Mirror, mirror on the wall, is nature predictable at all? Tracing students' ideas on ecosystems' predictability

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ABSTRACT
This paper reports on a case study exploring (a) what students claim about how predictable ecosystems may be, (b) whether students' claims are related to a 'particular ecological interest', and (c) how students justify their claims. The study was performed with 324 postgraduate educational sciences students, who completed the latest version of our nine-scenario, two-tier questionnaire. Analyzing their responses we found that (a) they averagely hold 'moderate' ideas about nature's predictability, (b) there is no significant relation between their claims and the presence of a 'particular ecological interest', and (c) most seem to choose their justifications assuming a globally-unstable nature.

KEYWORDS
Ecological reasoning, nature's predictability, two-tier questionnaire, nature views

RÉSUMÉ
Cet article rend compte d'une étude qui explore a) les idées d'étudiants sur la nature prédictive des écosystèmes, b) si ces idées sont liées à un 'intérêt écologique particulier', et c) comment les étudiants justifient leurs idées. L'étude a été réalisée avec 324 étudiants inscrits en master des métiers de l'enseignement, qui ont répondu aux neuf scenarios de la dernière version de notre questionnaire à deux étapes. En analysant leurs réponses, nous avons constaté que (a) ils avaient en moyenne des idées 'modérées' sur la prédictibilité de la nature, (b) il n'y a pas de relation significative entre leurs idées et un 'intérêt écologique particulier', et (c) la plupart semble choisir leurs justifications assumant une nature globalement instable.

MOTS-CLÉS
Raisonnement écologique, prédictibilité de la nature, questionnaire à deux étapes, vues de nature

INTRODUCTION

Our era is characterized by remarkable changes in our understanding about scientific issues that concern several aspects of our lives and therefore can influence informed decision making on individual and community levels (Raved & Assaraf, 2011). For instance, the ideas lay people hold on ecosystems' function may play an essential role in public debate and action about environmental issues like climate change or sustainability (Westra, 2008), while their ideas on vaccination may prove significant in the course of epidemics (Raved & Assaraf, 2011). Science education for everyone seems to be vital and this is the reason why in the last three decades the objective of educating future citizens gained significant ground against the one of educating future scientists (Assaraf & Orion, 2005). In fact, scientific literacy has become an educational priority, and, of course, environmental literacy is a major part of it and environmental issues have a central place in science curricula (Assaraf & Orion, 2005).

Although environmental literacy – a term coined over 50 years ago and used in environmental education since – has concerned an extensive number of studies, there is no single, broadly accepted definition of it. Nevertheless, most researchers agree that environmental literacy has several dimensions: (a) knowledge, (b) affect, (c) skill, and (d) behaviour (Erdogan & Ok, 2011). Knowledge, in particular, concerns (i) ecology ('ecological knowledge'), (ii) society and politics ('socio-political knowledge'), and finally (iii) environment ('environmental knowledge'). By 'ecological knowledge', we mean a general knowledge of important ecological concepts which leads to an essential understanding of how natural systems work (Erdogan & Ok, 2011). It has been argued that any attempt to enhance environmental literacy without developing a solid understanding of the natural world, would be disorientated (Assaraf & Orion, 2005). On the other hand, setting focus just on the conceptual understanding about nature does not necessarily lead to responsible environmental behaviour; the affective dimension, i.e. attitudes and values, is very important as well (Yavetz, Goldman & Pe'er, 2009).

Natural world's understanding cannot but include the concept of contingency in ecosystems' behaviour. Current ecological research offers evidence that ecosystems are complex and dynamic systems which may exist in more than one alternative stable states. Moreover, ecosystems may transit between multiple alternative stable states in an abrupt and contingent – essentially unpredictable – way when specific tipping points are reached (Gunderson, Allen & Holling, 2010). Nevertheless, popular culture (Ladle & Gillson, 2009), school science (Westra, 2008) and students' reasoning about ecosystems and their response to human-triggered disturbance or protection, seem to be quite far from this contemporary ecological view. On the contrary, they seem to be guided by the idea of the 'balance of nature' which implies a predetermined order and stability that render nature quite predictable (Ergazaki & Ampatzidis, 2012; Zimmerman & Cuddington, 2007).

For instance, in a series of case studies performed with educational sciences students at the University of Patras, it was found that they *rarely* suggested that it wouldn't be feasible to make predictions about the future of disturbed or protected ecosystems. When dealing with scenarios of ecosystems under human protection, they mostly appeared to believe that these would 'certainly' or 'possibly' remain the 'same' over time. Similarly, when dealing with scenarios of disturbed ecosystems, students mostly appeared to believe in their 'certain' or 'possible' 'full' and 'partial' recovery (Ampatzidis & Ergazaki, 2014, 2017; Ergazaki & Ampatzidis, 2012). Believing that ecosystems are predictable since they have an almost magical power to recover their initial state, may undermine the significance of avoiding human-driven disturbances (Westra, 2008) and thus impede the formation of responsible behaviour toward the environment in general.

Considering the above, we thought that it would be important to develop a data-gathering tool that could probably be used in large scale surveys about whether students of different disciplines in different places of the world accept or not the idea of nature's unpredictability. So, we started developing, testing and elaborating a two-tier questionnaire (Treagust, 1988) through a series of case studies. These have been performed with educational sciences' students in particular, since we have easy access to them and, more importantly, we believe that their ecological knowledge and environmental awareness, which may be expressed through their special concerns about nature and its protection (see 'particular ecological interest'), could be related with their motivation and capacity to introduce topics about nature in their future classes and thus contribute to children's environmental literacy (Liu et al., 2015).

In this paper, we report on our 6th case study, which was conducted with the 5th version of the developing tool and addresses the following research questions (RQs):

- RQ1: How predictable ecosystems may be according to educational sciences' students?
- RQ2: Is there a relationship between students' claims about ecosystems' predictability and their 'particular ecological interest' (PEI)?
- RQ3: How do students justify these claims when provided with specific justification options and what their justifications reveal about their nature views?'.

METHODS

The overview of the study

The participants of our 6th case study (CS6) were 324 postgraduate students of educational sciences at the University of Aix-Marseille, holding degrees in different disciplines. In fact, they were students of the 2nd and 4th author, and, after been informed about the study, they volunteered to fill in our two-tier questionnaire. To be more precise, what we asked them to fill in was the 5th version of the questionnaire, which was derived through a series of previous case studies. In CS1-2 students dealt with scenarios about disturbed/protected ecosystems, which were informed by previous research (Ampatzidis & Ergazaki, 2014; Ergazaki & Ampatzidis, 2012). More specifically, they had (a) to provide a claim about the ecosystems' predictability and future by choosing one of the options they were given, and (b) to justify their choice in their own words. The choices of the students as well as their free justifications helped us to define six reasoning types with regard to the ecosystems' predictability. These were used to articulate the alternative responses of a two-tier questionnaire which was delivered in CS3 and elaborated further in CS4-5 (for a more detailed presentation of the process, see Ampatzidis, Delserieys, Ergazaki, Jegou, & Castera, 2016).

The questionnaire

The questionnaire was based on (a) scenarios of disturbed or protected ecosystems, and (b) scenarios of social systems. Nevertheless, here we are concerned only with the former, which are briefly presented in Table 1.

For each scenario, students were required to do two things: (a) use the four-point Likert scale of the 1st tier to claim the degree to which they felt they could predict the future of the ecosystem in question, and (b) use the six-option list of the 2nd tier to choose a justification for their claim or articulate one in their own words. The 1st tier's Likert scale ranged from 'I can predict' to 'I cannot predict'. The 2nd tier's justification-options are shown in Table 2, using scenario 8 as an example.

TABLE 1

The Eco-Scenarios of the CS6-questionnaire

Scenario 1	Protected forest: prediction about the ecosystem's future?
Scenario 2	Introduction and subsequent removal of a population in a lake: prediction about the ecosystem's future?
Scenario 3	Introduction and subsequent removal of nutrients in a lake: prediction about the ecosystem's future?
Scenario 4	Forest fire: prediction about the ecosystem's future?
Scenario 5	Oil spill in the sea and subsequent removal of the oil: prediction about the ecosystem's future?
Scenario 6	Flooding of a meadow and subsequent retreat of the water: prediction about the ecosystem's future?
Scenario 7	Arrival of a new population in a forest and subsequent departure: prediction about the ecosystem's future?
Scenario 8	Extinction of a fish population in a river because of a fatal illness and subsequent re-introduction: prediction about the ecosystem's future?
Scenario 9	Decline of a fish population and subsequent fishing regulation: prediction about the ecosystem's future?

TABLE 2

Example of the 2nd tier: the option-list for justifying the degree of predictability in scenario 8

Option 1	I can predict that, several years after the re-introduction of the bleaks, the river will return to its initial state (i.e. to as it was before their extinction)
Option 2	I can predict that, several years after the re-introduction of the bleaks, the river will be different comparing to how it initially was (i.e. to how it was before their extinction)
Option 3	I cannot really predict but I think that, several years after the re-introduction of the bleaks, the river will be close to its initial state (i.e. close to as it was before their extinction)
Option 4	I cannot predict because I have no idea
Option 5	I cannot predict cause I think it is impossible to predict
Option 6	I think that, several years after the re-introduction of the bleaks, the river will be different comparing to how it initially was (i.e. to how it was before their extinction), but I cannot predict to what way it will be different
Other	(Free answer)

Finally, there was a question about students' PEI ('Do you have any particular ecological interest? If yes, please explain).

The data analysis

Moving from data collection to data analysis, we note the following. (i) The Likert scale items of the 1st tier about nature's predictability were assigned scores from 1 ('I can predict') to 4 ('I cannot predict'). These were used to calculate (a) Cronbach's alpha, in order to test the reliability of the questionnaire (α=0.78), and (b) each students' total score for the nine scenarios, in order to cope with RQ1. (ii) To cope with RQ2, we first coded students' responses to the PEI-question as 'yes' (1) / 'no' (2) and then we run a Mann–Whitney U test between the scores of students' claims about nature's predictability in the 1st tier and their PEI. (iii) To cope with RQ3, we coded students' 'option-based' and 'free' responses in the 2nd tier to three categories, which correspond to the *'views of nature'* by Gunderson et al. (2010).

- The 'balanced nature'-view suggests that if nature is disturbed, it will return to its previous state because of 'balancing'/'negative feedback' loops. So, option 1 along with option 3 responses were coded here.
- The 'anarchic nature'-view suggests that nature undergoes hyperbolic processes of growth and collapse because of 'reinforcing'/'positive feedback' loops. So, option 2 along with option 6 responses were coded here.
- The 'resilient nature'-view suggests that nature may shift abruptly between alternative stable states because of 'balancing' as well as 'reinforcing' loops. So, option 5 responses were coded here.

Finally, option 4 responses *('I cannot predict because I have no idea')* were not coded to any category, since they explicitly reflected students' ignorance.

RESULTS

Results about RQ1: students' claims on nature's predictability

The mean of students' total scores which was calculated by what they claimed about ecosystems' predictability with the aid of a 4-point Likert scale for each of the nine scenarios, was 22.14 (SD=5.48). Since the total score of each student could range from 9 to 36 as already explained, it seems that the participants of the study do not have a strong belief neither in a predictable nor in an unpredictable nature, at least averagely.

Results about RQ2: relationships of students' claims on nature's predictability & PEI

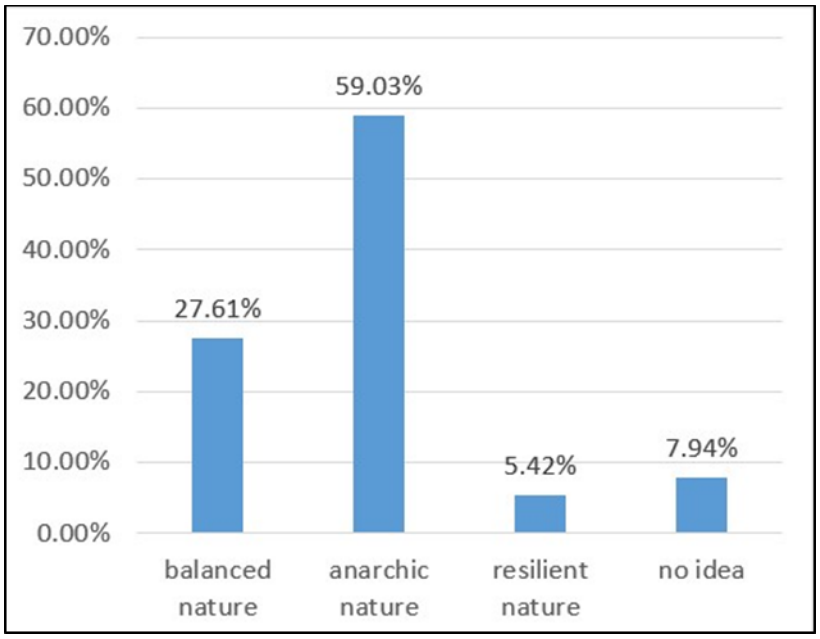
In order to check the relationship of students' claims on nature's predictability and their PEI, we first checked the normality of our data. The Kolmogorov-Smirnov test value was found 0.064 with a p-value of 0.003, so we concluded that our data deviated from a normal distribution. Thus, we decided to use the non-parametric test Mann-Whitney U.

When asked about their PEI, students who claimed that they have one (161/324), noted that they recycle, they do not consume animal products, they love nature, they love the animals, they do small things to help saving the earth. It seems that for them PEI means a specific attitude or behaviour concerning nature and its well-being. We run a Man-Whitney U test between the scores of students' claims about nature's predictability in the 1st tier and their 'particular ecological interest'. The z-value we found was not statistically significant (z=-0.344, p=0.731). So, it seems that having or not a PEI has nothing to do with our participants' belief in how predictable or unpredictable nature may be.

Results about RQ3: students' nature views

Coding students' responses in the 2nd tier, namely the way they justified their 1st tier-claims about nature's predictability, by drawing upon the three-fold scheme of Gunderson et al. (2010), we found that the 'anarchic nature'-view is the most popular among our participants (Figure 1). More specifically, 59.03% of them chose to justify their claims on ecosystems' predictability in ways that refer to a nature that experiences ups and downs through 'reinforcing' feedback loops. The view of the 'balanced nature' seems to come 2nd in our participants' reasoning. A significant percentage of them (27.61%) chose to justify their claims on ecosystems' predictability in ways that refer to a nature that is capable of coping with disturbances by restoring its previous state through 'balancing' loops. Finally, the view of the 'resilient nature', although currently scientifically valid, it doesn't seem as appealing to our participants: only 5.42% of them chose to justify their claims on ecosystems' predictability in ways that refer to a nature with multiple stable states and the capacity to shift from one to another in rather unpredictable ways.

FIGURE 1



Students' nature views according to their justifications in the 2nd tier of the CS6-questionnaire

DISCUSSION

Students seem to be 'moderate' in their ideas about the predictability of nature; when asked about how predictable ecosystems may be they averagely appear to believe in a nature that is neither strongly unpredictable nor strongly predictable.

Moreover, students' ideas about nature's predictability do not seem to have a relationship with the presence or absence of a 'particular ecological interest' on their behalf. The PEI-question was so open that students would be free to interpret the PEI-notion in different ways. From their responses it is evident that having a 'particular ecological interest', for some of them means that they 'recycle' or they are 'vegans', while for others that they 'like to hike' or 'love nature' or animals in particular. In other words, some students confirm a 'particular ecological interest' because of their attitudes towards nature or the environment,

whereas others because of their behaviours. So, the absence of a relationship between students' ideas about nature's predictability and their PEI may indicate that neither their attitudes nor their behaviours with regard to nature have to do with their ideas about nature's predictability. This is similar with what Yavetz, Goldman and Pe'er (2009) found when exploring the environmental literacy among Israeli pre-service teachers: a small correlation between attitudes and knowledge and no significant correlation between behaviour and knowledge. We need, though, to acknowledge that our data concern only a specific part of the 'knowledge' dimension of environmental literacy, as well as that some students may haven't been able to link PEI with their attitudes or behaviours because of the very open way the PEI-question was articulated.

Regarding students' 'nature views', as indicated by the ways they chose to justify how predictable they think ecosystems are, we should notice that these may interfere with their environmental reasoning and specifically their approach to nature's preservation. Believing in a globally unstable nature ('anarchic nature') as most of our participants do, one may assume that protecting nature's status quo is absolutely crucial because of the nature's fundamental instability (Gunderson et al., 2010). On the other hand, believing in a globally stable nature ('balanced nature') as many of our participants do, one may assume that protecting nature is irrelevant since ecosystems are 'teeter-totter'-like and have an almost 'magical' power to recover initial state (Westra, 2008).

Finally, it should be noted that the reliability coefficient of the 5th version of the questionnaire we used in the case study reported here, is rather satisfactory. So, it seems that we gradually managed to come up with a data-gathering tool that could actually be used in larger scale studies of students' understanding about a *both* conceptually *and* environmentally important idea like the one of nature's contingent behaviour.

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