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Application of Web-based Learning Material for Teaching States of Matter in 8th Grade Primary School Chemistry – A Pilot Study Results

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Abstract: This paper presents results of a pilot study that investigated the progression in primary school students' conceptions of the structure and states of matter while learning with a new instructional approach dealing with these concepts. The study begun in May and was continued in September 2013. In the first part of the study we included 108 7th grade students (aged 12-13) from two primary schools, and in the second part we continued the study with 57 8th grade students (aged 13-14) from one school. Web-based learning material was applied as instructional tool during teaching of Structure of matter and States of matter, containing both macro and sub-micro level of representation. Students were asked to fulfill tests of knowledge dealing with macroscopic and submicroscopic level of representation. Results showed better understanding of structure and states of matter but also some persistent misconceptions that could be addressed in the following period.

INTRODUCTION

One of the fundamental concepts in science is structure of matter. The proper understanding of this concept is crucial for learning other scientific concepts. However, students tend to develop their understanding of science concepts in accordance with formal teaching as well as their everyday experience. Therefore, students could have conceptions that do not agree with scientific laws and theories, and teaching itself can be one cause for them (Osborne and Cosgrove, 1983). They can be caused by teachers who use inadequate instructional methods (Johnson, 1998), by some representations of particulate nature of matter in existing textbooks (Andersson, 1990).Also, teachers without sound scientific background can introduce misconceptions to their students (Del Pozo, 2001; Kokkotas, Vlachos and Koulaidis, 1998).

Determination of misconceptions in chemistry education is not new in scientific research. They are of particular interest for researchers in science education because they influence learning of new scientific knowledge (Özmen, 2004). Ausubel (1961) states that students' cognitive structure of knowledge impacts on interpretation of new knowledge. When students are exposed to new information, the misconceptions that are already incorporated in their cognitive structure affect the integration of new knowledge. This causes weak or wrong understanding of new concepts (Azizoğlu, Alkan and Geban, 2006). In case the misconceptions were acquired before teaching, teachers need to recognize them and consider them when teaching (Barke, Hazari and Yitbarek, 2009).

Misconceptions formed in school are primarily caused by inadequate curricula, teaching materials and textbooks (Barke, Hazari and Yitbarek, 2009).
Johnstone (1982) introduced three levels of representation in science: macroscopic (phenomenological, observable phenomena), submicroscopic (atomic, ionic, molecular), and symbolic (symbols, formulae, equations). Teaching strategies in chemistry should lead towards understanding of chemical concepts on all three levels (Johnstone, 1993). Scientists describe matter on macroscopic and on submicroscopic level, and students need to learn the relationship between levels (Johnstone, 1993; Stieff, Ryu and Yip, 2013).
Research has shown that students have problems in understanding the meaning of these three levels and they do not connect their observations on macro level with explanations on submicro level and writing on symbolic level, which leads to making ideas on their own, mostly the wrong ones (Barke, Hazari and Yitbarek, 2009). Jumping from macroscopic to symbolic level without considering submicroscopic can cause students to simply memorize formulae and equations. This makes chemistry "dry, lifeless and hard to understand" (Barke, Harsch and Schmid, 2012). Understanding processes on the level of atoms, ions and molecules is crucial for explaining concepts described or observed at macro level (Gabel, 1994; Papageorgiou and Johnson, 2005). Complete understanding of chemical concepts is acquired only when all three conceptual levels are interchanging in student's memory (Devetak, Vogrinc and Glažar, 2009, Chittleborough, 2014).
When teaching chemical concepts in primary school, teachers still mainly address and describe macroscopic level instead of linking macroscopic to submicroscopic (Gilbert and Treagust, 2009). In order for students to understand specific concepts (e.g. differences on structure and states of matter), teacher should switch from macroscopic to the submicroscopic level, which sometimes can be a significant challenge for students to understand (Stieff, Ryu and Yip, 2013).
One of the teaching strategies that showed good results in teaching science is e-learning. It is defined as instruction delivered on a digital device such as a computer or a mobile device that is intended to support learning (Clark and Mayer, 2011.). E-learning tools have profoundly transformed pedagogical approaches. A variety of media elements can be used in e-learning: (text, audio, still and motion visuals (Clark and Mayer, 2011.). The impact of e-learning on students' achievement is complex and depends also on other factors, but studies showed that students learn best with e-learning when interactively engaged in the content. Use of technology can motivate students; it significantly improves their performance, and shifts a teacher-centered to a more learner-centered classroom environment (Olson, Codde, deMaagd*et al*., 2011).
According to curricula for nine-year long primary school education in Federation of Bosnia and Herzegovina, students start to learn some fundamental scientific phenomena within subject "My environment" (1st to 4th grade), "Nature" (5th grade) and later on in "Biology" (6th to 9th grade), "Physics" (7th to 9th grade) and "Chemistry" (8th and 9th grade). Within "Physics" in 7th grade students learn some concepts relevant for this study: structure of matter and states of matter (SSM) on submicroscopic level (particulate nature of matter). Within "Chemistry" in 8th grade, students expand their knowledge about SSM. All concepts are taught on macroscopic and submicroscopic, without symbolic level.

RESEARCH METHODOLOGY

The aim of the first part of this study is to get insight into the most common misconceptions regarding structure and states of matter at the end of 7thgrade of primary school. The aim of the second part is to explore the potential application of a web-based learning material (WBLM) designed for teaching Structure and States of matter at the beginning of 8thgrade of primary school in order to address detected misconceptions.

Participants

Participants in this study were primary school students, aged 12-13 (7th grade) and 13-14 (8th grade) years. Data were collected using tests of knowledge (TK) during May (TK 7th grade), September (TK 8th grade-1) and December (TK 8th grade-2) 2013; they were confidential and given on voluntary basis. In the first part of the study we have included 108 students from two primary schools in Sarajevo. The second part of the study we have continued with students from this group who attended one primary school (n=67, aged 13-14 years).

Research instruments

Test of knowledge 7th grade (TK 7th grade) designed for the purpose of this study was used in the first part of the study. It contained 9 objective items (multiple-choice, true-false, matching and completion), regarding macroscopic and/or submicroscopic level of representation of states of matter, mostly taught within Physics in 7th grade but also known from everyday experience.

E-unit – web-based learning material (WBLM) was used as an instructional tool when teaching Structure and States of matter (SSM) within Chemistry in the 8th grade. This e-unit contained 7 sections composed of text, pictures, videos and tasks for checking students' attention and knowledge at the end of each section. It was designed for the purpose of this study, using eXecute (a tool for design and development of electronic textbooks) and delivered to students using PCs in IT classroom.

Test of knowledge 8th grade (TK 8th grade) designed for the purpose of this study was used to establish the effects of a web-based learning material (WBLM) on understanding concepts of representation of states of matter. TK 8th grade contained 10 items of similar type as in knowledge test TK 7th grade.

Research design

Structure of matter and states of matter (SSM) are taught in primary school within Physics at the end of the 7th grade. Therefore, test of knowledge TK 7thgrade was conducted in May 2013 in two primary schools, just before the summer break.

At the beginning of 8th grade when, according to Curricula, SSM are taught again within Chemistry, we have applied e-unit as instructional tool to teach this content. In order to do so, we have combined classes of Chemistry and Informatics (IT). Teaching SSM lasted for three teaching hours: introduction to WBLM, learning SSM, and working on tasks, accompanied by filling questionnaires (results not presented in this paper). Students were working in pairs in six separate groups, due to the number of available PCs. Teachers' role was to explain details about the way that students need to learn and to assist students during learning.

One week after teaching we administered the test of knowledge TK 8th grade-1, containing concepts taught using WBLM. The same knowledge test (TK 8th grade-2) was repeated three months after teaching in order to test the retention of knowledge.

RESULTS AND DISCUSSION

Test of knowledge – TK 7th grade

TK 7th grade has been administered in two primary schools in urban region of Sarajevo in May 2013, in order to get insight into students' conceptions on states of matter on macroscopic and submicroscopic level, taught within Physics during April and May. Frequencies of correct responses are presented in Table 1.

Table 1: Frequency of correct responses: test of knowledge TK 7th grade

Item No.	1	2	3	4	5	6	7	8	9
Frequency f (%)	94.6	25.7	21.1	80.3	57.2	48.7	44.1	82.4	54.6

On TK 7th grade (Table 1) 2nd and 3rd item were most difficult ones. They both were multiple-choice items: 2nd item where students should answer what happens with water when it evaporates – only 25.7% knew that water became gaseous and went to the air; 3rd item where students should say what water is composed of and only 21.1% knew it is composed of water molecules. Molecules as particles in substances are briefly introduced within Physics (they are more thoroughly addressed within Chemistry in 8th grade) but it was expected that 7th grade students know fundamental facts about transition from liquid to gas. Other items with greater percent of correct answers were mostly about macroscopic observation from everyday life including explanation on submicroscopic level.

Most frequent 7th grade students' misconceptions are shown on Table 2:

Table 2: List of most frequent misconceptions identified in this study - TK 7th grade

7th grade	Number	%
1. We cannot obtain liquid water from water vapor since it disappeared.	31	28.7
2. We cannot obtain liquid water from water vapor since it has changed.	37	34.3
3. Bubbles formed when water is heated are made out of gaseous hydrogen and oxygen.	22	20.4
4. Bubbles formed when water is heated are made out of heat.	48	44.4
5. Evaporation can shrink water molecules.	45	41.7
6. Freezing can shrink water molecules.	19	17.6
7. If we make a leaflet of gold, its atoms become closer to each other.	22	20.4
8. If we make a leaflet of gold, its atoms become straightened.	31	28.7
9. Water is composed of hydrogen and oxygen molecules.	37	34.3
10. Water is composed of hydrogen and oxygen atoms (no chemical bond).	36	33.3
11. When spilled, water splits up to hydrogen and oxygen.	73	67.6

The most common misconceptions come from the fact that students assign macroscopic properties to submicroscopic particles (e.g. we can change the shape of atoms; water molecules shrink when water evaporates; we cannot obtain liquid water from water vapor because water is "changed"). In addition, they have misconceptions regarding the differences between chemical and physical change, concepts which are taught after Structure and states of matter.

Some phenomena about states of matter students know from everyday experience, but they are not able to explain them on submicro level. Some research already showed comparable findings (Rappoport and Ashkenazi, 2008; Treagust, Chittleborough and Mamiala, 2003;Kozma and Russell, 1997).

It was interesting to see if there was correlation between students' final marks in Physics and results of our test of knowledge TK 7^{th} grade. Only one physics teacher was willing to provide data about final marks of his students (n=40[1]).

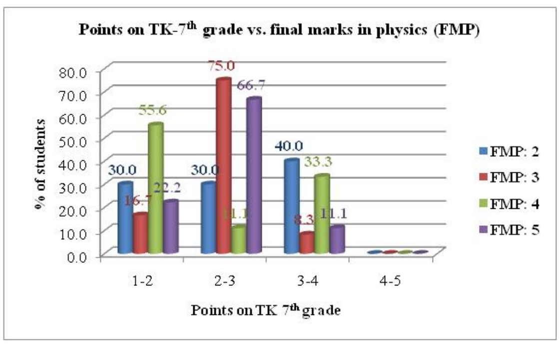


Figure 1: Comparison of results of TK 7^{th} grade and final marks in Physics in 7^{th} grade

Pearson correlation coefficient for these two sets of data (TK 7^{th} grade and final marks in Physics 7^{th} grade) shows low and insignificant correlation between students' marks and results of TK 7^{th} grade ($r = 0.0816$, $p>0.05$), confirmed also by mean and standard deviation (Table 3)

Table 3: Descriptive statistics for TK 7^{th} grade and FMP

	M	SD
TK 7^{th} grade[2]	2.64	0.73
Final Marks Physics	3.43	1.11

[1] Total number of 7^{th} grade students in this school is 41, but both physics and chemistry teacher recommended for one student to be excluded from this comparison (no data on FMP, TK 7^{th} grade: 9.5%)

[2] Mean and standard deviation are calculated for data obtained from one school whose physics teacher provided data on final mark in physics for students who participated in this study

Test of knowledge – TK 8^{th} grade

In order to teste-units (WBLM) and to see effects of its application, test of knowledge (TK 8^{th} grade) was administered twice: one week after teaching Structure and States of matter using WBLM (TK 8^{th} grade-1) and three months after teaching (TK 8^{th} grade-2)[3].

Table 4: Frequency of correct responses: TK 8^{th} grade

Item No.	1	2	3	4	5	6	7	8	9	10
f (%) TK 8^{th} grade-1	59.6	35.1	42.8	9.1	72.9	51.6	25.4	50.9	36.6	33.4
f (%) TK 8^{th} grade-2	45.6	33.3	45.7	31.5	85.1	56.1	29.8	73.7	64.9	44.2

There was a decrease in the number of correct answers for 1^{st} and 2^{nd} task, both regarding submicroscopic level. An increase was noted for tasks from 3^{rd} to 10^{th} – the highest for 9^{th} task containing submicroscopic representations of particles in different phases.

Table 5: Descriptive statistics: TK 8^{th} grade-1 and TK 8^{th} grade-2

	M	SD
TK 8^{th} grade-1	4.04	2.54
TK 8^{th} grade-2	5.27	2.47

As shown in Table 5, overall students' achievements (mean) are higher on TK 8^{th} grade-2, which is promising when considering retention of students' knowledge and potential teachers' actions after teaching. Pearson correlation coefficient for TK 8^{th} grade-1 and TK 8^{th} grade-2 shows moderate positive correlation ($r = 0.619$, $p>0.05$). A paired t-test showed statistically significant difference of a variance for these two sets of data (t (57) = -2.616.two-tail $p = 0.010$).

However, there were persistent misconceptions noted on both tests of knowledge in 8^{th} grade too.

Concepts about SSM were taught more extensively within Chemistry in 8^{th} grade than within Physics in 7^{th} grade – therefore we could not administer same test of knowledge both in 7^{th} and 8^{th} grade.

Some misconceptions noted for 7^{th} grade students persisted during 8^{th} grade on both tests: results of TK 7^{th} grade showed that some students believe that change in state of matter affects the size of particles (freezing (17.6%) or evaporation (41.7%) can shrink molecules (Table 2); some 8^{th} grade students think that molecules can be increased by

[3] Data analysis showed that there were 57 (85.07%) students who were learning using WBLM and participating on both tests of knowledge (TK 8^{th} grade-1 and TK 8^{th} grade-2)

freezing (TK 8th grade-1: 15.8%, TK 8th grade-2: 2.1%, Table 6).

Table 6: List of most frequent misconceptions identified in this study - TK 8th grade

	TK 8th grade -1	TK 8th grade -2
	%	%
1. Water molecules will stop to move if the water freezes.	33.3	43.9
2. Water molecule can be increased by freezing.	15.8	28.1
3. When the substance is in the liquid state, its volume can easily change.	36.8	36.8
4. Particles in solids are tightly packed and do not move.	47.4	33.3
5. Particle size of the salt admits at the micro scale.	66.6	78.9
6. There are different particles in different phases of the same substance.	8.8	12.3
7. Speed of the particles of the same substance is the same in all phases.	14.0	8.8

Some incorrect answers noted on TK 7th grade did not appear in 8th grade: e.g. water disappears (28.7%) or changes (34.3%) when evaporates (Table 2) as well as answers which were somewhat expected for 7th grade students since they learn about molecules and atoms more extensively in 8th grade (in water vapor there are molecules of hydrogen and oxygen (34.3%; Table 2). Such misconceptions were not noted after teaching with WBLM.

However, we have noted misconceptions regarding the arrangement of particles in different states of matter (Table 6): particles in solids do not move (TK 8th grade-1: 47.4%; TK 8th grade-2: 33.3%), water molecules stop moving when water freezes (TK 8th grade-1: 33.3%; TK 8th grade-2: 43.9%), even though WBLM contained animations on vibration of particles in solids. The most common misconception in 8th grade is about the size of particles, which shows that students still do not perceive their size.

CONCLUSION

Results of TK 7th grade administered in May 2013 showed that most students did not differentiate macroscopic and submicroscopic level of the structure and states of matter and that they have not developed concepts of atoms and molecules. Results of both tests of knowledge in 8th grade (TK 8th grade-1 and TK 8th grade-2) showed that even though some misconceptions were noted again, e-units do have a positive impact on students' understanding of particulate nature of matter.

There is a persistent misconception noted in 7th grade and again in 8th grade before and after teaching SSM: change in state of matter affects the size of particles. This shows how much misconceptions are incorporated in students' minds.

Tests of knowledge administered both one week (TK 8th grade-1, September 2013) and three months (TK 8th grade-2, December 2013) after teaching Structure and states of matter using e-units gave positive results when considering retention of students' knowledge. There is moderate correlation but also statistically significant difference on TK 8th grade-2. Explanation for this fact can be possible teachers' intervention after teaching this content and writing test.

According to the Piaget's theory of cognitive development, students at age 11 start to develop an abstract way of thinking (Wadsworth, 2004). Learning submicro-macro thinking is abstract and thus can be difficult for students at this age (Gilbert and Treagust, 2009), which is also confirmed by results of this study. This implies that those concepts in curricula that include processes on submicro level can be too demanding for students if they are taught in a traditional way, using teacher-centered teaching.

E-units as instructional tool helped in teaching structure and states of matter mostly in representing processes on submicro level. Perhaps more extensive application of WBLM could address misconceptions that were noted and mentioned above.

ACKNOWLEDGEMENT

We would like to thank all students and their parents who voluntarily agreed to participate in this study, as well as teachers of chemistry, physics, informatics, and principals of schools where the study was conducted.

APPENDICES

Appendix I - Test of knowledge 7th grade

1. Classify these substances by their aggregate state of matter: air, water, ice, sugar, water steam, gold, milk, oxygen, oil.
   Solid: ________________________________.
   Liquid: _______________________________.
   Gas: _________________________________.

2. You accidentally spill some water to the floor, but you do not have time to wipe it. Few hours later, the amount of spilled water decreased. What had happened to the water?
   A. The amount of water is decreased and occupies smaller area.
   B. Water turned into gas and went to the air.
   C. Water splits up to hydrogen and oxygen that went to the air.

3. What kind of particles are in the water?
   A. Water molecules.
   B. Water atoms.
   C. Atoms of hydrogen and oxygen.
   D. Molecules of hydrogen and oxygen.

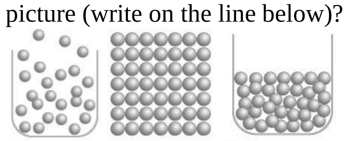
4. If you take a bottle of juice from the fridge and put it on the table in warm room, on the outer side of the bottle appear drops. What are they?
   A. Juice drops from the bottle.
   B. Water drops from the water steam from air.
   C. Drops of water and juice from the bottle.
   D. Drops of water from the bottle.

5. Imagine that you have made a gold leaflet out of bit of gold. What had happened to the atoms of gold?
   A. They have not changed.
   B. Each one of them straightened.
   C. They are lighter now.
   D. They are closer to each other.

6. Which procedure can shrink water molecules?
   A. Freezing liquid water.
   B. Melting ice.
   C. Evaporation of water.
   D. They cannot shrink.

7. A pot with water is placed to hotplate. Bubbles start to form at the bottom and lift towards the water surface. What are these bubbles made of?
   A. Heat.
   B. Air.
   C. Steam.
   D. Gaseous oxygen and hydrogen.

8. Which state of matter is represented on each picture (write on the line below)?



   _________ ___________ _________

9. If a pot containing hot water is covered, drops start to form on the cover. Where do these drops come from?
   A. Water drops from the pot.
   B. Water drops from the steam.
   C. Water drops from the air.
   D. Drops of cold air.

   If we uncover the pot, we can observe steam. Can we obtain liquid water back from the steam?
   A. We cannot obtain liquid water since it has changed.
   B. We cannot obtain liquid water since it disappeared.
   C. We can obtain liquid water if we cool the steam.

Appendix II - Test of knowledge 8th grade

1. Which statement about water is **correct**?
   A. Water molecules will stop moving if water freezes.
   B. Water molecules will stop moving if water evaporates.
   C. Water molecules will stop moving if a glass with liquid water is not disturbed.
   D. Water molecules will not stop moving.

2. Which procedure can be used to **increase** the water molecule?
   A. Freezing.
   B. Melting.
   C. Evaporation.
   D. Condensation.
   E. None of the above.

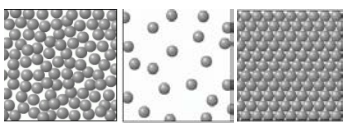
3. Encircle the **correct** statements:

A. Liquid substance can easily change its volume.
B. The shape of liquid depends on the container.
C. Gases do not have determined shape.
D. A substance cannot change its state from solid to gas.
E. Same substance can be found in several states of matter.

4. Encircle the **correct** statements:

A. Particles in water vapor are smaller than the particles in ice.
B. Particles in liquid water are properly distributed and do not move.
C. Particles in gases are distant from each other and they move fast.
D. Particles in solids are properly distributed and do not move.
E. When water evaporates, the size of the particles does not change.

5. The arrangement of particles in water in three phases are represented on following pictures (1,2,3):



1 2 3

Arrangement in ice is represented on picture ______, in liquid water on picture ________, and in steam on picture _______.

6. Using measurement scale, fulfill the sentences.

Measurement scale:

Macro scale				Micro scale			Nano scale		
1	1	1	1	100 µm	10 µm	1 µm	100	10	1

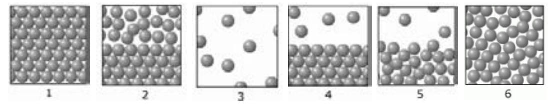
Considering their size, sort on the measurement scale:

A. The size of a child admits to the ________ scale.
B. The size of particles in salt admits to the _________ scale.
C. The size of plant cell admits to the _________ scale.
D. The size of a pen admits to the _________ scale.
E. The size of particles in ice admits to the _________ scale.

7. Write one example of condensation from everyday life:

8. Write one example of transition between solid and liquid from everyday life:

9. Particles arrangements are represented on following pictures. For each picture write the corresponding state of matter (or states) next to the number below pictures.



1: ____________ 4: _______________
2: ____________ 5: _______________
3: ______________ 6: _______________

10. Which statements are **correct** for substances in various states of matter?

A. There are different particles for the same substances in different phases.
B. Particles move freely in solids.
C. Particles in gases are more distant from each other than particles in liquids.
D. The speed of particles is the same in every phase.
E. When solid transfers to liquid, its particles move faster.

REFERENCES

Andersson, B. (1990). Pupils' conceptions of matter and its transformations. *Studies in Science Education, 18 (1)*, 53–85.

Ausubel, D. P. (1961).In Defense of Verbal Learning. *Educational Theory, 11(1)*, 15–25.

Azizoğlu, N., Alkan, M., Geban, Ő. (2006). Undergraduate Pre–Service Teachers' Understandings and Misconceptions of Phase Equilibrium. *Journal of Chemical Education, 83 (6)*, 947–953.

Barke, H.-D., Harsch, G., Schmid, S. (2012). *Essentials of Chemical Education*. Berlin, Heidelberg: Springer-Verlag

Barke, H.-D., Hazari, A., Yitbarek, S. (2009). *Misconceptions in Chemistry: Addressing Perceptions in Chemical Education*. Berlin, Heidelberg: Springer-Verlag.

Chittleborough, G. (2014). The Development of Theoretical Frameworks for Understanding the Learning of Chemistry. In Devetak, I. and Glažar S.A. (Eds.), *Learning with Understanding in the Chemistry Classroom*, (pp. 25-40). Dordrecht, Netherlands: Springer Science+Business Media B.V.

Clark, R.C., Mayer, R.E. (2011). E-learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning. (3rd Ed). Pfeiffer: San Francisco.

Del Pozo, R.M. (2001). Prospective teachers' ideas about the relationships between concepts

describing the composition of matter. *Journal of Science Education*, *23 (4)*, 353–371.
Devetak, I., Vogrinc, J., Glažar, S. A. (2009). Assessing 16-Year-Old Students' Understanding of Aqueous Solution at Submicroscopic Level. *Research in Science Education*, *39(2)*, 157–179.
Federalno ministarstvo obrazovanja i nauke (nd). *Okvirni nastavni plan i program za devetogodišnju osnovnu školu u Federaciji Bosne i Hercegovine.* Available at: http://www.sobih.ba/siteoo/images/stories/galerije/Zakonska_akta/okvini%20npp.pdf [07.04.2013]
Gabel, D. (1994). Improving Teaching and Learning through Chemistry Education Research: A Look to the Future. *Journal of Chemical Education*, *76 (4)*, 548–554.
Gilbert, J. K., Treagust, D. (Eds.) (2009). *Multiple Representations in Chemical Education*. Dordrecht: Springer Science+Business Media B.V.
Johnson, P. (1998). Progression in children's understanding of a 'basic' particle theory: Alongitudinal study. *International Journal of Science Education*, *20 (4)*, 412–493.
Johnstone, A. H. (1993). The development of chemistry teaching: A changing response tochanging demand. *Journal of Chemical Education70 (9)*, 701–705.
Johnstone, A. H. (1982). Macro- and micro-chemistry. *School Science Review64 (227)*, 377–379.
Kokkotas, P., Vlachos, I., Koulaidis, V. (1998). Teaching the topic of the particulate nature of matter in prospective teachers' training courses. *International Journal of Science Education, 20 (3),* 291–303.
Kozma, R. B., Russell, J. (1997). Multimedia and understanding: Expert and novice responses to different representations of chemical phenomena. *Journal of Research in Science Teaching, 34(9)*, 949–968.
Olson, J., Codde, J., deMaagd, K., Tarkleson, E., Sinclair, J., Yook, S., Egidio, R. (2011).*An Analysis of e-Learning Impacts & Best Practices in Developing Countries.* Michigan State University. [Online] Available at: http://cas.msu.edu/wpcontent/uploads/2013/09/E-Learning-White-Paper_oct-2011.pdf. &Ć.03.2014]
Osborne, R. J., Cosgrove, M. M. (1983). Childrens Conceptions of the Changes of State of Water. *Journal of Research in Science Teaching, 20(9)*, 825–838.
Özmen H. (2004). Some Student Misconceptions in Chemistry: A Literature Review of Chemical Bonding. *Journal of Science Education and Technology, 13(2),* 147–159
Papageorgiou, G., Johnson, P. (2005). Do Particle Ideas Help or Hinder Pupils' Understanding of Phenomena? *International Journal of Science Education*, *27(11)*, 1299–1317.
Rappoport, L. T., Ashkenazi, G. (2008). Connecting Levels of Representation: Emergent versus submergent perspective. *International Journal of Science Education, 30(12)*, 1585–1603.
Stieff, M., Ryu, M., Yip, J. C. (2013). Speaking across levels – generating and addressing levels confusion in discourse. *Chemistry Education Research and Practice, 14 (4),* 376-389.
Treagust, D., Chittleborough, G., Mamiala, T. (2003).The role of submicroscopic and symbolic representations in chemical explanations. *International Journal of Science Education*, *25 (11)*, 1353–1368.
Wadsworth, B. J. (2004). *Piaget's Theory of Cognitive and Affective Development: Foundations of Constructivism*. Boston, MA: Pearson Education.

Summary/Sažetak

O ovom radu predstavljeni su rezultati pilot istraživanja u kojem je istraživan napredak učenika osnovne škole u razumijevanju koncepta građe tvari i agregatnih stanja tvari primjenom novog pristupa u nastavi vezanog za ove pojmove. Istraživanje je počelo u maju 2013. godine s učenicima sedmog razreda osnovne škole i nastavljeno u septembru iste godine. U prvom dijelu istraživanja sudjelovalo je 108 učenika sedmog razreda osnovne škole (uzrasta 12-13 godina) iz dviju osnovnih škola, dok je u drugom dijelu istraživanje nastavljeno s 57 učenika osmog razreda iz jedne škole. Mrežno potpomognuti materijal za učenje koji je sadržavao i makroskopske i submikroskopske prikaze primijenjen je kao nastavno sredstvo prilikom poučavanja građe tvari i agregatnih stanja tvari. Zadatak učenika je bio da urade testove znanja također bazirane na makroskopskoj i mikroskopskoj spoznajnoj razini. Rezultati su pokazali bolje razumijevanje građe tvari i agregatnih stanja tvari, ali također i postojane miskoncepcije kojima bi se trebalo posvetiti u narednom periodu.