Experiments to Verify the Properties of Technical materials in the Subject of Technology in Lower Secondary Education

Milan Ďuriš[1], *Viera Tomková*[2], *Petra Kvasnová*[3]

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Abstract

This paper pays attention to the selected design of experiments that will be part of an inquiry-oriented model of students' education in the subject of Technology in lower secondary education in the Slovak Republic. The proposed model of education reflects the actual long-term objectives of students' education in the subject of Technology, which, despite the content of the curriculum in the updated Educational Standard for the subject of Technology, have not yet been fulfilled. The proposed educational model includes worksheets for students, which contain experiments with a methodology on how to experiment. Students discover new knowledge through inquiry-based activities during the implementation of the experiment, which they evaluate after the worksheet while applying formative assessment of their activity. This assessment includes a student self-monitoring record where the student records his/her response during the experiment and a self-assessment of his/her understanding of the learning unit. The article presents two experiments out of the proposed collection of experiments, along with their implementation methodology. This topic is addressed within the project KEGA nr. 006UMB-4/2022 Implementation of an inquiry-based learning model in the subject of Technology in lower secondary education focusing on the cognitive field.

Keywords: Elementary school, Model of education, Subject Technology, Experiment, Formative assessment

1 Introduction

Over the last few years, students' results in the OECD PISA international tests have resonated in the Slovak Republic, in which they have achieved statistically significantly lower

[1] Faculty of Natural Sciences UMB Banská Bystrica, Tajovského 40, 974 00 Banská Bystrica.
E-mail: Milan.Duris@umb.sk
[2] Faculty of Education UKF Nitra, Dražovská 4, 949 01 Nitra.
[3] Faculty of Natural Sciences UMB Banská Bystrica, Tajovského 40, 974 00 Banská Bystrica.

performance than the average performance of students in OECD member countries. Greater attention is being paid to this problem not only by teachers and the Department of Education but also by parents and society as a whole. The school reform of primary schools in Slovakia is aimed at new goals of education in the 21st century, which is why the Act of the National Assembly of the Slovak Republic No. 245/2008 Coll. on education and training (i.e., the School Act) and amendment and additions to certain acts have set the primary goal of education - educating students to the key competences. In the subject of Technology in lower secondary education, the performance standard specifies the objectives and professional competencies to be achieved and mastered by the student in a given year in the cognitive, affective and psychomotor domains.

2 Starting points of the Problem Addressed

Teaching the subject of Technology in lower secondary education is carried out following the updated State Educational Programme and terms of content according to the revised Educational Standard for the subject. Despite the targeted undergraduate training of future teachers of the subject of Technology at respective faculties, teachers in pedagogical practice do not manage to meet the set objectives in the subject of Technology to the required extent. This is mainly due to:

- insufficient material and technical equipment for the subject of Technology,
- the absence of experimental activities for students with ideas, materials, technologies and Technologies,
- the still predominantly transmissive way of teaching and the dominance of summative assessment of students,
- non-application of students' creativity and ideas in working and experimental activities and other reasons affecting the quality of education in the given subject in individual regions in Slovakia.

The objectives of the subject of Technology formulated in the updated State Educational Programme reflect the subject's content in the 5th — 9th grade of primary school. From the aspect of addressing the given issue within the project, we are primarily interested in the fulfilment of the following objectives in the subject of Technology:

- students experiment with ideas, materials, technologies,
- students distinguish and safely use natural and technical materials, tools, instruments and equipment,
- students apply creativity and their ideas in working and experimental activities,
- students learn to self-evaluate based on the experiments they have carried out,
- students acquire the necessary knowledge and skills relevant to employment opportunities, choice of their career path and further career and life orientation.

The updated Educational Standard for the subject of Technology in the 5th — 9th grade of primary school in individual thematic units also contains a performance standard, which formulates the performances that determine what the student should know and be able to do at the end of a given year within a particular thematic unit (ŠPÚ, 2015).

The assessment of a student cannot only be an assessment of his/her momentary performance but should be directed towards formative assessment and self-assessment. The essence of self-assessment is that students are responsible for their learning and are actively involved in the learning process. From a didactic point of view, self-assessment can be seen as a competence that promotes autonomy and independence from the teacher.

Self-assessment and self-control are the most important motivational tool for the student. Formative assessment of students in the teaching process aims at obtaining feedback on the progress of the student's learning, on weaknesses and mistakes, intending to eliminate them. As stated by several authors (Turek, 2014; Kalaš et.al., 2013; Shute & Kim, 2014; Ďuriš & Stadtrucker, 2016; Ďuriš et.al, 2017; Ďuriš et.al, 2018; Koedinger, McLaughlin and Hefferman, 2010; Ďuriš et.al, 2019; Pavelka et.al. 2020; Ďuriš et.al, 2023), formative assessment of students should be used more extensively as it improves the quality of their knowledge and skills.

To meet the above goals, the inquiry-based model of education will include learning how to apply experiential learning to students, how to use formative assessment to them, and how to develop and support students' key competencies and 21st century skills (creativity and innovation, creative and critical thinking, problem solving, etc.).

3 Structure and Execution of the Proposed Experiments

The structure of the proposed and selected experiments reflects the content of the thematic unit's technical materials and working procedures of their processing, which is included in the updated Educational Standard of the subject Technology in the 6th and 7th grades of primary school. The proposed experiments are part of the designed teaching tool called Workbook for the subject of Technology with demonstration tasks (Ďuriš et al., 2023). In the workbook, students will also become familiar with the basic theoretical information focused on the properties of technical materials (wood, metals, plastics). The individual tasks focus on:

- problem solving,
- development of students' research activities,
- developing and supporting students' key competences and 21st-century skills (creativity and innovation, creative and critical thinking, problem-solving),
- the application of formative assessment of students through a student self-monitoring protocol.

Since teachers cover the content with different emphases, we must keep students aligned. This is done by providing students with basic theoretical knowledge about technical materials,

wood, metals and plastics, and their mechanical, physical, technological, chemical properties (metals) before the experiment.

These properties are characteristic in that they can be observed directly or by simple experiments. Based on an experiment carried out by themselves, students can more easily understand the observed phenomena; they can explain and justify the changes that have occurred in the process of the performed experiment.

After completing each experiment, students carry out self-assessment and self-monitoring using the self-monitoring protocol. In the self-monitoring protocol, they answer the prepared questions focused on the experiment in their own words, and they express in writing their opinion on the experiment, how they understood the learning, and how they worked with the task in the experiment.

Mechanical properties of metals include the elasticity of metals. The structure and methodology of the experiment focusing on this property are given below.

Experiment nr. 1

Elasticity of metals

The aim of the experiment is to determine which of the given samples of metal wire has the most excellent elasticity.

Student's task:

Check the elasticity of the springs, which are made of three different metal wires (zinc-coated, copper and brass).

Tools:

- three different metal wires (zinc-plated, copper and brass) with a diameter of 1 mm with the same length (recommended length = 20 cm),
- coloured pencils (e.g., black, red, green),
- ruler,
- laboratory stand with clamps and holder,
- millimetre paper of A4 format,
- adhesive tape,
- laboratory weights,
- pliers with narrow jaws,
- stopwatch for measuring time.

Work procedure

1. Wrap each wire sample around a pencil. Make sure to leave a 2 cm long straight wire free at the beginning and the end.
2. Make sure that the wrapping is precise and that the different parts of the resulting spring are touching the pencil. If you have followed the correct procedure, you will end up with three springs of the same length.

3. Use the pliers to make hooks for hanging on each end of the springs.
4. Measure the length of each spring when it is at rest (unloaded) and write the value in mm in the table.
5. stick the millimetre paper on the laboratory stand using adhesive tape.
6. Hang the springs on the crossbar of the stand using the hook provided (to prevent the spring from slipping off, we recommend using lab holders to hold the springs in place).
7. Mark the initial length of the springs on the millimetre paper (*black pencil*).
8. Hang weights of equal weight on the free ends of all three springs.
9. Leave the weights for 5 minutes. Mark (*red pencil*) the length of the extended springs on the millimetre paper.
10. Remove the weights from each spring and allow the springs to hang freely for 5 minutes.
11. Record the length of the springs (*green pencil*) on the millimetre paper.
12. Write all the data from the millimetre paper in the table.
13. Based on the comparison of the lengths of the springs at the end of the measurement, determine which spring is the most elastic and which is the least elastic.
14. Write the result in order in the table (**1** - greatest elasticity, **2** - medium elasticity, **3** - least elasticity).

Complete the data in the table.

Spring	**Zinc-coated wire**	**Copper wire**	**Brass wire**
Standstill			
With weights			
Standstill (after weights removal)			
Determination of elasticity			

Explain, in your own words, what has caused the difference in elasticity of individual materials.
..... *student answers*
What is the property that allows a deformed material to return to its original shape when an external force is removed??
..... *student answer*
Write in your own words where a given property of materials is used in household or technical practice.
..... *student answers*
Your comments on the experiment (briefly justify the difficulty and clarity of the learning task):
..... *student answers*

In each row of the table, mark one of the emoticons with an (**x**) based on your understanding of the task and how you liked the experiment.

How did I understand the lesson? How was it to work out the task?	☺ Very well	😐 Good	☹ I need to improve
1. I know why the spring returns to its original shape when the external force is removed.	( )	( )	( )
2. I understood that not all materials have the same elasticity.	( )	( )	( )
3. I can name the property of metals that allows a deformed material to return to its original shape when an external force is removed.	( )	( )	( )
4. I understood the task and the experiment was clear and interesting.	( )	( )	( )

The technological properties of plastics include their weldability. The experiment's structure and implementation method focused on this property is presented below.

Experiment nr. 2

Weldability of plastics

The experiment aims to observe the weldability of plastics under heat and pressure.

Student's task:

Find out the principle behind a home food foil welder used to prepare packets of cut vegetables, fruit, or meat to be stored in the freezer.

Tools:

- polyethylene foil,
- scissors, ruler, marker,
- 2 laboratory slides,
- alcohol burner,
- matches,
- cold water container (3 dcl jam jar),
- stopwatch for measuring time,
- flat-jaw pliers.

Work procedure

1. Fill the container (jam jar) half full of water.
2. Cut out two rectangles of polythene foil, 40 x 60 mm in size.
3. Place the prepared rectangles of polythene foil between two laboratory slides so that 1 cm of the foil extends over the edge of the laboratory slides.
4. Light a wick with a match on an alcohol burner.

5. Grasp the laboratory slides between which the two rectangular polyethene foils are placed on the shorter side in the pliers.
6. Heat the overhanging edge of the polyethene sheets slowly over the flame of the burner (follow OHS).
7. After 15 seconds, immerse the bonded foil with pliers in a container of cold water.

Explain in your own words what caused the welding (joining) of the polyethene foil.
..... *student answers*
In your opinion, can both thermoplastics and reac to plastics be welded?
..... *student answers*
Write in your own words where the weldability of plastics can be used in real life.
..... *student answers*
Your comments on the experiment (briefly justify the difficulty and clarity of the learning task):
..... *student answers*

In each row of the table mark one of the emoticons with an (**x**) based on your understanding of the task and how you liked the experiment.

How did I understand the lesson? **How was it to work out the task?**	☺ **Very well**	😐 **Good**	☹ **I need to improve**
1. I know the reason why two polyethylene foils were welded (joined).	( )	( )	( )
2. I understand that some types of plastics are weldable by heat.	( )	( )	( )
3. I can name the property of plastics that causes them to bond by heat and pressure.	( )	( )	( )
4. I understood the task and the experiment was clear and interesting.	( )	( )	( )

4 Conclusion

We assume that the proposed model of education will not only be demonstrative and exploratory for students, and its implementation will not only apply experimental learning, but also formative assessment of students. This is the intention of the proposed inquiry-based learning model with the application of appropriately designed experiments in the subject of Technology. The given model of education should preferably be adopted by students of undergraduate studies in the Studying Programme Teaching of Technology (bachelor and master studies), the target group is also teachers of the subject of Technology involved in the

extension study of the subject of Technology, as well as qualified teachers teaching the subject of Technology in lower secondary education.

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