INFLUENCE OF PIAGET'S THEORY ON CONVINCING EXPERTS ABOUT THE DIFFICULTIES IN THE UNDERSTANDING OF SCIENTIFIC TERMS BY CHILDREN

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Abstract

In formal education, the teaching of natural sciences begins when children are about 12 years old. Teachers justify this with the difficulty and abstraction of concepts in these sciences, and they refer to the theory of child development by Piaget. However, numerous examples from everyday life, from non-formal education, analysis of the difficulties of individual terms as well as research in the field of mathematics and didactics of chemistry show that it is possible to teach natural science at lower stages of education.
Keywords: *Piaget's theory, teaching of natural science, formal education*.

Introduction

In Europe, science education begins when children reach the age of 12 (Grajkowski, Ostrowska and Poziomek, 2014). It is based on the belief that these subjects are difficult and require children's abstract thinking skills (Johnstone, 1991). According to the Piaget theory, the fourth stage of mental development (period of formal operations) is achieved by children at the age of 12 (Bee, 2004). This means that up to the age of 12, children's knowledge of natural sciences comes from informal and non-formal education. This knowledge may contain many inaccuracies and cause misunderstandings in the student's mind. This means that children may have difficulty accepting the new scientific meaning of words they have learned earlier. Such a situation makes it difficult for them to learn science. Research conducted in America by Sruggs and Mastropieri (1993) showed that more than 750 scientific words were introduced from kindergarten to sixth grade, and history does not differ in Europe.

The question then arises: Is it possible to teach science subjects at the lower levels of education? Considering the fact that according to research (Chiappetta, 1975), at the age of 12, at least 50% of children did not reach the fourth level of development according to Piaget's theory, it seems unreasonable to wait with the science of natural sciences to this age of children. On the other hand, numerous publications, for example in the field of mathematics, show that children reach certain skills earlier than planned Piaget (eg. the concept of "stability number"). There are also numerous publications on teaching chemistry and physics of young children. Non-formal education also shows that teaching science is possible at earlier stages of education (even in kindergarten or in grades 1-3 of primary school).

It seems that all these studies and reflections should result in the introduction of natural science (especially chemistry and physics) to the lower stages of formal education.

Research Methodology

The main goal of the research was to answer the question: *at what stage of formal education, particular terms in the field of sciences can be introduced.*

To answer the question posed, the research was carried out. The research was divided into three stages. *The first stage* from September 2018 to December 2018 were interviews with teachers. There were 10 discussions of about 25 teachers in the group (about 250 teachers took part in the research). During the discussion, conducted with the snowball technique, the teachers chose these concepts from the field of natural sciences, which they considered the most difficult. The concepts chosen by the teachers were analyzed in *the second part of the research* (in January and February 2019). Analyzing the didactic relationships on the concept maps, it was checked which terms are basic for learning. For these concepts, their definitions have been analyzed. Some concepts were chosen in pairs (when their definitions were similar, or when they had a similar use). Eight concepts were selected for further research (atom, cloud, electron cloud, proportion, electric current, wind, mathematical logic, programming / coding).

Justification for Choosing the Terms

The first chosen term was ATOM. It is a concept necessary to understand the structure of matter, which is why it is necessary for the teaching of chemistry and physics. Currently, in formal education, this term appears when children are about 12 years old. Although our previous research shows that it is possible to introduce this term earlier.

The second chosen concept was PROPORTION. The term is necessary and used in mathematics, physics, chemistry, and geography. This term in formal education appears late (7-8 class primary school), although children in everyday life often use it.

The next two selected terms: WIND and ELECTRIC CURRENT - have almost identical definitions but are introduced in formal education at various levels (4th grade and 7th grade of primary school). (Because the teachers of the term WIND consider it very easy and the term ELECTRIC CURRENT too difficult).

The following concepts were chosen on a similar basis: CLOUD and ELECTRON CLOUD, as well as the MATHEMATICAL LOGIC and PROGRAMMING. (Formerly programming was considered difficult but nowadays are programming courses for preschoolers.)

Experts were invited to *the third part of the study* (March 2019). This is due to the fact that experts are responsible for assigning content to the appropriate levels of formal education. Experts have been scientists dealing with didactics of natural sciences (conducting research in this field) and / or eminent teachers. A question-based questionnaire was used for the research. Experts were asked to answer 2 questions for each of the eight selected terms:

- How old must children have to be able to enter the term '...' in formal education? (choice of one of the 5 responses),

- Is the term easy ... or very difficult. (5-step Likert scale).

Research Results

The concept of ATOM has been considered by experts as moderately difficult. However, only 9 experts (out of 28) considered that this term should be introduced when children are between 13 and 15 years old. (That's how it is now in formal education.)

The term PROPORTION was also considered by experts as moderately difficult. 11 of them believe that the term can be introduced at the beginning of primary school education (in grades 1-3). However, as many as 13 think that the term can only be understood by older children (6 experts think that children should be more than 10 years old, another 6 experts believe that children should be older than 13 years and 1 of the experts thinks that only the student who has more than 16 years can understand this concept).

The concepts of WIND and ELECTRIC CURRENT have similar definitions:
- Wind - the movement of air masses caused by the difference in atmospheric pressures;
- Electric current - orderly movement of loads caused by the difference of electrical potentials.

However, the definition of wind is known to children much earlier than the definition of electric current. Experts consider the term WIND as an easy term, ELECTRIC CURRENT, as difficult or very difficult. As many as 14 experts believe that the term WIND can be introduced when children are between 3 and 6 years old. However, 13 experts believe that children must be 10-12 years old to teach about ELECTRICAL CURRENCY.

The terms CLOUD and ELECTRON CLOUD do not have a similar definition. However, using a comparison of the electron cloud with a cloud in the sky - we can explain this concept well. (The cloud has no visible boundaries - just like a cloud in an atom. Two smaller clouds can merge into a larger one - just as molecular bonds are formed. The formation of drops of rain from a blurred cloud is a good analogy showing the corpuscular-wave duality.) Despite the large parallels between the two concepts, the experts assessed them differently. 12 experts considered the term CLOUD easy to understand (after 8 very easy and medium difficulty). While 13 experts found the term ELECTRON CLOUD too difficult to understand (after 7 for medium difficult and extremely difficult). 15 experts found that the date of CLOUD can be already introduced in pre-primary education (3-6 years). Also, 15 experts felt that the term ELECTRON CLOUD can be made on formal education when children have more than 13 years.

A similar situation applies to a couple of concepts MATICATED LOGIC and CODING. Although experts consider both concepts to be moderately difficult, however, MATHEMATICAL LOGIC should be introduced at a later stage of education.

Table 1. Experts' answers regarding the difficulties of particular concepts.

	Atom	Propor-tion	Wind	Electric current	Cloud	Electron cloud	Mathemat-ical logic	Program-ming / coding
Very easy	0	0	7	1	8	0	0	0
Easy	8	9	**12**	5	**12**	1	3	4
Medium difficult	**12**	**13**	6	**11**	8	7	**11**	12
Difficult	6	6	3	**10**	0	**13**	9	7
Extremely difficult	2	0	0	1	0	7	5	5

Table 2. The experts' answers to the question: how many years must children have to enter a given concept.

	Atom	Proportion	Wind	Electric current	Cloud	Electron cloud	Mathematical logic	Programming / coding
3-6	1	2	**14**	1	**15**	0	3	4
7-9	**9**	11	8	9	9	4	5	7
10-12	**9**	6	6	**13**	4	9	8	**10**
13-15	**9**	6	0	5	0	**15**	**10**	5
16-18	0	1	0	0	0	0	2	2

Conclusions and Implications

Although the experts have current theoretical knowledge about the latest research and in their everyday practice use modern models of teaching - however, their beliefs about the difficulties of individual concepts have not changed. Therefore, the curriculum for teaching natural sciences is the same since the 1960s. The results of the research show that experts evaluate the difficulty of the concepts in a very different way. Especially these differences are visible in the case of terms with a similar definition (WIND & ELECTRICAL CIRCUIT) or in the case of analogical concepts (CLOUD & ELECTRON CLOUD). They believe that these concepts should be introduced at various stages of formal education.

The analysis of the difficulties in the definition of individual concepts as well as the analysis of their use in every day activities by children showed that there are no reasons to introduce some concepts earlier or later. It seems that the only reason for differences in the time of introducing the concept is the experts' habit.

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