Summary

EVALUATING OF NATURAL SCIENCE SUBJECTS: STUDENTS` POSITION IN THE BALTIC COUNTRIES

Vincentas Lamanauskas, Renata Bilbokaitė
University of Šiauliai, Lithuania

A number of the latest investigations specify the necessity of improving science education at all levels of the education system. A decreasing interest in sciences is one of the most acute problems of present education. The purpose of this research is to analyse how students evaluate the natural science subjects.

The results enclose that geography is the most interesting discipline for Baltic States' students. Less interesting disciplines are biology, chemistry and physics. The least interesting discipline is mathematics. Comparing data between countries there was found out that all disciplines are interesting for Lithuanians. Students in Latvia the least interested in all mentioned disciplines. Biology, chemistry and physics are the most difficult disciplines for Baltic States' students. Easiest discipline is geography. All disciplines looked more difficult for Lithuanians than to Latvians and Estonians. Comparing data between sexes that was found out that mostly all factors girls evaluated worse than boys, only geography was more difficult for male students.

It is very important to compare the evaluation, attitudes of the students belonging to the same region country, because earlier carried out researches show that in spite of common natural science education tendencies, rather significant differences exist between countries. It is believable, that they are predetermined by various educational approaches, teachers' competence and other different reasons.
Key words: comparative analysis, evaluation, natural science education, subjects.

COHERENCE OF NATURE OF SCIENCE AND INQUIRY IN SCIENCE INSTRUCTION

Danuše Nezvalová
Palacky University, Olomouc, Czech Republic
E-mail: danuse.nezvalova@upol.cz

Introduction

Although the reasons for concern about the quality of science instruction differ from nation to nation, the primary rallying point is perceived level of scientific literacy among each nation´s populace. In each case, whether the label "scientific literacy" was used, concerns have typically focused on the usefulness and relevancy of the subject matter included in science curriculum. The ability to use scientific knowledge to make informed personal and societal decisions is the essence of what contemporary science educators define as scientifically literacy. The phrase less is more has often been invoked to communicate the desire that instructional time focus on in-depth understanding of a reduced set of unifying science concepts. Helping students develop adequate conceptions of nature of science (NOS) and scientific inquiry has been a perennial objective in science education. Despite numerous attempts to improve students´ views of the scientific endeavor, students have been shown to possess inadequate understandings of several aspects of NOS and scientific inquiry (e.g. Aikenhead, 1973; Bady, 1979; Broadhurst, 1970; Lederman & O´ Malley, 1990; Mackay, 1971; Tamir & Zohar, 1991). The current curricular documents emphasis NOS and scientific inquiry. We try to communicate, first, what is meant by "NOS" and scientific inquiry and second, how of functional understanding of these valued aspects of science can be communicated to students.

Nature of Science

The phrase "nature of science" typically refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge or the development of scientific knowledge (Abd-El-Khalick & Lederman, 2000; Lederman, 1992). Scientists share certain basic beliefs and attitudes about what they do and how they view their work. These have to do with the nature of the world and what can be learned about it. NOS has the following attributes (AAAS, 1993):

The World is Understandable

Science presumes that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study. Scientists believe that through the use of the intellect, and with the aid of instruments that extend the senses, people can discover patterns in all of nature. Science also assumes that the universe is, as its name implies, a vast single system in which the basic rules are everywhere the same.

Scientific Ideas are Subject to Change

Science is a process for producing knowledge. The process depends both on making careful observations of phenomena and on inventing theories for making sense out of those observations. In science, the testing and improving and occasional discarding of theories, whether new or old, go on all the time.

Scientific Knowledge is Durable

Although scientists reject the notion of attaining absolute truth and accept some uncertainty as part of nature, most scientific knowledge is durable. The modification of ideas, rather than their outright rejection, is the norm in science, as powerful constructs tend to survive and grow more precise and to become widely accepted.

Science Cannot Provide Complete Answers to All Questions

There are many matters that cannot usefully be examined in a scientific way. There are, for instance, beliefs that - by their very nature - cannot be proved or disproved (such as the existence of supernatural powers and beings, or the true purposes of life). Students should be aware of the crucial distinction between observation and inference. Observations are descriptive statements about natural phenomena that are directly accessible to the senses. Important is also the distinction between scientific laws and theories. NOS is based on and/or derived from observations of natural world. It nevertheless involves human imagination and creativity. Teachers´ understandings of NOS, as recent research shows (Abd-El-Khalick & Lederman, 2000), does not necessarily translate into classroom practice. Certainly, teachers must have an in-depth understanding of what they are expected to teach. How NOS is situated in curriculum is referred as the syntax of NOS within instruction. Students understandings of NOS are best facilitated if situated within a context of inquiry (Lederman, 2006).

Scientific Inquiry

The ***National Science Education Standards*** (***NSES, 2003;*** p. 23) defines scientific inquiry as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world."

Scientific inquiry reflects how scientists come to understand the natural world, and it is at the heart of how students learn. From a very early age, children interact with their environment, ask questions, and seek ways to answer those questions. Understanding science content is significantly enhanced when ideas are anchored to inquiry experiences.

Scientific inquiry is a powerful way of understanding science content. Students learn how to ask questions and use evidence to answer them. In the process of learning the strategies of scientific inquiry, students learn to conduct an investigation and collect evidence from a variety of sources, develop an explanation from the data, and communicate and defend their conclusions. Scientific inquiry is a topic well suited to the middle school science curriculum. The ***National Science Education Standards (NSES, 2003)***, recognizes the importance of the topic and lists both abilities and understandings of inquiry. Students are naturally curious about the world. Inquiry-based instruction offers an opportunity to engage student interest in scientific investigation, sharpen critical-thinking skills, distinguish science from pseudoscience, increase awareness of the importance of basic research, and humanize the image of scientists. These approaches include:

- developing the understandings and abilities of inquiry;
- formulating and testing a hypothesis;
- collecting data and constructing and defending an explanation;
- developing, using, and analyzing models; and
- analyzing historical case studies.

A brief description some of the findings from the National Research Council (NRC, 2004) report follows:

- Understanding science is more than knowing facts.

Science is a way of knowing. More than a collection of facts, science is a process by which scientists learn about the world and solve problems. Scientists organize information into conceptual frameworks that allow them to make connections between major concepts. It is important for students to distinguish science as a way of knowing from other ways of knowing by recognizing that science provides evidence-based answers to questions. Furthermore, decisions should be based on empirical evidence rather than on the perception of evidence.

- Students build new knowledge and understanding based on what they already know and believe.

The knowledge and beliefs that students bring with them to the classroom affect their learning. If their understanding is consistent with the currently accepted scientific explanation, then it can serve as a foundation upon which they can build a deeper understanding. If, however, students hold beliefs that run counter to prevailing science, it may be difficult to change their thinking. Student misconceptions can be difficult to overcome. Simply telling students the correct answer is not likely to change their way of thinking. Inquiry-based instruction provides opportunities for students to experience scientific phenomena and processes directly.

- Students formulate new knowledge by modifying and refining their current concepts and by adding new concepts to what they already know.

Two things must occur for students to change their conceptual framework. First, they must realize that their understanding is inadequate. This happens when they cannot satisfactorily account for an event or observation. Second, they must recognize an alternative explanation that better accounts for the event or observation and is understandable to them.

- Learning is mediated by the social environment in which learners interact with others.

Students do not construct their understanding in isolation. They test and refine their thinking through interactions with others. Simply articulating ideas to another person helps students realize the knowledge they feel comfortable with and the knowledge they lack. By listening to other points of view, students are exposed to new ideas that challenge them to revise their own thinking.

The National Science Education Standards (***NSES,*** 2003) recognizes inquiry as both a learning goal and a teaching method. To that end, the content standards for the Science as Inquiry section in the ***NSES*** include both abilities and understandings of inquiry. The ***NSES*** (2003) identifies five essential elements of inquiry teaching and learning that apply across all grade levels:

1. Learners are engaged by scientifically oriented questions.

Scientists recognize two primary types of questions. The ***existence*** questions often ask why. ***Causal*** questions ask how. The teacher plays a critical role in guiding students to questions that can be answered with means at their disposal. Sometimes this simply involves changing a "why" question to a "how" question.

2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.

Scientists obtain evidence as scientific data by recording observations and making measurements. The accuracy of data can be checked by repeating the observations or making new measurements. In the classroom, students use data to construct explanations for scientific phenomena.

3. Learners formulate explanations from evidence to address scientifically oriented questions.

This element of inquiry differs from the previous one in that it stresses the path from evidence to explanation, rather than the criteria used to define evidence. Scientific explanations are consistent with the available evidence and are subject to criticism and revision. Furthermore, scientific explanations extend beyond current knowledge and propose new understandings that extend the knowledge base. The same is true for students who generate new ideas by building on their personal knowledge base.

4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.

Scientific inquiry differs from other forms of inquiry in that proposed explanations may be revised or thrown out altogether in light of new information. Students may consider alternative explanations as they compare their results with those of others. Students also should become aware of how their results relate to current scientific knowledge.

5. Learners communicate and justify their proposed explanations.

Students benefit by sharing their results with their classmates. This gives them an opportunity to ask questions, examine evidence, identify faulty reasoning, consider whether conclusions go beyond the data, and suggest alternative explanations.

Inquiry lessons can be described as either full or partial with respect to the five essential elements of inquiry described in the Table (1). Full-inquiry lessons make use of each element, although any individual element can vary with respect to how much direction comes from the learner and how much comes from the teacher. For example, inquiry begins with a scientifically oriented question. This question may come from the student, or the student may choose the question from a list. Alternatively, the teacher may simply provide the question. Inquiry lessons are described as partial when one or more of the five essential elements of inquiry are missing. For example, if the teacher demonstrates how something works rather than allowing students to discover it for themselves, then that lesson is regarded as partial inquiry.

Table 1. Essential Features of Classroom Inquiry and Their Variations.

Essential Feature	Variations			
Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies a question provided by the teacher, materials, or other source	Learner engages in a question provided by the teacher, materials, or other source
Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner is directed to collect certain data	Learner is given data and asked to analyze	Learner is given data and told how to analyze
Learner formulates explanations from evidence	Learner formulates explanations after summarizing evidence	Learner is guided in process of formulating explanations from evidence	Learner is given possible ways to use evidence to formulate explanation	Learner is provided with evidence
Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner is directed toward areas and sources of scientific knowledge	Learner is given possible connections	
Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanation	Learner is coached in development of communication	Learner is provided broad guidelines to use to sharpen communication	Learner is given steps and procedures for communication
More ◄— Amount of Learner Self-Direction —► Less Less ◄— Amount of Direction from Teacher or Material —► More				
Source: National Research Council. 2002. Inquiry and the National Science Education Standards: A Guide for Teaching and Learning. Washington, D.C.: National Academy Press.				

There is much confusion about the distinction between nature of science and scientific inquiry. It is useful to conceptualize scientific inquiry as the process by which scientific knowledge is develop and, by virtue of the conventions and assumptions of this process, the knowledge produced necessarily has certain unavoidable characteristics (i.e., NOS). From the perspective of The National Science Education Standards (2003) students are expected to be able to develop scientific questions and then design and conduct investigations that will yield the date necessary for arriving at conclusions for the stated questions. The Benchmarks for Science Literacy (AAAS, 1993) are a little bit less ambitious, in term of doing inquiry, as they do not advocate that all students be able to design and conduct investigation in total.

Two general approaches have been clearly evident over the years in the science education literature when it comes to the enhancement of students´ and teachers´ understanding of NOS and/or scientific inquiry. The first label approach, labeled here as the implicit approach suggests that by "doing science" students will also come to understand NOS and scientific inquiry (Lawson, 1982; Rowe, 1974). This approach was adopted by most of the curricula of the 1960s and 70s that emphasized hands-on, inquiry-based activities and process-skills instructions. Research studies have clearly indicated that the implicit approach was not effective in enhancing students´ and teachers´ understandings of NOS or scientific inquiry (e.g., Durkee, 1974; Haukoos & Penick, 1985; Riley, 1979; Spears & Zollman, 1977; Trent, 1965).

The second approach suggests that incorporating the history of science in science teaching can serve to enhance students´ views of NOS. However, a review of the efforts that aimed to assess the influence of incorporating the history of science in science teaching (Klopfer & Cooley, 1963; Solomon, Duveen, Scot & McCarthy, 1992; Welch & Walberg, 1972) indicates that evidence concerning the effectiveness of the historical approach is, at best, inconclusive. Most recently, the work of Abd-El-Khalick and Lederman (2000) has indicated that specific courses in the history and/or philosophy of science have little impact on students´ understanding of NOS and scientific inquiry.

There is a more than promising alternative instructional approach. The approach recognize that the goal of improving students´ views of the scientific endeavor should be planned for instead of being anticipated as a side effect or secondary product of varying approaches to science teaching (Akindehin, 1988). This approach, labeled here as explicit approach, uses instruction specifically focused on various aspects of NOS to improve students´ views of NOS. The explicit approach has been more effective in helping learners achieve enhanced understandings of NOS and scientific inquiry (e.g., Abd-El-Khalick & Lederman, 2000; Akindehin, 1988; Bell, Blair, Crawford & Lederman, 2003; Lederman, 1999; Ogunniyi, 1983; Olstad, 1969).

Conclusion

Inquiry and nature of science have become an almost ubiquitous themes in science education around the world. Abd-El-Khalick, et al (2004) noted that inquiry in science education is one of the few overarching themes that cut across pre-college science curricula in countries around the globe. The prominence of inquiry in science education highlights the need to understand what is inquiry and what are the challenges of implementation.

The teacher should attempt to promote student understanding of traditional subject matter using an inquiry-oriented teaching approach. Such approach provides students with experience in "doing" science, an experiential base upon which to reflect about the process and nature of science. NOS and scientific inquiry can serve as unifying themes that provide a meaningful context for the learning of the more traditional science concepts and principles. NOS and scientific inquiry are instructional objectives of primary importance that permeate all aspects of curriculum and instruction.

Science educators have come to believe that if students understand the source and limits of scientific knowledge they will be better equipped to make informed decisions about personal and societal problems that are scientifically-based. In short, understandings NOS are believed to be critical and essential components of the modern day battle cry of "scientific literacy". Understanding NOS as well as scientific inquiry, provides a guiding framework and context for the meaningful understanding of scientific knowledge. Students will come to understand NOS and scientific inquiry simply by "doing science". NOS and scientific inquiry need to be addressed explicitly during science education.

Studying the state curricular material of the science education in the Czech Republic, we can not find the concepts of inquiry and nature of science there. In the literature of didactics of physics, chemistry or biology is the same situation: the concept of inquiry and nature of science are not there. It is clear that the definition of the concept inquiry and nature of science we cannot find in the Czech literature. But we can find many concepts that are connected or related with the inquiry there: e.g. hands-on experiments, problem solving, formulating of hypotheses, designing experiments, gathering and analyzing data, drawing conclusions.

In the Czech Republic science instruction is still too traditional. Teachers knowledge about inquiry and nature of science is necessary for its implementation in the instruction. Teachers need to be well versed in scientific inquiry as a teaching approach. Teachers need to develop pedagogical skills necessary to teach effectively about and for inquiry and nature of science. Teachers must value knowledge and skills about inquiry and nature of science as important. Having the knowledge and skills to teach inquiry is a little of use if science teachers do not value the importance of these instructional outcomes. Such importance is not intuitively obvious to teachers and students. Curricular materials should enhance the valuing of the inquiry approach to science teaching. Teachers should recognize from their practice that this approach brings deeper understanding of the nature of science, better results of students and their higher motivation and interest to study science.

References

Ab-El-Khalick, F., & Lederman, N.G. (2000). Improving science teachers' conceptions of the nature of science: A critical review of the literature. International Journal of Science Education, 22(7), p. 665–701.

Abd-El-Khalick, F., BouJaoude, S., Duschl, R., Lederman, N.G., Mamlock-Naaman, R., Hofstein, A., Niaz, M., Treagust, D., & Tuan, H, (2004). Inquiry in science education: International perspective. Science Education, 88: 397–419.

Aikenhead, G. (1973). The measurement of high school students' knowledge about science and scientists. Science Education, 57(4), p. 349–359.

Akindehin, F. (1988). Effect of an instructional package on preservice science teachers´ understanding of nature of science and acquisition of science-related attitudes. Science Education, 72(1), p. 73–82.

American Association for the Advancement of Science AAAS (1993). Benchmarks for Science Literacy. New York: Oxford University Press.

Bady, R. A. (1979). Students' understanding of hypothesis testing. Journal of Research in Science Teaching, 16 (1), p. 61–65.

Bell, R. Blair, R., Lederman, N. G. & Crafword, B. (2003). Just do it? Impact of a science apprenticeship on high school students' understandings of nature of science and scientific inquiry. Journal of Research in Science Teaching, 40(5), p. 487–509.

Broadhust, N. A. (1970). A study of selected learning outcomes of graduating high school students in South Australian Schools. Science Education, 54(1), p. 17–21.

Durkee, P. (1974). An analysis of the appropriateness and utilization of TOUS with special references to high-ability students studying physics. Science Education, 58(3), p. 343–356.

Haukoos, G. D., & Penik, J.E. (1985). The effects of classroom climate on college science students: A replication study. Journal of Research in Science Teaching, 22(2), p. 163–168.

Klopfer, L. E., & Cooley, W.W. (1963). A history of science cases for high schools in the development of student understanding of science and scientists. Journal of Research in Science Teaching, 1(1), p. 33–47.

Lawson, A. E. (1982). The nature of advanced reasoning and science instruction. Journal of Research in Science Teaching, 19(5), p. 743–760.

Lederman, N. G. (1992). Students' and teachers' conceptions of nature of science: A review of the research. Journal of Research in Science Teaching, 29(4), p. 331–359.

Lederman, N. G. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede relationship. Journal of Research in Science Teaching, 36(8), p. 916–929.

Lederman, N. G. (2006). Syntax of nature of science within inquiry and science instruction. In: Flick, L. B. & Lederman, N. G. (Eds). Scientific Inquiry and Nature of Science. Dordrecht: Springer, p. 301–317.

Lederman, N. G., & O'Malley, M. (1990). Students' perceptions of tentativeness in science: Development, use, and sources of change. Science Education, 74(2), p. 225–239.

Mackay, L. D. (1971). Development of understanding about the nature of science. Journal of Research in Science Teaching, 8(1), p. 57–66.

National Science Education Standards. (2003). Washington, D.C.: National Academy Press.

National Research Council NRC (2004). Inquiry and the National Science Education Standards. A guide for teaching and learning. Washington, D.C.: National Academy Press.

Ogunniyi, M. B. (1983). Relative effects of a history/philosophy of science course on student teachers' performance on two models of science. Research in Science & Technological Education, 1(2), p. 193–199.

Olstad, R. G. (1969). The effect of science teaching methods on the understanding of science. Science Education, 53(1), p. 9–11.

Riley, J.P. (1979). The influence of hands/on science process training on preservise teachers' acquisition of process skills and attitude toward science and science teaching. Journal of Research in Science Teaching, 16(5), p. 373/384.

Rowe, M. B. (1974). A humanistic intent: The program of preservice elementary education at the University of Florida. Science Education, 58, 369-376.

Solomon, J., Duveen, J., Scot, L. & McCarthy, S. (1992). Teaching about the nature of science through history: Action research in classroom. Journal of Research in Science Teaching, 29(4), p. 409–421.

Spears, J., & Zollman, D. (1977). The influence of structured versus unstructured laboratory on students' understanding of process of science. Journal of Research in Science Teaching, 14(1), p. 33–38.

Tamir, P., & Zohar, A. (1991). Antropomorphism and teleology in reasoning about biological phenomena. Science Education, 75(1), 57–68.

Trent, J. (1965). The attainment of the concept "understanding science" using contrasting physics courses. Journal of Research in Science Teaching, 3(3), p. 224–229.

Welch, W.W., & Walberg, H.J. (1972). A national experiment in curriculum evaluation. American Educational Research Journal, 9 (3), p. 373–383.

GEOGRAFIJOS TERMINŲ MOKYMAS DIDAKTINIO ŽAIDIMO METODU: KAI KURIE TAIKYMO ASPEKTAI

Laima Railienė
Šiaulių universitetas. Gamtamokslinio ugdymo tyrimų centras, Šiauliai
El. paštas: laimarailiene@yahoo.com

Įvadas

Mokytojas ir mokinys susitinka ir veikia pedagoginėse situacijose. Jos gali susiklostyti natūraliai arba būti dirbtinai kuriamos. Vienu atveju mokytojas, atėjęs į klasę, derina savo veiksmus prie jau susiklosčiusių aplinkybių. Tada galima teigti, kad tokia situacija mokytoją valdo. Kitu atveju dar prieš eidamas į klasę mokytojas sąmoningai pasiruošia kurti tam tikro pobūdžio pedagoginę (-es) situaciją (-as). Pastarasis atvejis leidžia teigti, kad kalbama apie pedagoginę veiklą, kurios paskirtis – sukurti prielaidas moksleiviams sąmoningai kreipti savo veiksmus į ugdymosi veiklą. Tik bendra mokytojo ir mokinio veikla sukuria pedagogines situacijas. Jos gali būti penkių tipų: informacijos perdavimo, bendros veiklos, vadovavimo, konsultavimo, ekspertavimo. Bendroje mokytojo ir mokinio veikloje galima išskirti du komponentus: ugdymą ir ugdymąsi. Jei jos viena kitą atliepia ir yra kuriama veiksmų seka, natūraliai klostosi procesas (ugdymo ir ugdymosi), o rezultatas – pažinimas (Bižys, Linkaitytė, Valiuškevičiūtė, 1996).

Apie mokymąsi diskutuojama mokyklose, namuose, įstaigose, žiniasklaidoje. Pastaruoju metu labai akcentuojama mokymosi kokybė, įgytos bendrosios ir dalykinės kompetencijos. Taip pat pripažįstama, kad mokymasis yra labai sudėtingas procesas. Net mokslininkai ir iškiliausi pedagogai skirtingai jį traktuoja ir ginčijasi. Paskutiniu dešimtmečiu psichologai ir švietimo specialistai prakalbo apie konstruktyviai suprantamą mokymąsi, kuris reiškia tokią veiklą, kuri pabrėžia aktyvų individo vaidmenį apdorojant informaciją ir formuojant žinias. Šiuo metu labai sustiprėjęs dėmesys mokymuisi ir išmokimui klasėje. Dabartiniai mokslininkai sutaria dėl gero mokymosi bruožų. Išskiriami šeši ypatumai, nurodantys, kokios krypties reikėtų laikytis, kad pagerėtų mokymas ir mokymasis mūsų mokyklose: **mokymasis yra aktyvus konstravimo procesas, mokymasis yra sukauptų žinių susiejimas, mokymasis yra bendradarbiavimas,**