DIDACTIC IMPLICATIONS OF USING HISTORICAL APPROACH IN TEACHING THE CONCEPT OF GENE

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Abstract

In this study, we present the results of the application of a historical approach in teaching the concept of gene. However, this is one of the most problematic concepts of genetics in both secondary and university levels. The approach consists of identifying and bringing out the conceptions of pre-service teachers of biology. It aims in confronting the various historical models of the concept of "gene" built since its invention by Wilhelm Johansen in 1909 until the advent of molecular biology. These pre-service teachers act as scientists by carrying out a critical analysis of each of the six models listed in the literature. Also, they discussed its internal and external consistency as well as its limits. They suggest an alternative model which will be in turn analyzed and modified to reach the current model. Pre-service teachers are well aware of the cognitive processes and historical construction of this concept. They have the opportunity to review their spontaneous conceptions that hinder the construction of knowledge, in the consideration of historical scientific models. A test was administered to pre-service teachers before and after the activity. It consisted of a questionnaire about the concept of gene, its functions, and its related concepts. The same test was administered to a control group of pre-service teachers who received a classical instruction on the same subject. Therefore, this approach is more effective than the classical method because it allows an evolution of the conceptions of pre-service teachers.

Keywords: Gene concept, History of science, genetics education, pre-service teachers

Introduction

Genetics is a fundamental unifying theme of biology. Consequently, it is also relevant to our everyday life. The applications of genomics have raised complex ethical and legal issues that will require a comprehensive understanding of genetics. However, genetics is also one of the most difficult topics for both students and their teachers (Bahar et al.,1999; Agorram et al., 2010, 2015; Kindfield, 1991, 1994; Lewis and Wood-Robinson, 2000).

The concept of "gene" is one of the key concepts of genetics. Thus, it is used in the teaching of genetics with several meanings. These meanings include: a computer unit in explaining the transmission of traits, a physical unit (part of the chromosome, DNA) in molecular genetics, and a particle transmission function, mutation, and recombination. Furthermore, other meanings are used in population genetics. Students often experience difficulties in differentiating these units of meanings. Hence, they are unable to define a given conception of the "gene" in a given field. For instance, they cannot understand the unifying role played by the concept of "gene" in Genetics (Agorram, 2010; Gericke & Hagberg, 2007).

On the other hand, this concept has evolved considerably since its invention by Wilhelm Johannsen in 1909. Therefore, the use of the historical approach would emphasize the development and the changing of this concept since 1909 until today. The introduction of the history of science in genetics education should not be restricted to the recall of names and the dates of researchers of scientific discoveries. Thus, it should aim to work with especially students' conceptions about science and the building of scientific knowledge in general (King, 1991; Mathy, 1997; Monk and Osborne, 1997; Wandersee, 1992).

Therefore, the aim of this research is to analyze and evaluate the impact of a teaching activity based on the integration of the history of science, on the development of Pre-service teachers' conceptions about the concept of "gene". In addition, our research question is formulated as follows: Do the integration of the history of science in teaching the concept of "gene" induces a conceptual change?

Methodology

Description of the Approach

The sequence of teaching takes place in two steps. The first step is in identifying pre-service teachers' conceptions about the concept of "gene". To do this, we used a questionnaire with three open questions. The first concerns

the definition of "gene"; the second relates to its functions; and in the third, we asked pre-service teachers to make a conceptual diagram of the term "gene". Therefore, they should include concepts related to this term while building a diagram showing the relationships between them. Pre-service teachers are solicited to present their diagram to their colleagues after a first discussion is initiated between them.

In the second step, the teacher presents the various historical models for the functions of the gene (Gericke & Hagberg, 2007; Smith & Adkison, 2008). After then, pre-service teachers discusses each model by showing its weaknesses (Based on scientific progress at the time of development of each model). Each model is also compared with its predecessors by showing the modifications integrated to it and also its shortcomings. In this way of presenting the evolution of the concept of "gene", little importance is given to dates of discoveries in genetics, neither to the names of scientists even though they are routinely specified for each model.

Approach Evaluation

The experiment was conducted with two samples. The first sample is the control sample (18 pre-service teachers) which receives a classical course (expository course) on what a gene is, and the various historical models. The second sample is the test sample (18 pre-service teachers) that had teachings based on the approach described above. To assess the changing conceptions of pre-service teachers, we used a test (questionnaire previously described). This test was administered to both samples before the activity and after four weeks.

Therefore, the analysis of responses of the first two questions can characterize the different conceptions of pre-service teachers related to the concept of "gene". However, it can also be compared to the various historical models. Consequently, concept maps constructed by the pre-service teachers were analyzed using a grid with the following criteria:

- Completeness: The indicators are the number of concepts which was mentioned. Thus, there is a valid relationship between them.
- The Complexity: The indicator is the number of branches between the concepts.
- The Organization: The indicator is the number of hierarchical levels of the conceptual network.
- The Integration (Cohesion, Conceptual Integration): The indicator is the number of cross-relationships between the branches (Beyerbach & Smith, 1990; Markham et al., 1994).

Results and Discussion

Conceptions of Pre-service Teachers on the Concept of "Gene" and its Functions

Before Activity (Pretest).

Most of the interviewed pre-service teachers defined the gene as a DNA sequence that encodes a protein. This view is consistent with the neoclassical model. Conceptions which considered the gene as a unit determining a character are also common. Therefore, conceptions that emerge most frequently in the pre-service teachers are those of the neoclassical and Mendelian model. Thus, it is also used for identification. In some pre-service teachers, conceptions can be categorized into two or more models. Analysis of responses also shows the absence of conceptions of the most recent models (post-modern and genomics models). However, there were no significant differences between the two samples.

After the Activity (Post-Test)

Analysis of responses of the first two questions shows an increase in the frequency of pre-service teachers who defined the gene as a DNA sequence coding for a protein which expresses a given character. Most of the pre-service teachers are linking the gene to its product (character) via protein. The conception of the modern model is present, and is found in over half of the test sample. Thus, this is much more than that found in the control sample. Also, we found the presence of hybrid conceptions consisting of two or more elements of historical models in pre-service teachers of the both samples. So already at this level, we note that the conceptions of pre-service teachers in the test sample have evolved more than in the control sample. The activity had a positive contribution to the evolution of these conceptions. Hence, the analysis of conceptual maps confirms this trend.

Conceptual Maps

Table 1. Evolution of indicators of conceptual change following the teaching activity

Indicator	Before the activity		After the activity	
	Control	Test	Control	Test
Total number of mentioned concepts	168	175	205	267
Valid relationships between mentioned concepts	67	84	128	173
Number of branches	9	13	15	39
Number of hierarchical levels	21	27	29	38
Number of cross-relationships between branches	2	5	7	9

After the activity, there is an increase in the number of concepts mentioned by the two samples. However, the number of valid concepts is

greater in the case of the test sample (267 against 205 for the control sample) (Table 1). Moreover, pre-service teachers in the test sample have more relationships between these concepts than in the control sample. The conceptual network has expanded and become more complexified following the teaching activity (increase in the number of branches).

However, we note that the number of hierarchical levels and the interrelationships between the branches have increased slightly. This reflects that the conceptual networks of the pre-service teachers are not organized and the integration of different concepts is limited.

These results show that there is evolution in the conceptions of the pre-service teachers (who received the teaching activity based on the historical approach) who can mobilize more knowledge (more than the mentioned concepts) and manage to establish more relationships between these concepts. Nevertheless, they failed to establish connections between these concepts in a more complex way. This may be because these pre-service teachers are not familiar with conceptual maps.

Other tests should be performed among these pre-service teachers to assess the sustainability and viability of their conceptions which are the criteria of a conceptual change.

Conclusion

Although approaches based on the introduction of the history of science in education requires more time than conventional approaches. However, their interest is certain to change conceptions as have been demonstrated by much research (Guilbert & Meloche, 1993; Kassou & Souchon, 1992). The approach used in this research is of great interest because it allowed these pre-service teachers to:

– Change their knowledge about the concept of "gene".
– Make connections between different concepts studied in genetics and other disciplines of biology.
– Be aware of the problems of knowledge construction.
– Differentiate between the approach used in teaching concepts (educational progress) and the historical process of their construction.
– Be aware that scientific concepts are not built in laboratories regardless of social context.

Subsequently, this approach has also enabled these pre-service teachers to be more critical with respect to teaching methods. In addition, it makes them aware of the difficulties and complexity of learning their future students. They are also aware that the fact of "teaching" does not mean that there is "learning" automatically. Therefore, the analysis of the development and evolution of different knowledge would provide important indicators for the trainer on the nature of knowledge, obstacles to the construction of

scientific knowledge, and the conditions of evolution of scientific knowledge. This information would be very important to think and design training projects. However, the benefits of teaching the history of science are not immediate. The exploration and development of the historical dimension with a view of training the teaching of science, involves analytical work and construction. Thus, this is aimed at developing ideas from which to launch and organize training strategies and concrete relevance.

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