

Research Programme for Public Education Development of the Hungarian Academy of Sciences
MTA-ELTE Research Group on Inquiry-Based Chemistry Education
Inquiry-Based Chemistry Education and Systems Thinking project
Interim report (1st September 2021 – 31st August 2023)

This longitudinal research project is investigating the effectiveness of the development of experimental design skills by using a scheme that consists of questions concerning the control of variables, choice of materials and equipment and the order of the steps of the experiment. 931 Grade 7 students from 25 Hungarian schools were involved in September 2021. Members of the research group and schools participating in the project can be downloaded from the [website of the research group](#). The students' 4-year compulsory chemistry education is influenced by six student worksheets in each school year, provided by the research group. These also contain context-based and systems thinking tasks to maintain the students' interest.

The impact of the intervention in terms of experimental design skills (EDS) and disciplinary content knowledge (DCK) is measured by structured tests in the beginning of the project ('T0') and in the end of each school year ('T1' – 'T4'). Background data and answers to attitude questions are also collected. All data are statistically analysed by using the SPSS Statistics software (ANOVA and ANCOVA) to calculate Cohen's *d* and *Partial Eta Squared* (PES) effect size values.

The sample was divided into three groups after the analysis of the results of the T0 test in a way that they were not significantly different in either their average achievement in EDS and DCK tasks of the T0 test, or in the collected background data. (This was checked by a chi-square test.) Group 1 (control group) follows step-by-step instructions. Group 2 follows the same instructions as Group 1, but after the experiment, they also complete the scheme on their worksheets concerned with the design of the experiment. Group 3 is required to design the experiments, guided by the scheme.

[Student sheets 1-6 and their teacher's notes](#) for the first school year and [Student sheets 7-12 and their teacher's notes](#) for the second school year have been prepared and tried by the students participating in the sample. [T0 test and instructions for teachers](#) was used by 931 students and their teachers in the beginning of the project. [T1 test and instructions for teachers](#) was used by 890 students and their teachers in the end of the first school year. [T2 test and instructions for teachers](#) was used by 809 students and their teachers in the end of the second school year. (Unfortunately, two classes that had been participating in the first year, could not participate in the second year, because their teachers stopped teaching and their new teacher did not want to be a volunteer in the project.)

The data were collected and statistically analysed. Over the first two years, the intervention resulted in a medium effect size positive change in the EDS of Group 3 students compared to the control group (Group 1), as measured by the tests (Cohen's *d*: 0.26). In the first year, the change in performance in the EDS tasks was better for Group 3 students than for Group 2 students (Cohen's *d*: 0.43). However, this trend was reversed in the second year, with Group 2 improving more than Group 3 (Cohen's *d*: -0.26). Taking into account the first two years, the difference in the change in performance in the EDS tasks between the two experimental groups was found to be small (Cohen's *d*: 0.14). By the end of the second year of the project, there was only a small difference in the change in DCK between the experimental groups and the control group (Cohen's *d* value for Group 2: 0.10 and for Group 3: 0.11).

A questionnaire in two versions was filled in by 32 [in-service chemistry teachers](#) and 36 [pre-service chemistry teacher students](#) concerning their opinion about the students sheets of the first year. While the in-service chemistry teachers preferred the student sheets made for the Group 3, the majority of the pre-service teachers wrote that they would rather use the student sheets made for Group 2.

The project plan and the preliminary results have been presented at two international conferences. [The slides of Luca Szalay's presentation at ECRICE 2022 conference](#) can be downloaded from the project website. [The slides of Luca Szalay's presentation at the 10th EUROVARIETY conference](#) could also be found on the research group's website. Dissemination in Hungary happened partly in the form of talks at two workshops: at the Hungarian Academy of Sciences (see its slides as [Szalay Luca előadásának diasora az Academia Europea workshop-ján, 2021. 10. 21.](#)) and at another one organised by the Gedeon Richter Plc. for awarded chemistry teachers (see its slides as [Szalay Luca előadásának diasora a Richter-díjas kémiatanárok találkozóján, 2022. 09. 02.](#)). The results of the first year were presented orally at the [22nd National Conference on Education](#) (17.11.2022.). The project and its first results were presented at an online meeting of the [Didactic Subcommittee of the Pedagogical Committee of the Hungarian Academy of Sciences](#) (28.10.2022.). Each student sheet has been applied in the training of pre-service chemistry teachers at the Eötvös Loránd University. Mentors and tutors of pre-service chemistry teachers have also been informed at a Teams meeting on 26th September 2023 that was recorded for the ones who could not participate. Hundreds of in-service chemistry teachers have received an e-mail containing the summary of the first results of the project and the availability of the student sheets via mailing lists maintained by the Eötvös Loránd University, Institute of Chemistry and the Hungarian Chemical Society for chemistry teachers. Key information about the research is available [on the research team's website in English](#). Photographs taken about the students doing the experiments could be seen in the [galleries](#) (numbered according to the numbers of the student sheets).

The [theoretical underpinning of the project was published](#) in the Q1-rated journal '[Chemistry Education Research and Practice](#)'. A [paper](#) on the results of the first year of the project was also published in the same journal. The [manuscript](#) describing the result of the second year has been handed in a Q2 [Journal of Turkish Science Education](#) on 16th August 2023, but we have not received the referees' report yet. A [study](#) was published in Hungarian in the journal titled '[Magyar Tudomány](#)' and another [paper](#) in the journal titled '[Új Pedagógiai Szemle](#)'.

Budapest, 27th September 2023.