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CARACTERISTICS OF NATURAL SCIENCE MISCONCEPTIONS AMONG TRANSYLVANIAN HUNGARIAN TEACHER TRAINING STUDENTS

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Abstract

According to the constructive pedagogical trends, the formation of misconceptions significantly inhibits conceptual changes, thus resisting teaching and learning processes. The present research examines the knowledge of teacher training students from the point of view of natural sciences and pedagogy. We assume that the formation of natural science misconceptions is often facilitated by teachers who themselves have their own misconceptions regarding these notions. Our target group includes Hungarian university students from Romania who will be teaching natural science concepts during their teaching career (students of biology, physics, as well as preschool and primary teacher training students enrolled in the academic year 2018/2019). We intend to explore and investigate the natural science misconceptions and their peculiarities among students. The survey is based on a traditional paper-based questionnaire, in which we ask for conceptual maps, while we also ask specific definition-centered questions about natural science concepts, as well as open questions based on reasoning. Participants wrote many terms for the key concepts, with 262 students totalling 6874 terms, an average of 1145 terms per key term. The results of the open-ended questions and the conceptual maps suggest that there is a significant number of participants who are unfamiliar with the key concepts of natural science.

Keywords: Natural science misconceptions, Transylvanian Hungarian teacher training students, constructive pedagogy.

1. Introduction

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Misconceptions are cognitive structures that are deeply embedded in a person's knowledge system. These are incorrect, erroneous data and concepts that were learned (too) early, that are incompatible with today’s scientific knowledge, and may be present and persist even in adulthood. An individually constructed world may differ in many cases from scientific theories. If the new information contradicts the existing system of interpretation, it cannot be integrated correctly, thus resulting in misconceptions (Tóth, 2011). “Misconceptions are persistent erroneous notions in the minds of children or even adults, concepts that are incompatible with current scientific beliefs, systems of concepts, models of certain phenomena in the environment, ideas that are deeply rooted and often resistant to teaching” (Korom, 1997, 1999, 2002, 2005; Murphy & Alexander, 2008; Vosniadou, Vamvakoussi, & Skopeliti, 2008; Kádár, Farsang, & Ábrahám, 2015). Initial research explored the discovery, description and explanation of the negative outcomes of learning. Initially, experts believed that one of the reasons for incorrect acquisition is that students already have prior knowledge and experience, which are in fact mental models, primary representations of the physical world, all of which occur before they learn science, and can influence learning as a process (Korom, 2003).

Out of the seven paths of the constructivist learning model (indifference, seamless learning, preclusion, cramming, falsification, creative storage and conceptual shift), misconceptions are formed along the lines of falsification and creative storage. Falsification is when a learner modifies the new knowledge to be learned so that it can be linked to an existing system of interpretation (Tóth, 2011). New information is not modified during creative storage, nor is the system of interpretation altered, only to the extent to record the information as an exception (Nahalka, 1997).

There are five groups of misconceptions: *vernacular* misconception is the interpretation of a particular term, process or phenomenon based on everyday language use. In this case, the everyday meaning of the term differs from the meaning used in the scientific context (Dolphin & Benoit, 2016; Kádár & Farsang, 2018). A *preconception* is a group of misconceptions in which an everyday interpretation of a known concept, process, or phenomenon influences the interpretation of a new concept, process, or phenomenon from the scientific point of view. New information is not organically and correctly integrated into the individual’s cognitive structure, the individual's prior knowledge based on experience or self-concept remains decisive (Ross & Shuell, 1990; Vosniadou & Brewer 1992; Duit, Roth, Komorek, & Wilbers, 2001; Nieswandt, 2001; Eryilmaz, 2002; Park & Han, 2002; Schur, Skuy, Zietsman, & Fridjhon, 2002; Kádár & Farsang, 2018). *Cultural misconceptions* are misinterpretations of concepts, processes, or phenomena based on the embedding culture that strongly pervades everyday life as well (Vosniadou & Brewer, 1992; Samarapungava, Vosniadou, & Brewer, 1996; Sungur, Tekkaya, & Geban, 2001; Tsai, 2001; Eryilmaz, 2002; Alsparslan, Tekkaya, & Geban, 2003; Kádár & Farsang, 2018). We talk about *popular misconceptions* when interpreting a concept, process, or phenomenon based on contemporary media (news, movies, books, comics, etc.) (Barnett et al. 2006; Kádár & Farsang, 2018). *Conceptual misconceptions* occur when there is no conceptual shift when learning a concept, process, or phenomenon, the pre-formed, not necessarily correct scientific worldview does not change, the students created erroneous models of natural phenomena (Ross & Shuell, 1990; Vosniadou & Brewer, 1992; Eryilmaz, 2002; Chang & Pascua, 2015).

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Initially, research sought to answer the question in which field of natural science the learners have misconceptions. Later, the emphasis was on the nature and origin of misconceptions. Currently, the prevention of misconceptions and the elimination and modification of existing ones is an important research issue.

Our research examines the knowledge of teacher training students from the perspective of science and pedagogy. We assume that, in many cases, the formation of misconceptions in natural sciences is also facilitated by educators by having their own misconceptions about these concepts. Our target group includes Hungarian university students in Romania who will be teaching science concepts during their teaching career (students enrolled in biology, physics, preschool and elementary school teacher training in the academic year 2018/2019). We intend to explore and investigate natural science misconceptions and their characteristics among students. We chose to analyse natural science concepts (e.g., ecological footprint, gravity, greenhouse effect, etc.) that require an interdisciplinary (STEAM education) approach.

2. Problem Statement

In the course of pedagogical practice we often face the fact that despite a thorough and detailed knowledge of the environment and of nature, despite the cumbersome and difficult science curriculum, students have interpretations and explanations related to particular phenomena, concepts, and processes which do not correspond to the currently accepted scientific explanations and cannot give an adequate explanation for simple natural phenomena. Although they have heard or learned the concepts, they do not understand causation, although they know the definitions and can apply them in routine tasks, they are already having trouble using the same information in other contexts. This leads to misconceptions. There are several sources for the formation of misconceptions (didactogenic misconceptions) in the school teaching and learning process (Ludányi, 2009): inadequate teaching methods, didactic deficiencies, insufficient attention paid to mapping students' prior knowledge and way of thinking which results in the fact that we are unaware of the conceptual knowledge and schemas of the learners about a particular phenomenon, and even the teachers themselves may have misconceptions that they often pass on to their students (Ludányi, 2009; Tóth, 2002).

3. Research Questions

In our research we seek to find out what natural science misconceptions Transylvanian teacher students have and whether they are prepared for everyday life situations requiring science knowledge or not.

Research questions / hypotheses:

3.1. How common is the presence of natural science misconceptions among participants? / There is a high incidence of natural science misconceptions among students in the research.

3.2. What is the nature of the participants' natural science misconceptions? / Among the participants, misconceptions are misinterpretations due to the lack of knowledge transfer (between the fields of natural sciences), as well as the lack of causal relationships in the explanation of the concepts.

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3.3. How many concepts are associated with the key natural science concepts, and how closely (directly, indirectly, not at all) are they related to them from the point of view of content? / Most of the students surveyed (70%) associate directly related concepts with natural science concepts.

3.4. Are there any natural science concepts that students are unfamiliar with? / We assume that there are few concepts that students are unfamiliar with.

4. Purpose of the Study

The aim of the study is to map the typical scientific misconceptions (in biology, geography, physics, chemistry) related to particular concepts of university students.

5. Research Methods

5.1. Research methods

5.1.1. Participants and Procedures

Our target group includes Hungarian university students in Romania who will be teaching science concepts during their teaching career (students enrolled in biology, physics, preschool and elementary school teacher training in the academic year 2018/2019 at the Babeș-Bolyai University), a total of 312 university students.

5.1.2. Measures

The following methods were used in the research:

Query: Complex multidimensional questionnaire to assess the nature and content of misconceptions. Conceptual maps and open-ended questions for the interpretation of causal relationships in natural science concepts.
Content analysis: analysis of misconceptions along a developed set of criteria.

Answers to open-ended questions were processed along the categories developed by Abraham (Abraham, 1992, as cited in Korom, 2002). Categories rate misconceptions on a six-point scale [no answer (1 point), no comprehension (2 points), misconception (3 points), partial comprehension with misconception (4 points), partial comprehension (5 points), full comprehension (6 points)].

The method of conceptual maps was developed by Novak (1977) and then widely adopted in research methodology. Conceptual maps are "grasping and displaying structures, concepts, their elements and relationships that are difficult to access verbally. It is about depicting concepts in two dimensions, graphically depicting their internal and external relationships" (Szivák, 2002). Unstructured conceptual maps were processed according to quantitative and qualitative parameters. Quantitative aspects are represented by the number of words assigned to the concepts, while qualitative aspects were the extent to which the assigned words relate to the key concepts of natural science [directly (1), indirectly (2), not at all (3)]. The use of conceptual maps serves as a pillar of constructive pedagogy, since this technique can be used to explain knowledge construction. Unstructured conceptual maps shed more light on the content

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of the subjects' cognitive structures (Sántha, 2009). We used descriptive statistics tools for data processing.

Key terms analysed:

- unstructured conceptual maps of six key terms: *earthquake, photosynthesis, ecological footprint, gravity, mirage, greenhouse effect*
- 17 open-ended questions:

1. We drop an iron ball and a feather from the same height. Which one reaches the ground sooner?

2. If we do the same experiment in a vacuum, what happens?

3. Why do our glasses fog up when we enter a warm room from outside?

4. Do you think fungi are plants, animals or a separate group?

5. Why is long-term high fever dangerous?

6. We take antibiotics when:

7. Why are roads salted in winter?

8. Why is food prepared faster in the pressure cooker?

9. Why don't lakes freeze to the bottom in winter? What happens to the aquatic life lakes in winter?

10. On an average early summer night, when do we feel colder: when the sky is clear or when it is cloudy? Why?

11. What do we detect first during summer storms? Thunder or lightning? What is the explanation for this?

12. What is the reason why birds are able to swim on the surface of the water? What happens when water is contaminated with detergents?

13. Why are ice caps melting, and what will the consequences of this phenomenon be?

14. If we put a salad, a celery leaf and a green onion in the freezer, in what order do these vegetables freeze and why?

15. Why is it impossible to cook eggs at high altitudes?

16. Does drinking alcohol help digestion after eating a hearty, greasy lunch? Explain your answer.

17. In the past some drivers hung CDs on the rear-view mirror saying they reflect radar. Is it true they reflect radar and did the drivers get away without being fined?

6. Findings

6.1. The analysis of the answers given to open-ended questions

The cumulative processing of the answers to the open-ended questions leads to the conclusion that 31% of the answers (12% misconception + 19% partial comprehension and misconception) contains misconceptions (Table 1). If we look at all of the answers, we can see that in the case of only 30% of the answers are the issues fully understood, meaning that in the case of the remaining 70% there are some difficulties in interpreting the relationships presented in the question.

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Table 01. Aggregate processing of the answers given to open-ended questions using Abraham's six-level category (1-no answer, 2-no comprehension, 3-misconception, 4-partial comprehension with misconception, 5-partial comprehension, 6-full comprehension)

Frequency	1	2	3	4	5	6	SUM
F	422	61	521	774	1141	1263	4182
f (%)	10%	2%	**12%**	**19%**	27%	30%	100%

Table 2 shows a breakdown of the results for each question. Most misconceptions were found in question 16, which deals with the effects of alcohol consumption on digestion. This is followed by question 6 on the use of antibiotics and question 4 on the question of what fungi are. We also identified a high number of misconceptions regarding question 14 (which vegetable freezes first when put in the fridge) and 15 (why is it impossible to cook eggs at high altitude?).

Table 02. Individual processing of the answers given to open-ended questions using Abraham's six-level category (1-no answer, 2-no comprehension, 3-misconception, 4-partial comprehension with misconception, 5-partial comprehension, 6-full comprehension)

Questions/f (%)	1	2	3	4	5	6	SUM
1	0	0	0	1	3	**96**	100
2	13	1	16	4	44	22	100
3	2	2	0	11	31	54	100
4	0	0	**18**	1	3	**78**	100
5	7	3	16	29	34	11	100
6	4	1	**18**	37	8	32	100
7	0	1	1	25	49	24	100
8	8	0	2	15	43	32	100
9	12	2	11	35	33	7	100
10	11	2	16	12	43	16	100
11	2	1	11	5	12	**69**	100
12	21	2	11	22	18	26	100
13	5	2	2	30	29	32	100
14	20	1	10	**38**	27	4	100
15	22	3	13	**36**	20	6	100
16	12	2	**59**	9	14	4	100
17	33	1	6	7	52	3	100

The highest number of correct answers, that is full comprehension was found in the field of physics (question 1, 4, 11), validating our hypothesis according to which key concepts related to uni-disciplinary content do not pose a problem, however, there are issues related to the questions needing knowledge transfer or the explanation of causal relationships, even when related to everyday situations (see alcohol consumption).

a. The processing and interpretation of conceptual maps

Concerning the processing of conceptual maps, we can see that *photosynthesis* is the most well-known of the six key concepts, as the most expressions have been written for it, and its average is the lowest, i.e., it has received the most directly related categories in the processing (Table 3).

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Table 03. The results of processing unstructured conceptual maps

Key concepts **Aspects**	**Earthquake**	**Photosynthesis**	**Ecological footprint**	**Gravity**	**Mirage**	**Greenhouse effect**
Most frequent expressions	*natural disaster*	*plants*	*pollution*	*ground*	*desert*	*heat*
	crustal plates	*oxygen*	*nature*	*force*	*heat*	*global warming*
	movement	*light*	*man*	*attraction*	*imagination*	*plants*
Every related concept (f)	1294	**1497**	**920**	1088	1054	1021
Dispersion range (r)	11	15	8	11	9	12
Mean of Categories 1-3	1.85	**1.69**	**2.34**	2.12	2.09	2.29

The least known natural science concept is the *ecological footprint*. This key concept has the least number of expressions and the highest mean, that is, most terms that are not related to it, and the most blank, unanswered parts (Table 3).

7. Conclusion

The presence of natural science misconceptions is present in 31% of the participants, so our hypothesis is partially confirmed. The identified misconceptions can be characterised by the fact that they occur mainly in the explanations of causal relationships, and that they are anchored in naive theories related to childhood (e.g., “prolonged high fever is dangerous because high heat makes the blood clot in our body”, “We are more cold when the sky is clear because organisms release heat at night.”)

Participants wrote many terms for the key concepts, with 262 students totalling 6874 terms, an average of 1145 terms per key term. The number of directly related terms is only 25%, which is very few, so this hypothesis was not substantiated as we assumed 70%.

The results of the open-ended questions and the conceptual maps suggest that there is a significant number of participants who are unfamiliar with the key concepts of natural science, especially the concepts of *ecological footprint* and *greenhouse effect*. 42% wrote expressions that were completely unrelated to the key terms.

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References

Alsparslan, C., Tekkaya, C., & Geban, O. (2003). Using the conceptual change instruction to improve learning. *Journal of Biological Education 37*(3), 133–137.

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eISSN: 2357-1330

Barnett, M., Wagner, H., Gatling, A., Anderson, J., Houle, M., & Kafka, K. (2006). The impact of science fiction film on student understanding of science. *Journal of Science Education and Technology, 15*(2), 179–191.

Chang, C. H., & Pascua, L. (2015). The hole in the sky causes global warming: A case study of secondary school students' climate change alternative conceptions. *Review of International Geographical Education Online, 5*(3), 316–331.

Dolphin, G., & Benoit, W. (2016). Students' mental model development during historically contextualized inquiry: How the "tectonic plate" metaphor impeded the process. *International Journal of Science Education, 38*(2), 276–297.

Duit, R., Roth, W. M., Komorek, M., & Wilbers, J. (2001). Fostering conceptual change by analogies – between Scylla and Chrybdis. *Learning and Instruction, 11*(4–5), 283–303.

Eryilmaz, A. (2002). Effects of conceptual assignments and conceptual change discussions on students' misconceptions and achievement regarding force and motion. *Journal of Research in Science Teaching, 39*(10), 1001–1015.

Kádár, A., Farsang, A., & Ábrahám, E. (2015). Tudományos-fantasztikus filmek hatása a középiskolás tanulók földrajzi ismeretrendszerére. [The impact of science fiction films on the geographic knowledge system of high school students]. *Földrajzi Közlemények, 139*(4), 302–317.

Kádár, A., & Farsang, A. (2018). A láva a Föld magjából származik vagy mégsem – Néhány lemeztektonikához kapcsolódó tévképzet összehasonlító elemzése. [Lava comes from the Earth's core or not - Comparative analysis of some plate tectonics misconceptions]. *GeoMetodika, 2*(1), 5–24.

Korom, E. (1997). Naiv elméletek és tévképzetek a természettudományos fogalmak tanulásakor. [Naive theories and misconceptions when learning science concepts]. *Magyar Pedagógia, 97*(1), 19–40.

Korom, E. (1999). A naiv elméletektől a tudományos nézetekig. [From naive theories to scientific views]. *Iskolakultúra,* 9-10, 60–71.

Korom, E. (2002). Az iskolai tudás és a hétköznapi tapasztalat ellentmondásai. [Contradictions between school knowledge and everyday experience]. In B. Csapó (Ed.), *Az iskolai tudás* (139–167). Budapest: Osiris Kiadó.

Korom, E. (2003). A fogalmi váltás kutatása. [Researching the conceptual change]. *Iskolakultúra, 8,* 84-94.

Korom, E. (2005). *Fogalmi fejlődés és fogalmi váltás*. [Conceptual development and conceptual change]. Budapest: Műszaki Könyvkiadó.

Ludányi, L. (2009). Tanári tévképzetek kémiából. [Teacher misconceptions about chemistry]. *Iskolakultúra, 7-8,* 26−35.

Murphy, P. K., & Alexander, P. A. (2008). The role of knowledge, beliefs, and interest in the conceptual change process: A synthesis and meta-analysis of the research. In: Vosniadou, S. (Ed.), *International handbook of research on conceptual change* (583–616). London: Routledge.

Nahalka, I. (1997). Konstruktív pedagógia – egy új paradigma a láthatáron. [Constructive pedagogy - a new paradigm]. *Iskolakultúra, 7*(2), 21-23.

Nieswandt, M. (2001). Problems and possibilities for learning in an introductory chemistry course from a conceptual change perspective. *Science Education, 85*(2), 158–179.

Novak, J. D. (1977). *A theory of education. Ithaca*. New York, NY: Cornell University Press.

Park, J., & Han, S. (2002). Using deductive reasoning to promote the change of students' conceptions about force and motion. *International Journal of Science Education, 24*(6), 593–609.

Ross, K. E. K., & Shuell, T. J. (1990). The earthquake information test: Validating an instrument for determining student misconceptions. Conference paper, Ellenville. 32.

Samarapungava, A., Vosniadou, S., & Brewer, W. F. (1996). Mental models of the earth, sun, and moon: Indian children's cosmologies. *Cognitive Development, 11*(4), 491–521.

Sántha, K. (2009). Bevezetés a kvalitatív pedagógiai kutatás módszertanába. [Introduction to the methodology of qualitative pedagogical research]. Budapest: Eötvös József Könyvkiadó.

https://doi.org/
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eISSN: 2357-1330

Schur, Y., Skuy, M., Zietsman, A., & Fridjhon, P. (2002). A thinking journey based on constructivism and mediated learning experience as a vehicle for teaching science to low functioning students and enhancing their cognitive skills. *School Psychology International*, *23*(1), 36–67.

Sungur, S., Tekkaya, C., & Geban, O. (2001). The contribution of conceptual change texts accompanied by concept mapping to students' understanding of the human circulatory system. *School Science and Mathematics*, *101*(2), 91–101.

Szivák, J. (2002). A pedagógusok gondolkodásának kutatási módszerei. [Research methods for teachers' thinking]. Kutatás-Módszertani Kiskönyvtár c. sorozat. Budapest: Műszaki Könyvkiadó.

Tóth, Z. (2002). A kémiai fogalmak természete. [The nature of chemical concepts]. *Iskolakultúra*, *12*(4), 108−112.

Tóth, Z. (2011). A természettudományos tévképzetek kialakulása, feltárása és korrekciójának módszerei. [Methods of the formation, exploration and correction of scientific misconceptions]. Revákné Markóczi Ibolya & Nyakóné Juhász Katalin (Eds.) *A természettudományok tanításának elméleti alapjai* (23–36). Debrecen: Debreceni Egyetem.

Tsai, C. C. (2001). Ideas about earthquakes after experiencing a natural disaster in Taiwan: An analysis of students'worldviews. *International Journal of Science Education*, *23*(10), 1007–1016.

Vosniadou, S., & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology*, *24*(4), 535–585.

Vosniadou, S., Vamvakoussi, X., & Skopeliti, I. (2008). The framework theory approach to the problem of conceptual change. In. Vosniadou, S. (Ed.). *International handbook of research on conceptual change* (3–34). London: Routledge.