DOES STUDENTS' SELECTIVE ATTENTION INTERFERE WITH THEIR ACHIEVEMENT IN CHEMISTRY?

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Tertiary students’ attention at chemistry lectures attracted many researchers who aimed to develop better and more relevant teaching strategies. The main objective of this study was to explore the connection between pre-service primary school teachers’ chemistry knowledge and their confidence in knowledge, as well as the relationship between knowledge and visual selective attention. 79 participants completed a 4-tier chemistry test and a d2 attention test. The results indicate that there is a significant correlation between the participants’ achievements on the response tier, as well as on the reason tier, and their confidence in answering both tiers correctly. The analysis indicates that there is also a significant correlation between the pre-service primary school teachers’ achievements on the reason tier and their level of selective attention, but not between their achievement on the response tier and their previous achievements in chemistry in upper-secondary school. Moreover, the students who took Chemistry at their Matura exam, exhibited a higher level of concentration. This research not only shows that more emphasis should be placed on developing the understanding of chemical concepts, but also suggests that teacher educators should take into account pre-service teachers’ cognitive capabilities, especially when more demanding cognitive tasks should be addressed at core chemistry lessons, and to assess chemical knowledge. It can be assumed, that the implementation of more relevant teaching strategies could enhance the students’ cognitive and psychosocial functioning while learning, and increase motivation for a true and deep understanding of the course contents.

Keywords: chemistry knowledge, 4-tier test, a triple nature of chemical concepts, selective attention

INTRODUCTION

Johnstone (1982) proposed that the presentation of scientific concepts and processes should be based on multiple representations, or a threefold manner of representing science, i.e. a macroscopic level (observable phenomena), a submicroscopic or particulate level (various representations of atomic, molecular, and particle structures), and a symbolic level (mathematical and chemical symbols). Moreover, the interpretation of the phenomena at a macroscopic level by using submicroscopic representations is considered one of the fundamental ideas of modern chemistry and chemistry instruction (Eilks, 2013). Such visualizations support the students’ connecting the three levels of concept representations, and they were recognized as important chemistry learning tools (Al-Balushi & Al-Hajri, 2014; Kelly & Jones, 2008). In order to assess the students’ level of understanding of the three-level chemical concepts, various diagnostic instruments can be used. One possible way is the application of the multi-tier diagnostic instruments that come in various forms. The 2-tier test is a quite popular form, which has been used in numerous research. This form cannot distinguish correct responses on the basis of whether these are due to guesswork or content mastery. These limitations can be satisfactorily addressed with 3-tier or 4-tier diagnostic questions (Caleon & Subramaniam, 2010). To these instruments, a confidence rating – typically on a scale from just guessing (1) to absolutely confident (6), is added. If the confidence tier is added to both tiers separately, the instrument is transformed into a 4-tier one, and where a mean rating is required at the response and the reason tiers, it becomes a 3-tier instrument (Caleon & Subramaniam, 2010). Since the response and the reason tiers may be at different difficulty levels, it is reasonable to assume that students would exhibit different levels of confidence for both tiers. Multiple factors influencing the quality of students’ learning processes and the nature of the construction of their understanding of the basic concepts in different subjects had been researched for decades (Mayer & Alexander, 2011). As an element of the working memory and contributing to the cognitive part of students’ social-emotional functioning during learning, the attention phenomena is of special importance. Within the working memory model, attention incorporates the strategic prioritizing of information, and the ability to maintain information when distractions occur (Alloway & Alloway, 2013; Revlin, 2013). From that point of view, tertiary students’ attention at chemistry lectures already attracted many researchers who aimed to develop better and more relevant teaching strategies (Johnstone, & Percival, 1976; Bunce, Flens, & Neiles, 2010; Maltese, Danish, Bouldin, Harsh, & Bryan, 2016). On the other hand, the relation between the students’ deep knowledge of the chemical structures and processes and their selective attention has not been explored yet.
It should be highlighted that the results presented in this work originate from a bigger project titled “Explaining Success at Solving Chemistry Tasks at the Submicroscopic Level, and Investigating Prospective Chemistry Teachers’ Skills for Teaching These”, and from studying the pre-service students’ knowledge of the triple nature of chemical concepts, using a 4-tier test, and the manner in which the participants process visual information at the particulate level. The main objective of this study was to explore the relationship between the pre-service primary school teachers’ knowledge of chemical substances and chemical reactions in the presentations of the triple nature of chemical concepts, and their confidence in knowledge, as well as the relationship between knowledge and the pre-service primary school teachers’ visual selective attention. The research questions are as follows: (1) What level of knowledge do the pre-service primary school teachers’ show on the 4-tier knowledge test? (2) How confident are the pre-service primary school teachers in giving the correct answers on the knowledge test? (3) What is the relationship between the pre-service primary school teachers’ actual and prior knowledge of chemistry?, and (4) What is the relationship between the pre-service primary school teachers’ confidence and their concentration performance?

METHOD

Altogether, 79 pre-service primary school teachers from the Faculty of Education of the University of Ljubljana participated in the study. All of them were first-year students in the fall semester, aged 19 to 21, with the majority of females (93%), as an overall trend ratio among Slovenian teachers. 10.9 % of the participants finished Secondary Chemistry School with the upper-secondary school exit exam (Matura). A 4-tier diagnostic test comprising the concepts about the substances and chemical reactions, based on the triple nature of representations of the chemistry concepts (4t-SCRT) was applied. 4t-SCRT is a paper-and-pencil test with 15 multiple-choice chemistry questions based on submicroscopic representations. Each of the 15 chemistry questions comprises a response tier and a reason tier. Each chemistry tier were scored 1 point; altogether, the students could achieve 30 points. Each chemistry question (both tiers separately) was evaluated by the students in a confidence tier; these tiers were not included in the overall score. The students’ selective attention was measured with a d2 attention test (Brickenkamp, Boben, Logar, Ćuš, & Gosar, 2008). This is a time-limited test that assesses individual attention and concentration performance. The test is made up of 14 lines with 47 characters each. The respondents scan each line and cross out all the “d’s” with two dashes. The response time for each line is 20 seconds. The test has high internal consistency and validity, and was used in many research areas, including the education. For the purposes of this study, the measure of concentration performance (CP) was used, calculated from the number of the correctly crossed out d’s, from which the incorrectly crossed out letters were subtracted. According to the authors, this measure is the fundamental attention indicator, or the attention deficit indicator if the score is low enough. Additionally, the students were asked to indicate their age and gender, as well as their previous academic achievement in chemistry in the upper-high school (academic performance in each grade plus the points achieved at Matura). The researchers obtained the data on a collective basis during regular lessons, and analysed them with the SPSS software: the descriptive, bivariate correlation and the t-test for independent samples were calculated.

RESULTS

Pre-service primary school teachers achieved on average 13.6 points (45.3 % success) (SD = 3.8 points) out of max. 30 points on the 4t-SCRT, they achieved on average 7.0 points (SD = 2.2 points) on the response tier, and 6.6 points (SD = 2.0 points) on the reason tier. Each chemistry answer (both tiers separately) was also evaluated by the students on the confidence tier. On average, their first confidence tier (after the response tier) showed that they were 54.7% (SD = 13.6%) certain to have answered the response tier correctly. However, the confidence for the reason tier was a little bit lower, i.e. 50.1 % (SD = 12.6%). The difference between the pre-service primary school students’ confidence in their correct answer to the response and reason tiers is significant (t(77) = 9.57; p < .001). There is a significant correlation between the students’ achievements on the response tier and their confidence in answering the first tier correctly (r = .558; p<.001). In addition, similar significant correlation can be established when comparing the pre-service primary school teachers’ confidence in identifying the correct explanation for the answer to the specific chemistry task of the first tier of (r = .528; p<.001). The results also show that those pre-service primary school teachers who had taken the upper-high school exit exam (Matura) in chemistry scored significantly better on the response tier (M = 8.4; SD = 2.3) than those who had not taken it (M = 6.5; SD = 2.2); (t(70) = 2.93; p = .005). Similar results can be shown at the reason tier when comparing the participants who had
taken Matura ($M = 7.9; SD = 2.3$) and those who had not taken that exam ($M = 6.2; SD = 1.9$) at the end of secondary school ($t(70) = 2.81; p = .006$). The results also show the weak and positive correlation between the students who scored better on both knowledge tiers (the response and the reason tiers; the total score) and the level of their selective attention ($r = .265; p = .026$). The correlation between the students’ selective attention and the scores on the response tier is not significant, which means that visual attention does not relate to the chemistry knowledge with visual task input. Those students who scored better at the chemistry tasks of the reason tier also expressed higher levels of the selective attention ($M = 181.4; SD = 44.3$) than those who scored lower on the reason tier ($M = 203.1; SD = 38.3$); ($t(77) = -2.20; p = .031$). And finally, those pre-service primary school teachers’ who had taken Matura in chemistry showed significantly higher levels of selective attention ($M = 216.1; SD = 43.1$) than those who had not taken it ($M = 185.3; SD = 41.0$); ($t(65) = 2.54; p = .014$).

CONCLUSION
It can be concluded, that the pre-service primary school teachers’ scores on a 4t-SCRT (testing chemistry knowledge of chemical concepts of a triple nature, comprising the topics about substances and chemical reactions) are not sufficient, and that more emphasis should be placed on developing the understanding of chemical concepts, as primary school teachers teach the basic chemical concepts to students aged 6 to 11 in science classes. Their average confidence about the correctness of their responses on the knowledge tiers shows that pre-service primary school teachers’ express low to average self-confidence in their basic chemistry knowledge. It can be expected, that parallel to their mastering the basic chemistry knowledge understanding, the confidence in their chemistry knowledge would increase. However, the results show also that pre-service primary school teachers’ selective attention interferes with their chemistry knowledge of the triple nature of chemical concepts, comprising the topics about substances and chemical reactions. A weak, but positive and significant correlation was determined between the reason tier of the 4t-SCRT and the concentration performance, showing that at the identification of the correct reason for selecting the response, (first tier of the 4t-SCRT) selective attention plays quite an important role. It implies that the selection of the two-tier test for assessing the students’ knowledge could contribute to our understanding of the factors involved in the construction of the students’ knowledge with understanding. The results indicate that teacher educators should take into account pre-service teachers’ cognitive capabilities, especially when more demanding cognitive tasks should be addressed at the core chemistry lessons, and to assess chemistry knowledge.

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