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Ocean acidification education: educational resource analysis

María Lorenzo-Rial[a]*, Azucena Arias-Correa[a], José F. Serrallé-Marzoa[a] , María M. Álvarez-Lires[a]

[a]*Faculty of Educational Sciences, University of Vigo, Vigo 36005, Spain*

Abstract

This article aims to establish synergies between Science Education, Environmental Education and Marine Science (Campus do Mar), which has already begun, in order to provide ocean acidification education resources for Primary School teachers in pre-service training Global reports, based on emerging ocean acidification science, indicate that this process can be of the same magnitude as climate change; hence its importance to humanity's future. The existing on-line resources have been located, an initial revision of them has been carried out, and a set of analysis categories has been proposed in order to subsequently design educational interventions connecting scientific knowledge, values and attitudes. These will lead to acquiring scientific competence and to acting in favour of the environment as well as developing critical thinking. A collaboration with other institutions has begun to influence non-formal education.

Keywords: Science Education; Environmental Education; Marine Science; Teacher Training; Primary School Teachers; Ocean Acidification resources.

1. Introduction

For more than two decades, attention has been drawn to an urgent planetary situation. Climate change is a problem of enormous environmental, social, economic, and political consequence, it hinders equality (Araujo et al., 2015; Álvarez-Lires, 2015), and it poses a major challenge affecting humanity.

* Corresponding author. Tel.: + 986 81 20 00
E-mail address: marialorenzo@uvigo.es

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In this sense, the planetary limits concept proposed by the Stockholm Resilience Centre (Rockström et al., 2009) identifies the environmental processes that determine the stability of the components of the Earth's system. These include: climate change, depletion of the ozone layer, ocean acidification (OA), change in land use, the use of fresh water, loss of biodiversity and human interference in the nitrogen and phosphorus cycles. Finally, there is also chemical pollution and aerosol loading. Security limits have been set for the first seven concerns, and the lower ends of the margin of uncertainty as defined by science –those of least risk- have been chosen to implement a precautionary principle. As an example, for climate change the limit was set at 350 ppm (parts per million) of CO2, while science indicates that the risk of crossing an inflection point is within the margin from 350 to 550 ppm of CO2. Rockström (2011) states that we must rethink human development in this new era, the Anthropocene, and that we must urgently invert the trend of negative world climate change to stay within a safe zone for the Earth. Steffen et al. (2015) indicate that four of the planetary limits are in the danger zone: climate change, loss of biodiversity, eutrophication (interference with the global cycles of nitrogen and phosphorus) and changes in the Earth's system.

Among the nine processes mentioned above, OA is one of the threats to its sustainability: when CO2 released into the atmosphere penetrates seawater, a set of chemical reactions occur. This is a problem detected recently, but its implications could reach the importance of global warming. The studies cited show that the CO2 currently captured by the surface zone of the ocean - and its consequent rate of acidification - happens about 100 times faster than it did at the end of the last ice age (20,000 years ago), which was the last time CO2 increased significantly.

The increase in CO2 levels in the atmosphere not only raises the temperature of Earth's atmosphere, but it is also responsible for the drastic alteration of the inorganic carbon chemistry embedded in sea water, generating declines in pH, and giving rise to the OA process. The lowering of oceanic pH values is well documented. The last IPCC report (2013) states that the pH of surface seawater has decreased 0.1 units from the beginning of the industrial era, which corresponds to an increase of 26% in the concentration of hydrons. It is also estimated that the increase of OA will mean a lowering of seawater's pH varying between 0.06 and 0.32 units according to the scenario considered. OA modification implies, in turn, a change in the biogeochemical cycles of many marine compounds and elements. Among the effects resulting from the changes in the carbonic acid and carbonate equilibria in sea water, the most studied and probably the one with the greatest global impact is the decrease in the saturation state of calcium carbonate, which affects the calcareous skeleton building capacity of organisms such as molluscs, echinoderms, or coral but also affects the fall of phytoplankton (UNESCO, 2009). Scientific studies and reports focus on understanding the consequences and mechanisms of this global problem, and on identifying strategies to deal with it (UN GSP, 2012; Mace et al., 2014; Galaz, 2014). There is an urgent need to ensure that these findings are disseminated to address this problem.

2. Scientific education's role

Regarding education's role in this situation of planetary emergency, the Conference on Human Environment (Stockholm, 1972) made a plea to the education contribution in order to form an aware citizenry able to participate in the decision-making process. The Earth Summit (Rio de Janeiro, 1992) repeated the call, but the lack of response and worsening of the situation generated, at the Second Summit of the Earth (Johannesburg 2002), the launch of the Decade of Education for Sustainable Development (2005-2014) so that education can play its role in sustainable development (Vilches and Gil, 2007).

Martínez–Huerta (2009) suggests that sustainability-focused education helps us understand the relationship between the elements of sustainable development from a point of complexity, both in its diagnosis and in the possible solutions, since they give countless inter-retro-actions between economic, social, demographic, political, ideological, religious, etc., processes. (Morin, 2011). Thus, sustainability education (SE) is a complex and intentional process, as is every educational process, which involves acquiring conceptual knowledge and values, as well as the development of attitudes, aptitudes and modes of action in social interaction. This process cannot be carried out exclusively nor detachedly by educational systems, and it involves processes of formal and non-formal education (Varela Losada et al., 2014). Therefore, SE and Environmental Education (EE) must be oriented toward the development of a competition for action based on training the student group in the acquisition of critical thinking that contributes to the formation of an informed citizenry committed to the environment and that plays an active role in the joint search for solutions to problems related to sustainable development (Kyburz–Graber, 2013, Mogensen and Schnack, 2010).

If we refer to the pre-service teacher training in scientific matters, as in this case, the success of teachers' mediations will lie in teaching how to think, to speak, to do, to regulate themselves and to collaborate (Pujol, 2007), because the sciences have to serve, inter alia, to analyse and interpret phenomena and information. The sciences have to be communicable, and they constitute an activity (Izquierdo, 2007) that is carried out as a team and must be assessable. This will only be possible with the participation of reflective teachers, aware of how they learn (Alvarez Lires et al., 2013) and committed to education. Teachers that share "action" goals, use innovative methods in science classes, understand the interdisciplinary nature of environmental situations and are positioned at a critical paradigm (Araujo, 2015). What has been said so far is consistent with the educational model proposed from the context of the European Space of Higher Education (based on the development of competencies), implying a profound change in Spanish universities' teaching models, which must promote autonomous and collaborative learning. Problem-based learning (PBL), project work (Arias et al., 2009) or cooperative learning respond to these needs because they encourage meaningful learning that allow for taking on real life situations in the teachers' training to adapt to the current learning contexts and encourage the development of the appropriate teaching competencies (Álvarez Lires et al., 2013).

2.1. Ocean acidification education

In this case, we have dealt with OA because, as Fauville et al. (2012) and Wals et al. (2014) indicate, educating future generations on the certainties and uncertainties of this emerging science and its complex consequences for marine species and ecosystems can help them to evaluate the need to mitigate global change or to adapt to it, and it offers the possibility of seeking synergies between science education (SE), environmental education (EE) and marine sciences (MS). To do this, teachers in initial and ongoing training need scientific and didactic training as well as resources if they are to involve their students in inquiry, in individual and collective action, and in the development of scientific expertise (Álvarez-Lires et al., 2013). In this regard, Fauville (2012), who was already mentioned, affirms that SE and MS must be interconnected to promote a fruitful collaboration that leads to the citizenry's literacy and provides tools to preserve the marine environment through decisions and action.

On the other hand, interest in EE has increased in the last two decades, but it and SE remain separate and the majority of European curricula remain faithful to the traditional disciplines. And it is more serious when issues such as climate change and OA need an inter or multidisciplinary look. The complex aspect of sustainability and the need for a citizenry that can respond adequately to current challenges is such that EE and SE have to develop a symbiotic relationship (Wals et al., 2014). Stevenson et al. (2013) describe a trend in favour of this convergence that, combined with people's increasing interest in science, assisted by ICTs, can make education more responsive to dealing with global change (Fauville et al., 2013).

3. Analysis of online resources

Based on the above, we have begun to explore a way of collaborating with Campus do Mar, Campus of International Excellence of the University of Vigo, with the purpose of training the Primary Shool Degree students in preparation for their futures as teachers.

We have noticed the interest aroused by a conference organised in collaboration with Campus do Mar and the Consello da Cultura Galega (Council for Galician Culture) for students enrolled in Degrees in Early School Education and School Education, where dissemination workshops "Mergúllate no Océano" ("Dive into the Ocean") were carried out by Campus do Mar, paying special attention to OA. We have sought out innovative resources likely to be introduced in the lessons and we have found a collaborative experience between marine sciences and education in Sweden, in a style similar to that which we are trying to carry out (Fauville et al., 2012 and 2013).

The author has carried out a review of resources in digital format (34 resources for formal and informal education), which can be grouped into the following categories: Hands-on experiment, Virtual hands-on experiment, Field experiment, Scientists–students interaction, Students as knowledge creators and as community, Multimodal learning experiences educators, Analysis of scientific data in the classroom, in informal education, Science centres, Movies, Podcasts, Technology Entertainment and Design talks.

In the first analysis we have found that in the majority of them there is no information on their use in the classroom nor an evaluation of their impact. Since our aim is to make teaching interventions, we try to adapt the resources to the classroom reality by also determining the needs of teachers in pre-service training. To this end, we have developed an analysis table on the resources found by Fauville et al. (2012), to be applied to each one of the 34 that were found (see Table 1).

Table 1. Categories of resource analysis

Resource category	Education	Resource identification	Objective	Competences
Those already mentioned	Formal Informal	Denomination Institution URL	Scientific Educational Informative Not available	Key Education professionals Not available

Table 1 (continued)

Activity typology	Approach	Use of ICT	Assessment
Exploratory Structuring Application Others	Paradigm Projects PBL Dissemination Workshop Gender perspective	How For what Not available	Criteria Methods Tools Initial Training Formative Not available

A design for intervention will be developed and it will include an evaluation plan, the integration of the relevant scientific information, the use of cooperative strategies, within a sequence of learning based on the Karplus Cycle (Bonil and Pujol, 2008).

4. Discussion and conclusions

The majority of resources seems to be prepared by research groups in marine sciences and lacks approaches and methodologies of SE and EE (Fauville et al, 2013). It is complex to determine *a priori* what resources must be used in each learning situation, because without a detection of previous ideas it is not possible to establish the classroom profile but with the information from the analysis carried out, the scientific and didactic training needs of the indicated teachers in pre-service training will be determined (Álvarez-Lires et al., 2013). In addition, it is necessary to experience these resources within a formal didactic sequence, as intended, incorporating cooperative strategies and evaluation plans (Pujol, 2007). On the other hand, in-service teachers complain about the lack of training and teaching resources in OA, which indicates the need to address these issues, especially taking into account that this is an emerging science; these resources will can be used to the in service teacher training and consecuently those teachers will implement them in classroom of Primary and Secondary School (Sanmartí & Masip, 2011). As a result, the collaboration that we have begun can be productive, as it will allow for the incorporation of scientific-experimental aspects, as well as the achievement of synergies between EE, SE and MS in literacy in OA (Wals et al., 2014). At the same time, it can enable dissemination on the part of the MS groups (Fauville et al, 2012). Since EE involves scientific knowledge, attitudes, values and the development of a competence for action, it is necessary to promote the acquisition of critical thinking and the collaboration between institutions (Mogensen & Schnack, 2010; Varela-Losada et al., 2015). We have a partnership with the Consello da Cultura Galega (*Council for Galician Culture*) from the Galicia Government. Moreover, a project has been designed, which looks to be implemented in the Campus CREA S2i of the University of Vigo that will allow for the expansion of the initiative to non-formal education along with neighborhood associations, NGOs and Municipalities, beginning the process to form learning communities (Lenning, 2013).

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References

Álvarez-Lires, M., Arias, A., Pérez, U., & Serrallé, F. (2013). La historia de las ciencias en el desarrollo de competencias científicas. Enseñanza de las Ciencias. 31(1), 213-233.

Álvarez-Lires, M. (2015). Educación, tecnociencia, xénero e desenvolvemento sostible. III Xornada Universitaria Galega en Xénero. [CD-ROM]. Vigo: Universidade de Vigo.

Araújo, R., Lorenzo, M. A., Varela, M., & Álvarez-Lirez, M. (2015). Educación en Desarrollo Sustentable: El índice de género y medioambiente. Opción, 31(6), 36-54.

Arias Correa, A., Arias, D., Navaza, M. V., & Rial, M. D. (2009). O traballo por proxectos en infantil, primaria e secundaria. Santiago de Compostela: Xunta de Galicia (España).

Fauville, G., Säljö, R., & Dupont, S. (2012). Impact of ocean acidification on marine ecosystems: educational challenges and innovations. Marine Biology, 160, 1863-1874.

Fauville, G., Lantz-Andersson, A., & Säljö, R. (2013). ICT tools in environmental education: reviewing two newcomers to schools. Environmental Education Research, 20, 2, 248-283.

Galaz, V. (2014). Global Environmental Governance, Technology and Politics: The Anthropocene Gap. Edward Elgar Publishing. Cheltenham: UK.

Griggs, D., Stafford Smith, M., Rockström, J., Öhman, M. C., Gaffney, O., Glaser, G.,... Shyamsundar, P. (2014). An integrated framework for sustainable development goals. Ecology and Society, 19(4), art. 49.

Grupo de trabajo I del IPCC Contribución AR5. (2013). Climate Change 2013: The Physical Science Basis. Recovered from http://www.ipcc.ch/report/ar5/wg1/

UN GSP. (2012). Resilient People, Resilient Planet: A Future Worth Choosing. Report of the UN Secretary-General's High-Level Panel on Global Sustainability. New York: United Nations. Recovered from http://uscib.org/docs/GSPReportOverview_A4%20size.pdf

Izquierdo, M. (2007). Enseñar ciencias, una nueva ciencia. Enseñanza de las Ciencias Sociales, 6, 125-138.

Kyburz-Graber, R. (2013) Socioecological Approaches to Environmental Education and Research: A Paradigmatic Response to Behavioural Change Orientations. In R. B. Stevenson, M. Brody, J. Dillon & A. E. J. Wals (Eds.), International Handbook of Research on Environmental Education (pp. 23-32). New York: Routledge.

Lenning, O., Hill, D., Saunders, K., Solan, A.& Stokes. A. (2013). Powerful Learning Communities: A Guide to Developing Student, Faculty, and Professional Learning Communities to Improve Student Success and Organizational Effectiveness. Sterling, VA; Stylus Publishing.

Martínez Huerta, J. (2009). Educación para la sostenibilidad. En Manual de Educación para la Sostenibilidad. Centro UNESCO País Vasco, Fundación Iberdrola. Recuperado dehttp://www.urv.cat/media/upload/arxius/W-Cátedra_DOW_URV/Informes%20VIP/unesco_etxea_-_manual_unesco_cast_-_education_for_sustainability_manual.pdf

Mogensen F., & Schnack, K. (2010). The action competence approach and the 'new' discourses of education for sustainable development, competence and quality criteria. Environmental Education Research, 16(1), 59-74.

Morín, E. (2011). La vía: para el futuro de la humanidad. Madrid: Planeta Spain.

Pujol, R. (2007). Didáctica de las ciencias en la Educación Primaria. Madrid: Síntesis.

Rockström, J., Steffen, W., Noone, K., Persson, A., Stuart III Chapin, F., Lambin, E.,…Foley, J. (2009). Planetary Boundaries: Exploring the Safe Operating Space for Humanity. Ecology and Society, 14(2), 32.

Rockström, J. (2011). Nuestro Planeta. Programa de las Naciones Unidas para el Medio Ambiente medio ambiente para el desarrollo. PNUMA. Recovered from http://www.unep.org/ourplanet/2011/sept/sp/article5.asp

Sanmartí, N.& Masip, M. (2011). ¿Cómo hacer que la formación impulse cambios en un centro? Aula innovación educativa. Vol.201, 10-14

Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, EM., Carpenter, S.R.,…Sörlin, S. (2015). Planetary Boundaries: Guiding human development on a changing planet. Science, 347(6223), 1-17.

Stevenson, R. B., Brody, M., Dillon, J., & Wals, A. E. J. (Eds.) (2013). International Handbook of Research on Environmental Education. Routledge: New York.

UNESCO. (2009). La acidificación del océano. Resumen del segundo Simposio científico "El océano en un mundo con altos niveles de CO2" elaborado para gestores de políticas ambientales. Mónaco: Museo Oceanográfico de Mónaco.

Varela-Losada, M., Pérez-Rodríguez, U., Álvarez-Lires F.J. & Álvarez-Lires, M (2014). Desarrollo de competencias docentes a partir de metodologías participativas aplicadas a la Educación Ambiental, Formación Universitaria, 7(6), 27-36.

Varela-Losada, M., Vega-Marcote, P., Pérez-Rodríguez, U, & Álvarez-Lires, M. (2015): Going to action? A literature review on educational proposals in formal Environmental Education, Environmental Education Research, DOI: 10.1080/13504622.2015.1101751 Recovered from http://dx.doi.org/10.1080/13504622.2015.1101751

Vescio, V., Ross, D. & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. Teaching and Teacher Education, 80–91. Recovered from www.sciencedirect.com

Vilches, A., & Pérez, D., (2007). Emergencia planetaria: necesidad de un planteamiento global. Educatio Siglo XXI, 25, 19-49.

Wals, A. E. J., Brody, M., Dillon, J., & Stevenson, R. B. (2014). Convergence Between Science and Environmental Education. Science, 344(6184), 583-58.