An Investigation into the Understanding of Earth Sciences among Students Teachers

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Abstract

In this article, the students teachers' opinions, including rock formation and improper terms related to or different from these ideas, all of which are considered or must be considered in geology classes, have been analyzed. Alternative conception is used to inform our understanding of students teachers' ideas and describe any conceptual difficulties which are different from or inconsistent with the accepted scientific definition. The sample consists of 24 student teachers. We have stated that most student teachers have different alternative conceptions in mind even though they have previously followed one undergraduate Earth Sciences course. In order to explain the student teachers alternatives conceptions regarding rock formation, four basic unconscious beliefs have been discovered and described from the results of the analyses. These four beliefs, defined as: Rock - Scales of Space and Time - Stable Earth - Human Intervention, are used with the purpose of explaining the considered database outputs and alternative conceptions.

Key Words

Teaching, Constructivist Method, Earth Sciences.

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Kuram ve Uygulamada Eğitim Bilimleri / Educational Sciences: Theory & Practice
9 (2) • Spring 2009 • 597-606

Earth science is the study of solid and liquid matter that forms the Earth. The field of earth science encompasses the study of composition, structure, physical properties, dynamics, and history of Earth materials, and processes by which they are formed, moved, and changed.

We agree with Asarraf and Orion (2009) when they write "the earth science education gives the student the knowledge and the ability to draw conclusions regarding subjects such as preservation of energy, economizing on water, proper utilization of global resources." In addition, the teaching of Earth sciences may raise students' consciousness of what is happening around them, in their local environment, country, or the world.

As is obvious from its definition and scope, Earth Science education requires concentration on four fundamental fields: *(i)* The structure of the Earth (rock, mantle etc), *(ii)* The evolution mechanisms of the various parts of the Earth, *(iii)* The motion of the entire planet in a celestial sense (a study that started to gain its modern form in the time of Copernicus), and *(iv)* living organisms on the Earth.

A review of the literature on the topic indicates that most western countries' national curriculum in earth science education require children develop a scientific understanding of the Earth's materials and processes, of the Earth's structure, providing the context for such an understanding (King, 2008). In seeking to support student understanding in this domain, the constructivist theories of learning and teaching provide a model which highlights the importance of students' existing ideas as the focus for conceptual change.

According to the constructivist learning theory, students actively construct meaning from their experiences, using their existing conceptual frameworks (Osborne, & Wittrock, 1985). Mental models of how the world works are unique to the observer and not always easily explained to others. Models may be inconsistent and students may believe one thing but verbalize another (Vosniadou, & Brewer, 1992), perhaps in response to facts they have memorized. Teachers need to investigate student ideas and find ways to incorporate these viewpoints into the learning-teaching dialogue. Student beliefs that contradict those widely accepted by the scientific community are often persistent and reappear if not addressed directly.

Research on student understanding arises from a constructivist view

of science learning (Driver, Guesne, & Tiberghien, 1985). This view of knowledge posits that learning is a complex process in which instructional experiences interact with the learner's existing beliefs, experiences, and knowledge. Student learning always depends on what students bring to the classroom as well as the experiences they have therein. If learners already have theories of how the world works including their misconceptions, instruction must be structured to acknowledge and challenge such understanding (Driver, & Erickson, 1983).

In this article, we will use the term "alternative conceptions" to indicate student beliefs about the Earth's structure before formal instruction on the topic and "misconception" to refer to those ideas contradicting scientific consensus views. Student alternative conceptions and misconceptions concerning geoscience-related concepts have been well documented and analyzed by several researchers in the past. These include: Minerals, Rocks and Fossils: Happs (1982, 1985); Russell, Bell, Longden, & McGigan (1993); Sharp, Mackintosh, & Seedhouse (1995); Dove (1997, 1998) Ford (2005); The Earth's processes: Mountains, Volcanoes, Earthquakes, Weathering and Erosion and Geological time: Trend (1998); Zen (2001); Dal (2005, 2007a, 2007b, 2008); Earthquakes and the Structure of the Earth: Lillo (1994); Kali, & Orion (1996); Marques, & Thompson (1997); Sneider, & Ohadi (1998); Rutin & Sofer (2007); the Water Cyle: Bar (1989); Kali, Orion, & Eylon (2003); Asarraf & Orion (2009); Space Science: Sharp et al. (1995); and Vosniadou, & Brewer (1992).

Reviewing the literature on student ideas about geoscience education highlights a paucity of research in student teachers' ideas related to Earth structure and calls for more studies on the topic. In the literature, some studies such as Abraham, Williamson, & Westbrook (1994); Trumper, & Gorsky (1996); and Tsaparlis (2003) reported that students' alternative conceptions are derived from their teachers. If teachers hold alternative conceptions, they will have difficulty identifying their students' alternative conceptions and correcting them. For this reason, an investigation of alternative conceptions among student teachers would be worthwhile. In this article, the student teachers' ideas, including rock formation and the improper terms related to or different from these ideas, all of which are considered or must be considered in geology classes, have been analyzed.

Purpose of the Research

The purpose of this study is to reveal the general conceptual patterns of student teachers regarding rock formation. More specifically, we focus on the alternative conceptions of student teachers and their subconscious causes. This study has been designed to teach the methods which will be followed by primary school teachers to effectively teach Earth sciences and develop strategies to work out which alternative conceptions students might have. The methodologies will also aid student teachers in detecting the causes of misunderstandings in existing syllabus.

Methods

Sample

The sample consists of 24 student teachers (22 females and 2 males) who have attended the training course at the IUFM in Paris. The study was conducted during the first semester compulsory course called "geological processes." The purpose of the course is to study the concepts of "rocks, minerals, and fossils" that play an integral role in understanding the evolutionary and functional mechanisms of the Earth. Each member of the sample group has studied at least one other course on the formation of rocks at undergraduate level prior to enrolling in this course.

Procedure

During the study, we've used grounded theory (Straus, 1987) and content analysis methodology (Rosengren, 1981), which are both structured in order to develop a theory from the results of the analyses.

The analyses of four different works of student teachers are used as the database in this study: the first one was collected at the end of the class hour before any educational activity has been initiated and three others are collected at the end of the academic term after advancing in the courses.

Quantitative research method was used to ascertain the students' logical senses on the subject. We have concentrated on the minimum frequency of ideas in our limited sample, allowing us to perform more detailed analyses. These are effectuated quantitatively. The data have also been analyzed in terms of sex and age groups but as no discriminatory evidence was found, these classifications were later dropped.

Results

The study revealed that 9% of the sample explained the rock forming processes satisfactorily enough to convince the earth scientists, while 91% were not able to satisfy the earth scientists. Despite the fact that all the samples had previously studied at least one earth science course, they had serious, non-geological misunderstandings on rock formation. Although there was not a systematic way of misunderstanding in each work of the student teachers, the misconceptions included alternative conception models. By alternative conception models, we do not mean random, mistaken ideas but ideas that, while being wrong, included coherent thinking employing scientific ideas.

The results show that the student teachers' ideas about specific earth science concepts vary in terms of their differentiation, organization, and vocabulary, suggestive of different levels of understanding that facilitate their categorization as alternative conception models. These appear internally consistent and coherent in their approximation to a scientific understanding.

We have stated that most student teachers have different alternative conceptions in mind even though they have previously followed the same undergraduate earth sciences course. For example, student teachers designate that sedimentary rock is formed by sand clumping in the bottoms of rivers; in other words, they have this strange belief that pebbles enlarge. These ideas, which are already denied by scientific facts, construct a solid chain difficult to break once clustered.

Thus, we have defined here the basic categories of patterns of student ideas to which the works of each student teacher are encoded. The results of the analyses bring out 12 categories which are entitled as follows: Rock; Formation; The Changing Earth; Lithification; Sense of Time; Erosional Model; Igneous, Sedimentary, Metamorphic Rocks; Formed Where Found; Origin; Human Intervention; Natural Disasters; Accuracy.

In order to explain the conceptual patterns of student teachers regarding rock formation, four basic alternative conception models have been discovered and described from the results of the analyses. These four models, defined as Rock, Scales of Time, Stable Earth, and Human Intervention, are used with the purpose of explaining the considered database output and misconceptions.

Rock

59% of the sample used the term "rock" in the same sense as "stone", while 31% referred to rock as a category (such as arcose (a sedimentary sandstone that includes feldspar in it)) or mass. Similar to findings by Happs (1982) and Russell et al. (1993), when asked how a sandstone becomes a rock, 38%, instead of explaining the formation of a rock type that also includes pebbles, explained that the pebbles change and become more rounded because of atmospheric conditions. 48% of the sample explained lithification as pebbles growing and the unification of different minerals that melt together.

Scales of Time

Similar to findings by Trend (1998) and Zen (2001), 24% never mentioned timescales. 26% used the term "long time" and 15% associated this "long time" with "millions of years". 6% associated middle time scales with "thousands of years." 29% related the concept of "short time" to "years or less."

Stable Earth

Similar to findings by Bar (1989), Dal (2008) and Asarraf & Orion **(2009)**, only 36% of the sample relate rock formation to the changing effects of atmospheric conditions and only 32% related rock formation processes to natural disasters. 30% believed that rocks formed in a single place without any transportation process.

Human Intervention

Similar to findings by Osborne & Freyberg (1985), 32% of the sample mentioned human intervention in the changes and formation of the rocks through the transportation of particles.

Discussion

This study highlights the possibility that within a conceptually-confined area like geoscience, student teachers' ideas of closely related concept groups tend to be uneven, creating a critical barrier and preventing the long term development of a scientific, holistic idea of how the Earth functions as a dynamic, integrated system. As pointed out above, this necessitates a scientific, descriptive understanding of each concept group as well as a casual understanding of the relationship between them. The study revealed the student teachers' alternative conceptions in relation to the following four main types of alternative conception

models (barriers to learning), and indeed all the students' productions serve to emphasize these findings.

In light of these four structured alternative conception models, our research shows that the chain of generalized alternative conceptions results from the interaction of the students' individual world views (interacting with meaningful experiences to produce belief) with educational activity.

In considering the function of alternative conceptions on student teachers' ideas of earth science concepts, it may be that they operate in a analogous way to the possible sub-conscious intuitive theories of naïve physics held by student teachers which structure their knowledge acquisition of physical phenomena (O'Laughlin, 1992). Although such comparisons cannot be taken too far and would merit further investigation, it is suggested that student teachers' existing alternative conceptions may influence the way knowledge is interpreted and understood in this domain, particularly evident when the appropriate alternative conception is absent.

Constructivist point of view proposes a number of educational methodologies to avoid alternative conceptions in general. These methods typically concern pre-evaluations including the collective production of the models which will bring to light the students' opinions using activities they develop themselves and discussions which force them to express their ideas, while letting the students benefit from the manner of thinking of others (Develay, 1992; Driver, 1988; Weathley, 1991). Therefore, if we take the alternative conceptions into account in planning future activities in teacher education and science curriculum development, students may have a better chance to scientifically develop the fundamental concepts of science. Since these concepts are building blocks for later learning, their development will help students meaningfully grasp the advanced concepts of science.

As another approach, it can be proposed to analyze how geologists develop the theories explaining the Earths' structure and its internal and external processes. Considering that all geologists were once students, it can be useful to analyze each step up to and including their last one, which finally supports scientific wisdom in the field of rock formation. From this point on, it is necessary to apply a series of restructuring principles (by relating to other disciplines of natural science, namely

physics, chemistry, and biology) in an educational program of earth science courses stylized similarly to the geologist's manner of thought in order to develop ideas, avoiding alternative conceptions and shaping a better geological perception.

Finally, the education that student teachers receive will be transferred to the students that will shape the future of their country. Therefore, designing a way of learning that involves the elimination of alternative conceptions by setting up a kind of filter through the use of laboratories and field studies is especially important in science and technology courses, particularly in the Earth Sciences.

References/Kaynakça

Asarraf, O. B., & Orion, N. (2009). A design based research of an earth systems based environmental curriculum. *Eurasia Journal of Mathematics, Science & Technology Education*, *5*(1), **47-62**

Abraham, M. R., Williamson, V. M., & Westbrook, S. L. (1994). A cross-age study of the understanding five concepts. *Journal of Research in Science Teaching*, *31*, 147-165.

Bar, V. (1989). Children's views about the water cycle. *Science Education*, *73*, 481-500.

Dal, B. (2005). The initial concept of fifth graduate Turkish's students related to earthquakes. *European Journal of Geography*, *326*, 1-17.

Dal, B. (2007a). Fosil öğretimi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *32*, 52-65.

Dal, B. (2007b). How do we help students build beliefs that allow them to avoid critical learning barriers. *Eurasia Journal of Mathematics, Science & Technology Education*, *3*(4), 251-269.

Dal, B. (2008). Assessing what students' acquire about basic knowledge of geography. *International Research in Geographical and Environmental Education*, *17*(2), 114-131.

Develay, M. (1992). *De l'apprentissage à l'enseignement* [Öğrenimden öğretime]. Collection pédagogique: Paris, ESF Editeur.

Dove, J. (1997). Student ideas about weathering and erosion. *International Journal of Science Education*, *19*(8), 971-980.

Dove, J. E. (1998). Students' alternative conceptions in Earth science: A review of research and implications for teaching and learning. *Research Papers in Education*, *13,* 183-201.

Driver, R. (1988). Theory into practice II: A constructivist approach to curriculum development. In P. Fensham (Ed.), *Development and dilemma in science education* (p. 133-149). London: Falmer Press.

Driver, R., & Erickson, G. (1983). Theories-in-action: Some theoretical and empirical issues in the study of students' conceptual frameworks in science. *Studies in Science Education*, *10*, 37-60.

Driver, R., Guesne, E., & Tiberghien, A. (1985). *Children's ideas in science.* Milton Keynes, UK: Open University Press.

Ford, D. (2005). The challenges of observing geologically: Third graders' descriptions of rock and mineral properties. *Science Education*, *89*, 276-295.

Happs, J. C. (1982). *Some aspects of student understanding of rocks and minerals.* Science education research unit working paper (No: 204). New Zealand: Waikato University.

Happs, J. C. (1985). Regression on learning outcomes: some examples from the earth sciences. *European Journal of Science Education*, *7*(4), 431-443.

Kali, Y., & Orion, N. (1996). Spatial abilities of high-school students in the perception of geologic structures. *Journal of Research in Science Teaching*, *33*, 369-391.

Kali, Y., Orion, N., & Eylon, B. S. (2003). The effect of knowledge integration activities on students' perceptions of the earth's crust as a cyclic system. *Journal of Research in Science Teaching*, *40*(6), 545-565.

King, C. (2008).Geoscience education: An overview Studies. *Science Education*, *44*(2), 187-222.

Lillo, J. (1994). An analysis of the annotated drawings of the internal structure of the earth made by students aged 10-15 from primary and secondary schools in Spain. *Teaching Earth Sciences*, *19*(3), 83-87.

Marques, L., & Thompson, D. (1997). Misconceptions and conceptual changes concerning cntinental drift and plate tectonics among Portuguese students aged 16-17. *Research in Science and Technological Education*, *15*, 195-222.

O'Laughlin, M. (1992). Rethinking science education: Beyond Piagetian constructivism toward a sociocultural model of teaching and learning. *Journal of Research in Science Teaching*, *19*, 791-820.

Osborne, R., & Freyberg, P. (1985). *Learning in science: The implications of children's science.* Auckland: Heinemann.

Osborne, R., & Wittrock, M. (1985). The generative learning model and its implications for science education. *Studies in Science Education*, *12*, 59-87.

Rosengren, K. E. (1981). *Advances in content analysis.* Beverly Hills, CA: Sage.

Russell, T., Bell, D., Longden, K., & McGigan, L. (1993). *Primary SPACE Research Report: Rocks, soil and weather.* Liverpool: Liverpool University Press.

Rutin, J., & Sofer, S. (2007). Israeli students' awareness of earthquakes and their expected behaviour in the event of an earthquake. *School Science Review*, *88*, 57-62.

Sharp, J. G., Mackintosh, M. A. P., & Seedhouse, P. (1995). Some comments on children's ideas about earth structure, volcanoes, earthquakes and plates. *Teaching Earth Sciences*, *20*(1), 28-30.

Sneider, C. I., & Ohadi, M. (1998). Unraveling students' misconceptions about the Earth's shape and gravity. *Science Education*, *82*, 265-284.

Straus, A. L. (1987). *Qualitative analysis for social scientists.* Cambridge: Cambridge University Press.

Trend, R. (1998). An investigation into understanding of geological time among 10- and 11 years old children. *International Journal of Science Education*, *20*(8), 973-988.

Trumper, R., & Gorsky, P. (1996). A cross-college age study about physics students' conceptions of *force* in pre-service training for high school teachers. *Physics Education*, *31*, 227-36.

*Tsaparlis***,** G. (*2003*). Chemical Phenomena versus chemical reactions: Do students make connections? *Chemistry Education Research and Practice*, *4*(1), 31-43.

Vosniadou, S., & Brewer, W. F. (1992). Mental models of the Earth: A study of conceptual change in childhood. *Cognitive Psychology*, *24*, 535-585.

Wheatley, G. H. (1991). Constructivist perspectives on science and mathematics learning. *Science Education*, *75*, 9-21.

Zen, E. (2001). What is deep time and why should anyone care? *International Journal of Science Education*, *49*(2), 5-9.