Motivational Effectiveness of a Scenario in IBSE

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Abstract

Rapidly developed science and technology have affected the lives of us all. It is, therefore, necessary to motivate children and adults for the study of science and technology. There is expert consensus that science and technology education should be a compulsory part of the education of all children. Educators have the task of developing effective educational methods which are appropriate for teaching/learning science and technology. Inquiry based science education is a suitable method for the science education of all groups of students (gifted, ungifted students and students with other special educational needs). The motivation of students in science and technology education is the key for effectiveness in developing their knowledge and skills. We aimed to find practical motivational techniques and instruments in inquiry based science education. Our research method for the description of the state of motivation was a Delphi study, accompanied by questionnaires and interviews. We present the arguments discovered regarding why inquiry based science education represents an appropriate motivational method for science education. Our research result is that a scenario is a core motivational element in inquiry based science education. The scenario is a narrative which motivates students to solve scientific problems. We also present good examples of the use of the scenario as a part of inquiry based science education in practice developed by our design-based research. Science teachers need consistent support and access to the best methods and practice. Therefore we are implementing the scenario as an element of inquiry based science education in pre-service and in-service teacher education in the frame of the European project PROFILES.

Keywords: effectiveness; IBSE; motivation; scenario; science and technology education

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1. Introduction

Science and technology have developed rapidly and have affected our lives. There is expert consensus that science and technology education should be a compulsory component in education. It is necessary to prepare today’s students for their roles as adults. This new attitude to science and technology education involves especially skills and knowledge important for successful everyday lives, referred to as "learning for life and work" and/or "twenty-first century skills". These skills include mainly critical thinking, problem solving, cooperation, effective communication and self-education (Pellegrino & Hilton, 2012).

It is necessary to consider what science and technology education students should receive. In this context, it is necessary to deal with the nature and structure of curricula, educational methods and motivation of students. It is important to develop educational methods which are appropriate for the teaching/learning of all students. We consider the motivation of students towards science and technology to be an essential and demanding task for teachers. Motivation can be induced in students by various means. It is also necessary to consider that motivation is not permanent. We can attract students’ interest, but this may decrease, therefore it is necessary to support it. Moreover, motivation is highly individual; what motivates one student is not necessarily interesting for others. It is therefore advisable to find the sorts of motivation that have the potential to be successful for most students.

In our experience, this motivational element might be a scenario, which combines several elements of motivation. It is a narrative (story) based on everyday problems, and research shows that it motivates students. It is designed to evoke interest and raise questions to find answers. Such motivation is more permanent. The scenario is the motivational basis of the IBSE modules prepared in the European project PROFILES (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science) (2014).

2. Rationale

Recent science education prefers the design of instructional environments that involve students in learning about scientific inquiry and the nature of science. Research supports teachers engaging their students in pursuing answers to questions important in the lives of adolescents, as well as those questions important to scientists (Brown, 1990; Schwab, 1976). Constructivist views of learning lend theoretical support to teachers in facilitating students in reconstructing their own knowledge through a process of interacting with objects in the environment and engaging in higher-level thinking and problem solving (Driver, Asoko, Leach, Mortimer, & Scott, 1994). Efforts to engage students in inquiry-based instruction date back to J. Dewey (1938). Dewey believed that children learn from activity, through extended experiences in real world problem-solving and from discussion with others. Authentic problems that students solve collaboratively differ from traditional school science "experiments" that tend to be verification labs in which students seek the "right" answer. In contrast to passively completing worksheets, students construct their understanding by solving real-world problems.

Practicing teachers often use terms as "doing science", "hands-on science", and "real-world science" for description of inquiry-based learning approaches. But there is a danger in equating IBSE with the currently accepted notion of "hands-on science" in which students carry out a series of hands-on activities that often are unconnected to substantive science content. In this case the nature of IBSE can be lost. Inquiry-based teaching strategies need to harmonize with theories of how children learn science which include students revising their understanding through teachers building on students' experiences (Driver, Asoko, Leach, Mortimer, & Scott, 1994). The integration of socio-constructivist perspectives of learning with hands-on instruction enhances the opportunity for knowledge construction of inquiry (Rogoff, 1994; Solomon, 1989).

It is necessary to motivate students to solve problems in IBSE. We can motivate students through extrinsic and intrinsic motivation. For several reasons, we prefer intrinsic cognitive motivation that results in changes in students' interest. According to experts and to our research a suitable form might be a scenario. A scenario is a narrative which stimulates student interest in solving scientific problems. Narratives play an important role in our lives. According to Andrews, Squire, & Tambokou (2008), it is possible to accept the premise that, as human beings, we come to understand and give meaning to our lives through narratives. In the gathering and telling of "stories", we are gathering knowledge from life and knowledge about life (Bochner, 2007). People ascribe importance to ideas described in narratives because they try to find the answer to their questions or new ideas (Josselson, 2006). But, a scenario is more than the uncritical writing or gathering of stories. Its purpose is to enable a better understanding of
issues. It makes science learning more relevant, more interesting and hence more meaningful for students and lastly more successful. After considering the scenario, students move from the situation to the science question(s) to be studied. Students are expected to construct meaning in a motivational manner through exploring the scenario.

The goal of the scenario is to motivate, to promote students’ interest in solving scientific and technology issues. The scenario is often based on students’ lives and experiences. A properly conceived scenario should raise questions students want to solve. This is the advantage of IBSE because students with different levels of knowledge and skills or interests (gifted - ungifted; future scientists - non-scientists) ask and then solve different questions. Therefore it is possible to apply an individual motivational approach to everybody.

The PROFILES project approach (Bolte, Streller, Holbrook, Rannikmae, Hofstein, & Naaman, 2012) has been developed based on a 3-stage model. The model is based on the recognition that there is a need to initiate the learning from a familiar and student-relevant situation. But even that, by itself, is not sufficient. It is also seen as important that students identify with the initial situation and feel that it is within their sphere of action. In this initial approach (in PROFILES using a scenario), teachers stimulate students through the relevance of the learning situation, issue or concern. In the second stage the students’ triggered self-motivation encourages them to be involved in the IBSE learning processes. Finally, in the third stage, the students build on their science learning to transfer their learning to the relevant socio-scientific situation encountered in the scenario and to develop reasoned justification for decisions made. To summarise, the idea is that the relevance is triggered by the PROFILES modules’ titles, and further amplified by means of a scenario. For this the titles relate to the students’ world, using familiar words (unknown, non-general scientific words are absent).

Students are actively involved in exploring the scenario which is intended to promote curiosity, intrigue as well as to be seen as meaningful by students. The science learning needed to sustain consideration of the scenario happens through guiding students to undertake inquiry-based science education in a manner which promotes a meaningful and acceptable scientific challenge to students (whether a structured, guided or open form of IBSE is utilized). Based on experts and on our research, we suppose that the scenario as a part of IBSE has motivational effectiveness in science education on different groups of students (gifted and students with other special educational needs).

3. Research methods

We aimed to find arguments regarding why IBSE represents an appropriate educational method with strong motivation of students and to present examples of good practice in IBSE teaching/learning motivation. Our research question is:

Why is IBSE with a scenario an appropriate motivational method? The answers to our research questions are an important point for the wider motivational use of IBSE.

We used a curricular Delphi study (Osborne, Ratcliffe, Collins, Millar, R., & Duschl, 2001; Bolte, 2008) and design-based research (Reeves, 2006). The curricular Delphi was developed within the PROFILES project. The objective of our curricular Delphi study was to find out the views of different groups of respondents to the contents and aims of science education in general as well as to engage them to express an opinion on IBSE and motivation.

Design-based research can be described as a cycle (see Fig. 1): analysis of a practical problem, development of solutions, iterative testing of solutions, reflection and implementation (Reeves, 2006).

1. Analysis of practical problems: We identified the existing educational problems in the motivation of students in science education.

2. Development of solutions with a theoretical framework: We have created teaching materials in the form of IBSE modules with motivational scenarios.

3. Evaluation and testing of solutions in practice: Science teachers (participants of PROFILES project) were the authorised implementers and evaluators of the IBSE modules with motivational scenarios. They used action research as their core method. We used a questionnaire concerning the scenario.

4. Documentation and reflection to produce “Design principles”: The final stage of our research was the documentation and the establishment of a set of design principles for implementation of motivational scenarios.

We used design-based research for the development of a scenario as a motivational instrument in IBSE.
4. Results and discussion

Our Delphi study on science education was carried out in three rounds between the years 2011-2013. We asked four groups of participants: 56 students (age 14-16), 30 science teachers (secondary schools), 28 science educators (university teachers) and 25 scientists. We present only a part of the results from the descriptive-statistical analyses in the Delphi study (see Tab. 1) with regard to the priority-practice differences in the views of all participants (top five aspects).

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Priority-practice difference (6 scale points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Rational thinking / analysing / drawing conclusions</td>
<td>2,2</td>
</tr>
<tr>
<td>2 Judgement / opinion-forming / reflection</td>
<td>2,2</td>
</tr>
<tr>
<td>3 Applying knowledge, thinking creatively / abstractly</td>
<td>2,2</td>
</tr>
<tr>
<td>4 Motivation and interest</td>
<td>2,0</td>
</tr>
<tr>
<td>5 Inquiry-based science learning</td>
<td>2,0</td>
</tr>
</tbody>
</table>

Large differences between the assessments of priority and actual realization in science educational practice speak about a big discrepancy between priority and reality in some aspects such as IBSE and motivation. Other data for each group of respondents can be found on the project PROFILES (2014).

The results of our design-based research are a set of IBSE modules with a motivational scenario. A scenario from the module: “Safety of the human body: swimming and diving” may serve as an example of the motivational scenario:

**Scenario:** John went cycling with his parents. At noon they came to a river. It was really hot and John was very sweaty and looked forward to cooling down. He wanted to jump into the cold water immediately. His mother stopped him and told him he had to wait to cool down, because otherwise he could even drown. John laughed, thinking it was a superstition that parents tell their children, because they are afraid that they might catch a cold. But he is hardy and is not afraid of cold water. Who is right?

In our case, students usually ask the following questions:

- How does the human body cool down?
- What causes vasoconstriction?
- Why is the body temperature an important indicator of health?

The next step of IBSE is students’ activities where students research, seek information leading to the solution, discuss with peers in groups and perform experiments. Example of instructions for the experiment:

- Measure the normal blood pressure in the left arm
- Put your right arm into the bucket of cold water (see Fig. 2)
- Measure the pressure in your left arm again
- Compare the results and evaluate the condition of your vessels

![Fig. 2. Right arm in the bucket of cold water.](image)

The third and the final IBSE phase is students’ decision making. In our case, students, using the inquiry, came to the following conclusion:

- **Rapid cooling leads to a sudden increase in blood pressure due to vasoconstriction of blood-vessels**
- **Sudden increase of blood pressure may lead to heart failure and subsequently to drowning**
- **It is necessary to cool down gradually to prevent sudden vasoconstriction resulting in collapse**
- **External physical and chemical conditions might threaten our health or even life**

We wanted to make sure that the scenario really had motivational effectiveness. Therefore we used a questionnaire where students were asked several questions (tasks) concerning the scenario. The questionnaire was distributed to 362 students who used a scenario in their instruction based on the IBSE module “Safety of the human body: swimming and diving”: We present some important findings in Tab. 2.

Table 2. Scenario – students’ questionnaire results.

<table>
<thead>
<tr>
<th>Questions, tasks</th>
<th>Extremely interesting</th>
<th>Very interesting</th>
<th>Interesting</th>
<th>Fairly interesting</th>
<th>Somewhat interesting</th>
<th>Very uninteresting</th>
<th>Extremely uninteresting</th>
</tr>
</thead>
<tbody>
<tr>
<td>For me, the scenario was:</td>
<td>4</td>
<td>21</td>
<td>49</td>
<td>12</td>
<td>11</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Please indicate how often you referred back to the scenario when creating questions, solving tasks, etc.</td>
<td>Never</td>
<td>Rarely</td>
<td>Sometimes</td>
<td>Fairly often</td>
<td>Often</td>
<td>Very often</td>
<td>Always</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>2</td>
<td>9</td>
<td>15</td>
<td>47</td>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td>The level of help that the scenario gave me in understanding the issues of the module may be described as:</td>
<td>Extremely helpful</td>
<td>Very helpful</td>
<td>Helpful</td>
<td>Fairly helpful</td>
<td>Rather small</td>
<td>Very small</td>
<td>Extremely small</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>7</td>
<td>61</td>
<td>21</td>
<td>8</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

According to the research findings presented above, the scenario raises students' interest in solving a problem and helps them to understand it because 97% of students reported that the scenarios were interesting (to a certain extent) for them; 74% of students often or always referred back to the scenario when creating questions or solving tasks; and 69% of students reported that the scenario was a great help in understanding the issues of the module.
5. Conclusions and implications

Based on the presented research outcomes, we have verified that the scenario has strong motivational effectiveness because it arouses intrinsic motivation among students and supports them in learning about scientific inquiry and the nature of science. Similarly, we can conclude that IBSE is a suitable method for science education and motivation. IBSE enables not only preparation for life but also provides a starting point for lifelong science and technology education. The results of our research will be implemented in science teacher education especially in the PROFILES project.

References