

Assessment of selected aspects of inquiry during teaching topic Properties of plastics

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The aim of the contribution is to inform about results of formative assessment of teaching inquiry – based activities for the topic Properties of Plastics. Formative assessment was focused on providing a description of how teachers proceeded: what skills they assessed and how, what evidence they collected on student learning. We created the inquiry – based activities within the Establish Project. Subsequently, during teacher trainings, teachers were acquainted with these activities, they tried them and this was followed by training about possibilities of formative assessment of teaching these activities. During the training, teachers suggested and transformed given assessment tools for teaching listed activities with focus on selected aspects of inquiry. Verification took place at 6 primary schools and at 6 grammar schools, with 12 teachers in Slovakia, with participation of 150 students. During realization of inquiry – based activities, teachers focused on assessment of the following aspects of inquiry – observation, formulation of hypotheses, investigation of assumptions, suggestion of experiments, measuring/data collection, formulation of conclusions, discussion with classmates. To assess discussion and work in groups, teachers were using assessment tools focused on self–assessment of own work of a student in the group, as well as on cooperation with peers and development of communication skills. The results of assessment showed that students in the groups discussed suggested procedures together and they also proceeded together to formulate conclusions. Another element on which the teachers focused in assessment was measuring and collection of data, and formulation of conclusions. In this case, the tools of assessment were students' laboratory protocols. Most of the teachers used formulation of conclusions, as well as interpretation of results. For this assessment they used the tool – 'Self – reflection card after learning the subject matter'. They considered this means of assessment very important, because it provides them with feedback. Students learn to assess their knowledge objectively and teachers can use it to plan another teaching activities. After the end of verification, teachers filled out a questionnaire, in which they expressed their opinions about advantages and disadvantages of application of formative assessment into teaching at Slovak schools. The positive aspect which they see is that it provides the feedback about process of teaching, not only to the teacher, but also to the student; it is more motivating, less stressful and it assesses not only the knowledge, but also progress in development of individual competences and skills of the students. They also mention that students have to learn to assess objectively, because they are not used to it and they often overestimate or underestimate.

BACKGROUND

The aim of this contribution is to inform community of teachers with possibilities and tools of formative assessment for teaching inquiry – based activities of the topic Properties of Plastics. Assessment of chemistry teaching has not changed since the 1800's and it is based on search of answers to three questions: What should students know, understand and be able to do? How will they reach this goal? How will we know if they actually attain these goals? Most chemistry students are used to getting assessment information in the form of grades or achieved percentage score. These

numbers tell them about how they rank with other classmates, but it does not give them information about what they learnt or failed to learn. Formative assessment comes from the Latin word *formo*, which means adjust, shape. It is used mostly to inform student and teacher about learning, and it is rarely used for grading purposes. It can be written or verbal, prior to instruction, after instruction or during instruction. It is used for changing of ongoing processes and its expression is verbal evaluation – quality and constructive feedback. Forms of formal assessment are assessment of students by teacher, peer-assessment and self-assessment (Orna, 2010).

METHODS OF RESEARCH

Within the ESTABLISH Project, whose aim is to widely assert so called “Inquiry-based science education”, which can be described as a teaching of science using methods of active inquiry, we prepared teaching materials for Physics, Chemistry and Biology. All partners involved in the project prepared several units, in cooperation with Charles University in Prague, we prepared Unit Polymers for Chemistry, and within this unit, we prepared inquiry-based activities for the topic Properties of Plastics. The Unit Polymers develops abilities of students to search for information on the Internet, diagnose the problems, create thoughts models, discuss, communicate with classmates, suggest hypotheses, and distinguish alternatives. By performing activities and solving tasks in students’ worksheets, students understand the essentials of scientific inquiry. Activities are designed that students work in groups, discuss together, argue, and suggest solutions of problems. In these activities, structured and guided inquiry is applied. In the activity Properties of Plastics, teacher formulates problems, and experiment which enables to solve the problem is suggested either by teacher or by students.

For verification, we made these prepared inquiry-based activities available to teachers: *Determining density of Plastics, Combustibility of Plastics, Thermal stability of Plastics, Thermal and electrical conductivity of Plastics, Resistance of Plastics to chemicals*. Research was realized with 12 teachers and with participation of 130 students. Task of the teachers was to realize teaching inquiry-based activities from topic Properties of Plastics. For verification of teaching, they used tools of formative assessment, which they became acquainted with during course Preparatory attestation education for passing the first/second attestation exam in subject of Chemistry.

SPECIFIC SAMPLES OF VERIFICATION OF TEACHING PROPERTIES OF PLASTICS WITH INQUIRY - BASED METHODS, USING INSTRUMENTS OF FORMATIVE ASSESSMENT.

In the following section, we present specific samples of results of students’ self-assessment and peer-assessment after teaching inquiry-based activities of topic Properties of Plastics.

Sample n. 1: Assessment of understanding or “What have I learnt about density of plastics with inquiry – based method?” on the basis of metacognition.

Metacognition enables students to sum up what they did during the lesson and why they did it. At the end of the lesson, students are supposed to answer the questions: What did we do? Why did we do it? What have I learnt today? How can I use it? What questions about the topic do I still have? As an example, we present a sample of

metacognition of students after teaching inquiry-based activities in the 9th grade elementary school in the group of 16 students. The following activities were taught: Determining density of plastic materials polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC) by comparing with water density. Combustion of plastics – Beilstein’s test for halogens.

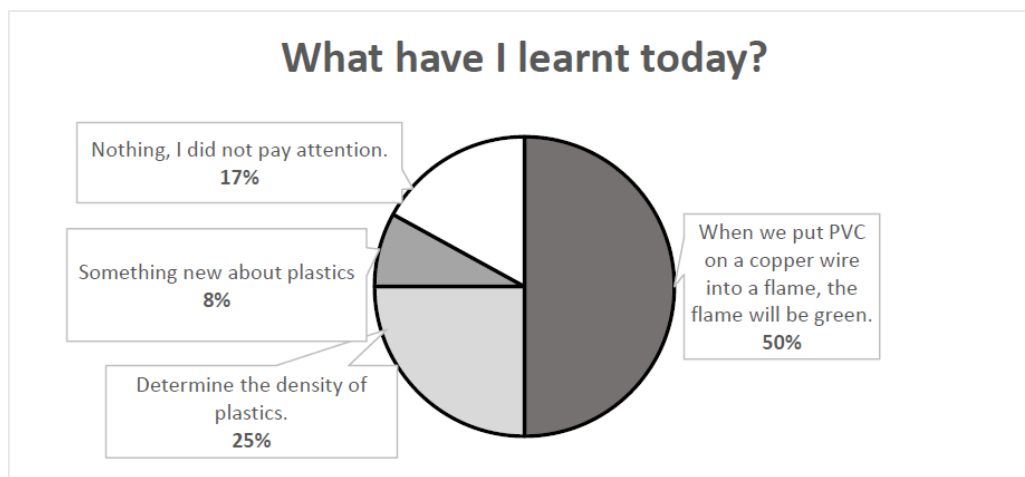


Figure 1: Graph with results of metacognition – students’ answers to question What have I learnt today?

Sample n. 2: Self-assessment table of a student after teaching inquiry-based activities

Another option after teaching inquiry-based activities is to let the students fill out a short table, which they hand in before leaving the class. As an example, we present the answers of 22 students of High school in Bardejov after the teaching of inquiry – based activities Determining density of plastic materials polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC) by comparing with water density, Combustion of plastics and Beilstein’s test.

Table 1: Answers of students in self-assessment table after teaching inquiry-based activities

<i>Self-assessment table of a student after teaching inquiry-based activities</i>	
Things I have learnt today	<i>Properties of particular plastics. What kinds of plastics exist. How to ignite the burner. How plastics are burning. Which plastics smell and drip during burning. How plastics are used.</i>
Things which were interesting	<i>Behaviour of plastics during combustion. Burning of a Ping-Pong ball. Finding out how many things are made of plastics. The colour of flame during combustion. Smell.</i>
Questions which I still have	<i>How plastics can be harmful to us. How to avoid problems with excessive amount of plastic waste. Why plastics burn in this way. Why you do not teach in this way more often. 14 students had no question.</i>

Sample n. 3: Questionnaire method for peer assessment of group work

As a specific example how to use this type of a questionnaire, we present the peer-assessment of group work of students from the third grade at High School in Velké Kapušany after teaching inquiry-based activities of the topic Properties of Plastics (**Determining density of plastics**, and **Thermal stability and thermal conductivity of plastics**). The questions were divided into three parts: discussion and the design of procedures, the formulation of conclusions, and the creation of answers to questions:

Please, read each item and mark the number that indicates how often the situation happened during group work. Use the following scale for your answers:

<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
<i>Almost never</i>	<i>seldom</i>	<i>sometimes</i>	<i>often</i>	<i>always</i>

Table 2: Percentual results of Assessment of students' group work questionnaire

ASSESSMENT OF STUDENTS' GROUP WORK		<i>1 almost never [%]</i>	<i>2 seldom [%]</i>	<i>3 sometimes [%]</i>	<i>4 often [%]</i>	<i>5 always [%]</i>
1	We discussed procedures for solving out the given tasks together.	0	0	5.3	47.4	47.4
2	I suggested procedures and the others agreed.	10.5	31.6	42.1	15.8	0
3	The others suggested procedures and I agreed.	0	0	57.9	36.8	5.3
4	We formulated conclusions together.	0	0	15.8	42.1	42.1
5	I explained to the others how to formulate conclusions.	31.6	31.6	26.3	10.5	0
6	Other classmates explained to me how to formulate conclusions.	10.5	26.3	42.1	21.1	0
7	We formulated answers to questions together.	0	0	21.1	52.6	26.3
8	I answered questions and justified them.	10.5	36.8	47.4	5.3	0

The answers show that in most of the cases, students formulated procedures together. During the formulation of conclusions, students cooperated significantly – they formulated conclusions together.

CONCLUSION

After teaching inquiry – based activities of topic Properties of Plastics and after the application of formative tools of assessment into teaching, teachers were given the opportunity to comment on effectiveness of using these tools, on their advantages and problems. From their comments we selected the following:

- This way of assessment is very important, because it provides feedback. Students learn how to assess their knowledge objectively and to compare it with their classmates. Teacher can assess better the level of student's knowledge and on this basis, teacher can plan the next teaching activities.

- The importance for the students is that they have a possibility to improve their performance, to improve their output, which is then assessed with a grade.
- This way of assessment strengthens the teacher – student relationship, which is very important for the confidence of students in their teacher. It creates feedback, which helps to form teacher's ideas at the lessons and helps the teacher with his work.
- Teacher gains knowledge about subjective feelings of students, e.g. about work in groups.

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