Shaping the Basic Learning Area of Science Education with Empirical Studies in the Context of the Curriculum:

The Case of CERN [1]

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Abstract

In this article, I have determined the origins of this decline and how the scientific community and teachers can react to it. The most important principles and results are the logic of cooperation between scientific organizations and Science for future high school education to produce the curriculum by reducing the initial 'national curriculum'. On-site visits, exhibitions and practical workshops. In addition, many types of organizations can serve as out-of-school resources. The first thing that comes to mind is museums, and research institutes are also important. Industries, foundations and many other organizations also play important roles. Research institutes, such as the European Organization for Nuclear Research (CERN), also have a network of out-of-school resources.

My experience in the field of empirical research findings in this study.

9. CERN Turkish Teachers Workshop was held between 27 January - 2 February 2019 in Geneva. The necessary information about my acceptance is given in the link.

Keywords

Science Education, CERN, collaborative curriculum development

Introduction

One of the most important requirements of the education of science literate individuals, which have been among the objectives of many curricula in recent years, is to develop understanding of the nature of science. However, studies show that science teachers also have some misconceptions about the nature of science.

In the first level of science education in Turkey, the curriculum, the other curriculum theory recently seen in the development and implementation rhetoric it was not the same.

The Ministry of Education 'determined to have a formal curriculum in Turkey. For different countries, however, without a formal curriculum, Science 1 level teachers have only accredited characteristics and their own pedagogies to be created for their students. Science

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* *Collider: The exhibition covers the work of the Large Hadron Collider (LHC) at CERN, the world's largest particle physics facility. Strategically, the subject matter had obvious appeal for the Science Museum, with its long term ambitions to tackle complex scientific topics, attract more adult visitors, and raise its international profile (Science Museum, 2012).*

teaching is held responsible for the teaching profession and is expected to be solved without formal assistance. There are three main areas for science educators to respond to within the curriculum, namely minority groups in Science, the objectives of 1-level Science students, and the view of Science education in society.

In this study, my experience in CERN and the studies conducted in this field are discussed within the framework of empirical research findings.

About CERN

CERN was established in 1953 under a UNESCO-sponsored convention signed by twelve European countries and twelve Europeans in a 1953 convention. These were twenty Member States, including most Western Europe and several Central and Eastern European countries. The visiting flux of visiting scientists from around the world keeps CERN young. The age distribution of visiting scientists often has a long queue of these students, professors who teach at universities in Europe and elsewhere. The hope of attracting these students provides a motivation for CERN’s social assistance activities.

On the CERN general homepage, you can take a virtual tour of CERN. The web is also a potentially powerful tool for school education. Many of the activities I have discussed here will cover the field work, including programs for secondary schools, interactive materials on the museum Web, within the framework of document analysis.

If observation is not the basis of science, what is it? The common answer to this question is that science presents explanatory theories about the material world. In the words of Rom Harre - iler theories are the crown of science, ”because for them our understanding of the world is expressed” (Harre, 1986, p. 168).

“Big leaps in science enable testable predictions, most importantly from the creation of world models and dreams that explain surprising observations, rather than when considering generalizations (which will be discussed later, although it plays an important role for such behaviors) from many observations.

As Norris argues, ‘Merely considering the mathematical tools that are available for data analysis immediately puts the study of method beyond what is learnable in a lifetime’ (1997, p. 245). Likewise, the experimental organic chemist has a large range and repertoire of methods that have been acquired through years of practice.

Cern aims have built strong partnerships with our donors to provide world-class education to students, teachers and young professionals in the STEM fields; to engage the public with science; to change lives through Technologies developed at CERN; and to foster dialogue between arts and science. With its varied programmes, the CERN & Society Foundation strives in particular to empower youth through advanced training.

At CERN, 76 secondary school science teachers were trained in contemporary particle physics, an innovative way to enhance and update their teaching in class. The Foundation was also able to support a record number of 62 summer students from developing countries for studies of particle physics, engineering and IT at CERN; and 10 students in entrepreneurship were hosted at CERN for the first time, to learn about new technologies developed by the Laboratory and to find novel ways of exploiting them for broader societal benefit.

As far as the future is concerned, the Foundation will maintain its focus on youth and education and support the capital campaign for the CERN Science Gateway, an iconic new education centre to be located in the area around the Globe of Science and Innovation.

Science Gateway Vision;

The Science Gateway project will allow us to:

• Increase and expand the impact of the education, communication and outreach actions aimed at the public

• Fulfil the +300,000 visit requests received annually

• Involve a range of people of all age groups (starting from 5 years old)

• Become more actively engaged with the local population and build ties with CERN's Member, Associate and

Non-Member States Activities intended for all age groups:

• Mini-workshops and laboratories involving practical and educational experience

• Interactive installations to explore physics in a basic yet entertaining way

• Virtual visits of CERN laboratories

• Temporary and permanent exhibitions, highlighting key elements such as: Arts at CERN, societal impact of CERN's scientific discoveries & technological innovations, and wellknown science personalities

• Live connections with other science centres or international partners for engaging scientific events.

In this article, I have determined the origins of this decline and how the scientific community and teachers can react to it. The most important principles and results are the logic of cooperation between scientific organizations and Science for future high school education to produce the curriculum by reducing the initial 'national curriculum'. On-site visits, exhibitions and practical workshops. In addition, many types of organizations can serve as out-of-school resources. The first thing that comes to mind is museums, and research institutes are also important. Industries, foundations and many other organizations also play important roles. Research institutes, such as the European Organization for Nuclear Research (CERN), also have a network of out-of-school resources.

My experience in the field of empirical research findings in this study.

Science Gateway, the new iconic centre for science, education and outreach, is scheduled for completion by summer 2022. The building is being designed by world-renowned architect Renzo Piano and his team, and will be funded entirely through external donations. The purpose of Science Gateway is to inspire the public, instilling in them curiosity for science and innovation, and especially encouraging young people to pursue careers in Science, Technology, Engineering and Mathematics (STEM) (2018, Annual Review of Science Gateway).

ABOUT LITERATURE REVIEW

Understanding Scientific Reasoning

Lederman (1992, p. 332) has identified four lines of research into topics related to the teaching of the nature of science:

* attempts to assess student conceptions of the nature of science (NOS);

* curriculum innovations designed to 'improve' students' conceptions of the nature of the nature of science:

* the assessment of, and attempts to improve, teachers' conceptions of the nature of science; and identification of the relationship between teachers' conceptions, classroom practice, and students' conceptions. In this last section of the chapter we will be discuss predominantly at the first and the third of these areas.

Table 1. Empirical Studies on the Subject

Author	Year	Information About The Research
Lederman	2006	Students' views, their sources and changes Space does not permit a full treatment of the substantial body of research that has been conducted in this domain. Hence, what is offered here is a selection of the work of the most recognized researchers who have explored this area. Best known is perhaps Lederman who has written his own review of research in the field to which the reader wishing a more extensive treatment is referred.
Driver et al., Lederman and O'Malley, Mead and Metraux.	1996 1990 1957	The dominant theme that has emerged from this work is that students view scientific knowledge as absolute and literal truths about the world and that the primary objective of science is to uncover or 'discover' new scientific facts
Lederman and	1990	undertook a survey of changes to 55 US high school grade 9 to 12 (age 14–18) students' views of science after a year of science classes. The students were in three

O'Malley		classes each taught by a different teacher.
***Table 1: Prepared by the researcher (Calımlı, A. 2019).**		

Lederman and O'Malley (1990) undertook a survey of changes to 55 US high school grade 9 to 12 (age 14–18) students' views of science after a year of science classes. The students were in three classes each taught by a different teacher. The instrument used to monitor the students' views consisted of items to which the students were invited to give open responses:

1. After scientists have developed a theory (for example, atomic theory), does the theory ever change? If you believe theories do change, explain why we bother to learn about theories.

2. What does an atom look like? How do scientists know an atom looks like what you have described or drawn?

3. Is there a difference between a scientific theory and a scientific law?

4. Some astrophysicists believe that the universe is expanding while others believe that the universe is shrinking: still others believe that the universe is in a static state without any expansion or shrinkage.

How are these different conclusions possible if all these scientists are looking at the same experiment and data?

Lederman and O'Malley coded the students' responses as either absolutist or tentative, which roughly translates into the more orthodox terms of realist or instrumentalist. An instrumentalist view is associated with the notion that scientific ideas are tentative and can be arrived at through various methods and are valued because they work rather than because they are true. For instrumentalists, the descriptions and explanations produced are not evaluated with respect to their match to reality, but rather with respect to how useful they are. Over the year of the study, the students' responses to item 1 showed a shift away from absolutist views towards more tentative views.

Responses to item 2 showed the most marked shift towards tentative views.

Responses to item 3 showed little change,

while responses to item 4 showed mostly bafflement on the part of students with the highest number of no responses and unclear responses.

It was a naturalistic study and so the three teachers had not been asked to diverge from their normal teaching over the year. The authors conclude that these students' views on the nature of science developed out of the science they were exposed to, and that the more science they learnt, the less absolutist they became a more recent cross-sectional survey study undertaken by Kang et al. (2005) explored Korean elementary, middle and high school students' NOS conceptions with 534 sixth graders, 551 eighth graders and 617 tenth graders. The authors found that less than 20 per cent considered the purpose of science as creating explanations. Instead, almost half the students considered scientific theories as facts proven through experimentation and testing.

Furthermore, Only about 25 per cent of students considered scientific theories to be the basis of scientific explanations and, even then, many of these students were found to hold misconceptions of the notion of explanation when interviewed, which they viewed as descriptive rather than causal. Similar findings emerge from a more extensive qualitative study conducted by Driver et al. (1996). They undertook an interview-based study focusing on whether students were capable of discriminating between theories and facts in science and how they related evidence and theories. Their study was undertaken with three different age groups (9, 12 and 16 years old). The authors created six probes that pairs of students had to discuss during an interview. In order to compare the results across ages, the probes presented used the same science content that was seen as being accessible to all age groups. This group of researchers concluded that students have difficulties determining the role of theories in science and how theories are evaluated against existing data.

Scientific theories were particularly dominant among the 9-year-old students. Furthermore, some students considered scientific theories as involving the correlation of variables. For example, when students tried to explain why a balloon with hot air inflates, they stated that the heat makes the air inside the balloon hotter, which makes the balloon blow up – essentially, Driver et al. (1996) found that, overall, older students demonstrated a more sophisticated understanding of scientific theories suggesting that students' understanding of the nature of scientific theories may improve with age and with science teaching that encourages or permits discussion and reflection on the nature of the subject.

If science teaching is to mean anything more than the acquisition of a few tags of knowledge and a certain skill in manipulation we must accord to science a place among the humanities. The teacher must try to give his pupils the conception of science as a process of development through human endeavour. He must avoid the dogmatic attitude shown in many elementary text books and help the pupils to gain some critical insight into the conclusions of science. The old dictum that science is exact measurement obviously requires modification and the teacher of science must endeavour to make his pupils realize the limitations and scope of physical measurements (Turner, 1927, p. 191).

In this context, it may be recommended to develop a wide range of practical implementations, not only for teachers in the United States, but also for other countries.

Koulaidis and Ogborn (1989) surveyed the views of 54 teachers of science and 40 student teachers associated with the Institute of Education, London, during 1984–85. They designed a questionnaire to monitor ideas on the nature of scientific method, the criteria of demarcation of science from non-science, ideas on patterns of scientific change and ideas on the status of scientific knowledge. The teachers and student teachers who took part in the study were presented with statements such as:

As science changes or develops, new knowledge generally replaces ignorance or lack of knowledge. New scientific knowledge follows no pattern of growth, being purely the result of what scientists happen to have done.

The teachers were invited to agree or disagree with the statements. Having analysed the teachers' responses, Koulaidis and Ogborn present a set of three broad tendencies that mark out the constellations of views which characterize most of the teachers and student teachers in their sample. These were 'inductivists', 'hypothetico-deductivists', and 'contextualists'.

The last are individuals who have a broadly Kuhnian perspective which sees science as being a socially situated product. Contextualists were further divided into three groups: (1) contextual rationalists who were essentially realists with a pragmatic view about what science could achieve; (2) relativists; and (3) undecided contextualists. The picture that emerged was not one of homogeneity. Both relativism and hypothetico-deductivism got scant support.

This evidence suggests that not only does the subject content influence one's views, but it looks as though experience in the classroom may modify those views as well.

In their classes, the 25 teachers devoted virtually no time to discussion of matters related to the nature of science, such as how the knowledge included in the curriculum came to be or the processes by which scientists validate knowledge – the only exception being an initial treatment of 'the scientific method' and an emphasis on the 'objectivity of science'. Gallagher argues that such emphasis is used to endow a higher epistemic status on science compared to other subjects.

Clearly little had changed since the 1950s when Anderson (1950), in a study of a high school teachers (56), ascribed ignorance of knowledge of the scientific method to teachers being too busy imparting the factual aspects of the curriculum to be interested and/or concerned about how science works. What effect does this state of affairs have on the teaching of science? Lederman and Zeidler (1987) looked at the views on the nature of science and classroom actions of, each with a minimum of five years service (average 15.8 years service). They also carried out classroom observations of the teachers at work as well as giving the teachers a 48-item questionnaire to complete. From their analysis of the data they concluded that the views the teachers expressed on the nature of science and scientific knowledge had little relationship, and therefore effect, on the actual classroom actions of the teachers. For beliefs to have any effect on actions, there must be choices of alternative actions. For most science teachers the choices are not formulated in terms of different approaches to the nature of science and scientific knowledge. Instead, the choices they face are technical.

Even if the nature of science is explicitly addressed by teachers, the extent to which explicit teaching of the nature of science can help to develop students' understanding is an open question. Zeidler and Lederman (1989) report a survey of 409 US students who studied with 18 high school science and biology teachers.

The students completed a questionnaire at the beginning and end of a fall (autumn) semester and were categorized as showing either a realist view of science or an instrumentalist view of science. Shifts in the students' responses between the beginning and the end of the semester were computed. Some students became more realist in their views while others became more instrumentalist.

During that semester a researcher collected data on the classroom behaviour of the 18 teachers. Transcripts were made of classroom talk, observation schedules were used to record events, and copies of notes on blackboards were taken down. The teachers' classroom language was then matched against the shifts in the students' responses. This and other more recent studies (Khisfe, 2008; Khisfe and Abd-El-Khalick, 2002) both lend weight to the view that student understanding of the nature of the discipline will only develop if the concepts are explicitly explored in classrooms.

However, teaching about the nature of science explicitly would appear to be a necessary rather than a sufficient condition. For instance, Leach et al. (2003) found in a study in English high schools with seventy 16–17 year old students, that a substantial minority of the students made no progress in their understanding.

This purpose of this study is to investigate how the course designed based on constructivist principles has been implemented, what actions have been taken to solve problems and what thoughts have arisen in the minds of teacher candidates with regard to the constructivist learning approach.

	Topics	Activity	Reflective Notes	Plan of action
Week 1	Introduction to the course	Case study analysis	In the case study analyses, it emerged that the teacher candidates, in their own analyses, explained the roles of teacher and students from traditional viewpoint. For example, they made comments such as “the student cannot give an answer as the teacher has not explained the topic”, “the students need to listen to the teacher more to learn the subject” and “they must repeat more often”, “The student couldn’t explain the problem as expected by the teacher.”	The content of the lesson was devised as a draft according to the needs of the students. For example, to allow teacher candidates to obtain the necessary theoretical knowledge, a reading list was prepared.
Week 2	Construction of the course	The content of the lesson was formed together with the teacher candidates	The teacher candidates requested from the instructor to explain topics and give course notes related to the topics presented to them.	It was decided to create four learning plans and four activities, to distribute the course notes prepared by the instructor and the reading lists on the topics to the teacher candidates to provide material source.
Week 3	Constructivist learning	Application of 5E teaching model. Teacher candidates studied in a group.	It was observed that participation among group members was limited. In particular, it was realized that the ability of groups to create activities in the learning environment in the learning plans based on constructivist learning was weak.	A learning plan based on the 5E model was requested for the next lesson from the groups.
Week 4	Constructivist learning	*Presentation of the 1st learning plan* on the topic of “teaching strategies”.	In the learning plans, there appeared little consistency between objectives, teaching-learning process and evaluation processes. Within the learning process, objectives were restricted to the knowledge level. For example, in the learning plans, objectives were expressed at comprehension and application level, nevertheless in the teaching-learning process, these objectives remained at knowledge level. Furthermore, at the evaluation stage, the product evaluation was emphasized but process evaluation was not taken into account.	It was decided to find and let them examine example activities that teacher candidates could use in the preparation of learning experiences so as to raise the level of objectives to comprehension and application level. Written notes and recommendation for improving lesson plans were given.

Week 5	Cooperative learning	The cooperative learning method was applied. Teacher candidates studied in groups	It was observed that teacher candidates derived a great amount of satisfaction from this process. By putting the method into practice, it served to help teacher candidates to internalize the topic.	It was decided to ask teacher candidates to prepare a learning plan for their own lessons based on cooperative learning method.
Week 6	Cooperative learning	*Presentation of the 2nd learning plan.* The plans drawn up by the groups were presented to the class.	It was observed that the principles of the methods had been adopted into the plans and expressed in the correct way. Nevertheless, raising objectives to the comprehension level was still weak and the homework devised to relate the topic to real life was also weak and insufficient. For example, on the topic of the 'Processing of Acids and Bases', the groups had set out the principles of the method to their lesson plans very well, however when it came to assigning homework that would allow students to transfer that knowledge of acids and bases to real life, it was observed that the assignments were unsatisfactory.	It was decided to explain the groups what was meant by a homework assignment related to real life and how such assignments could help to raise students to a higher cognitive level. Teacher candidates should learn how such homework is created, with clear explanations of each step of the process. Teacher candidates would be requested to bring in examples of their own and to focus particular on examples that help to enhance or underpin a subject. It was also decided to hold a tournament based on this topic.
Week 7	Mid-term exam week	The mid-term exam was set in a multiple-choice format and designed with the purpose of identifying students' misconceptions.	Teacher candidates were successful in answering questions related to the characteristics of the methods. Nevertheless, in comparisons between certain concepts: e.g. model and strategy, some mistakes were made. As for case study analysis, they had misconceptions in particular on the topic of the precautions that had to be taken by a teacher in a constructivist environment.	The teacher candidates were requested to produce a concept map for the next lesson with regard to their misconceptions and to evaluate the other's concept map together in pairs in the class. They were also asked that a student would draw a concept map on the board with the direction of other students and a moderator.

What we do not know much about is how pre-service teachers develop understanding and awareness of ways to teach 'the nature of science'. It may be the case that they do not have an understanding of the link between what they teach, how they teach and the impact on their students' view of science and scientists. It may also be the case that they do not believe that they can make much difference to their students.

The Implications for Teacher Education

Developing students' capability with a practice is not just a case of developing a skill. The ability to engage in practice is best seen as a competency (Koeppen, Hartig, Klieme, & Leutner, 2008) which is reliant on a body of knowledge which is specific to the context. The primary purpose of engaging in practice is to develop students' knowledge and understanding required by that practice, how that practice contributes to how we know what we know, and how that practice helps to build reliable knowledge. Knowledge of how we know (knowing how) is reliant on a developing a body of procedural knowledge or concepts of evidence (Gott et al., 2008). Knowing why such practices are necessary is dependent on what I choose to call epistemic knowledge. Such disciplinary knowledge, I would argue, is a necessary element of any competent teacher of science. What, then are its primary features?

Procedural Knowledge

Gott and Murphy (1987) define inquiry as an 'activity'. Within such an 'activity', they argued, students made use of both conceptual and procedural understanding.

The latter was a knowledge and understanding of scientific procedures, or 'strategies of scientific enquiry' such as 'holding one factor constant and varying the other' when controlling variables (p. 13). This insight had emerged from an analysis of their results where the research team had found that much of the variation in student performance on tasks could not be explained solely on the basis of an absence of appropriate conceptual knowledge e.g., the lack of a suitable model of the system being investigated. Rather, it was accounted for by 'procedural failures', i.e. students not holding the necessary procedural knowledge. This finding led them to the conclusion that ''the major influence on performance on this task is the availability to the child of certain relevant items of knowledge'' and that ''carrying out a scientific investigation, then, is primarily a display of understanding, and not of skill'' (Gott & Murphy: p244). As a consequence, Gott and Murphy argued for teaching of procedural knowledge explicitly suggesting that ''we must accept the need to develop an explicit underpinning [procedural] knowledge structure in the same way that we have developed such a structure for conceptual elements of the curriculum (Gott & Murphy: p. 52)''.

Final Comments

In 1996, the UK Government proposed that there should be a National Curriculum for Initial Teacher Training (NCITT). In terms of the nature of science, the proposals stated: 'As part of all courses [of initial teacher training], trainees must demonstrate that they know and understand the nature of science' (Teacher Training Agency, 1998).

This requirement rests on a premise that the nature of science is a concept that is well understood and commonly agreed. While there does seem to be an emergent consensus about the ideas that should be taught (Lederman, 1992; McComas and Olson, 1998; Osborne et al., 2003), implementing that in the practice of schools science still has far to go.

Research has demonstrated that the supposition that if teachers 'know and understand the nature of science' then they will incorporate elements of the nature of science in their lessons is flawed. The major advance of the past decade has been a consensual agreement that the nature of science or 'how science works' should be an important element of the school science curriculum.

Such policy documents rest on a final key assumption that teachers themselves have at least a working knowledge of key features of any contemporary picture of the nature of science; that they have the pedagogical content knowledge to teach the topic effectively; and then, that children will grasp its significance and salience.

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