PROFILES

IBSE EXPERIMENTS

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1. INTRODUCTION

- Experiments - the most important element of science education.
- Experiments strongly motivate students all ages and different levels of giftedness.
- The motivating potential is not utilized - the result of the experiment implementation is only momentary interest of students that quickly passes without any learning outcomes. Some teachers therefore reduce the amount of experiments.
- Because of a low number of lessons in curriculum for chemistry or physics experiments are considered ineffective.
- It is a mistake to give up experiments, but it is necessary to choose an appropriate type carefully and think about its implementation in lessons.
- Not only encourage students´ interest - also achieve the acquisition of required knowledge, understanding and skills.

1. INTRODUCTION

- Simple experiments are very important.
- Simplicity - transparent presentation of a phenomenon.
- Simplicity - use of material from everyday life - promotes understanding and allows the student to perform experiments.
- Student - active in understanding - constructivist pedagogical-psychological theories.
- A longitudinal study of students' "knowledge without understanding" terminated in finding that this "cognitive illness" is the consequence of teaching approaches which do not respect the nature of knowledge and skills acquisition.
- These problems are solved in inquiry-based science education.

2. IBSE

- IBSE - innovative method - an instructional learner-centred approach - integrates theory and practice using inquiry, develops knowledge and skills for a solution to a defined problem.
- Students - solve the problem, conduct self-directed learning, co-operate in teams.
- Teachers in IBSE lessons motivate students to solve problems independently and competently.
- IBSE comes from the recognition that science is essentially a question-driven, open-ended process and that students must have personal experience with scientific inquiry to understand this fundamental aspect of science [4].
- IBSE - stimulates teachers´ motivation.
- It is an effective method for students of all types: from the weakest to the smartest (including the gifted ones), boys and girls, students of all ages.

3. ROLES OF EXPERIMENTS IN IBSE

- Experiments play a crucial role in IBSE. Implementation of experiments is necessary for students' inquiry because it brings the possibility to interconnect theory and practice. Students can acquire both hands-on and minds-on experiments.
- According to researches, all participants in education recognize the important role of experiments. Within the project PROFILES, we implemented a Delphi study [1] where the issue of experimentation was commented by students, science education students at university, trainee science teachers, practised science teachers, trainee science teacher educators, science educators and scientists. Respondents assessed students' motivation in lessons from two perspectives. First, they presented their idea of the significance of experimentation in the part: “The Idea of Experimentation Priorities”, where they answered the question "Which priorities should experimentation has in science education?" They expressed their view of reality and their actual experience with experimentation in lessons in the part “The Views of the Real State Experimentation in Teaching”, where they answered the question "To what extent is experimentation realized in current science education?" The following tables are the results of this research (See Tables 1 and 2).

3. ROLES OF EXPERIMENTS IN IBSE

Which priority should experimentation has in science education?

VLP (very low priority), LP (low priority), RLP (rather low priority), RHP (rather high priority), HP (high priority), VHP (very high priority)

	VLP %	LP %	RLP %	RHP %	HP %	VHP %
Students (n=56)	0	4	13	**15**	**41**	**27**
Science education students at university (n=23)	0	0	0	**11**	**56**	**33**
Trainee science teachers (n=24)	0	0	0	**0**	**25**	**75**
Practised science teachers (n=30)	0	0	0	**18**	**55**	**27**
Trainee science teacher educators (n=16)	0	0	0	**17**	**50**	**33**
Science educators (n=28)	0	0	13	**5**	**36**	**46**
Scientists (n=25)	0	4	0	**16**	**40**	**40**

3. ROLES OF EXPERIMENTS IN IBSE

To what extent is experimentation realized in current science education?

VLE (to a very low extent), LE (to a low extent), RLE (to a rather low extent), RHE (to a rather high extent), HE (to a high extent), VHE (to a very high extent)

	VLP %	LP %	RLP %	RHP %	HP %	VHP %
Students (n=56)	9	18	18	**38**	**13**	**4**
Science education students at university (n=23)	0	33	33	**23**	**0**	**11**
Trainee science teachers (n=24)	0	0	100	**0**	**0**	**0**
Practised science teachers (n=30)	9	19	27	**45**	**0**	**0**
Trainee science teacher educators (n=16)	0	17	32	**17**	**17**	**17**
Science educators (n=28)	12	22	47	**12**	**7**	**0**
Scientists (n=25)	8	36	28	**20**	**8**	**0**

3. ROLES OF EXPERIMENTS IN IBSE

- All monitored groups believe experimentation should become an integral part of lessons. Interestingly, students (out of all the monitored groups) had the most answers in the lowest priority area when expressing ideas about inclusion of experiments in teaching. Based on additional controlled interviews, we believe that it is connected to poor implementation of experiments in teaching. Therefore, it is essential for teachers to manage not only experimentation, but also correct integration of experiments into teaching.

3. ROLES OF EXPERIMENTS IN IBSE

- Students also reported that they were presented mostly demonstration experiments, but they prefer their own initiative. Surprisingly, scientists and science educators, as the only representatives of teachers, when expressing ideas about inclusion of experiments, chose one of the options in the low priority area. Trainee science teachers assess the real situation of experimenting the most negatively. All of them expressed their opinion that experiments are included in lessons in a limited number. It is apparent that all groups give experimentation higher priority than it is given in real teaching/learning. When drawing conclusions, we realize this is only a small sample of respondents, but in accordance with the theory of the Delphi study, respondents were selected intentionally and verification of the results runs in three steps. Further findings confirm the above-mentioned data. In the final phase of the project PROFILES research results comparing 22 European countries, where the project has been implemented, will be available.

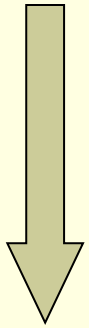
4. CHARACTERISTICS OF EXPERIMENTS IN LEVELS OF IBSE

- Very important students´ activity in all four levels of IBSE is experimentation. Implementation of experiments is crucial for inquiry. Experiments have to be organically included in certain IBSE, what is the main task for science teachers. It is important to use experiments in corresponding IBSE levels. We present characteristics of individual IBSE four levels experiments and examples of the implementation of experiments ([10], [11]).

4. CHARACTERISTICS OF EXPERIMENTS IN LEVELS OF IBSE

H. Banchi and R. Bell define according to experience how much guidance is provided to students by teachers four levels of inquiry:

- **confirmation inquiry**
- **structured inquiry**
- **guided inquiry**
- **open inquiry**



STUDENT'S INDEPENDENT

4. 1 CONFIRMATION INQUIRY

- conformation the knowledge of principles, concepts and theories
- the results of experiments are usually known in advance
- is useful in the beginning of IBSE when a teacher's goal is to develop students´ experimental and analytical skills - specific inquiry skills, such as collecting and recording data

4. 1 CONFIRMATION INQUIRY

Example:

Students put a paper box without a lid on a horizontal table. There is a string attached to the front part of the box. Students pour sand into the box gradually (at least three times) and by pulling the string they verify the friction force, which prevents the box from motion and grows with the increasing mass of the box. The second part of the experiment is to verify the dependency of friction force on surface roughness of the box bottom and the surface. Step by step students pull the empty box on surfaces of different roughness: plastic wrap, sheet of paper, textile cloth, polystyrene board, abrasive paper (see Figure 1), etc. Students fill in a worksheet with detailed instructions and a table naming the materials of the surfaces. Students check by behaviour of the body and the size of friction force. On this basis, the relevant theory is confirmed experimentally.

4. 1 CONFIRMATION INQUIRY

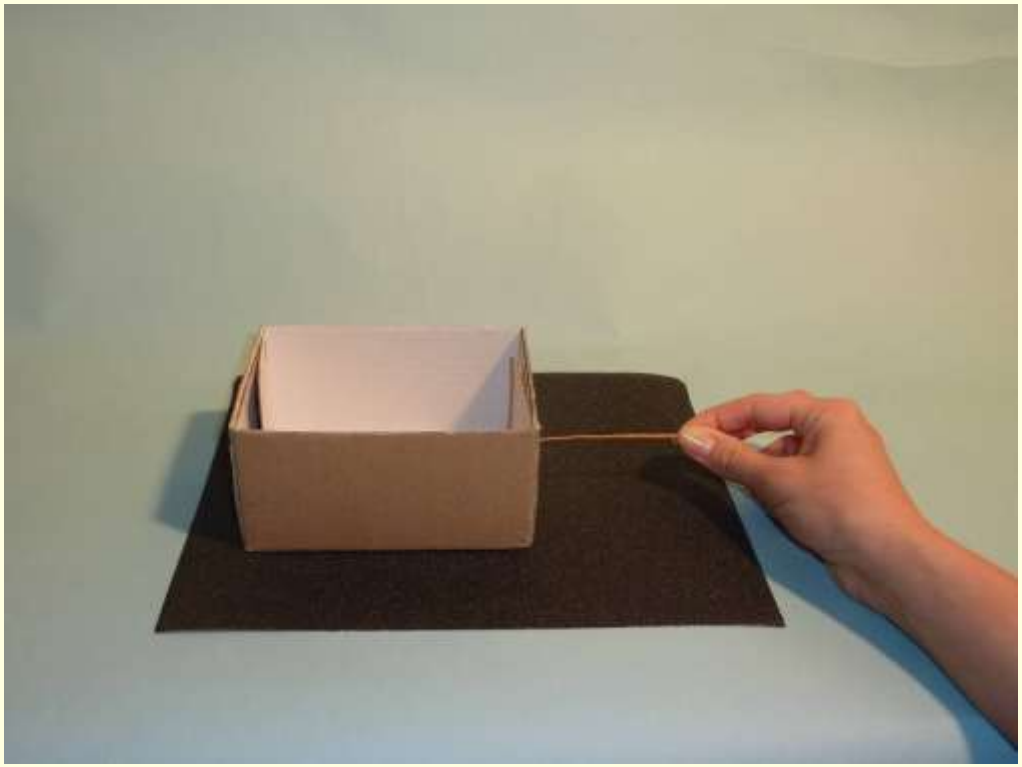


Figure 1. Friction of a paper box (abrasive paper)

4.2 STRUCTURED INQUIRY

- the teacher has an influence on procedure - helps students in inquiry by asking appropriate questions
- students generate an explanation supported by the evidence they have collected
- is very important for development of student's abilities to conduct more open-ended inquiry
- is very common in elementary science curricula as well as confirmation inquiry

4.2 STRUCTURED INQUIRY

Example:

Students discover how quantities of phenomena affect the size of the friction force. They are the size of the interface between the body and the surface, mass of the body and roughness of the interface. In the first part of the experiment the student pulls a wooden cuboid along a horizontal table with constant velocity. The cuboid is attached by a string and is pulled by a dynamometer. The experiment is repeated so that the cuboid is gradually placed on all the three different faces. It was found out that the size of the friction force does not change. In the second part of the experiment a weight is placed on the drawn cuboid, the weight is heavier in the repeated experiment (see Figure 2). The measured friction force is increased with the enlarged mass of the weights. In the third part of the experiment the cuboid is drawn on surfaces with different roughness. The friction force changes with the changing roughness of the interface. In the end it is possible to combine mass and roughness of the interface. Students record the behaviour of the body into prepared tables in a worksheet. The final analysis of the bodies leads to the conclusion that their behaviour depends on their mass and roughness of the interface. The aim of this experiment is that the students themselves discover by applicable law.

4.2 STRUCTURED INQUIRY

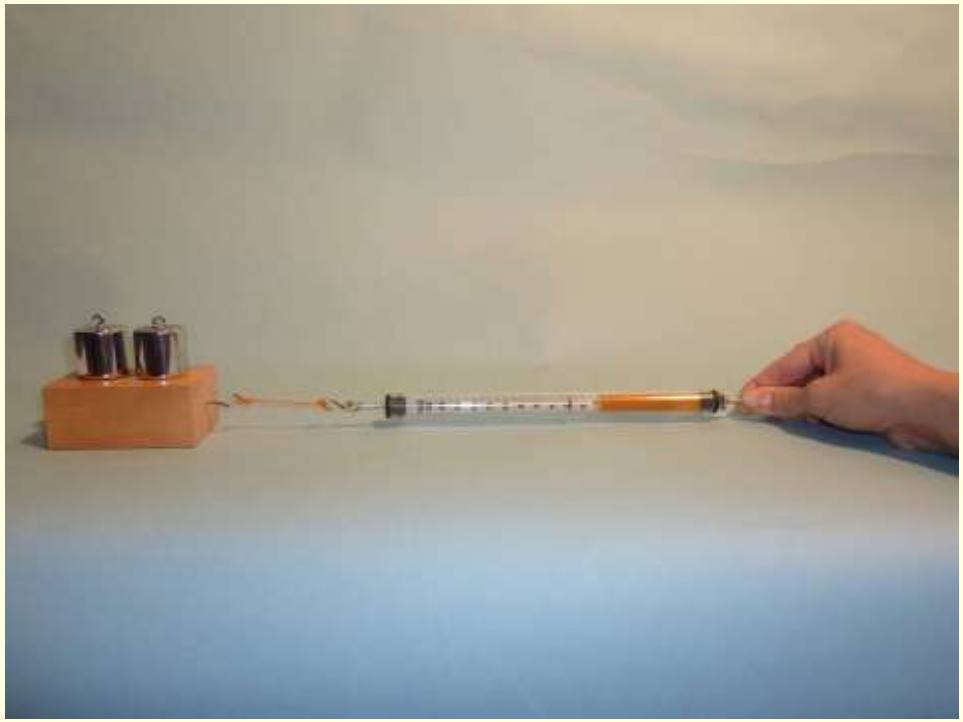


Figure 2. Wooden cuboid and friction

4.3 QUIDED INQUIRY

- the teacher is the "guide of inquiry„ -he encourages students using the research question and provides students with guidance about their investigation plans
- students are less supported - they design procedures to test their questions and the resulting explanations
- the teacher provides students with guidance about their investigation plans
- students should to have experiences to be able designing their own procedures
- outcomes of inquiry are better when students have had a lot of opportunities to learn and practice different ways to plan experiments

4.3 QUIDED INQUIRY

Example:

Teachers ask students only a research question. Students do not receive solution procedures and experiments. A common research question might be: "Find the factors and their laws in the behaviour of the body, moving on the surface." Students should seek their own experiments and needed equipment. They discover what quantities influence the size of friction force, if a body is moving on the surface and what is the connection between them: size of interface, mass, roughness (see Figures 3 and 4) etc.

4.3 QUIDED INQUIRY

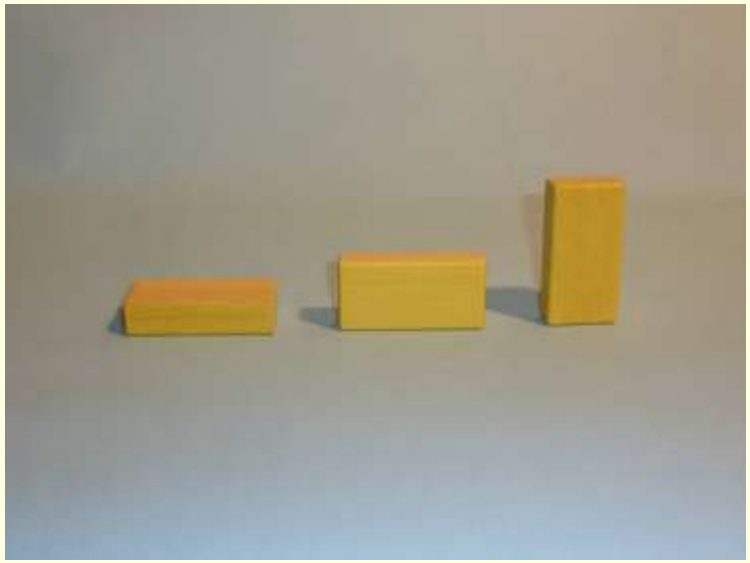


Figure 3.Three different faces of body

Figure 4. Bodies of different mass

4.4 OPEN INQUIRY

- is the closest to "science inquiry„
- students should be able to derive questions, design and carry out investigations, record and analyze data and draw conclusions from the evidence they have collected
- it requires a high level of scientific reasoning and cognitive demand from students
- it is suitable for development of gifted students

4.4 OPEN INQUIRY

Example:

Students are almost completely independent. The teacher acts as an implementing partner/consultant. Students are not supposed to specify the research question and experiments explicitly. There are suitable experiments, which reflect a set of phenomena. These include: looking for methods of reducing friction by air cushions (see Figure 5). Students solve problems of useful and harmful friction or friction in transportation, they discover laws of shear and rolling friction and static and dynamic friction. They always derive the results from experiments.

4.4 OPEN INQUIRY

Figure 5. Body movement on an air cushion

5. IMPLEMENTATION OF IBSE INTO SCIENCE TEACHER TRAINING

- Teachers' professional development is very important for improving the quality of science teaching. The experience shows no innovation will be sustained unless systematic and ongoing professional development of science teachers is provided to support the changes required in the instruction [5]. Teacher's pedagogical content knowledge (PCK) is created in a long-term and complicated process, therefore it is necessary to start with the preparation for IBSE in pre-service training and continue in in-service training.
- Teachers must be thoroughly familiar with IBSE to be able to apply the principles of this teaching on experimentation. To make IBSE experiments effective, it is essential for teachers to acquire some professional competence and specific pedagogy skills. They need to be able to determine what level of IBSE experiments can be used, what knowledge and skills should their students acquire using of experimentation. It is therefore essential to integrate this method into the teacher education programme and continuous professional development (CPD).

5. IMPLEMENTATION OF IBSE INTO SCIENCE TEACHER TRAINING

- Teacher training for implementation of IBSE experiments in education must be complex. It is important to realize that it is necessary to pay attention to several aspects: proper presentation of scientific phenomena, technically flawless experiment implementation, and selection of an appropriate IBSE level and optimal didactic integration of IBSE experiments in teaching. The most attention is paid only to the first two aspects. For IBSE experiments it is very important to keep all the aspects in mind, if IBSE experiments are to fulfil their educational role. The issue of IBSE experiments will be solved in a complex way in the project PROFILES.
- Project PROFILES (Professional Reflection-Oriented Focus on Inquiry-Based Learning and Education through Science) is a European project that aims to support teachers in innovation of teaching/learning [6]. Project deals with implementation of IBSE in instruction that could become a common part of school practice. The PROFILES project includes a set of specific educational modules which offer IBSE experiments prepared by experts and verified by teachers experienced in teaching.

6. CONCLUSIONS

- IBSE is a way which may be taken to increase knowledge and skills of the students in science. Experiments play a crucial role in IBSE because they are beneficial to promoting students´ interest and participation in science activities. The project PROFILES offers such experiments.
- Although science school experiments have great educational potential, teachers are not able to benefit from them fully. Therefore it is necessary to search and develop innovative educational methods and techniques including IBSE. It is necessary to implement these new ideas in science teacher training immediately.
- We have been living in the time when preparation of individual learning paths for each student has become a hot topic. Therefore, in the future, we will focus on research of experiments in education of students with special educational needs, including gifted students.

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Thank you for your attention.

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