

Motivational simple experiments in science education

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Abstract

The motivational role of school experiments in science education is still growing. Motivation in education is realized using cognitive motivational teaching techniques. Several cognitive motivational teaching techniques are based on observation and experimentation. From the pedagogical constructivist point of view it is important to develop appropriate school experiments for school practice. Presented cognitive motivational teaching techniques are based on special kinds of simple experiments such as: experiments of everyday life, entertainment-edutainment experiments, problem experiments, experiments supported by ICT etc. All presented simple experiments are developed by a use of design-based research including action research in school practice at primary and lower secondary schools.

Keywords

cognitive motivation; science education; simple experiments

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Introduction

Many science teachers and educators perform school experiments. They usually do not think about the concrete implementation of these experiments in teaching and learning science (Trna & Trnova, 2015). The school experiment should consist of three parts: correct presentation of scientific phenomena, successful technical and safety presentation, and appropriate educational implementation.

If teachers use a wrong teaching method for an experiment, they do not achieve the desired educational objectives including motivation. This study concentrates on development and increasing motivational effectiveness of school science experiments. Every educational activity based on experiments can be a motivational incentive for students, but simple experiments have strong motivational effects on students.

Problem statement

The process of learning science depends a great deal on students' motivation. Science teachers must be constantly aware of this fact. Motivation has a psychological basis and science educators should take it as a starting point for their research. The research results concerning the issue of motivating students must be implemented in continuous professional development (hereinafter CPD) of teachers.

Motives are psychological characteristics of a personality that we consider to be the internal cause of behaviour (Bransford, 2000). Motives consist of elementary

structures called needs. Needs are elementary motives, which we can imagine as the condition of lack or abundance in the organism, causing tension which starts activity. Motivation is a psychological process, in which motives are implemented into the behaviour and experiences of an individual by outside factors.

In teaching and learning can be find three special types of needs: social, achievement and cognitive needs. The set of social and achievement needs includes identification and positive relationships, status, influence, competence, realised goal of a successful performance and avoidance of failure. Social and achievement needs lead to external motivation of students which can be both positive and negative and this is the biggest disadvantage of these needs. This disadvantage is not included in the third type of cognitive needs. That is why we study cognitive motivation.

Science teachers must be equipped with appropriate professional knowledge and skills how to motivate students. The previous research (Trna & Trnova, 2006) indicated the most effective cognitive teaching techniques of students' motivation in science.

A set of cognitive motivation teaching techniques by which students can be motivated were identified. The two main groups of cognitive motivation teaching techniques were defined (Trna & Trnova, 2006):

Science cognitive motivation teaching techniques:

- Stimulation through unconscious perception and experimentation
- Using models of natural objects and phenomena
- Applying systematisation of science knowledge
- Use of similarity and analogy between natural objects or phenomena
- Undertaking problem tasks and projects
- Demonstrating simple experiments and toys
- Seeing paradoxes and tricks
- Watching films, video programmes, TV programmes and computer programmes
- Experiencing humour in science
- Visiting science museums and centres

Interdisciplinary cognitive motivation teaching techniques:

- Science for life (especially related to social issues – health, food, energy, and environment)
- Applications of science knowledge in technology
- Use of ITC in science
- History related to science discoveries and scientists' lives
- Analysis of scientists' quotations
- Use of sci-fi literature and films
- Application of the relation between science and art
- Use of philosophical aspects of science

Most of these cognitive motivational teaching techniques can be based on observation and experimentation. Simple experiments have the strongest motivational effectiveness. Combinations of cognitive motivational teaching techniques result in upgrading students'

motivation. An additional upgrade of motivational effectiveness can be realised especially with the use of interdisciplinary connections.

A simple experiment is a special type of school experiments defined variously (Haury & Rillero, 1994). The simple experiment can be defined by description of its aspects which are: transparency, activity of students, easy realisation, creativity of students and teachers, low costs, prevention of misconceptions, motivational effects, etc. (Trna, 2005). Simple experiments are the basis of hands-on and minds-on activities and the source of strong motivation. Simple experiments can activate cognitive needs such as problem solving, but can also satisfy the needs of our senses and kinaesthetic activity. This simultaneous activation of two or more cognitive needs can result in a strong motivational impact (Trna, 2011). Simple experiments are also beneficial in education, because they do not require complex and expensive equipment and students can perform them in class and at home.

Purpose of the study

Selection of appropriate science experiments and their effective implementation in teaching and learning are our main research tasks. The research questions were:

- *What motivational role do experiments play in science education?*
- *What kinds of experiments are appropriate for motivation of students?*

The answers to the both research questions are the basis of successful and effective students' motivation in science education. The development of curriculum materials, especially in the form of sets of appropriate motivation experiments and guidelines for their implementation must follow.

Research methods

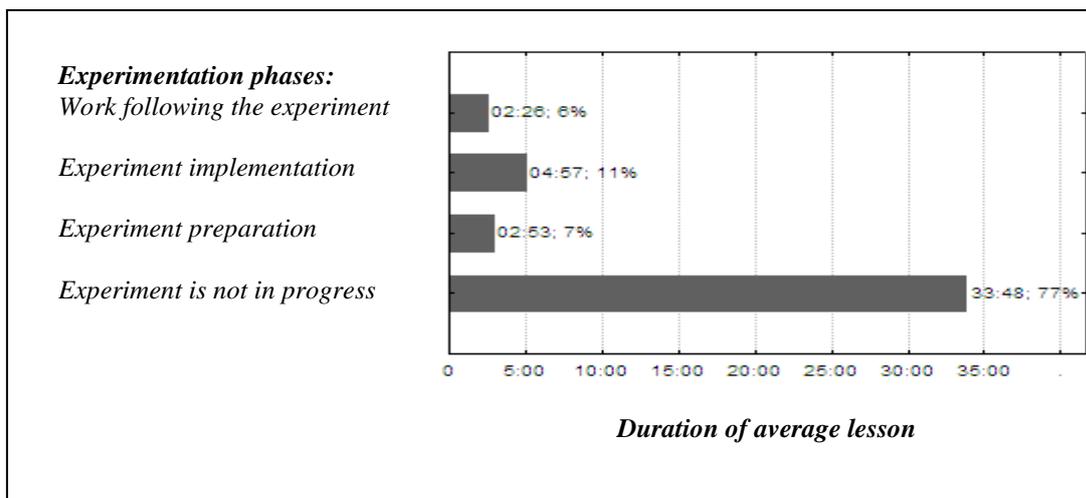
The first research question was answered using a video-study method. This method is based on an analysis of video recordings of lessons. This method was transferred from university centres in Germany (Kiel) (Tesch, 2005) and Switzerland (Zürich, Bern) to the Faculty of Education, Masaryk University (Janik & Mikova, 2006).

The second research question was answered using design-based research (Reeves, 2006). Several kinds of experiments appropriate for specific cognitive motivational teaching techniques were developed. Verification and validation of these types of experiments were done using action research in school practice.

Findings and results

According to the given categorical system, coding of experimentation phases was completed. The video-analysis was applied on 62 video-recordings of physics lessons with two physics topics: "Composition of forces" (27 video-lessons) and "Electric circuit" (35 video-lessons). A group of thirteen lower secondary school physics teachers from twelve schools were involved.

Graph 1. Representation of experimentation phases in physics lessons.



Source: own processing

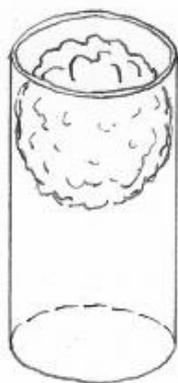
The category “experiment is not in progress” is the most frequent one (77%) in the analysed physics lessons (see Graph 1). If we compare results of all categories, there are unsatisfactory results: the total time spent on experimentation is insufficient and the proportion of the phases is unreasonable. It can be supposed that this condition causes a lack of students’ motivation for science education (Novak & Trna, 2009).

It is possible to expect that every school experiment has a motivational impact on students. The fact that simple experiments give the strongest motivational effect is verified by several studies (Trna, 2005). We developed a typology of simple experiments for the application in cognitive motivational teaching techniques based on simple experiments. All the simple experiments were created by the use of design-based research and were verified and validated using action research within a school setting:

- **Impressive simple experiments and observation:** These motivational simple experiments can be called “impressive” experiments, connected with the emotive experience of surprise and beauty. Here can be included demonstrations of optical phenomena: a rainbow, celestial observation, discharges in gas, as well as presentation of natural objects such as flowers, mineral crystals, coloured aquarium fish and exotic birds.
- **Simple experiments of everyday life and safe living:** Everyday living and safe living are two groups of very interesting educational contents used in science education. If we combine simple experiments from every day and safe living, we provide a powerful source for students’ motivation.
- **Entertainment-edutainment simple experiments:** Toys in the role of a simple experiment include the need to use senses, kinaesthetic activities and relaxation function. There is successful evidence of the motivational efficiency of toys. Bubble makers, yo-yos, click-clacks and kaleidoscopes are good examples.
- **Simple experiments supported by ICT:** New possibilities in education benefit from information and communication technologies (ICT). ICT can be used effectively also for implementation of simple experiments in teaching science. The motivational effect of these experiments is based on students’ interest in using ICT.

- **Problem and paradox simple experiments:** Problem and paradox simple experiments have a very strong motivational impact. We are presenting an example of such simple experiments: *We put a paper ball into a tube (e. g. toilet paper tube). The paper ball has to be of the same diameter as the tube so it does not fall out easily (see Picture 1). We hold the vertical tube with the paper ball in one hand and try to tap with splayed fingers on the top of the tube to get the ball out of the tube. The ball does not fall out and surprisingly crawls upwards inside the tube. Explanation: Surprising behaviour of the ball is caused by its inertia.*

Picture 1. Inertia of a paper ball.



Source: own processing

Conclusions and recommendations

School science experiments are significant instruments for effective and motivational science education. Simple experiments have strong motivational effectiveness and can be used in several cognitive motivational teaching techniques. There are several applications of these experiments in teaching science.

A science teacher has to obtain detailed information about simple science experiments and about their role in science education. Not only knowledge but also acquiring skills to experiment simply is very important (Royer, Cisero, & Carlo, 1993). Acquisition of these professional skills happens through teacher's experience and that's why the acquisition is not possible during pre-service teacher training.

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