University of Necmettin Erbakan, Ahmet Keleşoğlu Education Faculty, Secondary Science and Mathematics Education Department

KONYA/TURKEY

AN APPLICATION TO CLOSE THE GAP IN GENERAL CHEMISTRY TEACHING: CHEMISTRY VISUALISATIONS

OUTLINE of the PRESENTATION

- Introduction
- Purpose of the Study
- Design
- Sample and Educational Background
- Process steps in Teaching/Instruction
- Data Collection and Analysis
- Results and Discussion

INTRODUCTION

- Atomic structure and the particulate nature of matter are substantial topics in science education in worldwide.

- As has been pointed out in many studies, because of the abstract nature of the sub-micro world of atoms, students have difficulty understanding these concepts (Harrison &Treagust, 1996).

- It is pointed out that the theoretical and mathematical reality of matter is related to difficulties in understanding atoms and sub-atomic particles (Lijnse, Licht, de Vos, & Waarlo,1990) .

- Difficulties or misconceptions in students' learning about atom and particulate nature of matter have been discussed in many studies (De Posada, 1997; Gilbert & Watts, 1983; Griffiths & Preston, 1992; Novick & Nussbaum, 1978).

Table 1. Common Misconceptions identified for atoms (Griffiths and Preston, 1992 , from Table 1, p. 616).

Misconceptions	
Structure/shape of atoms	1. An atom resembles a sphere with components inside. 2. An atom resembles a solid sphere. 3. An atom looks like several dots/circles. 4. Atoms are flat. 5. Matter exists between atoms.
Size of atoms	1. Atoms are large enough to be seen under a microscope. 2. Atoms are larger than molecules. 3. All atoms are the same size. 4. Heat may result in a change of atomic size. 5. Collisions may result in a change of atomic size.
Weight of atoms	1. All atoms have the same weight.
Animism of atoms	1. All atoms are alive. 2. Only some atoms are alive. 3. Atoms are alive because they move.

Several other papers report students’ misconceptions relating to atoms and molecules (Garnett, Garnett & Hackling, 1995; Griffiths, 1994; Herron, 1978; Janiuk,1993).

- These studies conclude or suggest that students' misconceptions are being caused by incorrect teaching, inability to perform formal operations, lack of prerequisite knowledge, and absence of the relevant concepts in long-term memory.

- The topic of Matter is a fundamental part of the Turkish science curriculum (e.g., Adadan 2014; Ayas et al. 2010; Ministry of National Education - MoNE, 2013).

- In fact, the worldwide science curricula (Trends in International Mathematics and Science Study—TIMSS, 2015) refer to Matter topic.

- For quality learning to occur, teachers need a Particulate Nature of Matter and Atomic structure background to assist in developing students' ideas.

- Therefore, focusing on the prospective science teachers (PSTs)’ comprehension of the atomic structure and/or the particulate nature of matter (PNM) is significant

Purpose of the Study

- With the light of above-mentioned perspective, in the current study our aim is to examine the effects of the chemistry visualisations on the comprehension of prospective science teachers related to the topic of “Atom” in the introductory General Chemistry Lesson.

- In the current study, with the term “visualisations” we refer to the videos and simulations.

Design

- The current study used a mixed-method approach within a pre-experimental static group comparison design (Creswell, 2013). It was based on qualitative data collection and data analysis procedures.

Participants and Educational Background

- Experimental group consists of forty freshman science student teachers and control group consists of thirty-nine freshman science student teachers. All participants were informed about the intentions, nature, and methods of the study. All agreed to participate voluntarily.

- In their future careers prospective science teachers will be required to teach about atoms and their structure at elementary levels (in grades 7 and 8) before moving on to different historic models of the atom.

- All participants in the present study had earned admittance to the university through an entrance exam, which entitles them to a four-year undergraduate teacher education program.

Process steps in Teaching/Instruction

- The co-author of the present study have realized the teaching in experiment and control group. The content of the lessons is the same in the experiment and control group. She taught the atom subject in eight lesson hours (8x45) for each group.

- She used visualisations-assisted lecture method, and question-answer technique in the teaching of the experimental group. Before the instruction, the visualisations related to the atom topic were gained from various web sites (e.g.https://www.youtube.com/watch?v=FdiH78aTvnc for Dalton Atom Theory and https://phet.colorado.edu/tr/simulation/legacy/hydrogen-atom) and visualisations were examined in terms of the suitability of the subject content and pedagogic aspects by researchers.

- Firstly, she has provided a discussion environment by asking general questions about the subject, in order to reveal students' prior knowledge and expose them their prior knowledge and also focus them on the subject.

- During the demonstration of visualisations, she made necessary explanations and asked questions to the students to avoid misconceptions and to direct the attention of the students.

- She has taken the role of guidance in reaching them to the right answers. In the wrong answers given by the students, the visualisations were shown again and students were reached to the right answers. The visualisations used during the processing of the topics were shown with the help of a smart board.

- In the control group, the subject was processed by using the lecture method, question-answer technique. As in the experimental group, Firstly, instructur provided a discussion environment by asking general questions about the subject in order to reveal students' prior knowledge and expose them their prior knowledge and also focus them on the subject.

Data Collection and Analysis

- Prospective science teachers were asked to fill out a questionnaire to collect data. The questionnaire consists of four open-ended questions which were prepared by the researchers inspired by previous related studies (Harrison and Treagust, 1996; 2002). Filling in the whole questionnaire took approximately 35 minutes.

- Tha data was subjected to inductive content analysis. Different categories and frequencies of the resulting categories were then determined. The PSTs' written answers to each of the four questions in the questionnaire were evaluated by the following categories based on the related studies.

- For determining learners' comprehension/understanding levels in detail with a qualitative perspective, researchers (e.g., Adbo and Taber 2009; Ayas et al. 2010; Coştu 2008; Özmen 2011) use as such following categories:

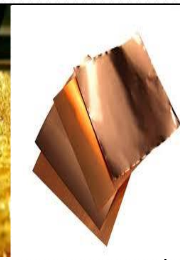
Table 2. Data Analysis Categories

Category	Category Content
understanding	Responses that include all of the scientific ideas about the question
partial-understanding	Responses that include some of the scientific ideas about the question
not understanding/no-response	Student responses that are not relevant to the question and lack scientific value and questions that students leave blank or response that is as same as the question.

- Two researchers then carried out independent coding on the whole data sample. The agreement rate of the coding was above 95% and was thus very good (Miles and Huberman, 1994). The few cases of disagreement were later solved by joint negotiation and recoding.

Results and Discussion

- **Table 3. Comparison of the comprehension categories of experimental and control group related to the topic of “Atom”**

Questions	Comprehension Level	Experimental Group (f/%)	Control Group (f/%)
1. What do you think to been made of the materials shown in the pictures below? Please explain.     Gold Bloc / Gold Bracelet / Copper / Copper Plate	Understanding	18/45	2/5.1
	Partial-understanding	7/17.5	18/46.2
	Not understanding/No-response	13/32.5	15/38.5
	Missing data	2/5	4/10.3
	Total	40/100	39/100
2. When a piece of iron rusts, the mass increases. When a match is lit, the mass is reduced. Explain that these two observations refute the law of conservation of mass.	Understanding	9/22.5	5/12.8
	Partial-understanding	20/50	19/48.7
	Not understanding/No-response	9/22.5	11/28.2
	Missing data	2/5	4/10.3
	Total	40/100	39/100
3.How did Rutherford get results from the experiment he did to confirm the Thomson's atomic model? How did Rutherford develop a model? Please explain.	Understanding	12/30	8/20.5
	Partial-understanding	19/47.5	22/56.4
	Not understanding/No-response	7/17.5	5/12.8
	Missing data	2/5	4/10.3
	Total	40/100	39/100
4. A basic atom contains 18 electrons. How many of these electrons are in orbitals with l = 0?(Temel haldeki bir atom 18 elektron içermektedir. Bu elektronlardan kaç tanesi l=0 değerindeki orbitallerde yer alır?)	Understanding	22/55	12/30.8
	Partial-understanding	1/2.5	11/28.2
	Not understanding/No-response	15/37.5	12/30.8
	Missing data	2/5	4/10.3

- As you can see in Table 3; the frequency value of “understanding” category in experimental group is higher than those in control group for all questions.

- This finding of the current study indicate that the learning opportunities provided in experimental group (for example, viewing online videos, simulations, classroom discussions) are effective in a certain rate and enabled all the participants in experimental group to develop a better comprehension of the atom topic.

- The participants were provided with two opportunities in the experimental group learning environment to construct the verbal and visual, which they actively processed in two different channels (verbal: ear; visual: eye) functioning through multiple representations (macroscopic, sub-microscopic) in their working memory and integrated into their pre-existing knowledge.

- However, it is noteworthy that the frequency value of the experimental group's “partial understanding” (e.g. in second and third questions) and “Not understanding/No-response”(e.g. in first and fourth questions) category is fairly high and close to the frequency value of the control group.

- Perhaps, above findings need to be connected with the missing steps of the instructional design so that experimental group students could have achieved even more.
- What were the missing steps of the instruction used in experimental group???

- Consider her teaching please…

- Noting the teacher’s willingness to take the steps to transform her teaching is worthwhile.
- She did not analyse the PSTs preexisting knowledge to understand them before teaching. The PSTs did not have an opportunity to represent their prior ideas at the submicroscopic level visually. She did not expose them their preexisting knowledge evidently.

- The PSTs did not frame the arguments visually on paper using a research-based approach The teacher introduced the theoretical ideas prematurely.

- She mainly used the visualisations in a teacher-centered manner instead of student-centered manner. The primary PSTs did not place their worksheets in their evidence portfolio for further study and reflection.

References

- Adadan, E. (2014a). Model-tabanlı öğrenme ortamının kimya öğretmen adaylarının maddenin tanecikli yapısı kavramını ve bilimsel modellerin doğasını anlamaları üzerine etkisinin incelenmesi. *Ondokuz Mayıs Üniversitesi Eğitim Fakültesi Dergisi, 33*(2), 378-403.
- Adbo, K., & Taber, K.S. (2009). Learners' mental models of the particle nature of matter: A study of 16-year-old Swedish science students. *International Journal of Science Education, 31*(6), 757-786.
- Ayas, A., Özmen, H., & Çalık, M. (2010) . Students' conceptions of the particulate nature of matter at secondary and tertiary level. *International Journal of Science and Mathematics Education, 8*, 165-184.
- Coştu, B. (2008). Learning science through the PDEODE teaching strategy: Helping students make sense of everyday situations. *Eurasia Journal of Mathematics, Science & Technology Education, 4(*1), 3-9.
- Creswell, J. W. (2013). *Araştırma deseni*. [*Research Design*] (Selçuk Beşir Demir, Trans.). Istanbul, Turkey: Eğiten Kitap.
- Harrison, A. G., & Treagust, D. F. (1996). Secondary students mental models of atoms and molecules: Implications for teaching science. *Science Education, 80,* 509–534.
- Harrison, A. G., & Treagust, D. F. (2002). *The particulate nature of matter: Challenges in understanding the submicroscopic world.* In J. K. Gilbert, O. De Jong, R. Justi, D. F. Treagust & J. H. Van Driel (Eds.), *Chemical education: Towards a research-based practice* (pp. 189-212). The Netherlands: Kluwer Academic Publishers.
- Griffiths, A. K., & Preston, K. R (1992). Grade-12 students' misconceptions relating to fundamental characteristics of atoms and molecules. *Journal of Research in Science Teaching, 29*(6), 611–628.
- Lijnse, P.L., Licht, P., de Vos, W, & Waarlo, A.J. (1990). Relating macroscopic phenomena to
- microscopic particles: A central problem in secondary science education. Utrecht, The Netherlands:
- CD-β Press.
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousend Oaks: Sage.
- Novick, S., & Nussbaum, J. (1978). Junior high school pupils' understanding of the particulate
- nature of matter: An interview study. Science Education, 62, 273–281.
- Özmen, H. (2011). Turkish primary students' conceptions about the particulate nature of matter. *International Journal of Environmental and Science Education, 6*(1), 99-121.

USEFUL LINKS

- 1-)https://www.youtube.com/watch?v=FdiH78aTvnc, Dalton Atom Teorisi
- 2-)https://www.youtube.com/watch?v=4QAzu6fe8rE – Katot Işın Tüpü
- 3-)https://www.youtube.com/watch?v=VdoTVk4BFmk, Kanal ışınları
- 4-)https://www.youtube.com/watch?v=X2uvuSThtuI – Thomson Atom Modeli
- 5-)https://www.youtube.com/watch?v=5pZj0u_XMbc, Rutherford Atom Modeli
- 6-)https://www.youtube.com/watch?v=nwnjYERS66U, Millikan yağ damlacıkları deneyi
- 7-)https://www.youtube.com/watch?v=fZnYE3kvhhA, Elektromagnetik dalga
- 8-)https://www.youtube.com/watch?v=cfXzwh3KadE, elektromagnetik dalga
- 9-)https://www.youtube.com/watch?v=fm2C0ovz-3M, bohr atom modeli
- 10-)https://www.youtube.com/watch?hl=en&gl=US&client=mv-google&v=K-jNgq16jEY&fulldescription=1&app=desktop , Atom ve Orbitaller (Uzay yönelimleri)
- 11-)https://www.youtube.com/watch?v=4WR8Qvsv70s –Orbitaller
- 12-)https://www.youtube.com/watch?v=P2IsIkSn5bk -- Elektron çekirdeğin etrafında nasıl hareket ediyor?
- 13-)https://phet.colorado.edu/tr/simulation/legacy/hydrogen-atom,