Experiments in the Development of Gifted Students in Science

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1 Introduction

Systematic support of students gifted in science is an important part of educational strategies of developed countries. This support involves identification and development of giftedness. Research findings (Laznibatová, 2003; Fořtík, & Fořtíková, 2007) demonstrate the importance of early identification and development of giftedness. School and family (Tannenbaum, 2007) have to create suitable conditions for the support of giftedness (Renzulli, 1986). According to experts (Monks, & Ypenburg, 2002) about 2-3 % of students are exceptionally gifted: talented. However, in suitable conditions for the development of giftedness, the rate of students excelling in some areas might increase up to 20-25 % (Freeman, 2010). Therefore, it is necessary to develop appropriate teaching and learning methods for gifted students.

Satisfaction of diverse educational needs of gifted students is always challenging and requires creation of suitable environment in which everyone can be developed according to his/her dispositions and needs. There is no universal recipe to create such environment because it can be affected by many factors such as class size and composition, amenities and opportunities of schools for differentiation and/or inclusion etc. In this respect, especially teachers play a very important role because they greatly influence students by the way of teaching. According to experts (Osborne, & Dillon, 2008; Rocard et al. 2007) used teaching/learning methods often fail because they are not in accordance with the needs and expectations of students. Only 15% of European students are satisfied with the quality of teaching science and nearly 60% of students say that the teaching of science is not sufficiently interesting. Gifted students often present a challenge for teachers. These students often have in school low level of motivation because the school curriculum is not challenging to them. Sometimes, the most gifted students may even become the most disruptive due to their boredom, because they have special properties that distinguish them from their peers.

According to research findings (Trnová, 2012) experiments can motivate all students and can promote their intrinsic motivation. Educational experts say (Hříbková, 2010; Portešová, 2005; Winner, 1996, etc.) that implementation of experiments into science instruction provide a suitable environment for the development of gifted students. We have selected characteristics of experimentation which E. Winner (1996) gives:

- Gifted students make the first steps in specific areas earlier than their peers.
- Experiments provide gifted students the opportunity to work at a higher level than their classmates. They can solve more complex tasks, even when dealing with the same issues as their peers.
- Gifted students learn faster and in other ways than their peers, they are stand-alone, creates new unconventional ways of solving problems, because they are more creative.
- Gifted students require minimal help from parents, learning is very easy for them and at the same time they are able to motivate themselves.
- Experiments, which are based on students' activities, support students' creativity (findings of new solutions etc.). If teachers choose an appropriate procedure, they may to work independently and at their own pace.
- Gifted students are able to set their own objectives for which doggedly go.
- They have an abiding interest in new things and they are able to maximally concentrate.

In conclusion, we can say that experimentation is very motivational method for the development of students gifted in science because experiments provide possibility to solve problems on their own ways.

2 Experiments in the motivation of students gifted in science

Intrinsic motivation (interest) is important factor affecting the development of students gifted in science (Skrabankova, 2011). Renzulli (1986), Mönks, and Ypenburg (2002) argue that motivation plays a decisive role in the development of students' giftedness. Renzulli (1986) created a three-ring model of determining factors for the development of giftedness: creativity + ability + motivation (called task commitment). Mönks and Ypenburg (2002) modified Renzulli´s model and replaced the expression "task commitment" with the general term "motivation". Experiments have a significant motivational potential that is why they can be used as a source of strong intrinsic motivation for gifted students.

We realized research dealing with the interest of gifted students in experimentation (Trna, 2014b). In the year 2011, we also conducted the description research of educational needs of gifted students in science. The research sample consisted of 15 students aged 15-18 from upper secondary schools who were gifted in science (Trnova, & Trna, 2012). Their giftedness was verified by experts from pedagogical-psychological board and by the declaration of their teachers. We used questionnaire as a research tool. We present (see Tab. 1) a part of the questionnaire results: a list of specific educational needs of gifted students indicated by more than 50 % of them.

Table 1. Specific educational needs of students gifted in science

Which activities would you like to do in classes; which activities interest and attract you?	*Gifted students N =15*
Experimentation	**100 %**
Measurement	93 %
Identifying the fundamental processes in nature	93 %
Observation	93 %
Analysing phenomena	87 %
Expressing an opinion and defending it	87 %
Solving projects	80 %
Substantiation of solutions	80 %
Formulating conclusions	73 %
Describing phenomena	73 %
Verification of hypotheses	67 %
Data processing	67 %
Creating hypotheses	60 %
Evaluation	53 %

The results of our research shows that gifted students consider experiments significant for their education and development.

We verified the effectiveness of experiments as an incentive to gifted students through action research in 2014. The motivation of students in these experiments was greatly enhanced by the combination of satisfying their cognitive needs: experimentation, problem solving, measurement, observation, etc.

As a specific example we present a learning task with an experiment for gifted students (age 14-15) in physics and chemistry: "Density of liquids" (Trna, 2014a). This experiment can help the correct understanding of density as an important quantity in science. Gifted students solved the learning task: how to demonstrate and verify behaviour of different densities of liquids. They worked on this task with the use of the set of coloured sugar solutions at various densities (concentrations) (see Fig. 1, 2):

Figure 1. Coloured sugar solutions at various densities (concentrations)

Figure 2. Combination of coloured sugar solutions at different densities

These experiments have a strong emotional efficiency also due to the beauty of the coloured solutions.

3 Role of experiments in identification of science giftedness

Based on characteristics of gifted students we found a set of their special behaviour in science (Trnova, Trna, & Skrabankova, 2013), which are:

- They are not satisfied with passive memorizing
- They ask more questions than their peers
- They are curious and have unusual ideas
- They are independent and often prefer working on their own
- They use information to support their ideas
- They draw conclusions and bring new solutions
- They are able to link seemingly unrelated things into a meaningful unit
- They are creative
- They want to know how things work
- The interests of gifted students differ from the interests of their peers.

Implementation of experiments into instruction helps to respect these special behaviour of gifted students. Experiments can be used as a part of diagnostic technique and tool for identification of scientific giftedness as well (Kanevsky, 1992). We have developed a special set of experiments that can be used when searching for hidden giftedness in science in young children. We used these experiments for the diagnosis of latent giftedness of children (aged 5 to 11) from kindergarten and primary school. We implemented these experiments into simple learning tasks. Gifted children were able to solve these learning tasks successfully using these special experiments.

As examples we present one experiment in the learning tasks:

Task 1: *Paul has built three towers of wooden bricks (see Fig. 3). But only one of them is standing, two towers have fallen down. Which tower is standing?*

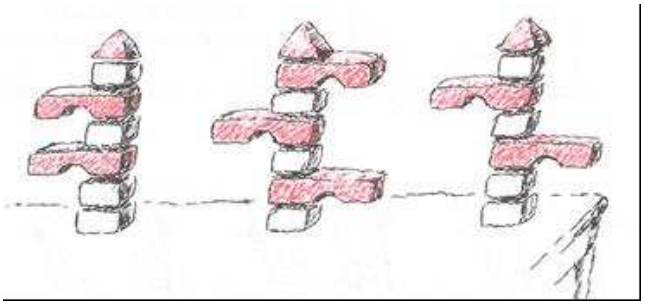

Figure 3. Towers of wooden bricks

4 Experiments in the development of students gifted in science

Experiments can contribute to the development of giftedness. One way is creation of alternative variants of the experiment and open venues for the creation of new or alternative experiments. As an example, we present one experiment demonstrated by a teacher and alternative experiments made subsequently by gifted students:

Experiment 1: *A glass tube with water is closed at both ends. There is an air bubble in the water (see Fig.4). If the tube is inclined appropriately, the bubble begins to move upwards with uniform motion (constant velocity).*

Figure 4. Uniform motion: teacher's experiment

Experiment 2: *A glass test tube with water in it is closed. There is a glass ball in the water (see Fig. 5). If the tube is inclined appropriately, the ball begins to move down with uniform motion (constant velocity).*

Figure 5. Uniform motion: gifted students' alternative experiment I.

Experiment 3: *A glass test tube with water in it is closed. There is a polystyrene ball with a diameter close to the interior diameter of the test tube (see Fig. 6). If the test tube is inclined appropriately, the ball begins to move upwards by with uniform motion (constant velocity).*

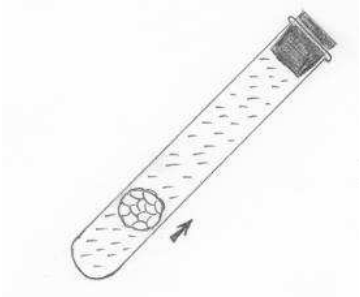

Figure 6. Uniform motion: gifted students' alternative experiment II.

Implementation of this educational procedure in science education of gifted students supports the development of students' skills in experimentation and develops their creativity.

5 Conclusions and discussion

School environment is one of the main factors in the support of gifted students. Thus the role of the teacher is totally irreplaceable. Science giftedness (and a latent giftedness especially) cannot be developed without identification and motivation. Our research has shown that experiments can be used for identification, motivation and development of students gifted in
science. It is, therefore, necessary to include the specific educational methods regarding how to use experiments for the support of giftedness in pre-service and in-service teacher education. Since the education of gifted students is realized in very variable conditions and situations, it is necessary for the teacher to

be creative also in experimentation. The development of creativity and teacher mastery of specific methods for the development of gifted students must be a part of the continuous professional development of science teachers. They should obtain detailed information about these experiments and about their role in the education of gifted students. Development of these professional teacher competences need experience of the teacher which is not possible to acquire only in pre-service teacher education at university. For this reason, there is a need to prepare quality courses of implementation of experiments for in-service teacher education.

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