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FOSTERING INQUIRY SKILLS DURING CHEMISTRY EDUCATION: CONCLUSIONS FROM AN EDUCATIONAL INTERVENTION PROGRAMME FOR GRADE 10 STUDENTS

Summary of the PhD dissertation

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The analysis of the National Core Curriculum (2012), the chemistry framework curricula and the school-leaving examination requirements showed that the development of inquiry skills is an important goal of chemistry teaching in Hungary, but the results of the textbook analysis show that there is a lack of exercises that require formulating questions, hypotheses, designing experiments and working with variables. There is therefore a need for additional tasks and tried and tested educational intervention programmes that can be directly implemented in teaching (Szalay et al., 2020; Szalay et al., 2021). In our research, we have developed an intervention for tenth-grade students related to the teaching of the „Carboxylic acids and esters" unit. The programme aims to foster the control of variables strategy (CVS). These skills are essential for proper experimental design and for drawing evidence-based conclusions (Chen & Khlar, 1999). Without them, students cannot distinguish confounded experiments and unconfounded experiments and thus reach unreliable conclusions (Kuhn, 2007). Developing CVS can also help students to develop critical thinking and problem-solving skills (Kuhn, 2008). The programme is primarily based on inquiry-based learning (Orosz et al., 2023), which we found in a previous case study to be effective when appropriate scaffolding is provided. The educational experiment took place in spring 2019. The intervention followed a control- and experimental-group, pre-posttest research design. The sample consisted of grade 10 students from urban high schools. The experimental group consisted of five classes (N = 121; Age = 16.7 years, SD = 0.4 years; boy 42.1%, girl 57.9%) and the control group contained six classes (N = 151; Age = 16.8 years, SD = 0.4 years; boy 50.3%, girl 49.7%). Inquiry skills were assessed with an online test (*Inquiry skills test*), and the CVS was assessed using paper-and-pencil tests (*CVS tests*). In addition, we examined the impact of the intervention on students' attitudes towards chemistry and chemistry learning motivation, using an adapted questionnaire (*Chemistry Motivation Questionnaire II – CMQ II*, based on Glynn et al., 2011). The results show that the intervention had a small effect on students' performance in the *Inquiry skills post-test* (Cohen's d = 0.315). The experimental group had a larger mean score than the control group, but the difference was not significant. The experimental group had a significantly better average performance in the *CVS post-test* than the control group. The effect size is medium (partial eta-squared = 0.159) when the results of the *Inquiry skills pretest*, the *CVS pretest* and the *CMQ II pretest* are included as covariates in the model. Thus, the program has been shown to be effective in enhancing students' skills in identifying and controlling variables. There is no significant effect of performance categories when included as an independent variable in the model, nor is the interaction of performance categories and the intervention significant, suggesting that low, medium and high-performing students benefited equally from the programme. Furthermore, there is no significant effect of gender when included as an independent variable in the model, so it can be concluded that the development does not differentiate between boys and girls. During the intervention, both the experimental and control groups' motivation to learn chemistry decreased, which is in line with the results of Salta and Koulougliotis (2015). Analysis of variance and effect size calculations suggest that the intervention did not affect learning motivation and attitudes towards chemistry. Student feedback suggests that students in the experimental group enjoyed the topics and felt that they gained a greater understanding. Of the methods used in the intervention, inquiry-based learning was the most popular, followed by games and worksheets. Our research has shown that the CVS of tenth-grade students can be fostered through our intervention programme during chemistry teaching. In the thesis, we present the implications of the findings, the limitations, and the possible improvements.

Keywords: chemistry education, inquiry skills, control of variables strategy, inquiry-based learning, educational intervention, secondary school

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