse that strives to dominate nature,

> Wonder is poetic and is content to view things in their wholeness and full context [. . .] When a flower is taken apart and examined as pistil, stamen, stem and petals, each part is seen exactly and a certain curiosity is satisfied; however, curiosity is not wonder, the former being the itch to take apart, the latter to gaze on things as they are. (Taylor, 1998, p. 169)

While acknowledging the crucial importance of curiosity and the empirical treatment to which it leads, and also the importance of modeling in school science education, as has already been pointed out, the importance of wonder evoked by the actual object of study should also be acknowledged. Starting the teaching-learning process not with a hands-on activity, or with some technological applications, but from natural phenomena as the real sources of wonder, is quite crucial. Granted that the natural world is directly or indirectly linked to our object of study, a sense of wonder about the natural world can help students become aware that natural phenomena and natural objects or entities are involved, in some way, in our own existence. For example, instead of giving batteries, wires, and light bulbs in order to introduce concepts and ideas from current electricity, the teacher can evoke a sense of wonder by encouraging students, and especially young children, to observe spectacular natural phenomena (e.g., on video students can watch lightning), by helping them become aware that phenomena such as these are significant since they are involved in our own existence (e.g., our own body, the things we smell and touch).

Thus the students are helped to see things in new light. As Witz (1996) points out, it would be more important to bring into focus the rich nature of a natural phenomenon than to focus merely on theoretical principles and/or technology connected with them.

The actual phenomenon or object – be it a manifestation of electricity, or the anatomy of the body, or the group behavior of chimpanzees – is the real source of wonder [….] For this purpose, a study of the more natural and less technological manifestations of electricity and magnetism which fascinated the early investigators might be preferable, with gradual extension to construction of simple prototypes of electrical apparatus only a few years later, and 'real' electricity and magnetism later. (Witz, 1996, pp. 601-602)

In distinguishing between "knowing", as a moment of awareness, in which contact occurs between the knower and the known – the contact being "nonconceptual, nonimaginal, nondiscursive, and extremely brief" - and "having knowledge," as a state consisting of "descriptive or interpretive claims to the effect that such-and-such is the case" (Pihakka, 1997, cited in Richards, 2001, p. 66), one can more readily appreciate the role wonder can play in fostering environmental awareness.

There is, of course, a question regarding the possibilities older students have for experiencing a sense of wonder. Although for very young students wonder can be evoked through many as yet unfamiliar phenomena, for older students many phenomena are quite familiar, due to both personal experiences and prior teaching/learning experiences. However, what should be noted is that wonder can be evoked through simple, ordinary and familiar situations, thus making one see something usual and ordinary as unusual and extraordinary. Martin Heidegger, in fact, in distinguishing between curiosity and wonder, had pointed that out:

Unlike curiosity which presupposes that there is a distinction between the usual and the unusual, ordinary and extraordinary, wonder is an attunement in which one finds the usual to be extraordinary. (Stone, 2006, p.208). In this sense, wonder can be evoked through the most familiar natural phenomena (e.g., rain, snow), that are neither spectacular like lightning or sea waves, nor unfamiliar, like aurora borealis or stellar explosions.

In exploring ways in which one can gain knowledge of Nature, Bonnett (2004a, 2004b) does point out that caring and surprise are two approaches that are in line with "Nature as self-arising" along with both the "otherness" of Nature (i.e., Nature exists apart from us, apart from our purposes and intentions) and the "epistemological mystery" (i.e., nature can never be fully known) that accompanies it. Bonnett's arguments lead to the impossibility of gaining knowledge through an analytic, instrumentalist and "invasive" rationality, due the aforementioned characteristics of Nature, but also lead to aesthetic ways of knowing.

The aesthetic appreciation of Nature

Providing young children with opportunities to appreciate the beauty of the natural environment through direct experiences is crucial not just for the development of an emotional bond with it, but for the development of children's sense of place. According to environmental psychology literature, children's sense of place is affected by a number of factors, including aesthetic factors (Bechtel & Churchmen, 2002). There is also evidence that, in addition to prior exposure to different environments, vicarious familiarity with diverse environments through the media may also affect children's choice and evaluation of favorite places (Korpela, 2002). An aesthetic, therefore, appreciation of the natural world, though a vicarious experience, especially through the experience of a sense of wonder, may very well encourage environmental awareness, by affecting, at the same time, children's choice of favorite places in nature. One of course could argue that an aesthetic appreciation of the natural world is not environmental awareness. Yet the experience of a sense of wonder, evoked through such an aesthetic appreciation, can foster environmental awareness by raising awareness of the beauty of the natural world.

Natural beauty, as Richards (2001) argues, has an adaptive value since it may advance a greater connection with the natural world. Although this could also be contested, there is a pressing and legitimate question: why do we respond so quickly and intensely to certain images of the natural world? Why do natural forms around us (i.e., mountains, forests, clouds, trees, waterfalls, flashes of lightning) capture our attention, evoke appreciation, and inspire even awe? Fractals forms in particular, found in these natural forms, can be associated with transcendent experiences of beauty, even with the sublime (see Santayana, 1955). It makes therefore sense to talk about "a transcendent reaction of our deeply aware ecological self (Richards, 2001, p. 63), and about beauty leading to "a deeper holistic awareness" (Richards, 2001, p. 66). This "holistic awareness" also echoes Whitehead's (1933) view that beauty and awareness are linked in a complex network of relationships between the various components of reality.

> Beauty concerns the inter-relations of the various components of reality, the inter-relations of the various components of Appearance, and also the relations of Appearance to Reality. (p. 341).

Because Richards' (2001) idea of "holistic awareness" includes cognitive, affective, aesthetic, and even ethical factors, the possibility of raising environmental awareness through the complex interplay of aesthetic and ethical factors deserves particular attention. In actual fact, the relationship between aesthetic and moral value, and by extension, the relationship between aesthetic and moral/ethical judgement (Blum, 1994; Irvin, 2008; Muelder-Eaton, 1999), makes the aesthetic appreciation of nature an idea that can guide learning activities aiming to develop environmental awareness through moral/ethical judgement.

Indeed, if aesthetic experiences range from negative to positive and ethical reasoning or conduct range from bad or wrong to / good or right, there are many possible combinations resulting from the relationship between aesthetics and ethics. The ideal, of course, situation would be one that leads to an experience that is both extremely pleasing to the senses and extremely positive from an ethical point of view. However, situations or actions, which are both displeasing and unethical (i.e., polluting the natural environment, exploiting/wasting natural resources) both displease the senses and are ethically deplorable and unacceptable. Certainly there are many ethical actions, which require altruism, even sacrifice, but which are not aesthetic at all (i.e., risking one's life to save the natural environment).

What are the implications of the above for science education? The aesthetic appreciation of Nature is in line with a 'romantic' approach to science, according to which a hands-off approach was considered the appropriate for science education, but which was abandoned (see Bossi & Poggi, 1994). Although such a 'romantic' approach is not the 'standard' approach to teaching and learning science nowadays, it can nevertheless be incorporated in most teaching/learning models, provided that time is given to students to perceive aesthetic beauty in natural phenomena. Given that most such phenomena have an aesthetic dimension, the curricular question concerns whether Nature itself is presented to the students. Of course, one could ask: What about concepts such as force, energy, momentum, electric charge, sound? The answer is that we need situations in which these concepts are embedded (e.g., the motion of clouds, the motion of sea waves, a volcano, a tornado, the water cycle, a flash of lightning). In other words, we need to select phenomena and situations, which 'aesthetically' exemplify the concepts to be introduced. On the other hand, in the case of certain concepts (e.g., energy, the water cycle), we can select situations (e.g., energy production, water consumption), which facilitate the raising of aesthetic awareness along with the ethical values associated with such awareness. In both cases, the students are provided with opportunities to develop their environmental awareness.

An argument, of course, about associating natural phenomena and non-living entities with ethical/moral reasoning can be raised, since such reasoning goes against Aristotelian, Kantian, and utilitarian ethics. As Sorell (2000) points out, such kind of ethics constitute an anomaly for moral theory. However, in line with a holistic/ecological perspective (Doll, 1993; Slattery, 1995; Slattery & Rapp, 2003), the inclusion of non-living entities is imperative.

If aesthetics and ethics are both about love, about 'a caring for the other', about a 'let-it-be-for-the-other' attitude, as Murdoch (1959) argues (cited in Bonnett, 2011, p.152), then the aesthetic appreciation of Nature, through an appreciation of the beauty of natural phenomena (through direct or vicarious experience), can provide students with opportunities to develop environmental awareness even when the instructional aim is the learning of an abstract concept (i.e., energy, momentum).

Narrative understanding and the story of the universe

The fact that there are two modes of thinking, namely, the narrative and the paradigmatic (Bruner, 1986), and that storytelling is an all important cognitive tool (Bruner, 1990; Egan, 1997, 2005), makes science stories quite popular among both teachers and students. In line with post-modern science, storytelling is based on a pedagogy, in which traditional dichotomies between fact and fiction, reality and epistemic subject cease to exist. Gough (1993, p. 621), echoing Bruner (1986, 1990), has stressed this point: "An appropriate pedagogy for contemporary science [. . .] tacitly embraces [. . .] the relatedness of the observer and the observed and the personal participation of the knower in all acts of understanding". He goes on to say that such a pedagogy "implies a reversal of many taken-for-granted assumptions about the relationship between fiction and reality" (p. 621). The distinct differences between the narrative forms found in scientific reports, or in school textbooks, on the one hand, and in mass media journalism and fiction on the other, are, according to Gough (1993), neither necessary nor desirable.

Storytelling, of course, has been used by both science educators and environmental educators. As far as environmental education is concerned, storytelling is considered an effective strategy, in cases in which direct experience is impossible, and also in cases in which the consequences of our experience are negative or undesirable (De Young & Monroe, 1996). In science education though there is question about the kind of stories that we tell students. Certainly there is evidence that learning, for example, about electricity, can be very effective through the use of stories (e.g., Hadzigeorgiou, 2006; Hadzigeorgiou, Klassen, & Froese-Klassen, 2012). But what kind of stories help raise environmental awareness? This is a crucial question given that in science education, storytelling is used mainly as a means of effective teaching of scientific ideas. The plot, of course, of the story helps humanize science, by providing a human context, but the teaching of science content knowledge, along with ideas from the nature of science, is the primary aim of the story (Hadzigeorgiou, 2006; Klassen, 2006). And yet, stories about concepts such as energy and its transformations, plants and animals, the water cycle, and the atmosphere can help raise environmental awareness, provided that their significance in relation to human life is fully grasped.

But science stories can also tell the story of humanity and the universe. The Nikola Tesla story, for example, is not only a story about the victory of alternating current over direct current but also a story about humanity and the universe itself (see Hadzigeorgiou et al. 2012). The story about atoms, to take another example, is a story about the universe. However, O'Sullivan (2002), points out that:

> The difficulty is that scientists have until recently given us the story only in its physical aspects not in the full depth of its reality or in the full richness of its meaning. The greatest single need for survival of the earth or of the human community in the late twentieth century is for an integral telling of the Great Story of the Universe. (O'Sullivan, 2002, p. 7)

It is interesting to note that Swimme (1988), in line with the idea of the "Great Story of the Universe", talked about "The Cosmic Creation Story", that is, a story about the evolution of human life since the Big Bang:

> Rocks, soils, waves, stars—as they tell their story in 10,000 languages throughout the planet, they bind us to them in our emotions, our spirits, our minds, and our bodies. The Earth and the universe speak in all this. (Swimme, 1988, p. 56).

Littledyke (1996) points out that this particular story is a story of science, but "it is both poetic and meaningful, giving both a sense of human ancestry and connection with the cosmos" (p. 209). This connection with the cosmos is quite crucial in postmodern education.

It is evident that the "Great Story of the Universe" incorporates the natural environment as a living organism, in which human beings and Nature co-exist. This particular story can help students to become aware of the interconnection of science, human issues, problems, and their own life. This interconnection, in turn, can facilitate the awareness that the apparent insignificance of some issues and problems can be very significant indeed and affect everyone on the planet. It should be noted that Gregory Bateson (1979) had recommended that the idea of interrelationship be introduced to all grades of education. In light of the idea of interconnection, stories in the context of science education, whether about concepts such as energy, the water cycle, and the atmosphere, or about socio-scientific issues, such as biodiversity, the greenhouse effect, nuclear waste and coastal pollution, should promote the idea of relatedness of human beings and nature.

A word of caution, however, should also be said at this point. In talking about the "Great Story of the Universe", one may be tempted to interpret it as 'the one true story' about the universe. Given the loss of faith in objectivity, as well as the blurred boundaries between fact and fiction, the story of the universe, from a postmodern perspective, should invite deconstruction and skepticism (see Gough, 1993). In so far as it approaches reality from multiple perspectives, in so far as it encourages relatedness of nature and human beings, and is also meaningful to the students, it can be considered pedagogically appropriate.

It also deserves to be pointed out here that the "Great Story of the Universe" (or rather "A Story of the Universe") has two important and interrelated advantages: First, it encourages the (re)connection of the self with Nature, and second, it increases the possibilities for students' connection with the wider world. In regard to the (re)connection of self and Nature, such story is a story in which, both the story-teller and the student are part of it. Gough (1993) has argued, that although storytelling has helped to raise our awareness of the nature and extent of numerous environmental problems, these problems may themselves have resulted from modern science's stories, in which the story-maker or story--teller is 'detached' from the natural environment. In this sense "The Great Story of the Universe" facilitates the reconnection of human beings with Nature. It is this reconnection that helps raise environmental awareness, through the awareness that "survival is the one universal value that transcends the proclamation of difference" (Gough, 1993, p. 610). In regard to the possibility of students' connection with the wider world, 'the Great Story of the Universe" is a story, which, in line with postmodern educational discourse, is compatible with such motions as "cosmic and interrelational consciousness" (Doll, 1993, p. 181), "interdependence, and global responsibility" (Postman, 1995, p. 112), "expansion of the horizon of consciousness to the universe itself" (O'Sullivan, 2002, p. 7), and "one's feeling for tentative connection .to the larger world" (Oliver & Gershman, 1989, p. 14). In other words, the “Great Story of the Universe” (or a story of the universe), in providing opportunities for students’ connection with the wider world, helps raise environmental awareness, in a more global sense. This is crucial for young students, who perceive the natural world in a narrow way, that is, by associating it with their immediate natural environment. Moreover the “Great Story of the Universe” may very well result in an ethics of caring about what is distant and remote and not just about what is near to them.

Conclusion

The urgency of integrating environmental education into the whole system of formal education, and also across the school curriculum, cannot compensate for lack of strategies that raise environmental awareness. Despite difficulties and problems, some possibilities, especially within science education, for fostering environmental awareness exist (see Littedyke, 1996, 2008), and there may be some others. One of those possibilities, according to this paper, refers to a pedagogical strategy that helps keep the natural environment into focus and in the foreground of the teaching-learning process, thus making the relationship between the self and the natural world explicit. This strategy, in actual fact, is in line with a proposal to reconsider the aims of scientific inquiry, by focusing upon issues/problems of living (Maxwell, 1984, 1992), and also helps make school science learning more meaningful, since the instructional focus is on the interrelationship between the self, science, and the natural world. Recent empirical evidence of the correlation between nature awareness and science achievement (Chandler & Swartzentruber, 2011), can certainly provide food for thought to those who are still skeptical about what has been discussed in this paper.

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