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Primary Students' Conceptions about Issues in Astrobiology

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Abstract

Although students' conceptions about the natural world have been explored the research that studies the students' conceptions of issues related to the universe and the existence of life on it is limited. The present study aims to investigate lower primary students' conceptions on issues in Astrobiology. In particular, students' conceptions about the origin of the universe, the existence of the elements used by life on Earth elsewhere in the universe, the existence of life on other planets, the existence of other objects similar to the Sun, the existence of planets not orbiting the Sun, the elements needed for life and the possibility of life in extreme temperatures, were investigated. A questionnaire which was designed to be elicited students' conceptions was used as a research data collection tool. The questionnaire was given to 214 students aged 8 years old in Greece. Data analysis enabled the identification and registration of students' conceptions. It was found that most students use conceptions on several issues of Astrobiology differ from the views of school science knowledge.

Keywords: Students' conceptions; Learning science; Primary school; Astrobiology.

INTRODUCTION

Students' conceptions about the natural world have been investigated by an extensive amount of research the last forty years [1-4]. It was found that in most cases the students' conceptions about the natural world differ from the views of scientific knowledge and that they are barely influenced by teaching [1-2, 4-5].

The need to carry out research on students' conceptions results from three positions adopted by this work. The first is connected with the constructive view of learning, according to which knowledge is not passively received but built by the student [3, 6-7]. The assumption that the student builds knowledge implies that the student is the one who decides to change his views. The second position relates to the finding that the students, before they begin their education in the school context, have already formulated their own conceptions about the natural world [1, 8]. The third refers to the relationship between students' conceptions and teaching. Knowledge of students' conceptions enables better organization of more effective teaching [9].

One of the fields of Natural Sciences is Astrobiology which mainly deals with the existence of life in the universe. The issues negotiated by the Astrobiology are directly related to crucial questions of adults and students in their daily lives (such as questions related to the beginning of life, evolution and future of life in the universe, the existence of life on other planets, and if man can survive on other planets of the universe). Also, in primary and secondary education and especially in their curricula have included Astrobiology's issues obviously recognizing the need for their study.

Research on students' conceptions of issues in Astrobiology has mainly focused on students of secondary education (see: Section "Literature review"). Therefore, there are no studies to investigate primary school students' conceptions on issues in Astrobiology. The exploration of lower primary school students' conceptions on issues in Astrobiology is the subject of this work.

THEORETICAL FRAMEWORK

Students' conceptions about the natural word: general conclusions

There has been an extensive number of empirical research on the conceptions that students have and use about the natural world [1-2, 4, 8]. The main conclusions, common to a large number of these studies, are summarised below.

(a) Before students get to school, they have formed conceptions about the natural world based on their sensory experiences from the natural and social environment. In most cases the initial conceptions of students differ from the views of the scientific knowledge and its school version [8] [10].
(b) Students' conceptions often resist any attempt to modify them and follow them till their adulthood, and are less influenced by traditional teaching (in which knowledge is transferred from the teacher to the students) [11-13].
(c) Some conceptions recorded by the survey appear to be quite widespread among students [8].
(d) In some cases students may keep both the explanation of the teacher and their own pre-existing conceptions, after the teaching. It is also possible to obtain a sort of merging or interaction of the two concepts systems [8].
(e) The cultural context in which they live and especially the language through which they communicate play an important role in shaping students' conceptions [14].

Common characteristics of students' conceptions about the natural word

Empirical research on students' conceptions for a variety of subjects of scientific knowledge have shown that these conceptions have certain common characteristics, regardless of the place of origin and age of students, presented below [1, 8].

Perceptually dominated thinking: Students tend to base their reasoning on observable features in a situation. For example, students say that sugar disappears when it dissolves rather than the sugar continuing to exist [15].

Limited focus: Students usually consider only limited aspects of particular physical conditions, with the focus on their attention, appearing to depend on the saliency of particular perpetual features. For example, students say that two ice cubes in a room (that have different sizes) have different temperatures (ignoring their environment) [16].

Context dependency: Students often call upon different ideas to interpret a situation which a scientist would explain in the same way. For example, students believe that when we have a hot object in contact with a hotter object then heat transfer for a hotter object to a hot object, but when we have a cold object in contact with a colder object then cold transfer for a colder object to a cold object [17].

Undifferentiated Concepts: Some of the conceptions students use has a range of meanings which can be different and considerably more extensive than those used by scientists. For example, students confuse temperature with heat [18]. These are notions which are clearly

differentiated from a scientist's perspective, however students do not have the need to make such distinctions.

Linear causal reasoning: Students, due to the implementation of a local and not a total consideration of examined systems, tend to describe and interpret the changes of systems using linear, temporal or local, causal chains, each part of which refers to a simple phenomenon. Students tend to explain changes in a linear causal sequence. Thus A causes B which causes C to happen rather than understanding that two systems may interact with each other [1]. For example, in considering a container being heated, they think of the process in directional terms with a source applying heat to a receptor whereas from a scientific point of view, the situation is symmetrical with two systems interacting; one gains energy and the other loses it [1].

The conceptions are very stable: Students' conceptions about the natural world seem to be remarkably stable. Stability and durability that characterizes students' conceptions can also be seen in relation to conceptual change, which, when carried out constitutes a long and slow process. For example, the percentage of middle students who responded positively to the statement: "the sun revolves around the earth" was about 30% [19].

LITERATURE REVIEW

Although the topics of Astrobiology interest several students and often appear in the media, the research which studies students' conceptions of these issues is limited [20-22].

Regarding the elements necessary for life, the research of Offerdahl et al. [22] showed that the majority of students (secondary and higher education) considered that water is essential for life and that life can exist even without sunlight. These requirements for life are in line with the scientific view. However, unlike the scientific view many students stated that oxygen is necessary for life.

Hannson and Redfors [21] investigated the conceptions of 16 years old students for issues in Astrobiology through a questionnaire. The investigation showed that most students stated that: (a) the universe has always existed, (b) in the rest of the universe exist elements necessary for life, (c) there are other stars similar to our sun, and (d) water and light are necessary for life.

Additionally, an analysis of the responses from students in surveys revealed that most students aged 10-11 years know that the sun is a star [23], while most secondary school students thought that the sun is bigger than other stars [24]. Hansson and Redfors [20] and Bailey et al. [25] found that although most students (of secondary education) thought that there are the necessary elements for life on other planets, very few students argued that these elements formed the stars.

It follows from the above that secondary school students' conceptions of issues in Astrobiology have been investigated. However, surveys to examine the conceptions of primary school students for issues in Astrobiology are absent. As a result, the need for investigation of primary school students' conceptions for issues in Astrobiology has emerged.

PURPOSE AND RESEARCH QUESTIONS

The purpose of this study is to investigate the conceptions of students aged 8 years for issues in Astrobiology. In particular, the present study aims to answer the following research questions:

(a) What are students' conceptions about the origin of the universe?
(b) What are students' conceptions about the existence of the elements used by life on Earth elsewhere in the universe?
(c) What are students' conceptions about the existence of life on other planets?
(d) What are students' conceptions about the existence of other objects similar to the Sun?
(e) What are students' conceptions of the existence of planets not orbiting the Sun?
(f) What are students' conceptions about the non-necessity of sunlight for life to exist?
(g) What are students' conceptions about the necessity of water for life to exist?
(h) What are students' conceptions of the possibility of life in extreme temperatures?

METHODOLOGY

Research process and participants

This survey was conducted in three phases. In the first phase a written questionnaire to investigate conceptions of students for issues in Astrobiology was formed. In the second phase we applied the questionnaire to students aged 8 years. In the third and final phase after the data were collected, then they were analysed.

The survey involved 214 pupils aged 8 years from eight different primary schools of Greece. Students hadn't been taught courses related to Astrobiology.

The questionnaire

Data collection was done through a written questionnaire. The questions were multiple choice and were compiled taking into account the issues of research and the results of surveys on secondary school students' conceptions of Astrobiology [21].

The construction of the questionnaire was completed in two stages. Initially, the questionnaire was given to a small number of students (10 students) to detect any obscure or illegible signs for students. Also, it was given to three primary teachers and a researcher of the Science Education to test the questionnaire for any deficiencies or ambiguities. After the students' observations and trainers, corrections were made and the questionnaire took its final form.

The questionnaire contained eight questions focused on the following themes:

(a) the origin of the universe (question 1),
(b) the existence of the elements used by life on Earth elsewhere in the universe (question 2),
(c) the existence of life on other planets (question 3),
(d) the existence of other objects similar to the Sun (question 4),
(e) the existence of planets not orbiting the Sun (question 5),
(f) the non-necessity of sunlight for life to exist (question 6),
(g) the necessity of water for life to exist (question 7) and
(h) the possibility of life at extreme temperatures (question 8).

Data collection and analysis

We obtained special permission from the schools principals and the teachers of the classes. We also provided beforehand the students concerned as well as their parents with information

about the nature, the purposes, the content, the expected duration and the procedures of the research, and we obtained their consent.

The process of completing the questionnaires took place in classrooms of primary schools. The questionnaire was given to the students by the researcher during the course in the presence of their teachers. The completion of the questionnaire took the students about one class period (45 min).

The research data were the students' answers to the questionnaire. Frequencies and percentage frequencies of students' answers were identified.

RESULTS

The origin of the universe

Table 1 shows the distribution of answers of the students about the origin of the universe. It appears that most students believe that the universe has always existed (20.6%). However, there are enough students who believe that the universe has an origin (17.7%), that scientists do not agree if the universe has an origin (16.6%) or that people cannot know if the universe has a beginning (15.9%). It is comparatively smaller the percentage of students who do not know about the origin of the universe (14.9%) or who believe that the universe has an origin but something already existed (14%).

Table 1. Students' conceptions about the origin of the universe: frequencies (N, N%).

Students' conceptions	N	N%
The universe has a beginning	38	17.7
The universe has an origin, but something already existed	30	14.0
The universe has always existed	44	20.6
People may not know if the universe has a beginning or has always existed	34	15.9
Scientists do not agree if the universe has a beginning or has always existed	36	16.6
Do not know	32	14.9

The existence of the elements used by life on Earth elsewhere in the universe

Regarding the existence of elements necessary for life elsewhere in the universe emerged (Table 2) that most students thought the elements necessary for life are only on earth (53.3%). It is comparatively smaller the percentage of students who thought the elements necessary for life exist also elsewhere (31.7%).

Table 2. Students' conceptions about the existence of the elements used by life on Earth elsewhere in the universe: frequencies (N, N%).

Students' conceptions	N	N%
The elements necessary for life are only on earth	114	53.3
The elements necessary for life exist also elsewhere	68	31.7
Do not know	32	15.0

The existence of life on other planets

Table 3 shows the distribution of students' answers about the existence of life on other planets. It appears that most students believe that there is life on other planets (48.6%). However, there are enough students who felt excluded that there is life on other planets (37.4%).

Table 3. Students' conceptions about the existence of life on other planets: frequencies (N, N%).

Students' conceptions	N	N%
There is life on other planets	104	48.6
It is impossible that there is life on other planets	80	37.4
Do not know	30	14.0

The existence of other objects similar to the Sun

Regarding the existence of celestial bodies like the sun emerged (Table 4) that most students believe that there are other objects similar to the Sun (55.1%), while it is comparatively smaller the percentage of students do not believe that there exist no other objects similar to the Sun (33.7%).

Table 4. Students' conceptions about the existence of other objects similar to the Sun: frequencies (N, N%).

Students' conceptions	N	N%
There exist other objects similar to the Sun	118	55.1
There exist no other objects similar to the Sun	72	33.7
Do not know	24	11.2

The existence of planets not orbiting the Sun

Table 5 shows the distribution of answers of students on the existence of planets that do not revolve around the sun. It appears that most students believe that planets exist that do not orbit the Sun (43.9%). However, there are other students who believe that all planets orbit the Sun (37.4%). It is comparatively smaller the percentage of students who do not know the answer (18.7%).

Table 5. Students' conceptions about the existence of planets not orbiting the Sun: frequencies (N, N%).

Students' conceptions	N	N%
Planets exist that do not orbit the Sun	94	43.9
All planets orbit the Sun	80	37.4
Do not know	40	18.7

The non-necessity of sunlight for life to exist

Table 6 shows the distribution of answers of students about the non-necessity of sunlight for life to exist. It appears that most students believe that sunlight is necessary for life (73.8%). It is comparatively smaller the percentage of students who think that sunlight is not necessary for life (13.1%).

Table 6. Students' conceptions about the non-necessity of sunlight for life to exist: frequencies (N, N%).

Students' conceptions	N	N%
Sunlight is necessary for life	158	73.8
Sunlight is not necessary for life	28	13.1
Do not know	28	13.1

The necessity of water for life to exist

Regarding the students' conceptions about the necessity of water for life to exist (Table 7), it has emerged that most students believe that water is necessary for life (76.6%). It is comparatively smaller the percentage of students who believe that water is not necessary for life (16.9%).

Table 7. Students' conceptions about the necessity of water for life to exist: frequencies (N, N%).

Students' conceptions	N	N%
Water is necessary for life	164	76.6
Water is not necessary for life	36	16.9
Do not know	14	6.5

The possibility of life in extreme temperatures

Table 8 shows the distribution of answers of students about the possibility of life in extreme temperatures. It appears that most students do not know the answer to this question (33.6%). It is comparatively smaller the percentage of students who think that there may be a form of life to extreme temperatures above 100°C or below the 0°C (26.2%) or that it is impossible to form life in extreme temperatures above 100°C or below 0°C (22.4%).

Table 8. Students' conceptions about the possibility of life at extreme temperatures: frequencies (N, N%).

Students' conceptions	N	N%
There may be a form of life at extreme temperatures above 100°C or below 0°C	56	26.2
There can be no form of life at extreme temperatures above 100°C or below 0°C	48	22.4
There may be a form of life at extreme temperatures above 100°C or below 0°C but on another planet not earth	38	17.8
Do not know	72	33.6

DISCUSSION AND CONCLUSIONS

In this paper we investigate the conceptions of students aged 8 years old for issues in Astrobiology. The analysis of data showed that several students have and use conceptions that are different from the views of scientific knowledge.

Regarding the origin of the universe the most widespread conception is that the universe has always existed. However, other students believe that the universe has a beginning. Regarding the existence of elements necessary for life elsewhere in the universe, the most common conception is that the elements necessary for life are only on earth. For the existence of life on other planets the most widespread conception is that there is life on other planets. Also, several students consider that there are no other celestial bodies similar to the Sun and that all planets orbit the Sun. Regarding the elements necessary for the existence of life, students consider that not only water is necessary for life but also sunlight. Finally, most students do not know if there may be a form of life at extreme temperatures above 100°C or below 0°C.

Many of these conceptions of students resulted from this work were detected in the investigation of Hansson and Redfors [21] held with students aged 16 years old. The above finding suggests that students' conceptions of issues in Astrobiology are highly resistant. The durable character of students' conceptions about the natural world is well documented in the relevant research literature [11, 16-17, 26-29].

The results obtained from this study can be attributed to the thinking characteristics of students. Children tend to view things from a self-centered or human-centered point of view. Thus, they often attribute human characteristics, will or purpose, to objects and phenomena [30]. Moreover, children's thinking seems to be perceptually dominated and limited in focus [1].

In the present paper the limited sample restricts the research and its results. In addition, data collection in this study was made through a questionnaire. The use of an interview or the use of a questionnaire together with an interview could possibly contribute to a thorough investigation of students' conceptions in Astrobiology.

Despite the above restrictions, this paper makes a positive contribution to the research on students' conceptions because it studies primary school students' conceptions in Astrobiology, an issue that lacked research data. The results of this paper can contribute to both supporting research activities and designing teaching material for the instruction of issues in Astrobiology. The results of this paper also demonstrate the need to radically change science teaching models. The traditional teaching approach (where knowledge is transferred from teacher to students) standing powerless to affect and change students' conceptions.

Recent views on science learning rooted in constructivist views on learning argue that the student does not passively receive knowledge but actively builds knowledge through cognitive, social and cultural processes [31]. The intellectual and practical work associated with the processing and reviewing of students' conceptions is based on the involvement of students in science practices [32]. The term science practices refers to the main practices that scientists apply while studying and constructing models and theories about the world [32]. In order for students to be educated in science, the following eight science practices have been suggested [31-32]: (a) asking questions, (b) developing and using models, (c) planning and carrying out investigations, (d) analyzing and interpreting of data, (e) using mathematics and computational thinking, (f) constructing explanations, (g) engaging in argument from evidence and (h) obtaining, evaluating and communicating information. It is argued that the active involvement of students in science practices can improve learning outcomes. In particular, the involvement of students with science practices can help them understand the process of development of science knowledge, to build basic ideas and concepts of science, peak their curiosity and interest and motivate them to do further research [33].

This work focused exclusively on the study of primary school students' conceptions for issues in Astrobiology. Further research is needed in order to study systematically the evolution of students' conceptions as they move from the ranks of primary school classes to secondary education. Furthermore, the research results of the present work can contribute to the development of instructional material about issues in Astrobiology. In order for this material to assist in changing students' conceptions, it is essential to take into account their initial conceptions as recorded in this study. However, further research is required so that the instructional material that will be accumulated can be implemented for the primary school students and its learning results can be evaluated.

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