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Science and poetry: poems as an educational tool for biology teaching

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Abstract
In this article we present the results of a biology teaching module offered at university bachelor level for law students and social sciences students in Lima, Peru. The objective was to trigger philosophical reflection on the notion of nature (cognitive dimension) and to assess if and to what extent the use of poetry contributes to the students' understanding of nature by adding emotional and conative (desire for action) dimensions. We accounted three dialectical moments of natural sciences and nature poetry in history and discussed their meaning in the context of biology teaching nowadays. We also highlighted the importance of poems as semiotic resources for science learning and explored bibliographic accounts of similar studies. Our results indicate that nature poetry fosters a holistic view of nature, allowing students to combine knowledge with value concerns, and cognitive with conative and emotional dimensions. Also, poetry allows them to connect or confront scientific information with traditional indigenous knowledge. Finally, we found that poetry afforded students a sense of freedom to present and discuss their personal experiences with nature. We concluded that this module can be used as a supplementary educational tool in biology courses and those meant to inspire action and reflection in the face of global environmental challenges.

Keywords Philosophy of interdisciplinary teaching · Environmental education · Nature communication · Nature poetry · Aesthetical communication

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Scientists and poets seem to perceive the world with different eyes. To such an extent even that the world of science seems incompatible with the world of poetry. To phrase it in philosophical terms: whereas nature poetry focusses on the *phenomenal* dimension (i.e. on nature as something which is visible, tangible and accessible in an experiential manner and from a first-person perspective), natural sciences are more interested in quantifiable aspects, or even in nature's *noumenal* dimension: the molecular dimension of natural processes (i.e. in nature as it is disclosed with the help of precision instruments and experimental contrivances). And whereas science (as "technoscience") is interested in elementary building blocks or basic causal factors, poetry tends to opt for a more holistic approach, addressing nature as a whole, articulating the way we experience a particular landscape for instance. Therefore, science and poetry seem to reflect a different mindset. They seem to work in wholly different directions.

But these kinds of dichotomies may be one-sided and may not apply to all forms of science or to all forms of poetry, especially if we take a broader perspective and consider not only the present but also look at the past. Titus Lucretius (99 B.C. -55 B.C.) for instance, in his opus magnum *De Rerum Natura/On the nature of things* (Lucretius 1975) uses poetry as well as poetic techniques such as metaphors and analogies to explain and endorse the atomistic worldview of the ancient Greek sage Epicurus. But we can also use a more recent example, namely the scientist Gregor Mendel (1822–1884) and his colleague, the Goethe scholar Franz Bratranek (1815–1884). Both were interested in studying plant life (during the 1850s and 1860s), in the same monastery at Brno, but both did this in a completely different manner (Zwart 2008). Whereas Mendel (1913) opted for a quantitative approach, in order to determine the elementary "factors" whose presence or absence determined the visible features (the phenotype) of plants (currently known as genes), Franz Bratranek opted for a more poetic stance. When Mendel began his research with peas in the monastery garden, Bratranek (1853) published a remarkable book, *Beiträge zu einer Ästhetik der Pflanzenwelt* [Contributions to the aesthetics of plant life] in which he studied plants and landscapes with the help of poetry. Considering the close connection and mutual admiration between Goethe and Alexander von Humboldt, it is not surprising to discover Humboldt´s conception of nature (Humboldt and Bonpland 1807) in Bratranek's discourse: Nature is a landscape first and foremost, as a meaningful *whole*, while a particular plant silhouette gives a landscape an identity, a face (Zwart 2003). In other words, typical plant forms reflect a landscape's physiognomy. Poets will write about a particular plant (an oak tree, for instance) in order to articulate the mood that is invoked in them by the landscape type in question (a European forest, for instance). Thus, correspondences can be discerned between the various dimensions of nature, not only between plants and humans (between landscapes and moods), but even between flowers and stars (Bratranek 1853, p. 205). Stars constitute a heavenly, sidereal garden, while both heavenly and terrestrial flowers may affect us in a certain way (Bratanek 1853, p. 14). Bratranek's scholarly views concur with the type of nature experience we expect to encounter in nature poetry of the Romantic type. Apparently, during the 1850s, a quantitative and experimental approach to nature (represented by Mendel) could operate alongside a more poetic perspective (represented by Bratranek).

According to the Romantic´s worldview, aesthetic elements -as artistic representations of meaning- were considered essential as a prerequisite to scientific understanding (Hadzigeorgiou and Schulz 2014) and even as a necessary preliminary stage in this cognitive process (Richards 2002). Darwin´s letters to his sister Catherine during his voyage on the Beagle (Buntin 2004, p. 25–26) unveil a reflexive self-exploration of scientific

observations through poetic narratives which certainly developed a sort of aesthetic appreciation/view alongside his research:

> "But in man´s own wilderness
> void of cottages and cobblestone
> and into the saline deck
> of navigator´s ship, perseverance
> usurps evolution, discarding it quite
> entirely. No, you should not dance here
> Dare say that I should not, either-
> but for these birds and vines
> and islands. And the faint memory
> of a distant home"

Although this type of genre was not reflected in Darwin´s books, he certainly recognized the importance of this perspective. As cited by Richards, "Darwin wanted to deliver to the reader an aesthetic assessment that lay beyond the scientifically articulable" (2002, p. 521).

Rather than seeing science and poetry as *incompatible*, we should perhaps see them as *complementary* approaches for both science teachers and researchers seeking to work out an aesthetic conception of inquiry science and conceptual change (Hadzigeorgiou and Schulz 2014).

Conceptual framework

Holism, sensitivity, conation and iconoclasm.

We have argued that reductionism (i.e. the quest for elementary particles and molecular building blocks) is a prominent feature of contemporary technoscience. At the same time, we argued that this reductionist trend may not necessarily apply to all forms of scientific inquiry, in all episodes of history. Quite often, science may adopt a much more systemic or even holistic view, rather than a reductionist one.

Dialectically speaking, three moments can be distinguished in natural sciences history. Initially, researchers (and this includes ancient scholars such as Aristotle, Epicurus and Lucretius) were interested in nature *as a whole*, in nature *as such* (the first dialectical moment). Books such as *De Rerum Natura* (Lucretius 1975) aimed to present a worldview, a comprehensive picture. Humboldt also was famous for presenting a worldview for understanding nature through his map ("Naturgemälde") of the Andes for instance (Humboldt and Bonpland 1807). This map portrayed a transversal section of Chimborazo mountain, which was an intricate image of nature where everything was connected (Wulf 2015). After the decline of Romanticism, however, researchers began to embrace a quantitative approach towards science (Dahlin 2001). Modern, experimental science (laboratory science), tends to opt for a more reductionist course, focussing on specific processes or components of natural systems.

Rather than a worldview, science now aims to produce knowledge that is specific, detailed and precise (the second dialectical moment). At a certain point, however, scientists will try to bring these various knowledge fragments back together again so as to recover the

whole picture, by developing a more comprehensive or systemic view: the resurgence of holism, albeit on a higher level of technical sophistication and precision (the third dialectical moment); for instance by paying attention to the system (the ecosystem) as a whole, or even by endorsing Gaia theory (Harding 2006). In the "complexity paradigm", biological systems are featured by their highly organised classes of units rather than to the single elements of the class (Morante and Rossi 2016).

Whereas in the ancient period nature research and nature poetry often went hand in hand, it was during the second dialectical moment that natural science and nature poetry became segregated and evolved into incompatible mind-sets and understandings. Whereas the scientific view was considered "objective", the experiences and insights conveyed by poetry were rather regarded as "subjective". The question now is whether and to what extent science and poetry can become reconciled again. Is convergence possible?

To address this question, some other aspects of the tension between science and poetry should be taken into account as well. Besides opting for a phenomenal (holistic) approach, for instance, another distinguishing feature of poetry is that it tends to combine cognition with affection and conation (Hilgard 1980), a tripartite classification which roughly coincides with *knowledge* (insight), *emotion* (sensitivity) and *desire* (action). In other words, besides cognitive experiences concerning the question what nature is and how natural systems work, poetry also conveys (positive or negative) valuations (by voicing experiences of admiration or intimidation, for instance). In nature poetry, nature can be experienced as overwhelming, or as vulnerable, or threatening, etc. Whereas experimental technoscience is bent on modifying and controlling nature, moreover, poetry will rather convey what Martin Heidegger (1959) referred to as *Gelassenheit*, i.e. the attitude of letting nature be. This discrepancy has also been referred to as an anaesthetic and alienated view of nature in scientific knowledge production, which is overcome when we "let the thing think" in us (Dahlin 2001).

But again, in some of the more holistic branches of natural science, such as environmental, climate or biodiversity research, other elements besides cognition may play a part as well. Although these forms of investigation tend to present themselves as objective and technological, they may nonetheless convey the insight that we are facing a global crisis in terms of ecological disruption, climate change and mass extinction, and that something should be *done* about it. Somehow, we must do more to acknowledge the value of nature and change our mode of existence, our way of life. In other words, besides cognitive dimensions, "holistic" research fields may entail emotive and conative dimensions as well, and perhaps it is precisely here that the pathways of science and poetry may cross again.

A dialectical schema may again be discerned here. Initially, during the "first moment", nature was not only an object of analysis, but also of admiration. This combination of observation and valuation is reflected by the etymology of the verb *to observe*, from the Latin term *observare* originally means: to preserve, to heed and to respect. Subsequently, in the context of the modern scientific view, nature observations turned more objective, so that nature became increasingly disenchanted and objectified (the second moment). According to the modern view, there is no intrinsic value in nature, and the claim that nature (or "the natural") is good, is often considered a natural fallacy. Currently however, we seemed to have passed this point. Nature is again seen as something that deserves respect and should be preserved or even mimicked (in the context of biomimicry for instance, i.e. the desire to develop more nature or at least nature-compatible technologies and products: the third dialectical moment). And precisely here, new opportunities for reconnecting science and poetry may emerge as well.

A final tension between natural science and nature poetry involves the tendency of science towards quantification, while poetry is considered a more imaginative practice, focussing on *images* rather than on *measurements* of nature. The French philosopher of science Gaston Bachelard, a follower of Carl Gustav Jung, critically stresses the "iconoclasm" of science in this respect, i.e. the tendency of science to move away from traditional or even archetypal images and to replace them by quantitative and formal descriptions (Zwart 2020). In contrast to science, Bachelard (1948) argues, poetry remains sensitive to a more imaginative style of thinking and perceiving, guided by what he refers to as archetypal images, i.e. the image of nature as a living being, a super-organism. Dialectically speaking, the iconoclasm of science notably applies to the second moment, when a tension emerges between iconoclastic research and imaginative poetry. On the other hand it is clear that the relationship between science and imagination is a fairly complicated one, only because contemporary technoscience is a rather prolific producer of powerful images of nature (from the *Double Helix* and the *Code of Life* up to the *Big Bang*). Once again, a dialectical pattern may be discerned here. Initially, the study of nature resulted in a worldview, an imaginative understanding of nature as a whole. This applied, for instance, to Lucretius' *De Rerum Natura*, a highly imaginative account of nature. Modern technoscience, however, is decidedly more iconoclastic, moving away from traditional images of nature in order to produce a more quantitative account (the second moment). But ultimately, a comprehensive, panoramic view of nature as a whole may once again emerge from this (the third moment) and precisely here, science may become more imaginative or even poetic again. As we discuss in this paper, these possibilities can be extended towards science education settings, using poetry as a mode of representation that may contribute to students' comprehension of scientific research fields such as biology (Pantidos, Ravanis, Valakas and Vitoratos 2014). Let this serve as an introduction into the philosophical and historical backdrop of our approach. We will now zoom in on the question how the science—poetry convergence can be effectively fostered in the context of a science education classroom.

Poems as semiotic resources for science learning

In the context of the science education classroom, the emotive and conative dimensions of science understanding can be strengthened by applying a series of semiotic resources. In a semiotic approach, "scientific concepts brought into the science classroom are drawn out, written out, acted out, talked about" (Bezemer and Kress 2019). As described by Pantidos, Ravanis, Valakas and Vitoratos (2014) poetry may serve as a functional and morphological vehicle for expressing ideas, concepts or feelings, enhancing the notion of narrativeness with poetic significance. The use of these modes of representation may create a fertile context for "meaning making" where imagination helps students to acquire complex forms of knowledge (Pantidos 2017). Poetry in the science classroom can be examined as a complementary communication vehicle to be used both as a teaching narrative and also as a semiotic framework for students to combine new knowledge with their emotions and life experiences. This approach, examined by Dahlin (2001) as the "aesthetic dimension" of knowledge formation, purports to make the transition from immediate lifeworld experience to the idealizations of scientific theories less difficult for students. Poems provide the opportunity to "connect everyday life events with their explanation in scientific terms" (Pantidos, Ravanis, Valakas and Vitoratos 2014).

In addition, it has been argued that students in academic science education should develop a "'philosophic understanding" along with a "romantic understanding", which

involves reasoning about science and its subjects as a whole" (Hadzigeorgiou and Schulz 2014). This especially allows science teachers to foster students' engagement in sciences courses by emphasizing more explicitly "the nature of nature" (Østergaard 2015). Pantidos, Ravanis, Valakas and Vitoratos (2014) propose for instance incorporating poetical forms such as verse and rhetorical figures into the narratives of physics teaching, which contributes to the process of meaning-making and fosters student´s comprehension. These authors emphasize in their studies growing scientific evidence that link the importance of science poetry interaction (as part of the "morphology" of learning environments) to cognition.

Let this suffice as an explanation of *our* reading guide, i.e. of the way in which *we* purport to analyse student poetry. A thorough theoretical and conceptual introduction of the relationship between science and poetry was not part of the module, although some relevant concepts were presented briefly at the beginning of each session. Participants were "naïve subjects" so to speak.

The study

University classroom´s cultural setting

Generally speaking, we may outline three academic circumstances in which a Peruvian university student is required to attend a course in biology (or ecology): (a) the student is pursuing a program to become a Biologist; (b) the course is a prerequisite for other—applied sciences—courses, as part of an engineering/medicine program; (c) the student is enrolled in a social sciences program under the premise of holistic formation. This last situation has been the scenery of the present study.

This study took place in the Pontificia Universidad Católica del Perú, a private university located in the capital city of Lima, during two academic terms in the springs of 2017 and 2018. Students were attending either biology (2017) or ecology (2018) courses offered by the first author of this article in the Faculty of Humanities' General Studies, before moving forward to specialized studies in the Humanities, Law or other Social Sciences Programs in the same university. About fifty per cent of these students were enrolled to become future lawyers. In terms of demographics, most students' age ranged from seventeen to nineteen years old with a higher proportion of girls (eighty per cent) in comparison to boys. Despite the fact that most attendants came from relatively privileged socio-economic contexts; this was not a homogenous classroom-group in socio-cultural terms since students came from different geographies in the country, including Andean urban landscapes, as the majority of students came from metropolitan Lima.

Such educational settings are notably interesting because they entail a confrontation between "universal" scientific knowledge on the one hand and local or indigenous knowledge on the other. These should not be seen as competitive, however, but rather as complementary. Culturally speaking, indigenous knowledge offers rich and authentic contexts for science learning (Zidny, Sjöström and Eilks 2020). In Peru, there are "ancient symbols" related to nature that are part of general Peruvian culture, although they are especially present in particular geographical settings, for instance the notion of "mother Earth" known as "Pachamama" or the reference to sacred mountains called "Apus" (Alcántara Hernández 2014). These are "holistic" cultural elements framed within the Andean Cosmovision most students were acquainted with.

Teaching biology in the context of sustainability

Besides this interaction between scientific and cultural components, we also notice that science education is becoming more explicitly oriented towards addressing societal challenges such as sustainability. Nowadays, both locally and globally, there is an urge to involve issues of biodiversity and sustainability when teaching sciences courses such as biology and ecology (among others). As cited by Østergaard (2017), there is an urgent need for a critical discussion in science education when it comes to engaging learners for a sustainable future.

Science and poetry classroom module: what is nature?

The idea that natural science and nature poetry constitute complementary strands of nature involvement was adopted as the starting point for an educational module, developed a decade ago in the context of a philosophy course for science students in the Netherlands (Zwart 2014). The module consisted of three components. First, participants were asked to read and discuss a *research paper* which employed nature poetry as a window into scientific, technological, cultural and normative transitions in the history of nature management (Zwart 2003). Subsequently, students were invited (as a group assignment) to develop and present a *definition* of nature (a well-considered answer to the question "What is nature?"). Finally, these same participants were asked (again as a group assignment) to compose and present a *poem* on nature. During the evaluation session, the question was addressed to what lessons could be learned and insights could be gained, notably from the final assignment: What were the strengths and weaknesses, the added value if you like, of poetry writing as an educational exercise?

In this paper we analyse the results of an effort to develop a Peruvian version –methodologically speaking—of a similar module, but now in a different setting, namely: an academic biology course in Peru. The purpose of the module is to trigger philosophical reflections among participants on their understandings and valuations of nature. And the question of this article is whether and in what way the use of poetry allows students to deepen their understanding of nature and their relationship with nature and to learn from nature. Methodologically, this module was performed in three sessions of the course.

Session I: delivering a concept of nature

An introductory lecture on visions of nature theory was presented to the students. The purpose of this lecture was to provide students with further theoretical elements to discuss and elaborate a concept of nature. By the time the module took place, it was expected that students could handle basic terms such as "life", "ecosystem" and "species". Conceptually speaking, however, "nature" as a term is seldom explicitly used and explored in such an academic context and the same goes for the visions of nature which may provide a "philosophic framework" to work with. Visions of nature is an umbrella concept that comprises *(i) images of nature* as the diverse ideas people consider as nature and the types of nature they distinguish, for instance: agricultural landscapes, a city park or a dog would be considered less natural than an Andean lake or a puma; (ii) the *importance of nature* and its intrinsic value, which excludes nature´s instrumental value for humans,—for instance: Amazon forest as jaguar habitat versus Amazon forest as a site of carbon storage; and (iii)

images of human-nature relationship that people envision as ideal (Van den Born, Lenders, de Groot and Huijsman 2001), for instance, the "steward" role of humans for preserving hot-spot species. After this lecture, groups of three to four students developed their own definition of nature as the first assignment of the module.

Session II: poetry reading session

In this class, a lecture on Peruvian nature poems, songs and other forms of cultural representations (paintings, fabrics, etc.) were presented as inspirational ingredients to reflect on the contours of a literary history of Peruvian nature. At this point students were still ignorant of the imminent task that was coming (to create a poem). Some of the narratives used by the teacher included textual extracts about fierce pumas, sad and dripping Andean grasslands, and landscapes bulging with patriotic symbols; but we also discussed what probably was one of the first environmentalist discourses concerning the city of Lima titled "the river, the bridge and the mall" (Porras Barrenechea 1965). This discourse was actually making a call to the Lima society about the drastic landscape change the city was suffering. What was particularly interesting is that this last narrative piece was partially incorporated in a song that is locally known as "the cinnamon flower".

At the same time, based on a paper on the history of the Dutch landscape (Zwart 2003) students were invited to think about which historical landscape markers would enable us to develop a moral geography. For instance, in Peru the human-nature relationship passed through different moments involving different influences": e.g. the pre-Columbian landscape with traces from ancient cultures (Incas), the colonial period (Spanish influences), the republican period, industrial revolution (affected by western economic and cultural models) and so on, all of them with their respective images and representations.

Session III: sharing and evaluating poetry

Subsequently, the second assignment of the module was explained and the same groups of three to four students were invited to write a poem about nature to capture what nature really means for them, expressing their own visions of nature in verse. It was clarified that the objective of the task was not to produce poetry of high-brow literary quality (although the explicit use of poetic forms such as sonnets was encouraged), but to think, discuss and portray nature in the way they see it, more or less in a "verse narrative". Finally, students were invited to present their poem to the whole group.

The purpose of this session was to share, analyse and discuss the poems produced in the context of the assignment. To help addressing this goal, a brief presentation of nature poetry typology was showed (Zwart 2014), ranging from childhood memories via Mother Earth poetry up to protest lyrics (cf. below). During this session, all the poems were shared in the class via power point presentations and reading aloud and the authors were invited by the teacher to comment on their work. Special attention was given to the process of elaboration and to the core inspirational ideas, and finally the students were given the task to classify their poems according to the typology previously discussed. Subsequently, students were invited to compare the poem assignment with the definition assignment, comparing the experience, outcomes and the difficulties entailed in it.

The main idea of this final exercise was to find out whether the poetry assignment was a meaningful exercise for them and whether this—aesthetic—experience might contribute

towards a meaningful learning. To enrich the feedback, a structured survey of the "poetry and science module" was handed to the students at the end of the session (Appendix A: Survey), the results of which will be discussed later on.

Student´s comments from session three of 2017 course worked as feedback to elaborate the survey that was e-mailed to them after the module finished (with 53% of response rate) and was used again at the final session of the module in the course of 2018 (with 100% of response rate).

Thirty students participated in the module during the course of 2017, while sixteen participants filled in the survey. For the 2018 course, fifty-eight students took part in the module and all completed the survey.

The concept of nature: preliminary analysis

It has to be kept in mind that this module was developed at the end of the courses of biology and ecology, therefore, students handled a series of concepts in relation to the Earth 'elements, living forms as well as ecological and climate issues our planet is facing. In this context, it is fair to say that the nature 'definition assignment was received by students as any other task in the course and they tended to rely on their recent acquired knowledge to explain the concept of nature, as showed below.

Student's definitions of nature can be comprised into two groups. One group is related to the concept of ecology but emphasizing the subject, for instance "nature is the ensemble of biotic and abiotic elements" and "nature is everything… precedes our existence and generates conditions to keep life". Another group of definitions includes the human being as one of nature 'living elements: "nature is the space that allows the interaction among species (animals, plants, humans) and is the main source for human and animal life" ….and justify the need for taking care of it: "nature is the environment that sustain human life, therefore the importance to protect it is essential".

Holism, valuation and conation in student poems: preliminary assessment of the results

In this section we will present and discuss a concise anthology of poems written by students–originally in Spanish and later translated to the English–. First of all, we noticed that the poems address a limited number of basic themes. And the theme which is by far the most frequently addressed is the "Mother Nature" subject, envisioning nature as a comprehensive whole. A first poem which substantiates this topic is a poem entitled *A Letter to Mother Nature.*

A Letter to Mother Nature
To begin, thank you
Thank you for providing a home
For giving us more and more
And be a nice place
Thousands of people live in you
A great mother, are you
And even though we do not take care of you,
A lot we need from you

This, is a typical or even archetypal nature poem, we would argue, presenting nature as a whole, even as a living being, a "great mother", giving life to "thousands of people", and thereby reflecting what Carl Gustav Jung and Gaston Bachelard refer to as the "mother earth archetype", a concept which can also be recognized, for instance, in the Gaia concept: nature as a caring mother figure, giving and protecting life. A similar image is conveyed in a poem entitled "Mother Nature", the first stanza of which runs as follows:

Mother nature,
source of beauty and joy,
With your light you wake us up,
next to the dew of the plants.

A similar idea can be discerned in a poem entitled "Ode to nature":

Mother, the breeze you breathe,
source of beauty that inspires me.

Closely related to this image, we would argue, is the idea that nature is both caring and all-encompassing. For instance, in other students' poems fragments:

Nature is everywhere
and I am part of it

Or:

Before I was born,
you harbored all that flourished,
flora and fauna enrich our planet,
and are part of nature.

This also applies to another poem in which nature is addressed as "mother", entitled *Jungle*:

From the road that goes
in the old and mother jungle,
it seems fearless and eternal
although full of weed

When I walk, I feel you watch me
But in the darkness
where I lost the milestones
I still watch little birds
Flowers, dunes, "premuras"
Carnivorous and "rudas"
(premuras and rudas are plant species)

Again, nature is experienced as a person, a "mother", someone who watches us (and watches over us), and this watching behaviour is mutual: while nature is watching us, we are watching birds and indigenous plant forms: species that give the landscape a face as it were.

In short, a relatively large number of poems presented by participants confirm that poetry addresses nature in a holistic, affective and conative manner and also are vivid

testimonies of student´s capacity to build up new representations of knowledge. Poetry may be seen as compensation for the iconoclastic and reductionistic disenchantment brought about by science. Several poems raise the question, however, whether technoscientific and poetic experiences of nature can become reconciled, in other words, whether the second moment (of estrangement) can be overcome ("sublated"). And a normative aspect is voiced as well, for the attitude of care is far from reciprocal. We are forgetful of our dependence on nature, forgetful of how much we need her. And the authors want to atone for this forgetfulness by addressing nature respectfully, for instance via a letter. Indeed, the genre as such (a letter to nature) already suggests that the authors consider nature as a person.

This is also exemplified by the next poem we would like to cite and which reflects that nature is not only experienced as omnipresent, old and wise, but also as being under threat:

Dear Huaytapallana
Glaciers are thousands in the world
but in Huancayo we only have one

Oh Huaytapallana, from your being sprouts
the Andean purity,
that crystal clear water,
that slips between the furrows,
brown and green peasant property

Oh majestic nature,
You made this beauty possible,
Illustration of Andean purity
which is in danger every day

Huaytapallana is the highest peak in the Huaytapallana mountain range in the Andes of Peru and represents nature as giving and supporting life. It represents the majestic side of nature, so that to see is to admire. But instead of acknowledging this, the "purity" nature is endangered, by us humans no doubt, although we humans (the dangerous factor) are not explicitly mentioned in this poem. Overall, these student poems reflect the ambiguous relationship of humans with nature, something that is very complex to explain or even portray in a more argumentative philosophic discourse, namely: are humans part of nature? This was barely reflected in the previous definition assignment where students explained nature as a functioning ecosystem of living and non-living elements (an academic perspective).

On the one hand we are evidently part of nature, as living creatures, but on the other side, we seem to represent an external, disruptive factor, an extra-natural threat. This can be regarded as a second core theme in nature poetry by students: nature, the caring mother (theme 1) is threatened and besieged by humans (theme 2).

This is quite pronounced in another student poem produced in the context of our module:

Detriment to Nature
Gold, silver and copper,
they feed a portion,
which results in corruption,
and they leave the soil poor.

Water of the vast river,
hiding fantastic creatures,
concealed under dim,
full of plastic dirt.

The macaw goes extinct
the virgin, the pure, the natural,
little by little goes away,
Man has become individualistic…

Or:

You who know everything,
and here we are, slowly feeling,
the consequences of the damage,
that we cause in you.

And while nature is "sheltering" us, we…

….prefer to wipe out what surrounds us,
it's time to take care of it, it's time to join it.

Here, it is clear that our dependency on nature has transformed into sheer exploitation, so that the majesty of nature (represented here by "fantastic creatures hiding in nature's waters) are concealed by plastic dirt (evidently a product of human productivity). Thus, the initial dependency of nature (the first moment) had given way to an estrangement from nature (the second moment, of negativity), but precisely by evoking this situation of estrangement, the poem implicitly seems to raise a question: can nature and humanity somehow become reconciled again (the third moment)? These moments were explicitly brought up during our interactive analysis of students' poems. A similar question is raised by another poem:

The sea
The maritime variety is a singular marvel,
A large list of flora and fauna can be appreciated,
A colorful decoration given to us by the algae,
And the fish that give life to finite salty waters.

Emotions flow when the sun hides,
At night, the reflection of the moon can be appreciated,
The sound of the waves makes me dream and imagine,
These are moments that I do not want to forget.

Nature is presented as something to marvel at and to appreciate, and this especially applies to maritime flora and fauna. The poem suggests, however, that, during the day, we tend to forget the wonder of nature, while it is during the night that our imaginative admiration of nature comes back to us, so that we want to recover from our forgetfulness of nature. The following poem, however, rather articulates the opposite experience: the moment of waking up and the realisation how we pose a worrisome threat to the "whiteness" of nature, a whiteness that corresponds with the "purity" of nature addressed in poem "Dear Huaytapallana" (already discussed above).

Upon awakening in the morning
and open my window
I see a sad reality in the distance,
The whiteness of the mountain seems to reach its end
Visits diminish, worry grows,
The population does not know how to act, just remember
Those times where the sunshine
gave directly to the whiteness of
the mountain, the river and the small population

This poem not only conveys affection (sadness) but also conation, the desire to act and to remember, although sadly we humans ("the population") some to have forgotten how to interact with nature.

A similar experience is voiced in the following poem:

Looking around
The stunning greens around, colors and shapes I can see,
I'm under a big oak tree and its leaves cover me,
The light and brightness through manage to appear,
Tell me, can you see it?

A clear blue above me,
And in it little singers I can hear,
Crystal clear water also sings and sounds,
And through it creatures play
Tell me, can you see it?

Here, however, the poem opts for an approach described by Bratranek (1853): the oak tree is described poetically as a plant which represents (the brightness, lights and sounds of) nature as a whole. The oak tree (and the birds inhabiting it) makes nature tangible, giving nature a face as it were: the tree as a condensed archetypal image of caring nature as a whole. The caring aspect is suggested for instance by the fact that the tree's foliage covers the author. But again, the poem raises a question, and once again the question concerns *us*: can we "see it", or are we forgetful of nature?

Students explaining nature: student evaluations

In this section we present the analysis of students' answers on both open questions and survey about their experience in the module.

Sense of freedom and aesthetical communication

Students were invited to compare both assignments, first in a general way and subsequently more focused on the communication aspects. As a first question, they were asked: *Which differences can you identify between writing a poem and writing a definition?* Some students revealed to have experienced more freedom when writing a poem than when developing a definition although there were others that did not feel this way. The survey revealed that around 60% of the participants recognized to have felt more freedom to express their

own ideas on nature and to have reflected in a deeper way when writing the poem in contrast to the definition assignment. Meanwhile, around 30% of the students stayed neutral to these arguments, and by doing so, assigned equal importance to both approaches (Appendix B. Table with survey results). As a communication tool, students pointed out that "through the poetry exercise there are several ways to explain nature" and they recognized "it was a subjective and artistic activity while the definition assignment was referred to as a more objective process (more technical and less artistic)". Some students also considered that "the poem has an implicit message while the definition focuses on a more explicit one". Hence, students recognized the aesthetic aspect of poetry (artistic value) to communicate subjective aspects or with an implicit message (holistic character).

Writing a nature poem: A friendly task?

The second question students discussed concerned the degree of difficulty they experienced in both assignments: *Was it easier to write a poem or a definition?* Approximately, a quarter of the class thought that "writing a poem of nature was easier than writing a definition" but the majority thought the definition assignment was easier "because they could use the previous concepts of the course". In addition, for some participants, writing a definition allowed them to bring up shorter and simpler ideas while for others the poetry exercise "was a more complex task than writing a definition because it requires more elaboration". Thus, although writing poetry may seem a "friendlier" task, it was certainly not experienced as more easy-going or noncommittal. These arguments reflect the level of difficulty of the task. For this reason students were asked in the survey whether this was the first time they wrote poetry, and if not, how often they had done it before? 62% of the students stated that this was not the first time they wrote poetry. For the 2018 group ($N=58$), 36 students had done this activity at least once (and 14 students with a frequency of once a month or more). For the 2017 group ($N=16$), 8 students stated they had performed this activity before but very rarely (Appendix B. Table of survey results). Still, for most participants (around 70%), bringing up poetry and nature at the same time represented a challenge.

Nature poems are personal representations of knowledge about nature

The final question for discussion was: *What does the poetry exercise add to your comprehension of nature*? Students said that poetry allowed them to reflect on nature based on their own experiences, making the process very personal and with a more informal approach and ease. One student pointed out that the activity of poetry "allowed you to show what nature´s intrinsic value is". Note that the notion of "intrinsic value" was presented to the students within the first introductory lecture. In the survey about 63% of the class agreed that the poetry assignment allowed them to find out something additional—of a personal subjective character—about their relationship with nature. Various forms of relationship emerged. Some students emphasized the beauty of nature as such, independently of humans, while others zoomed in on the human-nature relationship (e.g. mutual dependence). When valuing the poetry assignment by itself, 69% of the students supported this activity as an educational tool—mostly because it allowed them to discover personal ideas about nature—while 77% of the participants acknowledged the poetry experience as both interesting and rewarding (Appendix B. Table with survey results).

While the definition exercise led students to compose and somehow replicate a concept from what was learnt in the course, the poetry exercise entails the very essence of education including its conative value if we reflect on the relevance of the topic as a sense of stewardship for nature and the latin root *educere* of education which means "lead out". According to Bass and Good (2004), *educere* represents education as a process of questioning, thinking and creation, while *educare* -a second root- means to train or mold, the preservation of knowledge, which in our study would be represented by the definition of the nature 'exercise. In this sense, the poetry assignment may be recognized as an education tool to discover other layers of meanings of the concept with higher subjective and conative content.

Going beyond the scientifically articulable

Most students positively valued the possibility to include emotion (poems expressing sensitivity and beauty) and conation (poems with a clear urge of action) in the assignment despite the high degree of elaboration required for producing a poem. Students recognized what Bratranek said about the disenchantment of the "objective" science in contrast of the more "artistic" (subjective) process of the poetry. This aspect invites us to postulate that poetry may become a channel to discover personal perspectives on the intrinsic value of nature, a subjective dimension of the concept portrayed by students' images, sounds and feelings through each stanza. Poetry allows them to connect with their "view", their philosophy of nature, and the writing of poetry, comparing it with the poetry of others, introduces unforeseen aspects of their own view. We do not argue that poetry by itself foster scientific understanding but it may feed the drive to discovery in the arena of science. Poetry enables students to explore for themselves how current biological paradigms work and how their own words and interpretations add important emotive and conative aspects to these cognitive interpretations. In addition, it allows them to enact a confrontation between objective ("universal") and indigenous knowledge. Poetry often appeals to indigenous knowledge, e.g. the "Mother Nature" concept, thus challenging us critically to reconsider views on nature and science entailed in contemporary (Western) science education. And this may contribute to the development of more balanced and holistic worldviews, based on intercultural understanding, and fostering sustainability (Zidny, Sjöström and Eilks 2020).

One of the highlights of the students' comments was that poetry enabled them to transmit their own experiences and make them feel closer to it. In the poems, students incorporated their own memories, their personal worries, their—sometimes even secret—longings concerning nature, and by doing this, the topic of nature also became a topic about themselves. Von Humboldt (1847) wrote that "nature must be also experienced through imagination and emotion". Could we say, on the basis of this study, that through the revelation of our experiences we can strengthen our "feeling for" and sensitivity towards nature as a form of learning? We believe it does.

According to the present study, we argue that poetry has the power to motivate, inspire and invite students to explore their ideas about nature, even if these ideas are not appealing to or shared by everyone. To the extent that this is the case, poetry could be considered as a complementary tool for teaching and a powerful vehicle for students´s learning, in the form of a relevant supplementary module for biology and other nature-related courses.

The survey´s statement about finding some "additional value of nature" by means of poetry is also worth discussing: What is it exactly? In the previous paragraph we presented

poetry as a tool, a doorway to deepen our knowledge of nature, but could the process of composing poetry also fulfil a different function, e.g. articulating missing aspects, obfuscated in standard, objective accounts, fostering our understanding of nature as a whole? In that case, we may postulate that a renewed conception of nature (including emotive and conative dimensions) could be enhanced by the practice of poetry (third dialectical moment).

Finally, we conclude that science and poetry are not only complementary practices in certain educational contexts but also that poetry might help to fill the gap between knowledge –generated by science- and true empathy for nature, which is of key importance in this era of global environmental disruption and mass extinction. Besides collecting global data about nature, the sharing of poetic experiences may also foster our sensitivity to and responsibility for the value of nature.

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