Identification of specific pathways in solving the task *Synthesis of sodium chloride from elements* at triple levels of chemical representations among pre-service chemistry teachers

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The complexity of teaching and learning chemistry concepts can be explained by the representation at three levels: the macroscopic, the submicroscopic, and the symbolic levels (Johnstone, 1991). Research confirms that students often develop misconceptions of specific chemistry concepts at the submicroscopic level, including the redox reactions (Kelly and Hansen, 2017). Students' motivation for learning chemistry, formal reasoning abilities, chemistry pre-knowledge and visualisation abilities can influence students' learning processes. To understand these processes in more detail, individuals' eye movements can be measured and after careful consideration might be used for interpreting processes during solving the context-based tasks, since the direction of the human gaze is closely linked to the focus of attention as individuals process the visual information that is being observed. It is known that the eye tracker provides objective support for the measurement of cognitive effort or cognitive activities (Devetak, 2021).

The purpose of this research is to identify the understanding of specific redox reaction among pre-service chemistry teachers through context-based 3D submicrorepresentations task achievements.

55 pre-service chemistry teachers of different years of education at the university level participated in this study. Pre-service teachers had to conceder context-based redox reaction between sodium and chlorine. Pre-knowledge achievement test, test of logical thinking, chemistry motivation questionnaire, a visualisation ability test, and eye-tracking apparatus, with think aloud method were used in this study.

Qualitative analysis of eye movements (gaze plots) determined whether the participant used an expert or non-expert strategy to solve the task. The results show that there are statistically significant differences in achievements of solving the task between students who choose expert (M=10.12; SD=2.55 $\overline{R}$=32.07) or non-expert (M=7.43; SD=2.41; $\overline{R}$=16.07) strategy (Mann-Whitney U=120.00; p=.001; r=.477). Students showed the highest interest for the macro level while solving the task. Many misconceptions were identified when pre-service teachers tried to explain the observations at the submicroscopic level or when trying to connect of all three levels at the same time. There are non-significant correlations between pre-service teachers' task achievements and their intrinsic motivation for learning chemistry (r=.028; p=.838), visualization skills (r=.210; p=.125) and working memory capacity (r=−.007; p=.959). Medium and significant correlation were identified between pre-service teachers' task achievements and their pre-knowledge (r=.311; p=.021) and the level of formal reasoning abilities (r=.377; p=.005).

These results are significant for chemistry teachers' educators. It is important that pre-service chemistry teachers adequately understand specific chemical concepts at three levels of presentations. These understandings are crucial to them for them to be able to apply the most effective chemistry teaching strategies in the chemistry classroom.

Keywords: redox reaction comprehension, triple nature of chemical concepts, pre-service chemistry teachers

References:

Johnstone, A. H. (1991). Why is science difficult to learn? Things are seldom what they seem. *Journal of Computer Assisted Learning, 7*(2), 75–83.

Devetak, I. (2021). Using an eye-tracking approach to explain students' achievements in solving a task about combustion by applying the chemistry triplet. In I. Devetak & S. A. Glažar (Eds.), *Applying Bio-Measurements Methodologies in the Chemistry Classroom* (1st ed., pp. 129–153). London: Springer International Publishing.

Kelly, R. M. & Hansen, S. J. R. (2017). Exploring the design and use of molecular animations that conflict for understanding chemical reactions. *Quimica Nova, 40*(4), 476–481.