The effect of the development of the experimental design skills on the students' attitude

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Our approach for development of the experimental design skills[1]:

modifying 'step-by-step' instructions to practical activities requiring one or more steps of the experiments to be designed by the students.

[1] Szalay, L., Tóth, Z., (2016), An inquiry-based approach of traditional 'step-by-step' experiments, *Chem. Educ. Res. Pract.*, 17, 923-961.

The aims of the 4-year longitudinal study:

Is there any significant change in students'

- disciplinary content knowledge,
- experimental design skills,
- *attitudes (AQ)* and
- *school performance (SP)*

depending on the type of instructions?

Research group:

- 25 chemistry teachers, 5 university chemistry lecturers and 4 pre-service chemistry teacher students

Instruments:

- 4 school years (2016-2020);
- 6 students sheets + teacher guides;
- 5 tests (**Test 0**: September 2016; 4 post-tests in the end of the school years **Test 1, 2, 3** and 4; each consists of 18 items: 9 items for disciplinary content knowledge, 9 items for experiment design skills and 3-4 attitude questions

Sample:

- 18 secondary schools in Hungary, 31 classes of students (they study chemistry for 4 years), 920 students, divided randomly into three groups described below

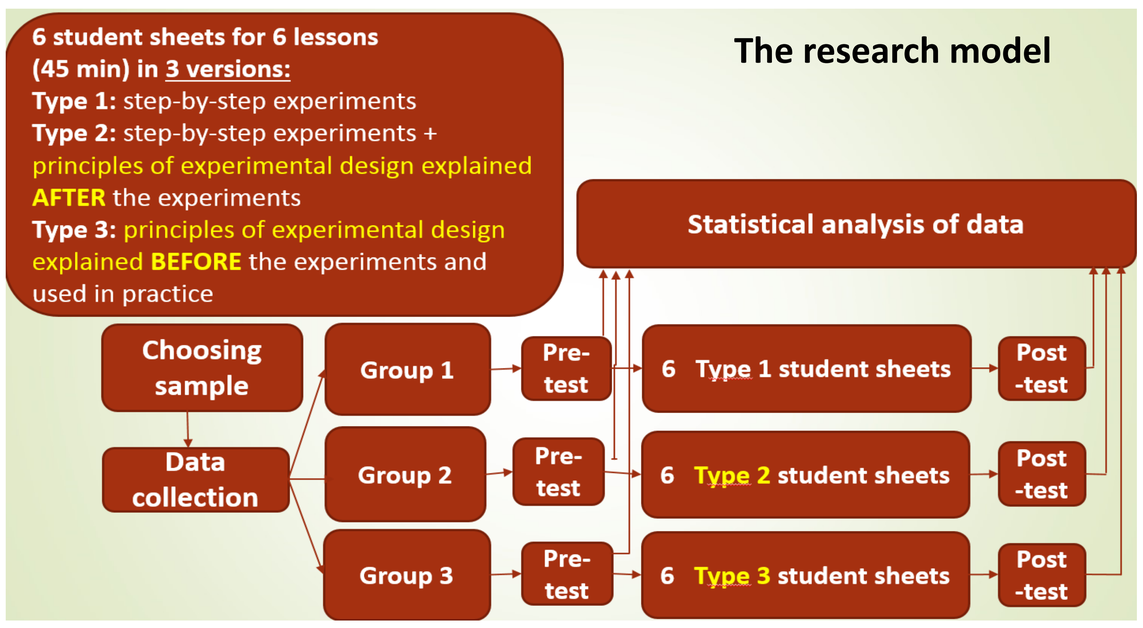
Activities of the 3 groups of students:

- **Group 1 ('control'):** follow 'step-by-step' recipes when doing the experiments (Type 1)
- **Group 2:** follow the same 'step-by-step' and principle of experimental design explained after the experiments (Type 2)
- **Group 3:** doing the same student experiments as Group 1 and Group 2 , but design one or more experiments before doing them (Type 3).

Statistical methods:

- ANOVA,
- calculating Cohen's *d* (an effect size to indicate the standardised difference between two means[2])

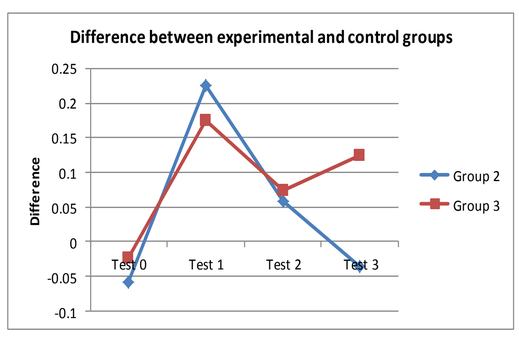
[2] Cohen J., (1988), *Statistical power analysis for the behavioral sciences*, 2nd ed., Lawrence Erlbaum Associates, USA, pp. 20-27.

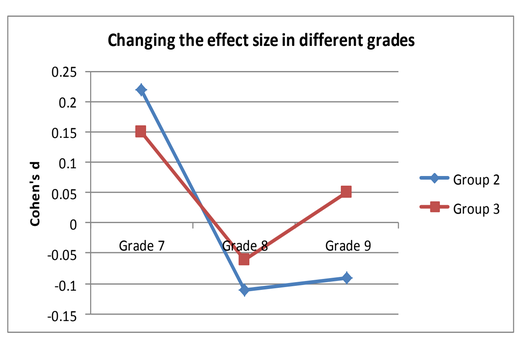


RESULTS

AQ1: How much do you like science/ chemistry?

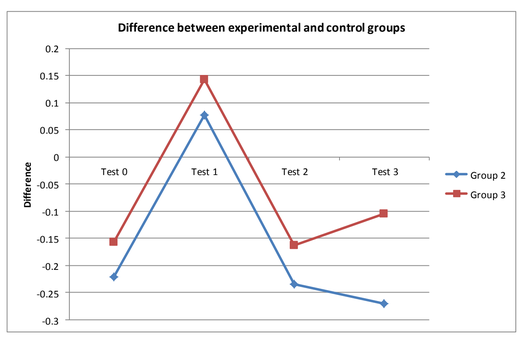
(0-4 Likert scale)

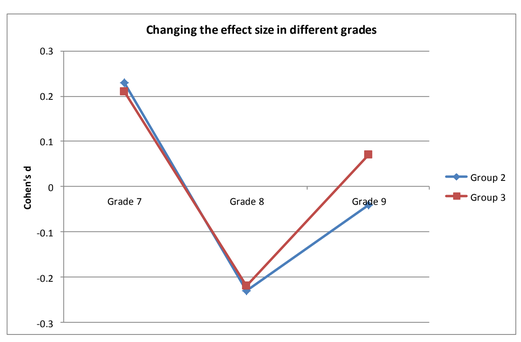




AQ2: How important is it to use scientific experiments to support our ideas?

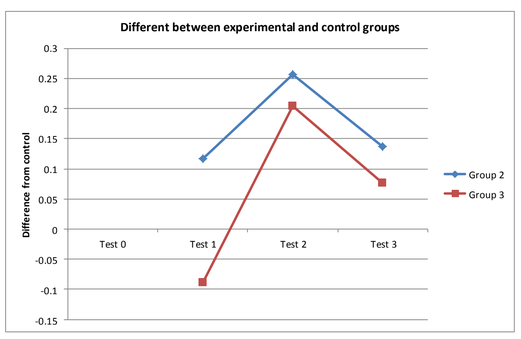
(0-4 Likert scale)

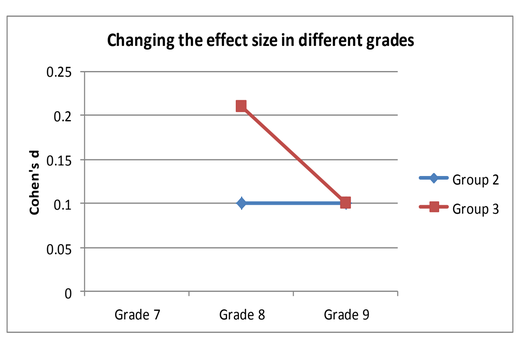




AQ3: Preference of 'step-by-step' experiments to self-designed experiments

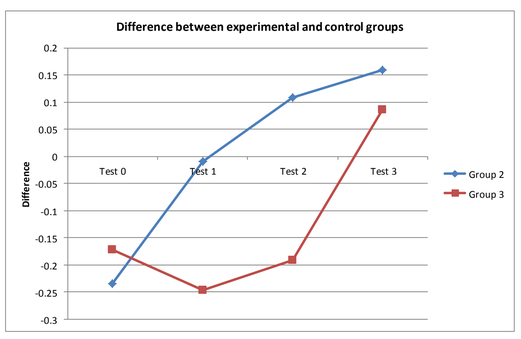
(0-4 Likert scale)

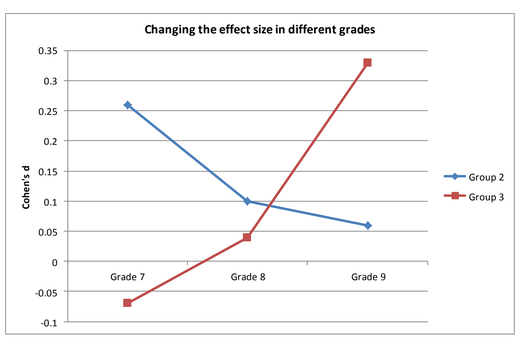




SP: Mark in science/chemistry

(1-5 scale)





AQ1:

- Positive effect in Grade 7 for both experimental groups
- Negative effect in Grade 8 for both experimental groups
- No significant change in Grade 9

AQ2:

- Positive effect in Grade 7 for both experimental groups
- Negative effect in Grade 8 for both experimental groups
- Small increase in Grade 9 for both experimental groups

AQ3:

- Small 'negative' effect in Grade 8 for Group 3
- No significant change in Grade 9

SP:

- Decrease in mark for Group 2
- Increase in mark for Group 3

Conclusions:

- Students of both experimental groups have positive change in attitudes to chemistry and the importance of experiments than that of students of the control group in Grade 7. However these positive attitudes decreases strongly in Grade 8.
- In Grade 7 the preference of 'step-by-step' experiments is higher in case of Group 3 than Group 1 or 2, but in Grades 8 and 9 there is no significant difference between the groups.
- It seems that experimental design has positive effect on the mark of the students.

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