How to Motivate Science Teachers to Use Science Experiments

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ABSTRACT
A science experiment is the core tool in science education. This study describes the science teachers' professional competence to implement science experiments in teaching/learning science. The main objective is the motivation of science teachers to use science experiments. The presented research tries to answer questions aimed at the science teachers' skills to use science experiments in teaching/learning science. The research discovered the following facts: science teachers do not include science experiments in teaching/learning in a suitable way; are not able to choose science experiments corresponding to the teaching phase; prefer teachers' demonstration of science experiments; are not able to improvise with the aids; use only a few experiments. The important research result is that an important motivational tool for science teachers is the creation of simple experiments. Examples of motivational simple experiments used into teachers' training for increasing their own creativity and motivation are presented.

Keywords: Experiments, Motivation, Science Education, Teachers' Training, Teachers' Professional Skills.

1. INTRODUCTION

Science experiments play a crucial role in science education. The reasons are the decisive role of experiments in science research and the cognitive importance of experiments in science education [1]. That is why the science teachers' professional competence to use science experiments in teaching/learning science is a very important part of their pre-service and in-service training [9]. Teachers' experimental skills play a crucial role in the acquiring of students' science skills at all. [13] These teachers' skills are a very important part of their pedagogical content knowledge (PCK). Experience in the use of science experiments is an integral part of the individual pedagogical content knowledge of every science teacher [4]. A crucial point of the science teachers' professional competence to use experiments is their motivation for experimentation.

We focus on research and development of motivational teaching/learning methods based on experiments and their implementation in science education and science teachers' training. We should be interested not only in motivation of students but also motivation of teachers [10].

The results of our development of these motivational methods are: the method of family science education [11]; the ICT-based collaborative action research [12]; problem tasks based on experiments; measurement on human body etc. All these methods as the outcome of our design-based research include simple experiments as the source of strong motivation of teachers and students.

2. RATIONALE

The educational role of science experiments has brought us to the conclusion that acquiring professional science teachers' skills to use science experiments is necessary. The science teachers' professional psycho-motor skills to use science experiments consist of three groups of skills which differ in the content and methodology:
(1) Skills to perform research science experiments – a complex of dispositions to carry out science experiments in science research (skills of 1st order);
(2) Skills to perform school science experiments – a complex of dispositions to carry out science experiments in science education (skills of 2nd order);
(3) Skills to implement school science experiments in teaching/learning science – a complex of dispositions to apply effectively the selected science experiments in teaching/learning science (skills of 3rd order).

Studies on the process of acquiring teachers' professional skills to use science experiments mention five basic stages ([4], [7]).
(1) Motivation stage;
(2) Stage of science teacher's orientation in the acquired skill;
(3) Stage of stabilisation of a new skill;
(4) Stage of completing the skill and its inclusion into a wider contextual frame;
(5) Integral stage during which a new skill is integrated into the skill structure.
The first three stages can run during the science teachers' pre-service training, the fourth and the fifth stages, which presuppose science teaching experience, are possible to complete in the science teachers' in-service training.

Science teachers' skills to use science experiments have quite a complicated structure which consists of an internal and an external part. The internal part of each of these skills consists mainly of:
- Congenital disposition (ability);
- Acquired disposition (knowledge, habits, experience);
- Styles of recognition, thinking and learning;
- Motives, emotions, etc.

The external part of each of the skills has the form of a teacher's performance at an appropriate activity in teaching. This part can be observed and studied.

3. RESEARCH QUESTIONS AND METHODOLOGY

This study tries to answer research questions aimed at the science teachers' skills to use science experiments in teaching/learning science. Special attention is paid to the teachers' motivation to experimentation. Our research questions follow:
Are science teachers able to use effectively science experiments in teaching?

Our working hypothesis connected to this research question is expressed as:
Science teachers are not able to use effectively science experiments in teaching.
The second major research question focused on the development of science teachers' skills to use science experiments is the following:
How to motivate science teachers to use science experiments?

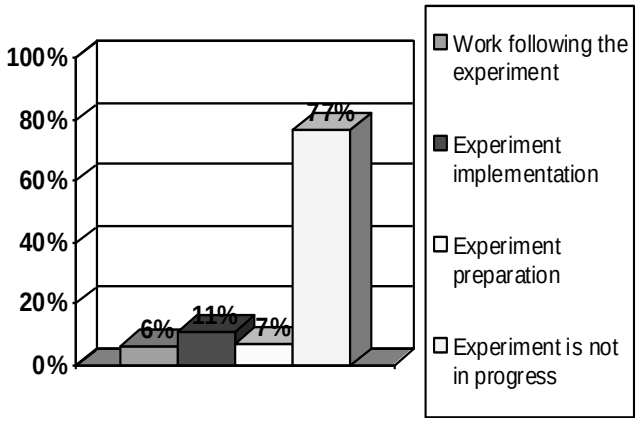
The methodology we use in our research is the combination of video-study, curricular analysis of the science teachers' training process, questionnaires, interviews, and design-based research and development of motivational methods for science teachers' training.

4. RESULTS

4.1 Implementation of experiments

For the testing of our first research question we have used the method of video-study [5], which is based on the analysis of 62 video-recordings of physics lessons [2]. All physics lessons were filmed in 2004-2005; the topics were *Composition of forces* (27 lessons; 8 teachers) and *Electric circuit* (35 lessons; 11 teachers). Twelve lower secondary schools were concerned (the age of students 14-15), 13 teachers participated in a video-study. These videos as a source of much data have been comprehensively analyzed and the results have subsequently been published ([3] etc.) during last years.

Table 1. Implementation of experiments



The category "experiment is not in progress" in Table 1 is the most frequent one (77%) in the analysed lessons. If we compare the results of all phases, there are unsatisfactory results: the total time spent on experimentation is insufficient and the proportion of the phases is unreasonable. Research findings based on video-study describe the phases of the use of experiments and show that experiments used by teachers are not always appropriate for the improvement of students' knowledge and skills [3]. Sequential video study is in progress, which aim is to identify changes which have occurred since the year 2004/05.

The curricular analysis of the science teachers' training process in the Czech Republic and another EU country (Poland, Slovakia, Austria etc.) has discovered some factors which can affect the unsatisfactory condition of school science experimentation. Appropriate attention is devoted to the training of skills when using science experiments. The training of teachers' skills to use science experiments consists of three parts:
(1) Description and explanation of a physics phenomenon by use of an experiment;
(2) Technique of the use of school science experiments equipment;
(3) Didactics implementation of a school science experiment into teaching/learning.

The science teachers' training of skills how to use school science experiments is mostly limited only to the phenomenon description and the technical part of carrying out school science experiments. The third didactics part is often reduced or missing. This fact often results in pedagogical mistakes. We have discovered some of them when using the video-study method and other pedagogical research methods:
- Science teachers do not include science experiments in teaching/learning in a suitable way;
- Science teachers are not able to choose science experiments corresponding to the teaching phase;
- Science teachers prefer teachers' demonstration of science experiments;
- Science teachers are not able to improvise with the aids;
- Science teachers use only a few experiments.

The analysis of the research outcomes supported our hypothesis that science teachers are not able to use effectively science experiments in teaching. The questionnaire and interview survey with science teachers have confirmed our assumption that the main reason for this unsatisfactory situation is the low motivation of science teachers and poorly developed skills to use science experiments.

4.2 Creation of simple experiments

Our action research and other methods (questionnaire, interview) have revealed that an important motivational tool for science teachers is the creation of simple experiments. Here are examples of simple experiments that were implemented into teachers' training as an example for increasing of their own creativity and motivation.

Hands in science (physics phenomena demonstrations):

Gravitation
We indicate the existence of gravitational field by stretching one arm upwards and keeping the second one swinging along the body. After several tens of seconds we put both hands back up in front of our body and compare skin tones. The raised hand is partially bloodless and its tone is light. The second one, on the contrary, turned red thanks to hyperaemia. This phenomenon is caused by gravitation field of the Earth which brings about different hydrostatic blood pressure in each hand.

Water jet
We demonstrate a compressed water jet by compressing water in a clenched fist dipped in a container.

Sound source
A sound signal can be created by fingers: the whistling with fingers in the mouth. The sound arises also from snapping fingers or handclapping. The same phenomenon comes up by tapping knuckles and fists banging on a board.

Vaporization
We put one hand into water and let it dry out. The comparison of both hands shows that the wet hand is cooler. Vaporized water takes heat of vaporization away from the wet hand

surface. Cooling the hand can be increased by blowing or waving. At the same time, water vapour is vanishing intensively from the hand surroundings and thus the process of vaporization and cooling the hand picks up speed.

Thermal radiation
We put our palms together. After a while we can feel higher temperature. The palms pass radiated heat on each other and thus it does not leak to surroundings (see Figure 1). The same effect arises when we bring a palm closer to the face.

Figure 1. Thermal radiation

Electrification by friction
We rub our dry palms intensively. They are to be electrified by an opposite electric charge. The electric charge is indicated by attracting a light suspended object (e.g. blown up balloon suspended on a thread).

Slit diffraction
We open a palm and put fingers close to each other. There arises a narrow slit between some of them. We observe a source of light (day sky, fluorescent lamp etc.) by that slit. We can see dark diffraction circles in the slit. It is possible to measure the width of the slit or the distance from an eye, to move head or hand. We examine behaviour of the diffraction circles whose number changes.

Science teachers can create their own simple school science experiments after the presentation of these experiments-examples. This teachers' creation strongly increases science teachers' motivation to the use of science experiments in science education [8]. This method of science teachers' training supports the development of skills in the use of science experiments. The analysis of the creation of simple science experiments by science teachers we used as a part of our research of the development of motivational methods for science teachers' training.

5. CONCLUSIONS AND IMPLICATIONS

Our research findings illustrate the fact that experiments used by science (physics) teachers are not always appropriate and sufficient for the development of students' physics knowledge and skills. We have to improve primarily the didactics part of the implementation of school science experiments into teaching/learning. A very important motivational tool for increasing science teachers' own creativity and motivation is the creation of simple science experiments.

Simple science experiments can be effectively applied to the motivation of students in science education. Science teachers have to obtain information about simple science experiments and about their role in science education.

Not only knowledge but particularly acquiring the skills to use of science experiments is very important [4]. It is not possible to complete the development of these professional skills during pre-service science teacher training. That is why there is a need to prepare quality courses of simple science experiments and insert these into in-service science teacher training.

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