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CONFERENCE BOOK

SYMPOSIUM

ROUNDTABLE

Students' knowledge of ocean acidification and its impact on marine organisms

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Theoretical background

The world ocean becomes more acidic due to the fact that it absorbs most of the increased anthropogenic carbon dioxide (CO2) in the atmosphere, leading to ocean acidification (Doney et al. 2009), which is a major threat for marine species and ecosystems, since it affects the calcareous skeleton building capacity of organisms such as molluscs, echinoderms, or corals and the fall of phytoplankton. Considering that citizens through their everyday lives contribute to the increased CO2 emissions, the scientific community considers it a priority to establish public awareness and understanding of ocean acidification (Andersson & Mackenzie, 2011), so as citizens and students, who are regarded as future decision-makers, can make informed lifestyle choices to minimize this impact. However, the dearth of research concerning either public's or students' knowledge of ocean acidification or the carbon cycle has articulated participants' low awareness (e.g. Hartley et al., 2011; Spence et al., 2018).

According to Ocean Literacy Framework (National Marine Educators Association, 2010; National Oceanic and Atmospheric Administration 2013), ocean acidification could be taught at 11-12 year-old primary students. Generally, existing teaching approaches concerning ocean acidification are disconnected from the carbon cycle, although it is a complex environmental problem directly associated with the increased CO2 emissions in the atmosphere. Moreover, to the best of our knowledge, there are no relevant studies concerning ocean acidification teaching to primary students either disconnected from the carbon cycle or not.

Key objectives

The aim of the present study is to estimate 11-12-year-old students' knowledge of the carbon cycle and ocean acidification before and after a teaching intervention. The present study will provide important information whether the introduction of ocean acidification in a carbon cycle context can help young learners understand the human impact on this complex environmental problem. This would be the first crucial step to help them realize how important everyday individual action is for the mitigation of such environmental problems.

Research design and methodology

The study was conducted with a convenient sample of eighty-five 11 to 12 years-old students from 5 classes in two public primary schools located in a coastal provincial town, in Greece. A questionnaire consisted of 18 items was developed to examine students' knowledge of components and processes of the carbon cycle and ocean acidification. Participants were to answer "agree", "disagree" and "do not know", with the last option given in order to exclude the choice of random response. Each correct answer was coded as "1" and each incorrect answer, as well as the "I do not know" option, as "0". The changes in students' content knowledge were estimated using descriptive statistics performed with SPSS v23.0. Cronbach's alpha was applied to assess reliability.

Findings

The value of Cronbach's alpha showed a low internal consistency of the content knowledge questionnaire before the intervention (α=0.509) probably due to the many missing values, and an acceptable internal consistency after the intervention (α=0.619). The results of the independent-samples T-test showed that the pre- and post-intervention measurement was statistically significant for the knowledge test (Fig. 1).

Before the intervention, the items of the questionnaire concerning the seawater pH change because of the increased CO2, carbon release during decomposition, and the role of carbon in respiration and photosynthesis, were particularly difficult for the students (Table 1). In addition, the students were not aware of the role of decomposers in the carbon cycle, the dissolution of CO2 in seawater, and the release of carbon into the deep during decomposition of dead organisms (Table 1).

After the intervention, students' performance increased in all items, exhibiting statistically significant difference in 13 out of 18 statements (Table 1). However, their scores presented only a slight increase on items concerning the role of CO2 in plants' respiration, the seawater pH change due to increased CO2 levels and the role of decomposers in the carbon cycle (Table 1).

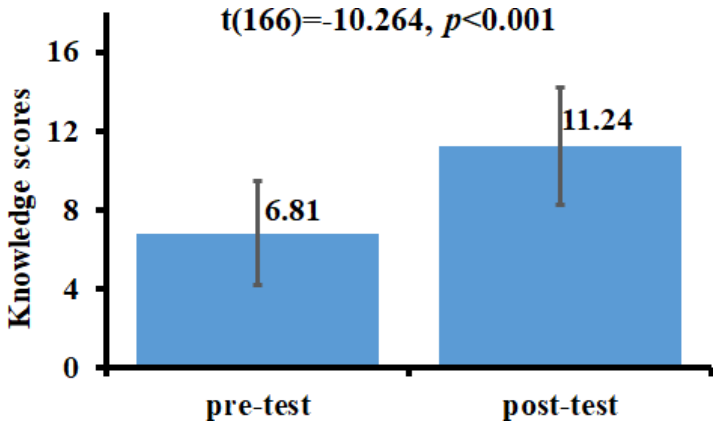

Fig. 1 Students' mean knowledge scores in pre- and post-intervention tests

Conclusions

The findings of the present study showed that primary students after the intervention identified that carbon is being transferred from the atmosphere to the earth systems, both land and ocean. However, they had a difficulty to realize the cyclic nature of carbon cycle, since they misunderstand the output mechanisms of the carbon cycle, mostly plant respiration and decomposition.

Table 1. Relative frequencies of correct answers for the pre- and post-intervention knowledge test, and significance level between the tests

Knowledge questions	Pre-test (n=85) %	Post-test (n=83) %	*p*-level
1. There is carbon in the atmosphere, in plants and animals, in soil, in subsoil and in the ocean	82.1	97.6	***
2. Plants use carbon dioxide from the air for their respiration	16.5	24.1	ns
3. Phytoplankton use carbon dioxide from water in photosynthesis	15.3	60.2	***
4. Humans and animals breathe in oxygen and breathe out carbon dioxide	76.5	86.7	***
5. Carbon is continually recycled in the earth	32.9	55.4	ns
6. Photosynthesis in land and marine plants is part of the carbon cycle	40.0	68.7	*
7. Carbon is released during decomposition	12.3	69.9	***
8. Some carbon gets into the deep ocean when living things in the ocean die	27.4	47.0	ns
9. Decomposers (such as bacteria) break down dead organisms and release oxygen	22.0	36.1	***
10. Fossil fuels are sinks for carbon until they are burned and then they become sources	53.7	71.1	ns
11. Ocean is the biggest carbon sink	43.2	75.9	*
12. Land is the biggest carbon sink	32.9	72.3	***
13. Carbon dioxide in the atmosphere has increased in the last years	66.3	78.3	ns
14. Carbon dioxide is hardly dissolved in ocean water	26.2	51.8	*
15. Increased carbon dioxide emissions have no effect on the ocean environment	51.9	61.4	*
16. Increased carbon dioxide levels increase seawater pH	6.1	24.1	***
17. Increased amounts of dissolved carbon dioxide in the ocean do not affect organisms having shells	50.0	74.7	***
18. Increased amounts of dissolved carbon dioxide in the ocean are harmful for the corals	36.1	68.7	***
Mean percentage	**38.4**	**62.4**	

s: non-significant
*: significant at the 0.05 level
**: significant at the 0.01 level
***: significant at the 0.001 level

Concerning ocean acidification, although students mistakenly interpreted acidification as an increase in pH values and not as a decrease, they realized that excess anthropogenic carbon outputs cause carbon accumulation in the atmosphere, which is transferred to the sea and brings the carbon system out of balance, affecting the calcareous skeleton building capacity of marine organisms. This finding indicates that they realize that humans' everyday actions concerning CO2 emissions may affect ocean acidification and, consequently, the health of the ocean and its inhabitants.

Reference list

Andersson, A. J., & Mackenzie, F. T. (2011). Ocean acidification: Setting the record straight. *Biogeosciences Discussions*, *8*(3)

Doney, S. C., Fabry, V. J., Feely, R. A., & Kleypas, J. A. (2009). Ocean acidification: The other CO2 problem. *Annual Review of Marine Science*, *1*, 169-92.

Hartley, L. M., Wilke, B. J., Schramm, J. W., D'Avanzo, C., & Anderson, C. W. (2011). College students' understanding of the carbon cycle: contrasting principle-based and informal reasoning. *BioScience*, *61*(1), 65-75.

National Marine Educators Association (2010). *Ocean literacy scope and sequence for grades K-12, published in the National Marine Educators Association, U.S.A*. (Special Report #3 on The Ocean Literacy Campaign Featuring the Ocean Literacy Scope & Sequence for Grades K-12).

National Oceanic and Atmospheric Administration (2013). Ocean literacy: The essential principles and fundamental concepts of ocean sciences for learners of all ages Version 2, U.S.A. Published June 2005, revised March 2013.

Spence, E., Pidgeon, N., & Pearson, P. (2018). UK public perceptions of Ocean Acidification–The importance of place and environmental identity. *Marine Policy*, *97*, 287-293.