Which Skills Do High School Students See as Improving Thanks to Chemistry

Irena Chlebounová[1], Petr Šmejkal[2]

Charles University, Faculty of Science, Czech Republic[1,2]

Abstract

The research has been focused on feelings, attitudes and usefulness of Chemistry for life for students in their last year of learning Chemistry. The study was done at an eight-year "common" grammar school. The group of 102 (18 – 19 years old) students from six different classes got a questionnaire with 21 statements and 33 open questions. By using 11-point Likert scale, they indicated their progress or regress in skills and competencies in Chemistry during last three years. Open questions gave students an opportunity to comment the marks they made on the Likert scale. Students were taught by four teachers with different teaching styles (two of them using teacher-centered model while the other two student-focused model with elements of active learning). The questionnaires were analyzed using common statistical methods to reveal differences between groups. The paired t-test accompanied by qualitative explanation showed significant differences between two educational styles. Unlike the teacher-centered education, the student-focused active learning has resulted in increased self-confidence in case of all 21 statements among the respondents.

Keywords: *key competencies, teaching methods, active learning*

1. Introduction

Western society needs people confident in their skills and competencies and able to cooperate. It was shown, that hands-on activities and laboratory work with supportive feedback create environment for learning with more understanding of complex sections of the curriculum, autonomy and ability of cooperation. [1] The achievements of students who learn through cooperative learning are higher than traditional teaching also in working with complex ideas, in essential skills and ability to lead a team. [2] It decreases misconceptions and enhances motivation and self-confidence. [3] Research in Taiwan revealed problem with negative attitudes of high achieving students towards Science. Active students decreased their anxiety of Science through collaborative learning and outperform passive learners. [4] The effectiveness of active learning is high for critical thinking, solving problems, argumentation, and inquiry habits. In Ireland is implementing "learning by doing" instead of memorization. [5] Finland research demonstrated effects of students-centered education model on deep understanding and improved learning. [6] The climate of cooperation, involvement and motivation are created also through educational games. This stimulates among other benefits moral quality (fair play). [7] In many grammar schools in Czech Republic is still alive the traditional way of teaching (teacher-centered model) with a lot of memorization. The both authors see it in Prague through Pedagogical training of their students of teaching.

2. Methodology

2.1 Purpose

This study was conducted to investigate whether change of teaching style from traditional teacher-centered method to student-focused method increases students' confidence in Chemistry used skills and competencies. It compares 1 group of 5 classes, where the teaching style was changed, with 1 class of control group, where no change in teaching style happened. The research question: Is there any significant difference in self-confidence of students taught by student-focused method and traditional teacher-centered method?

2.2 Sample

The sample included 102 students, all of them in final stage of their education in Chemistry at an eight-year grammar school in Prague. Group of 76 students of experimental group were taught three years by the teacher A (teacher-centered model "chalk and talk", no laboratory work of students, just demonstration experiments, strict rules, feedback evaluative of the person). The 53 of them (4 classes) spent next three years with the teacher B and 23 (1 class) with the teacher C (B, C = student-

focused active learning, laboratory work in the groups of 3-4, cooperative learning in groups of 2–5, games, excursions, hands-on activities, encouraging feedback from both teachers, projects). The control group, tested to avoid an influence of time spent with one teacher) consisted of 26 students (1 class) taught without any change by the teacher D (teacher-centered educational model with powerpoint presentations, no laboratory work of students, no games, no excursions, without strict rules).

2.3 Procedure and Instruments

Students got custom questionnaire prepared by the first author with 21 statements and 33 open questions (to explain the reason of choice) with questions focused on feelings, attitudes and their position to usefulness of Chemistry for their future life. For this article, 7 statements + 7 open questions connected with laboratory skills were analyzed:

1. I learned the basic laboratory skills and the rules of the chemical laboratory.
2. I regularly document my own laboratory work.
3. I know how to use measuring instruments (for example, MBL system ~~Vernier~~).
4. I measure and evaluate my data (compare it to someone else's data).
5. I interpret the values written in the graph.
6. I am a valid team member. I follow the rules of teamwork.
7. I understand the context in the chemical curriculum.

Students evaluated their confidence in skills on 11-point Likert scale (0 = I do not know how to do it, 10 = I can do it on 100%). Pretest describes how students were confident at the beginning of fourth year of Chemistry (teachers A, D). Posttest describes self-confidence of students at the end of their Chemistry study (teacher B + C, D).

Data were analysed in SPSS software (version 25) using descriptive statistic and paired t-test at 95% confidence interval of the difference.

3. Results and Discussion

Table 1 shows compared means of pretests and posttests by paired samples t-test. Table 2 reveals students' explanations of the choice for their self-confidence on the Likert scale. Table 1 and 2 show that the cooperative active learning in experimental classes (teacher B + C) led to significant differences ($p \leq 0.05$) in self-confidence of students (N = the number of students) in comparison to the traditional teacher-centered model of their previous teacher (A) in all 7 selected skills. These results are consistent with results of other researches focused on cooperative and active learning. [1] - [7]

The control group (teacher D) did not reach significantly better self-confidence in:
2 - documentation of own work (students do not have to write protocols from laboratory work)
3 - measuring with Vernier (they did not see it in lecture of teacher D)
6 - being valid member of the team (they mostly just listen to their teacher and write notes)
7- understanding of the context in chemical curriculum (the difficulty and amount of curriculum has increased and students are not motivated in learning).

The control group increased students' self-confidence in:
1 – learning of basic skills and rules of the chemical laboratory (they know rules),
4 – measuring and evaluating data and
5 – interpreting values written in the graph (they have done it in Mathematics, Physics and German).

The results show that students' self-confidence in some activities is dependent on the real experience (laboratory work).

Table 1 Paired Samples T-Test (95% Confidence Interval of the Difference)

Pair of Statement Pretest - Posttest	Mean Pretest	Mean Posttest	Mean Pretest - Posttest	N	Significancy *p* (2-tailed)
1 experimental group	5.04	7.59	-2.554	74	0.0001
1 control group	3.76	4.52	-0.760	25	0.049
2 experimental	3.69	5.68	-1.987	74	0.0001
2 control	1.40	2.16	-0.760	25	0.078
3 experimental	2.03	4.11	-2.082	73	0.0001
3 control	0.88	0.81	0.077	26	0.832
4 experimental	5.38	7.26	-1.878	74	0.0001
4 control	4.50	5.46	-0.958	24	0.001
5 experimental	5.96	7.32	-1.356	73	0.0001
5 control	5.23	6.27	-1.038	26	0.001
6 experimental	6.52	7.58	-1.055	73	0.0001
6 control	6.08	6.54	-0.462	26	0.083
7 experimental	3.67	6.01	-2.340	72	0.0001
7 control	4.88	4.50	0.3846	26	0.505

Table 2 Frequent Answers Explaining Evaluation of Statements

Question	Answers
1 experimental group	We work more often in the laboratory than with the previous teacher. I am more confident, I enjoy working in it.
1 control group	We do not have any laboratory work. I have never been in lab.
2 experimental	I do not document work having different role in my group (to do experiments, to take photographs). We have not done any protocol with the previous teacher. Now, we have to do it.
2 control	I do not work in laboratory, so I do not have experiences with the documentation of experiments. I have never done it.
3 experimental	I measured with them just twice. We have not used Vernier with the previous teacher.
3 control	I do not know, what does the word Vernier means. I do not remember any measurement with Vernier tool.
4 experimental	I know how to do it and I enjoy it. I need instructions, how to do it.
4 control	I do not remember doing it. I know how to do it and I enjoy it. We did it in the other subjects.
5 experimental	Yes. If the graph is clear.
5 control	I have acquired this ability through another subject. I never did it.
6 experimental	I have no problem with this if the tasks are clearly divided between members of the group and they work together. I try to be a valid member of group.
6 control	I could be more involved in teamwork. We do not work in groups.
7 experimental	The explanation is clearer than explanation done by previous teacher. I understand more how the theme is related to the another. Sometimes I do not see connections between terms. I have gaps in my knowledge. I do not remember much from the Chemistry.
7 control	We learn more complex curriculum than before. I need more time for understanding. It depends on difficulty level of the curriculum. I do not care about Chemistry and understand nothing.

The limitation of the study is the small number of respondents (102).

4. Conclusion

There is significant difference in the self-confidence of students who were taught by students-centered model and traditional teacher-centered model.

There is significant difference in the self-confidence of students experimental group (with the change of teaching model) and control group (without any change of traditional teacher-centered educational model). Students who experienced cooperative active learning with laboratory work, hands-on

activities, team work, games, excursions and positive encouraging feedback from their teacher increased their self-confidence in the skills and competencies like learning of the basic skills and rules of the chemical laboratory, documentation of own work, measuring with Vernier, measuring and evaluating the data, interpreting the values written in the graph, being valid member of the team, and understanding the context in the chemical curriculum.

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