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Strategies for solving the chemical problem of redox reaction of sodium chloride synthesis from elements: An eye-tracking analysis

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INTRODUCTION

Chemical problem-solving leading to comprehension learning is a demanding and complex learning activity (Sevian et al., 2015), where a solution leads to several challenging stages that the student must solve through the appropriate use of information and reasoning (Yuriev et al., 2017). It is well known that novices, unlike experts, use a simple algorithm to solve contextual problems. In solving, they usually do not connect more levels of representation than experts do effectively (Parchman et al., 2017; Yu et al., 2015).

THE AIM OF THE STUDY

The purpose of the study was to determine what chemical problem-solving strategies pre-service chemistry teachers use and how these problem-solving strategies differ between non-experts (participants with poor chemical pre-knowledge who solved the problem using the non-expert path) and experts (participants with higher chemical pre-knowledge who solved the problem using the expert path).

METHODS

Fifty-five pre-service chemistry teachers between the ages of 19 and 24 participated in the study (M = 22.0; SD = 1.1). They participated in the study voluntarily. Solving the contextual problem of the redox reaction of sodium chloride synthesis from elements was tracked using the Tobii Pro X2-30 eye-tracker and the thinking-aloud technique. The obtained audio-visual data were analysed using a qualitative research approach.

RESULTS

The main results obtained by qualitative analysis of the participants' eye movements and expressed thinking process during solving a chemical problem using a non-expert fixation path (*Fig. 1 and 2*) by the participants:

(1) more attention to the instruction of the problem,
(2) more connections between the instruction and other areas of interest,
(3) more attention to the macroscopic than to the submicroscopic and symbolic levels of the representation,
(4) a greater number of connections between different areas of interest within the same level of representation than between different levels of representation.

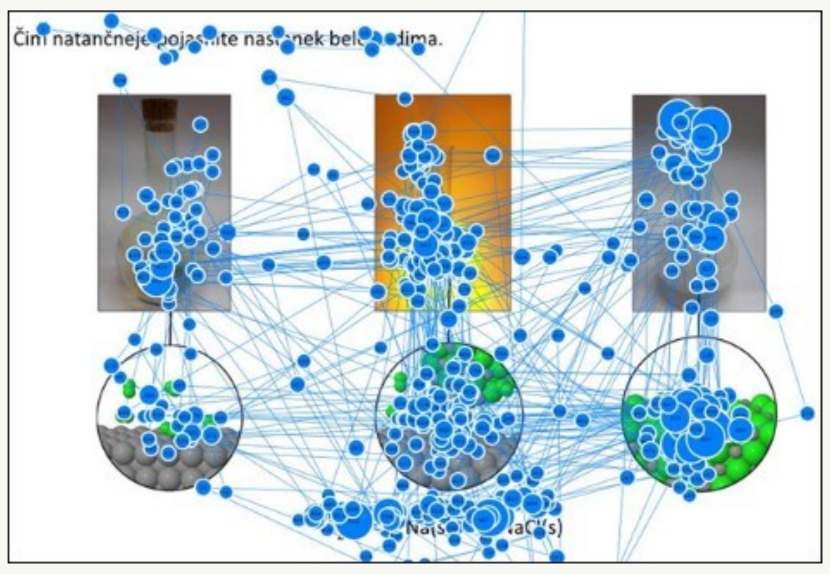

Fig. 1 Non-expert path of fixations in solving a chemical problem (student with poor prior chemical knowledge).

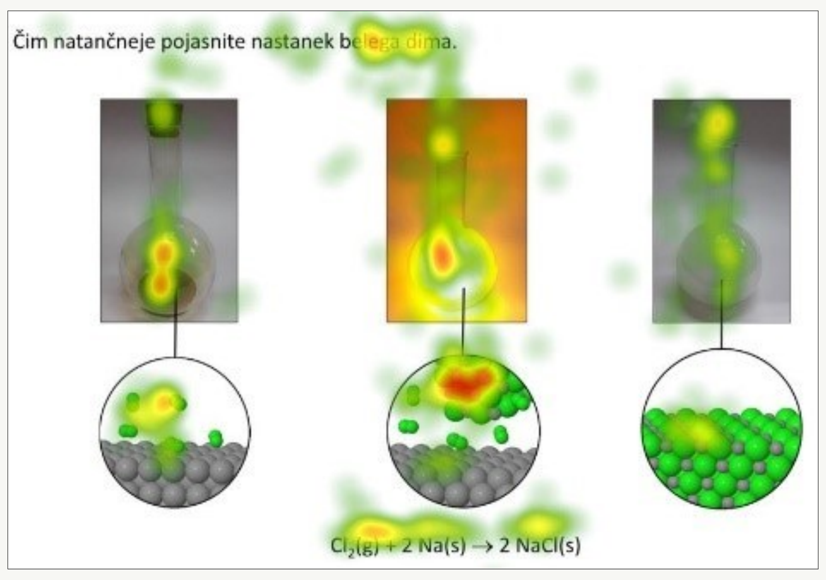

Fig. 2 Heat map of fixations to the area of interest in solving a chemical problem (student with poor prior chemical knowledge).

In summary, several misconceptions and misunderstandings were identified when solving a chemistry problem. These participants had great difficulty identifying the type of the chemical reaction, defining which substance is a reducing agent and which is an oxidising agent, and what white smoke is, that is produced in the reaction of sodium chloride synthesis from elements.

Participants who solved the problem using the expert path (*Fig. 3 and 4*) of fixations made a smaller number of fixations to the areas of interest they observed for longer time. During the problem-solving process, they repeatedly focused on the areas of interest that comprise critical information for successfully solving the problem.
In general, it can be summarized that participants who solved a chemical problem using an expert fixation path made multiple connections between different areas of interest at different levels of representation of the chemical concept. It can be concluded that solving chemical problems using an expert fixation path promotes switching between different levels of representation.

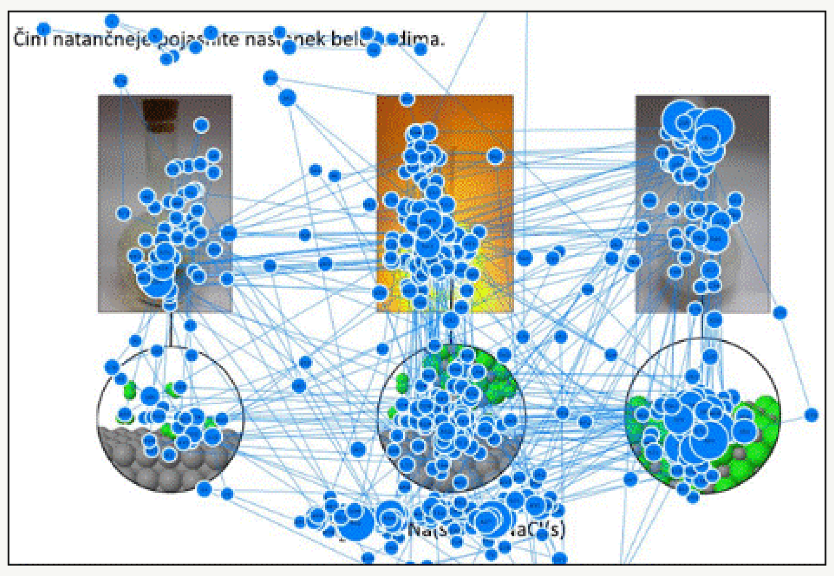

Fig. 3 Expert path of fixations in solving a chemical problem (student with good prior chemical knowledge).

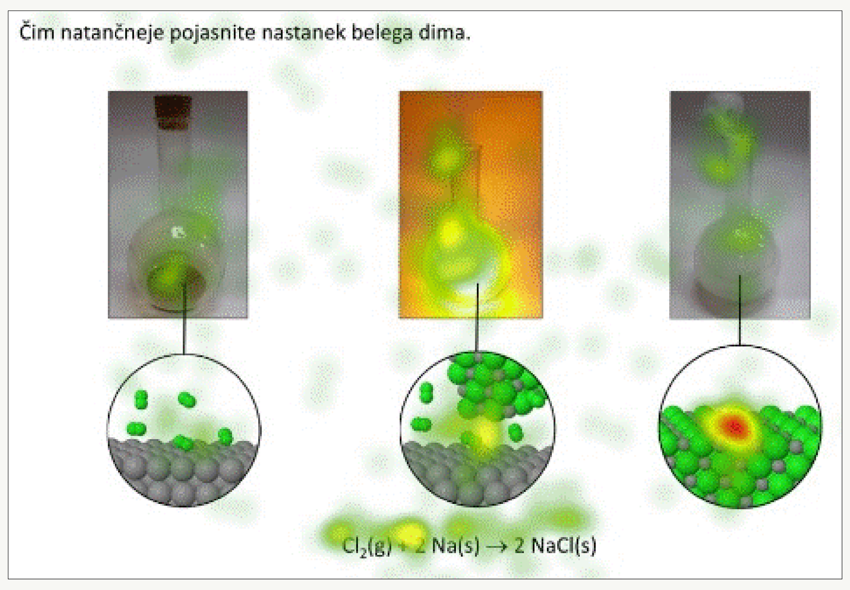

Fig. 4 Heat map of fixations to the area of interest in solving a chemical problem (student with good prior chemical knowledge).

For participants, who solved the chemical problem using the expert fixation path, it can be noted that individual areas of interest were observed less frequently and for longer periods of time than for those who solved the chemical problem using the non-expert fixation path.

CONCLUSIONS

It can be concluded that students with good prior chemical knowledge had different strategies for solving the chemical problem than students with poor chemical knowledge. It is obvious that the amount of prior chemical knowledge influences the choice of problem solving strategy, which in most cases also leads to the correct solution. The responses of students with good prior chemical knowledge contained little or no misconceptions and incomplete understandings. These students, unlike students with poor prior chemical knowledge, tend to focus only on areas of interest when solving a chemistry problem. In general, it is also true that students with good prior chemical knowledge make a smaller number of fixations on selected areas of interest and observe them for a longer time, which is not the case for students with poor prior chemical knowledge. It can also be observed that students who solved a chemical problem using an expert fixation path made multiple connections between different levels of chemical concept representation. In this case, information processing in solving a chemical problem involved the simultaneous use of the macroscopic, submicroscopic, and symbolic levels of chemical concept, resulting in the formation of more durable and higher quality chemical knowledge.

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