THE CONCEPTUAL DEVELOPMENT OF PRIMARY SCHOOL STUDENTS CONCERNING STRUCTURE AND CHANGES OF MATTER

Ph.D. Thesis

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1. Introduction and Aims

Science education – especially chemistry education – is currently facing problems which frequently make it impossible for school chemistry education to fulfil the social expectation that it should give up-to-date and usable knowledge to the masses. Behind this widely intriguing issue lie first and foremost the advanced abstracting skills required by the field of chemistry and its special terminology, but economic, social and labour market factors also play a part in chemistry teaching failing and losing popularity. From the curricular, organizing, methodical and practical issues directly influencing the efficiency of teaching, this paper focuses on the learning process, especially conceptual understanding as a reason for learning difficulties.

This paper views conceptual development from a constructivist pedagogical standpoint, accepting that students are not passive receivers in the learning process, but play an active role in constructing their knowledge themselves based on their prior knowledge. Real learning can only occur when a new concept is integrated in the network of prior knowledge and fixed with diverse links therein. Failure of learning chemistry and difficulty of understanding often stem from the inability to acquire new concepts because of the learner's conceptual network, the content of or the organization of their prior knowledge, which very often leads to misconceptions.

The aim of this paper is not only to review the results of research on conceptual development and misconceptions carried out to date, but to provide new data on conceptual understanding and its disorders, mainly in connection with concepts featured in basic chemistry teaching. Using a method of analysis based on Knowledge Space Theory, the paper presents how knowledge structures and learning pathways of different learner groups can be compared, and suggests possible uses for diagnostic tools which help optimize the learning process. The paper reports on the results of two empirical surveys and on experience gained from the testing of a tool later to be used for diagnostic purposes.

1.1. Research Questions

1.1.1. For school beginners:

The first survey examined the prior knowledge of school beginners concerning water, states of water and water purification. We were able not only to detect the conceptual development of the individual, to detect and categorize their misconceptions, but to compare the knowledge structure of learner groups from different geographical regions and settlements, using new analytical methods. The aim of the survey was to establish:

- How school beginners interpret basic phenomena – changes of state, dissolving – in connection with water.
- Whether we can observe the aforementioned concepts combine and form a hierarchy in children's thinking.
- Whether the knowledge structure of a learner group can be mapped out in the examined field using methods based on Knowledge Space Theory.
- Whether there is a geographical difference between children living in cities or in the capital, living in Hungary or in Germany as far as water-related knowledge content and the structure of prior knowledge are concerned.
- Whether children's science theories concerning basic chemistry concepts similar to the ones described in international literature can be observed among Hungarian primary school students.
- Whether any misconceptions about water, the structure and states of water occur among school beginners.
- Whether a certain correlation between occurring misconceptions can be observed, and whether some beliefs make the occurrence of other misconceptions more likely.
- Whether the didactic concept „The Rostock Model" is an adequate tool to facilitate scientific concept development in learners.

I assumed children already have a notion for water-related phenomena prior to starting organized education; however, certain misconceptions seemed likely to occur. I expected knowledge structure analysis to validate results gained from content and quantity analyses, perhaps even to provide new aspects. I had no explicit expectations about the different sets of prior knowledge of the learner groups.

1.1.2. For those who begin their chemistry studies:

The second part of my survey concerned 7th or 8th graders (12-15-year-olds) who were about to begin their chemistry studies. I sought answers to the following questions:

- What prior knowledge children beginning their primary chemistry studies (especially 12-15-year-olds) have in connection with combustion, conservation of mass, dissolving and phase changes.
- Whether a hierarchy of the examined concepts can be observed.
- Whether critical learning pathways exist for different age groups.

- What naive theories exist among 9-15-year-old Hungarian children in connection with combustion, gases, phase changes, dissolving and conservation of mass.
- What level they are at concerning the understanding of quantitative issues of material changes; whether the difference between mass, volume and density is clear to them.

The survey was amended with an examination which confronted students with ready misconceptions already described in literature. In order to recognize tendencies of conceptual development I examined younger (9-12-year-old) and more mature (16-17-year-old and adult) groups small in numbers, seeking answers to the following:

- Whether a certain correlation between the occurrence of misconceptions and age, gender, attitude to chemistry and effectiveness during chemistry classes can be observed.
- Whether misconceptions are linked; whether it is expected that certain types of misconceptions make the occurrence of other misconceptions more likely.
- How consistent children are in their misconceptions, or whether different contexts mobilize different misconceptions concerning the same phenomenon.

I assumed misconceptions about the examined concepts can be observed among Hungarian children as well, but the number of those decreases with age and education, or are at least modified in content. Based on my practical experience I expected difficulties with concepts of quantity, and I assumed that misconceptions do not occur randomly, inasmuch as some types make the occurrence of others more likely. I also assumed that the knowledge structure of a learner group reflects the difficulties of understanding established with quantitative and content analyses.

2. Examination Methods

2.1. Data Collection, Sample

2.1.1. For school beginners:

The first survey was carried out as part of a current international collaboration project titled "Scientific and Technological Learning in Elementary Schools". The structured interviews combined with experiments were carried out in the fall of 2004 in two learner groups located in Budapest, one located in Debrecen and one in Rostock, altogether 92 school beginners were accessed. The experiments and the interview questions examined the understanding of the states and phase changes of water, and the awareness of water purification processes.

2.1.2. For those who begin their chemistry studies:

The second survey consisted of multiple parts and was divided in time. The large sample examination which forms the base of the survey was carried out in 14 primary schools of the 13th district of Budapest during the fall of 2002, reaching altogether 1.032 7th-8th graders. Students solved an open questionnaire which had versions „A" and „B" and which dealt with the behaviour of gases, the process of combustion and dissolving, and the understanding of the quantitative relations of those. In the second stage of the survey during the spring of 2005 I asked the same questions from 4th-5th-6th graders (103 pupils altogether) at a school located in the 13th district, in order to map out difficulties of understanding ranging through ages more clearly. The last data collection was carried out in the spring of 2007 among 7th-8th graders from three 13th district schools, a 5th grade class in a primary school and 7th and 10th graders of a secondary grammar school – altogether 150 students were concerned. They were required to form an opinion about statements parts of which were misconceptions published in literature. I involved 19 non-expert adults in the survey; teachers of science subjects (physics, biology, and geography) too, but none of them teachers of chemistry. With this I aimed to find out whether misconceptions arising during the tasks are „undertaken" directly as well by the children, whether there are difficulties of understanding and types of misconceptions that occur together on a regular basis, and whether it is possible to diagnose misconceptions about a certain area with the help of such questionnaires as quick tests. Background variables featured in the questionnaires provided opportunities to compare age, gender and attitude differences.

2.2. Evaluation Methods

Data processing was carried out on multiple levels with each age group. Content analysis was amended with quantitative analysis and group comparison using statistical methods. Individual results gave an opportunity to track each learner's level of understanding, but it was also possible to compare other aspects of learner groups by the help of knowledge structure analysis based on Knowledge Space Theory. I determined the critical learning pathway for each group for each topic, which represents how easy or difficult the concepts of the given field were for the children, depending on the position of the given concepts in the hierarchy and the prior knowledge of students.

3. New Scientific Results

3.1. Concerning Water-related Concepts of 1st Graders

3.1.1. The children's interpretation of evaporation as a phenomenon coincides with international observations.

The way children explain the disappearing of a wet handprint gives us indirect information on the development of their view of matter and their theories about the conservation of mass. The age group featured in the survey represents an interim between „the water disappears, perishes"-approach and the „it draws in"-approach, the latter representing the initial acceptance of the conservation of mass. Only in two cases could traces of the approach that accepts colourless gases thus typical of 11-year-olds be observed.

3.1.2. The interpretation of the process of dissolving among Hungarian primary school students too evolves through the following steps: „it disappears, turns into water, melts, dissolves and remains in the solution in the form of invisible particles"

The method of structured interviews was suitable to gain an insight into children's way of thinking as well. For example, after oral explanations it turned out that in one third of the cases the incorrectly used term „melt" denoted the correct interpretation of dissolving.

3.1.3. Children's theories of the structure of matter provide a relatively coherent background when interpreting various phenomena.

Although some children solve certain problems from a continuous view of matter, others from a macroparticulate point of view, the majority belonged to either one or the other group exclusively. In the case of seven problem pairs out of the examined ten the expected type of explanation was foreseeable. For example those who interpreted dissolving from a macroparticulate point of view, were highly likely to approach filtration from the same standpoint. From the undeveloped conceptual framework various beliefs, explanations and generalized experiences surfaced in different situations, which might have contradicted scientific notions, still, the answers possessed certain coherence.

3.1.4. As for the topic of the states of water, the results of content, quantitative and structural analyses did not show significant diversity between geographically different groups.

3.1.5. Results from knowledge structure analysis comply with those of content and quantitative analyses.

Knowledge structure analysis proved to be an appropriate tool to gain insight into the learning process, to establish the learning pathways of a learner group and the order in which their members acquire concepts. Learning pathways showed similarity in their fundamental features. The learning pathway for each group began with interpreting the melting of ice, followed by the dissolving of various substances. All three levels of analysis showed difficulty understanding the concept of evaporation, and in all four of the groups this seemed to be the most difficult task, the unit of knowledge in the examined knowledge space whose further discussion was the most promising, because the highest proportion of learners were prepared to comprehend this.

3.1.6. Units of knowledge form a hierarchy in the cognitive structures of the learners.

As for the topic of water purification, both quantitative and structural analyses showed a diversity of learner groups, perhaps due to the diverse prior knowledge about the subject matter. At the same time, in the case of each learner group the unit of knowledge about purifying ink contaminated water hierarchically builds on the unit of knowledge about purifying soil contaminated water. So that the learner can come up with a viable suggestion how to remove ink, they need to be aware of the theoretical background of the purification of soil contaminated water.

3.1.7. The „Rostock Model" didactic concept proved to be an appropriate tool to develop scientific concepts of learners.

The teaching unit based on and carried out with the „Rostock Model" didactic concept had a statistically commensurable effect on the 1st graders' way of thinking about water. Before teaching them learners generally used everyday concepts, while after teaching them, scientific concepts began to occur, albeit separately from, or building on everyday concepts.

3.2. Concerning concepts of structure and changes of matter among those who start their education in chemistry

3.2.1. Misconceptions described in domestic and international literature also appeared among the examined Hungarian 9-15-year-olds. I have not found new types of misconceptions, but new phrasings I have („… thus fire retrieved its feed")

3.2.2. Younger and more mature students do not differ as far as the number of misconceptions is concerned, but diversity shows in the content and subtlety of misconceptions.

Concerning the examined questions, in each age group each student had on average 1.8 misconceptions. Two thirds of the children had at least one or two misconceptions, only ten per cent appeared to have none. Naive theories of younger children were simpler and with fewer components, widening knowledge was well recognisable among those theories of more mature children. Only parts of their wrong answers were still misconceptions, in many cases they were attributable to an interim of the learning process.

3.2.3. A conceptual development in connection with the behaviour, the structure and the quantitative issues of gases can be observed in the examined age group. The majority of the results are similar to international observations.

From the Aristotelian continuous view of matter through phlogiston theory to the evolving particulate view students of the same learner group were on very different levels of conceptual understanding. It is unavoidable for pedagogical practice to map out prior knowledge and to apply differentiated work forms. As for accepting gases as substances, I observed proportions similar to those of the *Séré* (1985) data. In both surveys half of the children asked thought that compressing air causes it to reduce in mass. I perceived the particulate view of gases to a lesser extent than the results of *Novick and Nussbaum* (1978). Two thirds of the 14-year-olds examined by them showed particle approach, while the group I examined showed only a quarter.

3.2.4. A lot of vagueness can be observed in connection with using quantity concepts (mass, volume, density, concentration).

The majority of 6-11-year-olds can not differentiate between the aforementioned concepts, and does not understand the connections between them. 12-14-year-olds are still uncertain when using them; it is common among them to use these concepts as synonyms in their answers. It is essential to develop the appropriate view of matter in order to fully understand them.

3.2.5. In connection with gases, a hierarchy of concepts can be detected in learners' way of thinking

Misconceptions about the quantitative issues of gases, the acceptance of air as a substance, the interpretation of the gas state of matters and the identification of air as breathing gas in the inflated and deflated bicycle tyre do not occur randomly, because the concepts which are needed to understand these problems build up hierarchically. The learner who does not consider air (colourless gases) as substance will not attribute quantitative concepts (mass, volume) to it, resulting in them not being able to solve problems related to this. Questions on quantity act as indicators, incorrect answers given to them made other difficulties of understanding likely.

3.2.6. Joint occurrence of misconceptions can be established among 12-15-year-olds in the case of the examined topics.

It was more typical of children who showed signs of children's science in connection with combustion to have misconceptions about the quantitative issues of dissolving and the acceptance of air as substance.

3.2.7. From a quantitative point of view 12-15-year-olds achieved a statistically better result than younger ones, but there was no significant diversity between the performance and misconceptions of girls and those of boys. However, there appeared to be a close negative correlation between the number of the occurring misconceptions and the performance – in accordance with my expectations.

3.2.8. Knowledge structure analysis proved to be an appropriate tool to complement content and quantitative analyses.

In the case of both age groups a critical learning pathway typical of the group could be determined. Those tasks were put at the beginning of the learning pathway which proved to be easier based on quantitative analysis as well (basic interpretation of the combustion of paper was easy, understanding quantitative relations was more difficult, representing colourless gases from a particulate point of view was the most difficult) and to which less misconceptions were associated. At the same time with its help it was possible to establish a hierarchy of concepts. The asymmetric build of knowledge structures also underpinned those differences between learner groups which were established by quantitative analysis.

I made the following statements based on the analysis of Questionnaire II examining misconceptions:

3.2.9. With age the number of misconceptions reduces, but in the case of adults misconceptions can also be noted (with content and proportion similar to those of 10th graders).

3.2.10. Among those who start their chemistry education (13-15-year-olds), gender and plans to use chemistry in higher education (or lack of those) did not influence the amount of misconceptions.

3.2.11. There was a statistically significant negative correlation between the popularity of chemistry and physics and the number of misconceptions.

3.2.12. There was hardly any difference in the prevalence of misconceptions among the examined topics, which possibly means that the presence of misconceptions do not coincide with one particular concept, but it signals a certain incorrect view of the material world. I managed to detect „misconception-families": for example misconceptions about understanding the liquid state of matter made the presence of misconceptions about the structure and qualities of the solid state of matter and the incorrect interpretation of particles much more likely.

This is in part contradicted by the fact both internationally known and experienced by me that fragmented units of knowledge can surface from the developing and ductile conceptual structure upon certain keywords. A given student can use certain concepts correctly in one context and incorrectly in another.

3.2.13. From content analysis it became clear that understanding the concept of particles and the structure of matter is the key to acquire knowledge on the changes of matter. Based on this, upon comparing groups with undeveloped particulate views and groups with more particulate views the latter acquired statistically better results in the questionnaire, had less misconceptions, its knowledge structure was richer in units of knowledge of a higher level, its learning pathway differed from that of the previous group and was reflecting an interim that was hinting on ongoing conceptual changes.

4. Possible Applications of the Results

Ausubel's observation especially applies to teaching science subjects: „*The most important factor affecting the learner's knowledge is what they already know. We have to recognize it and teach accordingly.*" It is the best interest of the chemistry teacher to be aware of the theories and explanations their students have about the material world, their misconceptions (if any), for without this knowledge they can only create vague and transitory constructions in the knowledge structure of their students.

These require both the reform of methodology and the change of view on behalf of chemistry teachers. As long as assessment sheets, questionnaires or tools similar to interview drafts but thematically grouped, tested, evaluated and standardized are available to teachers, it might become daily routine that we gain information on the prior knowledge of our students by a routine check before introducing a new concept, and plan the teaching process accordingly. With the expected rapid spreading of new teaching technology devices such as interactive whiteboards and the accompanying voting units, teaching tasks will not increase substantially, as there will be no need to bother with correcting questionnaires – instant feedback will be provided not only on the class as a whole, but on each and every individual student. Aware of this, when planning the subsequent lesson we can select the appropriate didactic tool most suitable to the profile of the given learner group and the nature of the concept to be taught, and which appears to be adequate to generate conceptual changes.

It has been in the air for years and it is accepted by parts of the teaching community (although by no means generally) that in fact the role of teachers is being re-evaluated, that we must – however difficult it is – give up the notion that we are the only holders of knowledge. Fortunately new curricular tendencies put competence based education to the fore, and this is favourable for constructivist efforts. For example social competences can be improved with a group discussion or a debate at the beginning of a lesson, where a previously detected misconception typical of the given group serves as a base for a „provocative" experiment or a problem solving task given by the teacher in order to stimulate learners to articulate and clash their opinions and arguments. The above is carried out in such a manner that it facilitates the scientific understanding of the concept and the conceptual change.

Information valuable to practical pedagogy can be gained from utilising a method which does not principally measure individual performances, but informs the teacher about the preparedness and the prior knowledge of a learner group. Knowledge Space Theory applied in my survey helped to establish the knowledge structure of learner groups, the possible order in which they acquire concepts and the learning pathways of the group. Structural analysis of the answers makes it possible to establish the level of conceptual understanding, the level of embedding in the conceptual network. Comparing answers given by students against an expert hierarchy which assumes tasks building on one another, it turns out which task or unit of knowledge could be discussed most economically, i.e. what the learner group is most prepared to acquire based on their prior knowledge. With the help of this method the teaching process can be optimized, as we can avoid overdiscussing concepts well known by everybody or discussing a topic which the group is not yet able to understand due to lack of properly acquired prior knowledge. The method in its present state is slightly laborious; a further task could be to make it more suitable for practical use.

My research raised several new questions; I drew up hypotheses to answer some of them, others remain open and await further research yet to be carried out in the future.

5. Scientific Publications

5.1.Publications directly connected with the topic of this paper

5.1.1. Referenced scientific papers published in international journals

1. Ilona K. Schneider, Franz Oberländer, Zoltán Tóth, Éva Dobó-Tarai, Ibolya Revakne Markóczi
Natural scientific learning in primary schools: The Rostock Model
Practice and Theory in Systems of Education, *Vol. 1. No. 2.* (2006) pp. 1-23. *(http://eduscience.fw.hu).*

2. Zoltán Tóth, Éva Dobó-Tarai, Ibolya Revák-Markóczi, Ilona K. Schneider, Franz Oberländer
1st Graders prior knowledge about water: Knowledge Space Theory applied to interview data
Journal of Science Education, *Vol. 8. No. 2.* (2007) pp. 116-119.

3. Ibolya Markóczi-Revák, Beáta Kosztin-Tóth, Zoltán Tóth, Éva Dobó-Tarai, Ilona K. Schneider, Franz Oberländer
Effects of applying the Rostock Model on metacognitive development of pupils
Journal of Science Education, Vol. 9. No. 2. (2008) pp. 94-99.

4. Zoltán Tóth, Ibolya Revák-Markóczi, Ilona K. Schneider, Franz Oberländer, Éva Dobó-Tarai
Effect of instruction on 1st graders' thinking patterns regarding the description of water with every day and scientific concepts
Practice and Theory in Systems of Education, Vol. 3. No. 1. (2008) pp. 45-54.

(*http://eduscience.fw.hu*).

5.1.2. Referenced scientific paper published in a Hungarian journal:

Dobóné Tarai Éva
Általános iskolai tanulók tudásszerkezete (Knowledge Structure of Primary School Students)
Iskolakultúra. 17. évfolyam, 7-8. szám (2007) 119-131.

5.1.3. Non-referenced papers published in journals

1. Dobóné Tarai Éva
Gyermektudományos elméletek az égéssel kapcsolatban (Children's Views on Combustion)
Középiskolai Kémiai Lapok, *XXXI évfolyam, 2. szám* (2004) 186-194.

2. Dobóné Tarai Éva
Tanulói elképzelések az anyag részecsketermészetével kapcsolatban (Pupils' Views on the Particle Nature of Matter)
Középiskolai Kémiai Lapok, XXXI. évfolyam, 3. szám (2004) 285-296

3. Dobóné Tarai Éva
Oldódás - ahogy a gyerekek látják (Dissolving – The Way Children See It)
Középiskolai Kémiai Lapok, XXXI. évfolyam, 4. szám (2004) 352-361

4. Dobóné Tarai Éva
Kémiai fogalmak és gyermektudományos elméletek (Concepts of Chemistry and Children's Science)
A Kémia Tanítása, *13. évfolyam, 2. szám* (2005) 12-19.

5.1.4. Conference Lectures:

1. Dobóné Tarai Éva, Tóth Zoltán:
   Az égéssel, tömegmegmaradással, és az anyag részecske-természetével kapcsolatos gyermektudományos elméletek vizsgálata (A Survey of Children's Theories on Combustion, Conservation of Mass and the Particle Nature of Matter)
   XXI. Országos Kémiatanári Konferencia, Pécs, 2004. (Előadásösszefoglalók, 78-79. o.)

2. Dobóné Tarai Éva:
A „lélegző biciklikerék", avagy mi van a leeresztett kerékpárgumiban?- természettudományos fogalmak és gyermektudományos elméletek (The "Breathing Bicycle Tyre" or What Is There in the Deflated Bicycle Tyre? – Scientific Concepts and Naive Theories)
IV. Országos Neveléstudományi Konferencia, Budapest, 2004. (Program és Tartalmi Összefoglalók, 307. o.)

3. Dobóné Tarai Éva
States of water- Knowledge Space Theory- 1st graders knowledge structure about water and change of water
Angol nyelvű előadás a project megbeszélésen (Rostock, 2005.)

4. Dobóné Tarai Éva
Az anyag állapotával kapcsolatos fogalmak fejlődésének interjúkon alapuló vizsgálata (An Interview-Based Survey of Conceptual Development Concerning the State of Matter)
V. Országos Neveléstudományi Konferencia, Budapest, 2005. (Program és Tartalmi Összefoglalók, 158. o.)

5. Dobóné Tarai Éva, Tóth Zoltán, Revákné Markóczi Ibolya, Ilona Schneider, Franz Oberlaender
Anyagi halmazokkal kapcsolatos fogalmak vizsgálata (A Survey of Concepts Related to Mass Sets)
XXII. Országos Kémiatanári Konferencia, Veszprém, 2006. (Előadásösszefoglalók, 46.o.)

6. Dobóné Tarai Éva
Általános iskolás tanulóknak az anyaggal és változásaival kapcsolatos tudásszerkezete (Knowledge Structure of Primary School Students in Connection with Matter and Its Changes)
VI. Országos Neveléstudományi Konferencia, Budapest, 2006. (Program és Tartalmi Összefoglalók, 136.o.)

7. Dobóné Tarai Éva
Természettudományos fogalmakhoz kötődő alternatív tanulói elképzelések diagnózisa (Diagnosis of Students' Alternative Theories Related to Nature Science Concepts)
VII. Országos Neveléstudományi Konferencia, Budapest, 2007. (Program és Tartalmi Összefoglalók, 202.o.)

8. Revákné Markóczi Ibolya, Tóth Zoltán, Dobóné Tarai Éva

Kisiskolások természettudományos gondolkodásának vizsgálata – a Rostocki Modell (A Survey of Young Primary School Students' Scientific Thinking – The Rostock Model)
VII. Országos Neveléstudományi Konferencia, Budapest, 2007. (Program és Tartalmi Összefoglalók, 73.o.)

9. Tóth Zoltán, Revákné Markóczi Ibolya, Dobóné Tarai Éva, Ilona K. Schneider, Franz Oberlaender:
A tanítás hatása az elsõosztályos tanulók vízzel kapcsolatos fogalmi rendszerére (The Effects of Teaching on School Beginners' Conceptual Structure Related to Water)
I. Miskolci "Taní-tani" Konferencia, Miskolc, 2008. (Előadásösszefoglalók, 74. o.(www.uni-miskolc.hu/~btntud/imtk.pdf)

5.1.5. Posters presented at conferences:

1. Dobóné Tarai Éva:
Az anyag részecsketermészetével kapcsolatos gyermektudományos elméletek vizsgálata. (A Survey of Children's Theories on the Particle Nature of Matter)
XXI. Országos Kémiatanári Konferencia, Pécs, 2004 (Előadásösszefoglalók, 154. o.)

2. Dobóné Tarai Éva
A tömegmegmaradással kapcsolatos gyermektudományos elméletek (Children's Theories on the Conservation of Mass)
XXI. Országos Kémiatanári Konferencia, Pécs, 2004. (Előadásösszefoglalók, 155. o.)

3. Dobóné Tarai Éva
„…Könnyebb, mert a tűz táplálékát kinyerte" - Az égéssel kapcsolatos gyermektudományos elméletek ("...Lighter as fire retrieved its feed" – Children's Theories on Combustion)
XXI. Országos Kémiatanári Konferencia, Pécs, 2004. (Előadásösszefoglalók, 156. o.)

4. Dobóné Tarai Éva, Dr. Tóth Zoltán
Anyagi halmazokkal kapcsolatos fogalmak tudásszerkezete (Knowledge Structures of Concepts Related to Mass Sets)
XXII. Országos Kémiatanári Konferencia, Veszprém, 2006. (Előadásösszefoglalók, 83.o.)

5. Éva Dobó-Tarai, Zoltán Tóth, Ibolya Revák-Markóczi , Ilona K. Schneider, Franz Oberländer
A study of 1st graders' prior knowledge about water using interview based knowledge space theory
8th European Conference on Research in Chemical Education, Budapest, 2006. (*Book of abstracts, p. 134.)*

5.2.Publications not connected directly with the topic of this paper

5.2.1. Papers

1. Dobóné Tarai Éva, Tarján András
Környezetvédelmi praktikum tanároknak
Mezőgazda Kiadó. Budapest, (1999)

2. Dobóné Tarai Éva
Környezeti nevelő játékok.
Módszerkosár, Magyar Környezeti Nevelési Egyesület, Budapest, 3. szám, (2001) 1-3.

3. Dobóné Tarai Éva
Internetes barangolás: Recycle City angol nyelvű honlap ismertetése
Módszerkosár, *Magyar Környezeti Nevelési Egyesület, Budapest, 9. szám*, (2002) 1-2.

4. Dobóné Tarai Éva (2005)
Játékos kémia
In: Kíméletes kémia (szerk.: Bagári Kinga), Magyar Környezeti Nevelési Egyesület, Budapest, (2005) 109-129.

5. Bartha Cecília, Dobóné Tarai Éva
Környezetbarát kísérletezés a kémiaórákon
In: Kíméletes kémia (szerk.: Bagári Kinga), Magyar Környezeti Nevelési Egyesület, Budapest. (2005) 130- 147.

6. Dobóné Tarai Éva
Szakkör
In: Iskolánk zöldítése (szerk.: Victor András) Magyar Környezeti Nevelési Egyesület, Budapest. (2005) 183-189.

7. Dobóné Tarai Éva
Csak egy panel?
Krétakör, 14. évfolyam 2. szám (2007) 11.

8. Dobóné Tarai Éva
Interaktív tábla a kémiaórákon – Az első tapasztalatok
Középiskolai Kémiai Lapok, XXXIV. évfolyam, 5. szám (2007) 410-419

9. Dobóné Tarai Éva
Tanösvény a Kék Tagiskolában.
Tizenharmadik Kerületi Hírnök 2008. május 2. 6.

10. Dobóné Tarai Éva
Keverékek és oldatok szétválasztása – a témakör feldolgozása aktív tábla segítségével
Táblatanító 1. évfolyam, 1. szám (2008) 8-13.

5.2.2. Lectures and presentations

1. Dobóné Tarai Éva
A szilfa félék
Előadás, Herman Ottó Természetvédelmi és Bonsai Egyesület, Budapest, 2004.

2. Dobóné Tarai Éva
Őshonos fák Magyarországon
Előadás. Herman Ottó Természetvédelmi és Bonsai Egyesület, Budapest, 2005.

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