



**Abstract.** *Assessment in many Central- and Eastern-European countries is dominated by summative assessment (SA). Simultaneously, researchers and educators from western Europe and the US proclaim the formative assessment (FA) as an important element of the educational process and advise including it into curricula and everyday teachers' practice. The research presented herein reports an introduction of formative assessment classroom techniques (FACTs) during chemistry lessons at K7 level in Slovakia. In total 202 students participated in the research. They were divided randomly into a control (n=97) and an experimental (n=105) group, and the intervention covered 10 successive lessons. After the intervention, the student's outcomes were compared using the test checking student's knowledge and skills according to various domains of Bloom's revised taxonomy. The results suggested a statistically significant increase in the score of the experimental group, and a detailed analysis revealed that the increase was significant in both lower- and higher-order cognitive skills area. Finally, the students' reaction on the introduction of formative assessment was studied and showed their positive attitude towards the introduced method.*

**Keywords:** *chemical education, formative assessment classroom techniques, higher-order cognitive skills, secondary school.*

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## INFLUENCE OF FORMATIVE ASSESSMENT CLASSROOM TECHNIQUES (FACTs) ON STUDENT'S OUTCOMES IN CHEMISTRY AT SECONDARY SCHOOL

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### Introduction

Assessment is an inseparable and central element of educational process (Black, 1993). According to the Cambridge Dictionary, assessment is "the act of judging or deciding the amount, value, quality, or importance of something, or the judgment or decision that is made" (Cambridge University Press, 2019). Historically, the main role of assessment has been to determine and provide grades for promoting students to the next level (Moon, 2005). Scriven noticed that "evaluation is itself a methodological activity which is essentially similar whether we are trying to evaluate coffee machines or teaching machines, plans for a house or plans for a curriculum" (Scriven, 1967). Thus, assessment has the same conditions, no matter the area of assessment. Assessment is used to discover what students (people) know and what they can do (Baird, Andrich, Hopfenbeck, & Stobart, 2017).

Two fundamental types of assessment can be distinguished: summative assessment and formative assessment. Summative assessment (SA) sums up evidence, therefore is applied usually at the end of a certain part of the educational process. It provides information about students' progress in relation to the selected population (Harlen, 2000; Olson & Loucks-Horsley, 2000; Taras, 2005) and is mostly based on tests (Baird et al., 2017). The highest increase in the summative assessment importance was observed at the beginning of the 21<sup>st</sup> century when educational institutions (schools and universities) emphasized standardization of assessment (Lau, 2016). Formative assessment (FA), on the other hand, means ongoing evaluation during an educational process that provides extended feedback (Scriven, 1967). Many researchers emphasized fitting together summative and formative assessments (Barnett, 2007; Sambell, McDowell, & Montgomery, 2012; Taras, 2005). Sambell et al. (2012) highlighted the importance of balancing summative and formative assessments and point out that both should be a source of learning. Taras (2005) also proffered the vision of learning process based on both summative and formative assessments but sees SA as a judgment which is followed by feedback, thus, formative assessment follows summative one. On the other hand, Siweya and Letsoalo (2014) suggested that formative assessment can

be a predictor of summative assessment. Bell and Cowie (2001) focused on self- and peer-assessment, arguing that formative assessment should be done by both teachers and students. Similarly Barnett (2007) put emphasis on the development of students' capacity for self-reflective judgement and students taking ownership of assessment and genuinely wanting to learn, rather than simply being pushed to achieve certain grades. Regardless of the form, the major purpose of the assessment is to enhance student's learning process and outcomes (Shewbridge, Van Bruggen, Nusche, & Wright, 2014).

### *Formative Assessment*

Foundations of formative assessment, earlier called formative evaluation, can be found in Scriven's works (Scriven, 1967), where he discussed the process of new curriculum development. He claimed that "the role of formative evaluation is to discover deficiencies and successes in the intermediate versions of a new curriculum". After that work, there have been several approaches describing formative evaluation. Bloom said that formative evaluation is "another type of evaluation which all who are involved – student, teacher, curriculum maker – would welcome because they find it so useful in helping them improve what they wish to do" (Bloom, Hastings, & Madaus, 1971).

However, the modern reform in assessment and proclamation of formative assessment began after the publication of Black's and Wiliam's work entitled "Inside the Black Box" (Black & Wiliam, 1998), in which they presented the review of 250 studies about the classroom assessment. One of their conclusions was that "formative assessment is an essential component of classroom work and that its development can raise standards of achievement". Black and Wiliam (1998) revised previous approaches and stated that "assessment becomes formative assessment when the evidence is actually used to adapt the teaching to meet student needs".

To sum up, it can be said that formative assessment is an interactive process that should serve as a tool for improving the teaching and learning for all who are involved – the teachers, to know how to adapt next lessons, and the students, to know the areas of improvement. FA should make the educational process more dynamic and flexible. Diagnosis and adaptations should be done at the moment when it is still possible to change the learning sequence. Since Black and Wiliam (1998) introduced their vision of assessment for learning, many studies have been carried out to measure the effectiveness of this assessment for learning at various levels of education, and at various subjects (Black & Wiliam, 2009; Nicol & MacFarlane-Dick, 2006; Sadler, 1989; Topping, 1998; Yorke, 2003).

In cooperation with Wiliam (2007), Educational Testing Service (ETS) developed Keeping Learning on Track® Program where five key strategies of formative assessment are described: sharing learning expectations, questioning, feedback, self-assessment, and peer assessment (Bennett, 2011). These strategies are represented by various collections of techniques, for example 'Traffic Lights' (Bennett, 2011), 'Formative Assessment Classroom Techniques' (FACTs) or 'Classroom Assessment Techniques' (CATs) (Srivastava, Mishra, & Waghmare, 2018; X. Zhao, Van den Heuvel-Panhuizen, & Veldhuis, 2016).

### *Formative Assessment Classroom Techniques*

FACTs are small formative assessment activities that provide feedback on the lesson to the teacher, and at the same time, brief summary and feedback to the students about their learning. The examples of FACTs are vocabulary square, K-W-L chart, exit card, self-assessment card, T-card, concept map, true or false statements, and others (Keeley, 2008).

#### *Vocabulary square*

Vocabulary square (often called Frayer model) (Wickens & Parker, 2019) is a square divided into four blocks, which present definition, facts or characteristics, examples, and non-examples of the word/phrase given. It was developed by Frayer, Fredrick, and Klausmeier (1969) as a type of concept map. Mostly, it is used in social sciences to help students to support concept thinking, organize information (Bowe, 2019), categorize them (S. C. Greenwood, 2009), and support the vocabulary (Ilter, 2015; Palmer, Boon, & Spencer, 2014; Wickens & Parker, 2019). Nevertheless, this tool can be used in teaching and evaluation of understanding scientific concepts (Keeley, 2013; Nawafleh & Alomari, 2016).



### *K-W-L chart*

This is a logical three-step procedure that stimulates students' thinking, helps students to organize their ideas after reading a text and connect them with the previous knowledge (Finders & Balcerzak, 2013; Fritz, 2002; R. Greenwood, 2018; Rezqi, 2013). At the beginning of the lesson, students write what they know about the topic (*K*) and what they want to know (*W*). After the lesson, they write what they have learnt (*L*) (Ogle, 1986). The tool provides a visualization of new concepts and keeps students' interested during the lesson because they have to consider what they want to know about the topic (Fengjuan, 2010; Nita & Ridha, 2017; Swara, 2017). It is also used in education as a student-aimed strategy to meet theoretical and practical knowledge (Raines, 2017) and to improve performance and critical thinking in problem-based learning (Bailey, 2017).

### *Exit card*

Exit card, also called minute paper, one minute paper or 3-2-1 card is the FACT in which the teacher asks students to write down three main or the most significant points from that day's classes, two points which the students find interesting, and one question that they still may have about the topic (He, 2019; Srivastava et al., 2018; Stead, 2005; Wilson, 1986). However, many variations of these three main points can be found. The teacher should answer the students' questions during the next classes or on an individual basis (Stead, 2005). This FACT provides good feedback on students' understanding of the topic and it is very helpful in identifying students who need more or special assistance (Wilson, 1986).

### *Checklist*

The main goal of this tool is to identify which tasks have been completed and to provide guidance and reflection (Purwanti, 2015). For identifying the presence or absence of knowledge, there are different rating scales: 5-point (1=poor, 5=excellent), 3-point (I can do it alone, I can do it with little help, I cannot do it at all), 2-point (yes, no), and many more (BCIT, 2010; Ma et al., 2012; Seda Çetin & Eymur, 2017). A checklist is an assessment tool which can be used as a self-assessment tool (BCIT, 2010; Nimehchisalem et al., 2014), a peer-assessment tool (Hamnett & McKie, 2019), and as a tool to assess a student by a teacher (Seda Çetin & Eymur, 2017). Naeini (2011) presented a study in which the checklist is used by both, student and teacher, and then their scores are compared.

### *True or false statements*

This FACT is a self-assessment tool which can activate students' thinking about the particular scientific topic. The statements are given to students and they have to decide about the verity of them (Yüksel & Gündüz, 2017). Structure and number of these statements depend on the nature of the topic, whether are used to verify students' understanding of a particular problem or part of the lesson (Hubbard, Potts, & Couch, 2017; Keeley, 2008; Parker et al., 2012). This tool has some limitations because, as *i.a.* McCullough noticed, there is a 50% chance that the students' blind guess is correct (McCullough, 1993).

### *Concept map*

The concept map is a diagram which helps students to organize and visualize their knowledge. It has been developed as a tool for identifying students' ideas about the topic and forming relations and networks between them (Champagne, Klopfer, Desena, & Squires, 1981; Nicoll, Francisco, & Nakhleh, 2001; Novak, 1984). It can be used at the beginning of a lesson as a starting point for a discussion, as a tool for assessment of students' knowledge, or as a tool to monitor changes in students' knowledge during some period (Pendley, Bretz, & Novak, 1994; Regis, Giorgio Albertazzi, & Roletto, 1996). It develops students' conceptual understanding of chemistry, biology, mathematics, and physics (Holme, Reed, Raker, & Murphy, 2017; Marek, Raker, Holme, & Murphy, 2017; Erduran-Avci, Unlu, & Yagbasan, 2009; Holme & Murphy, 2012; Earl, 2007; Malone & Dekkers, 1984; Moyses, Rivet, & Fahlman, 2010; Nicoll et al., 2001; Novak, 1990; Raker, Holme, & Murphy, 2013; Francisco, Nakhleh, Nurrenbern, & Miller, 2002; Soika & Reiska, 2014).



### *Students' Attitudes Towards Formative Assessment*

To get the optimal effect of FA, it's essential to understand students' perceptions and attitudes towards it (Bader, Burner, Hoem Iversen, & Varga, 2019; Guo & Yan, 2019). It has been shown that students' perceptions about FA are related to the way they are using it (Jonsson, 2013; Kyaruzi, Strijbos, Ufer, & Brown, 2019). Typically, if students perceive the feedback as useful, their attitudes towards it are more positive. Another important factor influencing students' perception of FA consists in the time when the feedback is delivered. Students prefer feedback as soon as possible with a possibility to use it in the very near future. Feedback received after the course is less interesting and not useful (Jonsson, 2013). Some students consider formative assessment as an external motivator and claim that it provides an overview of the subject (Weurlander, Söderberg, Scheja, Hult, & Wernerson, 2012). It's not surprising since FA usually provides feedback on what was important in the lesson and what they should expect at the test. Other results showed that students consider assessment to be valuable only when it is warm and friendly (Kyaruzi et al., 2019) and that students perceive peer and self-assessment more positively than assessment done by a teacher (Bedford & Legg, 2007).

Although the assessment can have many forms and can be perceived in different ways, it must be consequential for students, teachers, parents, and finally for the society. Assessment is deeply grounded in schools' curricula and follows specific standards, very often established on the basis of Bloom's taxonomy ( Bulunuz, Bulunuz, & Peker, 2014; Crowe, Dirks, & Wenderoth, 2008; Lee, Kim, & Yoon, 2015; Motlhabane, 2017; Wei & Ou, 2018).

### *Bloom's Revised Taxonomy*

At the beginning of the 21<sup>st</sup> century, Anderson and Krathwohl introduced revised Bloom's taxonomy (Anderson & Krathwohl, 2001), which replaced the original three-layer hierarchical model (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956) with two dimensions: cognitive processes and knowledge.

The cognitive process has six hierarchical categories: remembering, understanding, applying, analysing, evaluating, creating. The knowledge dimension consists of four types: factual, conceptual, procedural, and metacognitive knowledge. These two dimensions could be used separately or as a combination of both (Radmehr & Drake, 2019). Zoller distinguished between higher-order cognitive skills (HOCS) and lower-order cognitive skills (LOCS) (Zoller & Tsapalis, 1997). LOCS items "require simple recall of information or a simple application of a known theory or knowledge to familiar situations and context." HOCS items require "quantitative problems or qualitative conceptual questions, unfamiliar to the student, that require for their solution more than knowledge and application of known algorithms, they require analysis, synthesis, and problem-solving capabilities, the making of connections and critical evaluative thinking."

### *Assessment in Slovakia*

Slovak Ministry of Education assists teachers in summative assessment and provides a framework for curricula – content and performance standards. Teachers in Slovak schools assess students' work, written tests, and oral performance during lessons using a five-point scale. Students also get grades at the end of the first and second semester of the school year (MŠVVaŠ SR, 2011). Therefore, ongoing and final summative assessment is obligatory. As has been described by Orosová, Ganajová, Szarka, & Babinčáková (2019), the dominance of summative assessment over the formative one in science education is evident. This situation was also noticed by the OECD review team who reported that students in Slovak school are assessed mostly summative and there is a big need for feedback for students (Shewbridge et al., 2014). One of the recommendations of the OECD report was to integrate formative assessment into teaching and learning.

The presented research is related to the trial introduction of FA into Slovak schools. It was carried out during chemistry lessons at the secondary school level. The research was meant to answer two questions: "How does the implementation of FA based on FACTs influence students' learning outcomes?" and "What are the students' attitudes towards learning with FACTs?"



## Research Methodology

### *General Background*

The research was conducted in five Slovak schools in three cities (Prešov, Košice, Spišská Nová Ves) situated in the eastern part of Slovakia. Four of those schools were secondary schools and one an 8-year-long gymnasium. In every school, two classes participated in the research, both taught by the same teacher. All the teachers were female and had significant teaching experience, however, they had a wide range of their pedagogical practice (33, 26, 21, 15, and 12 years). The teachers who took part in the research participated in the same training course devoted to using formative assessment 6 months before the research. The course consisted of 4 hours of classical classes and 2 e-learning classes. At first, the teachers attended lectures at the university, where they learned about different types of assessment, history of formative assessment, and various examples of FACTs. During the distance hours, they practised creating own FACTs for a given topic.

### *Participants*

The research sample consisted of 202 students, 75 (37.1%) male, 80 (39.6%) female, and 47 (23.3%) participants with missing gender information. Because of the anonymity of the research, the teachers were not obligated to provide information about students' gender. Participants were students of the 7<sup>th</sup> grade of secondary school or the equal level of 8-years gymnasium, therefore both at the K7 education level. There were 105 (52%) participants in the experimental group and 97 (48%) participants in the control group. The students were 12-13 years old.

### *Content Area*

In Slovakia, students start to learn chemistry as a separate subject at K7 grade of the secondary school or gymnasium (ISCED 2). In both types of schools, chemistry curricula are analogical, and chemistry course starts with a chapter covering the basics of laboratory practises and properties of chemicals. The second chapter is entitled "Mixtures" and covers 10 lessons. The research was carried out during this chapter. The formal SA standard for "Mixtures" covers (ŠPÚ, 2014):

- *Content standards:* classifying examples of matter forms into chemical substances and mixtures; giving examples of homogenous and heterogeneous mixtures; distinguishing the terms: solution, solute, and solvent; calculating the mass fraction of one substance in the solution; the mass of the solute and solution; preparing solutions of a given composition and by a given methodology; preparing (without a calculation) saturated solutions; separating mixtures according to a given methodology (evaporation, sedimentation, filtration, crystallization).
- *Performance standards:* examples of chemical substances and mixtures; homogenous and heterogeneous mixtures; solutions: solvent and solute; water solution, saturated solution; gaseous and liquid solutions, solid solutions (alloys); mass fraction of a substance in the solution; separation processes: evaporation, sedimentation, crystallization, filtration, distillation.

### *Research Design*

At the beginning of the research, a pre-test was written by students in all classes. It was meant to identify and compare students' entry level of chemical knowledge and skills. The results of the pre-test showed that all classes were at a statistically similar level ( $p > .05$ ). Therefore, in every school, the classes were randomly assigned to the control or experimental group. After the pre-test, the students attended 10 lessons on the section of "mixtures". Earlier, the teachers participating in the research developed lessons' scenarios for these lessons. In the control groups, the teachers were working as usual, in their ordinary way. The lessons for the experimental groups were carried out according to the same scenarios, but the teachers implemented formative assessment based on FACTs. The FACTs were developed earlier by the teachers, together with researchers and trainers during the training in FA mentioned earlier. After 10 lessons, the students wrote a post-test about mixtures and filled a questionnaire about the FACTs.



### Research Tools

#### FACTs

Eleven FACTs were used during lessons (Table 1). Vocabulary square, checklist, concept map, and exit card were used at the end of a lesson. True or false statements and K-W-L were used at the beginning and at the end of the lesson. All the FACTs were focused on self- or peer-assessment and each of them represented the content of particular lesson.

**Table 1**

*Type of the FACT used in the lesson*

Number of a lesson	Type of FACT
1	True or false statements
2	Vocabulary square, checklist
3	K-W-L
4	True or false statements
5	K-W-L
6	Checklist
7	Concept map
8	Exit card
9	True or false statements
10	Checklist

#### Tests

The pre-test and the post-test consisted of 10 items at the different domains of the Bloom's revised taxonomy. Tests were the same for both groups, control and experimental, and each of the 10 items was granted with 1 point for a correct answer. Items in both tests were created and evaluated by the National Institute for Certified Educational Measurements of Ministry of Education, Science, Research and Sport of Slovak Republic. The tests were created with cooperation of the teachers participating in the research. The items in the pre-test were checking student's entry level of chemical knowledge and skills, based on the previous topic. The post-test items concerned the section of "mixtures" within which the research was conducted. In the test, the Bloom's domains – remember, understand, apply, analyse – were represented by at least 2 items as presented in Table 2. The items were developed and standardized by the National Institute mentioned above, unfortunately, the database didn't contain items in the domains evaluate and create.

**Table 2**

*Assignment of the post-test items to Bloom's learning domains*

Number of an item	Learning domains for the post-test	Type of question
1	Understand (procedural knowledge)	single select multiple choice
2	Analyse (conceptual knowledge)	single select multiple choice
3	Analyse (procedural knowledge)	single select multiple choice
4	Understand (conceptual knowledge)	rank order
5	Understand (conceptual knowledge)	open-ended
6	Apply (procedural knowledge)	open-ended
7	Apply (factual knowledge)	single select multiple choice



Number of an item	Learning domains for the post-test	Type of question
8	Remember (conceptual knowledge)	semantic differential scale
9	Remember (factual knowledge)	single select multiple choice
10	Analyse (procedural knowledge)	single select multiple choice

### Questionnaire

After the last lesson, a questionnaire with 4 items was given to the experimental group to determine the students' opinion about the lessons and about the formative assessment:

1. I liked it when the teacher assessed me this way, not only by a grade.
2. This assessment helped me to realize where I have my shortcomings.
3. I think this assessment could help me with my school results.
4. It was fun when I used this kind of assessment.

The scale used was a 4-point Likert scale with answers: "I disagree strongly", "I disagree", "I agree", "I agree strongly".

### Data Analysis

The students' post-tests were evaluated. There was 1 point awarded for each correct answer and 0 points for an incorrect one, therefore the maximum score was 10 points. The results were entered into an Excel spreadsheet and analysed with SPSS ver. 18 (SPSS Inc, 2009). They were analysed for a total test score, scores according to the Bloom's learning domains, and for each question separately. The reliability of the test results was calculated using the Cronbach's alpha (Cronbach, 1951) and equalled to  $\alpha=.693$ . Also, normal distribution of the results was controlled for total scores, grouped items, and for each item separately, using the Kolmogorov-Smirnov test. In all cases,  $p<.001$  suggesting that the data are non-normally distributed, therefore non-parametric tests for comparing the results of experimental and control groups were used for further analysis – the chi-squared test (Pearson, 1900).

Similarly, the students' answers to the questionnaire were entered into an Excel spreadsheet. The answers were scaled numerically from 1 for the answer "I disagree strongly" to 4 for the answer "I agree strongly". The results were analysed with the SPSS. The Cronbach's alpha for the reliability of the questionnaire was calculated ( $\alpha=.740$ ). Also, mean and standard deviations were calculated. The significance level was defined as  $\alpha=.05$  for this research.

### Results of Research

In Table 3, the post-test scores of the experimental and control groups are presented.

**Table 3**

Post-test results analysed by chi-squared test, statistically significant differences between the control and research groups marked with bold

Items	Control group score [no. of points]		Experimental group score [no. of points]		$\chi^2$	df	p	
	Mean	Median	Mean	Median				
Entire test	3.2	3.0	5.3	5.0	51.706	9	<.001	
Items grouped	Remember	.58	.00	1.01	1.00	19.111	2	<.001
	Understand	1.77	2.00	2.23	2.00	17.471	3	.001
	Apply	.28	.00	.77	1.00	28.603	2	<.001
	Analyse	.58	.00	1.29	1.00	34.015	3	<.001

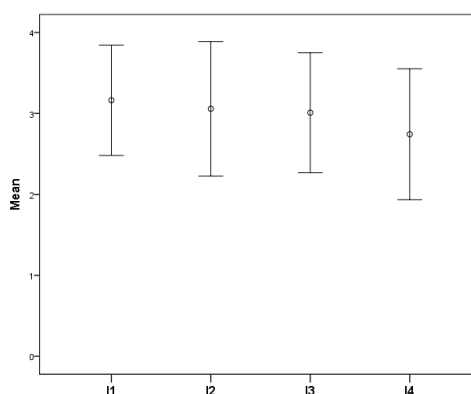


Items	Control group score [no. of points]		Experimental group score [no. of points]		$\chi^2$	df	p
	Mean	Median	Mean	Median			
1	.31	.00	.56	1.00	13.056	1	<.001
2	.19	.00	.53	1.00	26.269	1	<.001
3	.29	.00	.70	1.00	34.923	1	<.001
4	.66	1.00	.80	1.00	5.060	1	.024
Items separated	.80	1.00	.87	1.00	1.443	1	.230
5	.20	.00	.48	.00	17.616	1	<.001
6	.08	.00	.30	.00	14.651	1	<.001
7	.43	.00	.42	.00	.040	1	.841
8	.14	.00	.59	1.00	42.764	1	<.001
9	.10	.00	.05	.00	2.257	1	.133
10							

The results of the questionnaire concerning the students' attitudes towards learning with FACTs are presented in Figure 1. The results suggest strongly positive attitudes towards FACTs and formative assessment.

**Figure 1**

Results of the questionnaire measuring students' opinion about FA (items presented in Research Methodology/Questionnaire), errors bars represent the standard deviation of answers



The most frequent answer (approximately 50% of choices) for all 4 items was "I agree". The "I strongly agree" answer was chosen the most frequently in item 2, where 33 students (31.4%) selected it. Disagreement answers were also present in each of the items, however, the answer "I strongly disagree" was not used often. It was chosen the most frequently (5.7%) also in item 2, therefore for this item greatest discrepancies were observed, what is represented in Figure 1 by the largest error (standard deviation) bars.

## Discussion

For the entire test, the score of the experimental group was higher than that of the control group, and the difference was statistically significant ( $p < .0001$ ). This result lies in line with the results of Kishbaugh et al. (2012) who introduced FA during undergraduate chemistry and biology laboratory courses. In that study, FA was realized





a bit differently – it was based on rubrics, but also enhanced students' learning outcomes. The efficiency of formative assessment based on FACTs was studied by Srivastava et al. (2018) with a group of university students at the faculty of medicine. Her results showed that FACTs were useful in monitoring the students' conceptual learning and they were a timely remediation within instruction to close the learning gaps, which significantly improved learning outcomes. Zhao et al. (2016) used CATs with primary school mathematics teachers. The teachers in this research had no experience in using CATs, nevertheless, they liked this kind of assessment and the fact that they got much new information about their students' learning process. Similarly, Veldhuis & van den Heuvel-Panhuizen (2019) used CATs in mathematics education at the primary school level, also with extended assistance provided to the teachers during the CATs implementation. In both studies, by Zhao and by Veldhuis, implementation of CATs resulted in a significant increase in the students' achievements in mathematics.

Higher-order cognitive skills play an important role in education and should be developed to foster students' performance (Whittle, Benson, Ullah, & Telford, 2019; Zohar & Dori, 2009). Many innovations in chemistry teaching, such as inquiry-based methods (Hugerat & Kortam, 2014) and problem-based learning (Zoller & Pushkin, 2007), help develop students' HOCS.

Ghani, Ibrahim, Yahaya, and Surif (2017) incorporated one of the FACTs – concept maps – as an assessment tool into chemistry laboratory and observed a positive development towards understanding and higher-level thinking skills of participants. However, research on the impact of formative assessment on summative assessment compared to HOCS at secondary school has not been reported yet. The obtained results suggest that the group taught with FACTs achieved statistically higher scores not only in HOCS but in all four analysed domains: remember, understand, apply, analyse.

Despite the measured positive effect of using FACTs on students' learning outcomes, there is no evidence that teachers used the information obtained from the students' answers (in FACTs) to adapt the next lesson, in order to meet students' needs. Similar conclusions were presented by D.-C. C. Zhao, Mulligan, & Mitchelmore (2006) and X. Zhao et al. (2016). This could be due to the fact that formative assessment, in general, requires a lot of time for preparation, and mainly for evaluation. FACTs can be prepared, teachers can be educated but still, they need to implement these changes into their daily practice and answer to students' needs (Bennett, 2011). This fact creates opportunities for further research because, as was described by Cai and Wang (2009), memorization and understanding come together, and teachers have different opinions about what should come first.

It should be remembered that not only knowledge transfer plays an important role in the education process. Students' attitudes, perceptions, and motivation may increase the effectiveness of the learning process (Ames & Archer, 1988; Hacieminoglu, 2016). However, there are studies which reported no correlation between students' attitudes and their learning outcomes (Austin, Hammond, Barrows, Gould, & Gould, 2018; Rach, Ufer, & Heinze, 2013). In the presented research, the students appreciated the introduced form of assessment, they found it useful being assessed in this way before a test. Therefore, the students saw the importance of this assessment for their learning. Such a perception of the FA supported using it during chemistry lessons.

Rach et al. (Rach, Ufer, & Heinze, 2013) argued that positive students' perception of teacher's assessment does not necessarily increase the students' performance. In this research, an increase in students' outcomes after use of FA, and positive students' perception of this form of assessment was observed, however, the correlation between those two factors was not studied. Therefore, further studies are necessary to confirm it.

There were several limitations of this research. First of all, the students' answers in FACTs during lessons were not gathered and analysed. Such data could provide more details on students' progress and correlation between the 'scores' in formative and summative assessments. Also, the questionnaire on student's attitudes towards FA was filled only once, after the entire intervention. More frequent and detailed records, based on interviews, would give more precise results and information about changes in student's attitudes during the intervention process. Finally, the teachers' attitudes towards FA and FACTs were not studied. In general, they participated in the training and research voluntarily and had a positive attitude towards learnt methods, but a detailed analysis could provide information on their preferences in FA, and classroom practise.

## Conclusions

The presented research describes the impact of using FACTs during chemistry lessons on students' outcomes in a summative test. The student's performance was compared between control and experimental groups after 10 lessons. Results show a positive effect of FA on students' performance. A detailed analysis of the test items shows



that using FA affects not only lower-order cognitive skills but also those which require answers to quantitative problems or qualitative conceptual questions. Statistical analysis suggests that the observed difference is statistically significant. Therefore, FA stimulates also higher-order cognitive skills such as application and analysis. Still, the summative assessment shouldn't be replaced by a formative one, but FA should be introduced into everyday school practice to enhance students' learning, and balance between those two types of assessment should be established.

The obtained results of students' attitudes towards learning with FACTs suggest that the students consider formative assessment (FACTs) helpful in finding their shortcomings and improving their school results. Also, the students appreciate being assessed with FACTs before they are assessed by a grade in the summative test. Thus, FA reflects the students' expectations. Moreover, it helps in determining the students' needs and meeting them. Therefore, formative assessment realized in form of FACTs can be easily adopted into school practice, and the teachers shouldn't be concerned by the student's reaction on the new method of assessment. Summarizing this fact with a possible increase in student's outcomes, teachers who don't use FA so far should at least try it because there is nothing to be afraid of in it, nothing to 'lose', and a high prize to 'win'.

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