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IMPLEMENTATION OF FOSTERING GIFTEDNESS IN SCIENCE TEACHER TRAINING

Assoc. Prof. Dr. Josef TRNA
Masaryk University
CZECH REPUBLIC

Assist. Prof. Dr. Eva TRNOVA
Masaryk University
CZECH REPUBLIC

ABSTRACT

Wide support of giftedness in STEM (Science, Technology, Engineering and Mathematics) is a relevant social necessity. Gifted students have special educational needs. Fostering gifted students involves identification and development of their giftedness. This educational fostering of gifted students also plays an important role in their personal development. Crucial areas for the fostering of gifted students are: education of teachers in identifying and development giftedness, creation of a support system to help teachers and families in the education of gifted students, and setting up high-quality school facilities for gifted students. The creation of suitable conditions for the development of students gifted in STEM is an important task for teachers. This objective involves the identification and the development of giftedness to the highest possible level. The study presents the research results of science teacher training in educational methods suitable for fostering gifted students. Design-based research was used as the main research method.

Key Words: Giftedness, science education, teacher training.

INTRODUCTION

A significant group of students with special educational needs is the group of gifted students in STEM (Science, Technology, Engineering and Mathematics). Unfortunately, less attention is paid to gifted students than to disabled students (Rocard et al., 2007). Teachers should support this important group of students as well. For the support of gifted students teachers must be adequately educated. Therefore, the knowledge and skills necessary for fostering gifted students should be implemented into teacher education.

The fostering of gifted students involves many professional teacher competences, the most important of which is the identification and development of students' giftedness. School and family (Tannenbaum, 2007) should create suitable conditions for the fostering of giftedness (Renzulli, 1986). This educational support of giftedness plays a crucial role in a student's personal development and it may significantly affect her/his entire life. Low support for gifted students may be associated with the small number of them. According to some experts (Mönks & Ypenburg, 2002) only about 2-3 % of students are exceptionally gifted - talented. The surprising fact is that 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 and implement them into teacher training.

RATIONALE

People include all students gifted in STEM in one group. But students gifted in STEM, of course, may not be gifted in all STEM subjects. Usually there is giftedness in some of these subjects, which is combined with a general interest in science and mathematics as a "language" of Science, Technology and Engineering. Science is often considered the core of STEM education.

It is also necessary to analyse the relation between intelligence and giftedness. Psychologist Gardner (1999) in his multiple intelligence theory argues that giftedness in science relates to naturalist intelligence. "Naturalist intelligence enables human beings to recognize, categorize and draw upon certain features of the environment. It combines a description of core ability with a characterization of the role that many cultures value." (Gardner, 1999, p. 48). Sternberg (2003) combines giftedness and intelligence in his theory of intelligence: (1) analytical intelligence (the ability to analyse a problem and understand its parts), (2) synthetic intelligence (the ability to understand a problem, intuition and creativity), and (3) practical intelligence (application of analytical or synthetic intelligence in practice). Sternberg (2007) has recently included his theory of triarchic intelligence in a renewed model of WICS (W-wisdom; I-intelligence, C-creativity; S-synthesized). The development of giftedness is an individualised, demanding activity because each gifted student has many personal specifics including the type of intelligence.

Systematic fostering of gifted students especially in STEM is an important part of the national and international educational strategies. Current results of research have opened three core areas crucial for the fostering of gifted students:

1. Education of teachers to identify and develop STEM giftedness
2. Creation of a supporting system to help teachers and parents in the upbringing and education of gifted students in STEM
3. Setting up high-quality school facilities for gifted students in STEM

Teacher education for fostering giftedness in STEM is the focus of this study.

RESEARCH OBJECTIVES AND METHODS

We set a research objective to identify professional skills that the teacher needs for fostering students in STEM. The issue is to develop a model of a teacher training course to prepare teachers for the support of giftedness in school practice. The last issue is to verify this model in practice.

We used a design-based research method which can be described as a cycle: 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 education of teachers for fostering students gifted in STEM.
2. Development of solutions with a theoretical framework: We have created a teacher training course to prepare teachers for the support of giftedness in their teaching.
3. Evaluation and testing of solutions in practice: We verified this model in practice (action research).
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 of development and implementation of teacher competency to foster students gifted in STEM.

Educated teachers were closely involved in all our design-based research.

RESEARCH FINDINGS AND DISCUSSION

Using observation of science instruction and interviews with teachers we have gained a set of teaching skills that a teacher needs for fostering gifted students. Observation of instruction was carried out and interviews with teachers were conducted in 2010-2013 on a sample of 11 Physics and Chemistry teachers at lower secondary schools in the Czech Republic. Identification of gifted students in classes (33 different classes; every teacher taught 3 classes) was done using expert pedagogical-psychological examination and supplemented by the experience of teachers. In each of the surveyed classes there were 1-3 students gifted in physics and/or chemistry.

We have come to the following list of relevant teachers' skills:

- creation of or finding the appropriate educational methods and instruments for gifted students and implementation of these into education
- implementation of effective educational methods for gifted students
- combination of individual teaching of gifted students with teaching other students
- inclusion of special activities for gifted students into mainstream schooling
- motivation of gifted students
- development of creativity of gifted students
- cooperation in fostering gifted students with other teachers
- cooperation in fostering gifted students with their families

Based on the identified professional skills needed for fostering gifted students, we have compiled a pilot training course for teachers, the aim of which was to prepare these teachers to work with gifted students in STEM. We have implemented this course with a pilot group of nine teachers in 2014. Based on our experience and feedback from teachers, we included this course in pre-service and in-service science teacher education in our university. Now we present a few examples of modules of our course.

Motivation of gifted students

This module contains basic information about the importance of motivation for the development of gifted students.

(a) Extract of information package for teachers: One of the most important factors affecting the development of gifted students in science is intrinsic motivation in the form of interest. According to Renzulli (1986), Mönks and Ypenburg (2002) motivation plays a crucial role in the development of students' giftedness. Renzulli (1986) established a three-ring model of giftedness including creativity, ability and motivation (called task commitment); it possible to mark these as determining factors for the development of giftedness. Mönks and Ypenburg (2002) modified Renzulli´s model and substituted the expression "task commitment" with the general term "motivation". They argued that the development of giftedness depends largely on a supportive environment. In this context it is necessary to consider especially the family and the school environment. In these environments there are many problems and complicating factors. The support of family is very important as well as teachers who can develop giftedness (Trnova & Trna, 2012).

(b) Example of suitable elements for fostering gifted students: There are several methods and tools to motivate gifted students. As an example, a learning task based on a simple experiment suitable for the motivation of gifted students is presented.

Sugar rainbow (learning task based on a simple experiment): Density is a very important quantity in science and this experiment can help in understanding it correctly and in motivation for science. Gifted students solved the learning task: how to demonstrate and verify the behaviour of different densities of liquids. They use a set of coloured sugar solutions at various densities (concentrations) (Figure 1).

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

Students gradually pour individual solutions carefully into a glass cylinder, where a "sugar rainbow" forms (Figure 2).

Figure 2: “Sugar rainbow” of coloured sugar solutions

Solution and explanation: The individual layers of rainbow correspond to the different density of fluids (coloured sugar solutions).

According to the findings of our action research (conducted in 2014) simple experiments have a strong and effective incentive for gifted students. The motivational effect of these simple experiments was greatly enhanced by the combination of satisfying students´ cognitive needs: experimentation, problem solving, measurement, observation, etc. These experiments also have emotional effect efficiency due to the beauty of the coloured solutions.

Development of creativity of gifted students

This module contains basic information about the importance of creativity for the development of gifted students.

(a) Extract of information package for teachers: Creativity is included in all models of giftedness (Renzulli, 1986) etc. It is therefore evident that the development of creativity of gifted students is important for fostering their giftedness. According to experts (Sternberg, 1999; Amabile, 1996; Gryskiewicz, 1982) a creative teacher is necessary for the supporting of students' creativity. Gifted students' creative abilities are most likely to be developed in an atmosphere in which the teacher's creative abilities are also properly engaged (Jeffrey &Craft, 2004). Students must feel that they are expected to be creative (Barbot, Besançon, & Lubart 2011). Every student is creative. Research into creativity concentrates on defining and assessing the level (capacity) of creativity, which could be measured in different ways. Torrance tests (Torrance, 1974) or variants of them are used for measuring the level of creativity. It is obvious that how well a student solves a problem (level) is not the same as in what way it is done (style). In addition to the level of creativity it is necessary to take into account the style of creativity (Kirton, 1994), especially of gifted students.

(b) Example of suitable elements for fostering gifted students: There are several ways how to develop the creativity of gifted students. Simple experiments may contribute to the development of the creativity of gifted students. Students create alternative variants of the presented experiments and can invent new or alternative experiments. As an example, a learning task based on a simple experiment developed by a gifted student as an outcome of a learning task is presented:

Solid paper strip (learning task based on a simple experiment): Students place a strip of soft paper (e.g. for printing) over an empty glass. A coin put on this flat paper strip falls into the glass because the paper strip does not hold it. Gifted students solved the learning task: what should be done with the paper to stop the coin from falling into the glass.

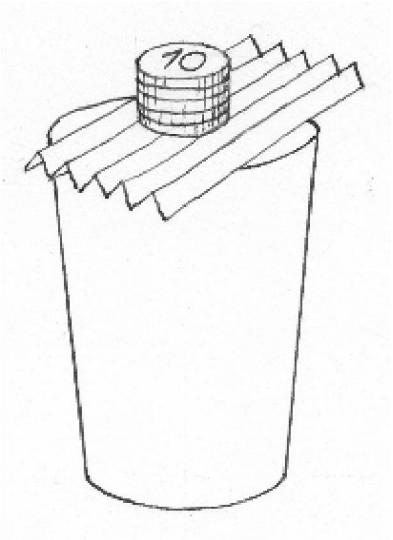

Figure 3: Solidity of a paper strip

Solution and explanation: If we pleat the same paper strip, the coin does not fall in (Figure 3). The pleated paper strip holds even a column of coins. A much greater deformational force is needed to deform pleated paper with a vertical carriage than flat paper.

Application of innovative teaching/learning methods for gifted students

This module contains basic information about innovative teaching/learning methods for the development of gifted students. The development of gifted students needs specific educational methods and tools. Our research verified the importance of inquiry-based science education (IBSE) for the development of gifted students in science.

(a) Extract of information package for teachers: IBSE supports the process of science learning (Narode, 1987). The core principles of IBSE are active involvement of students in discovering natural laws, meaningful content, critical thinking, and promoting positive attitudes towards science (Kyle, 1985; Rakow, 1986). Banchi and Bell (2008) defined four levels of IBSE: confirmation, structured, guided, and open. These levels are different according to the degree of the teacher's assistance (helping in the process, asking questions and formulation of expected results). Experiments can be applied in all four levels of IBSE. We found evidence of the great importance of experiments by a comparison of the specific educational needs of gifted students and core IBSE components (Trnova & Trna, 2012).

(b) Example of suitable elements for fostering gifted students: It is necessary to select and modify IBSE components for gifted students in science education according to their educational needs. We verified that simple experiments are among the IBSE components which closely correspond to the educational needs of gifted students. We have created specific simple experiments suitable for IBSE modules within the project PROFILES (2011). As an example, we present a learning task based on a simple experiment, which is suitable for IBSE gifted students.

Carbon in organic substances (learning task based on a simple experiment): Gifted students solved the learning task: to create a simple experiment to verify the presence of carbon in organic substances.

Figure 4: Carbon in paraffin

Solution and explanation: Evidence for the presence of carbon in paraffin can be proved through the formation of soot when burning a candle (Figure 4).

CONCLUSION

Educators, scientists, business people, politicians etc. state that it is necessary to foster gifted students in STEM. This latent giftedness must be identified and then developed. Creation of a supportive school, the family and the society environment are some of the main factors in fostering giftedness. But the role of the teacher is absolutely essential. Therefore, it is necessary to implement specific educational methods for fostering STEM giftedness in teacher education. Development of these professional competences is acquired though the experience of the teacher. Therefore, it is not possible to finish acquiring these competences is not possible finished during pre-service teacher education. The development of creativity and teacher mastery of specific methods for gifted students must be a part of the continuous professional development (CPD) of all STEM teachers.

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BIODATA AND CONTACT ADDRESSES OF AUTHORS

Josef TRNA is an associate professor of physics/science education and the dean of the Faculty of Education, the Masaryk University in Brno, Czech Republic, EU. He holds PhD in physics education and MA in mathematics and physics education. In doctoral studies he focused on motivation in physics education. He is experienced in secondary school mathematics, physics and science teaching. His main research domains are: motivation of students in science education, IBSE, diagnostics of students´ skills in science education, simple school experiments, educational video programs, curricula designing, education of gifted students, design-based research, connectivism etc. He co-operates with EU science educators and researchers on many projects. He has participated in a range of international science education conferences.

Assoc. Prof. Dr. Josef TRNA
Masaryk University
603 00 Brno , Porici 7- CZECH REPUBLIC, EU
E. Mail: trna@ped.muni.cz

Eva TRNOVA is a assistant professor of chemistry/science education at the Faculty of Education, the Masaryk University in Brno, Czech Republic, EU. She holds PhD in chemistry education and MA in chemistry and biology education. She is experienced in secondary school biology, chemistry and science teaching. Her research focuses on sustainable development education, IBSE, E-learning, development of students´ skills in science education, learning tasks in science education, education of gifted students, design-based research, connectivism etc. She has wide experience in in-service science teacher training and several European projects in science education. She has participated in a range of international science education conferences.

Assist. Prof. Dr. Eva TRNOVA
Masaryk University
603 00 Brno, Porici 7- CZECH REPUBLIC, EU
E. Mail: trnova@ped.muni.cz

REFERENCES

Amabile, T. M. (1996). *Creativity in context.* Boulder, CO: Westview.

Banchi, H., & Bell, R. (2008). The Many Levels of Inquiry. *Science and Children*, *2*, 26-29.

Barbot, B., Besançon, M., & Lubart, T. (2011). Assessing creativity in the classroom. *The Open Education Journal, 4*, 58-66.

Freeman, J. (2010). *Gifted Lives: What Happens when Gifted Children Grow Up.* New York: Routledge Chapman and Hall.

Gardner, H. (1999). *Intelligence Reframed. Multiple intelligences for the 21st century.* New York: Basic Books.

Gryskiewicz, S. S. (1982). *Creative leadership development and the Kirton adaption-innovation inventory.* Paper presented at the Occupational Psychology Conference of the British Psychological Society, Brighton, England.

Jeffrey, B., & Craft, A. (2004). Teaching Creatively and Teaching for Creativity: distinctions and relationships. *Educational Studies, 30*(1), 77-87.

Kirton, M. J. (1994). *Adaptors and innovators: Styles of creativity and problem- solving*. London: Routledge.

Kyle, W. C. (1985). What research says: Science through discovery: Students love it. *Science and Children*, *2*, 39–41.

Mönks, F. J., & Ypenburg, I. H. (2002). *Nadane dite.* Praha: Grada Publishing.

Narode, R. (1987). *Teaching Thinking Skills: Science.* Washington: National Education Association.

PROFILES project (2011, May 10). Retrieved February 10, 2015, from http://www.profiles-project.eu/

Rakow, S. J. (1986). *Teaching Science as Inquiry***.** Fastback 246, Bloomington, USA: Phi Delta Kappa Educ. Found.

Reeves, T. C. (2006). Design research from the technology perspective. In J. V. Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational design research* (pp. 86-109), London: Routledge.

Renzulli, J. S. (1986). The three-ring conception of giftedness: a developmental model for creative productivity. In R. J. Sternberg, & J. E. Davison (Eds.), *Conception of giftedness* (pp. 53-92). Cambridge: Cambridge univ. press.

Rocard, M., Cesrmley, P., Jorde, D., Lenzen, D., Walberg-Herniksson, H., & Hemmo, V. (2007). *Science education NOW: A Renewed Pedagogy for the Future of Europe.* Brussels: Office for Official Publications of the European Communities. Retrieved February 15, 2015, from http://ec.europa.eu/research/science society/document_library/pdf_06/report-rocard-on-science-education_en.pdf.

Sternberg, R. J. (1999). *Handbook of creativity*. Cambridge: Cambridge University Press.

Sternberg, R. J. (2003). Giftedness According to the Theory of Successful Intelligence. In N. Colangelo, & G. Davis (Eds.). *Handbook of Gifted Education* (pp. 88-99). Boston: Allyn and Bacon.

Sternberg, R. J. (2007). *Wisdom, Intelligence, and Creativity Synthesized.* New York: Cambridge University Press.

Tannenbaum, A. J. (2007). *Gifted children: Psychological and educational perspectives.* New York: MacMillan.

Torrance, E. P. (1974). *The Torrance Tests of Creative Thinking-Norms-Technical Manual Research Edition-Verbal Tests, Forms A and B- Figural Tests, Forms A and B.* Princeton: Personnel Press.

Trnova, E., & Trna, J. (2012). Development of Science and Technology Gifted Students through Inquiry-Based Science Education. In *Proceedings of the 8th International Conference on Education* (pp. 838-844). Samos, Greece: Research and Training Institute of East Aegean.