

IMPLEMENTATION OF CREATIVITY IN SCIENCE TEACHER TRAINING

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ABSTRACT

Creativity of students and teachers plays a very important role in education. The importance of creativity for education is evident from the interest of the OECD. According to experts a creative teacher is necessary to develop students' creativity. Students must feel that they are expected to be creative. Based on our design-based research, inquiry-based science education seems to be the appropriate approach for the development of creativity amongst students and teachers. The core principles of inquiry-based science education such as student activities, meaningful contents, developing critical thinking and motivating towards science correspond to the basic components of creativity. Inquiry-based science education involves basic processes that give rise to creativity. We present the research outcomes of the implementation of creativity development methods in science education and especially in science teacher training. Our research is carried out within the European project "Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science" (7FP).

Key Words: Creativity, science education, science teacher training.

INTRODUCTION

Since the end of the 20th century creativity has come to the fore of interest, not only for educational experts, but also for the wider society (Craft, 1999). Creativity, together with human skill, is a critical component for scientific and technological development and is one of the key sources of the development of society (Robinson, 2001). The importance of creativity is confirmed by the opinions of Florida (2006). He holds the view that the USA is currently undergoing an economic transformation, which has been variously described as a transformation to an "information economy," an "internet economy," a "technology economy," a "high-tech economy," a "knowledge economy," or even a "post-industrial society", but he prefers the term "creative economy". He finds it more inclusive, expressing the importance of creativity for economic development. According to his opinion the great challenge of our age is to tap and harness all human creativity because every single human being is creative. This means shifting from an economy based on physical inputs - land, capital, and labour - to an economy based on intellectual inputs, or human creativity. From this perspective, creativity is as important in education as literacy (Robinson, 2006) and therefore it should be included in education as a fundamental life skill (Craft, 1999) that will enable future generations to survive and thrive in the 21st century (Parkhurst, 1999).

Given the importance of creativity our society legitimately expects graduates to be not only educated, but also creative. Based on experts we can state that only creative teachers can develop student creativity (Robinson, 2006). The teacher's attitude greatly influences the development of creativity. But the findings from Czech schools (Laznibatova, 2012) suggest that teachers prefer intelligent students, who are not able to think creatively, to creative ones. Research confirms that good school assessment of students relates more to

intelligence than to creative thinking; it was proven that creativity does not affect school performance positively; it seems more likely that it reduces it (Carrol & Howienson, 1991). According to Sternberg and Williams (1996), it is possible to observe creativity in young children, but it is harder in older children and adults because their creativity potential has been suppressed by a society which supports intellectual conformity. Children's natural creativity is stifled when children start to differ from standard procedures in their activities. It begins in kindergarten when teachers correct children who draw things unusual colours or fancy shapes. This means that creativity is expected primarily from teachers. One possibility in which teacher creativity can be manifested is in their creative work with the educational content of science subjects; this is based on the creative application of subject knowledge in teaching/learning and creative educational practices (Trna, 2012, and 2013). Through their own creativity, teachers naturally affect the creativity development of their students (Al-Suleiman, 2009). Sternberg (2006) says that the creative teacher can be a model for his/her students and develop in them creativity by imitation. First of all the teacher should create a suitable climate. Students have to feel that it is desirable to think and act creatively. Creative education must be understood as an intentional activity, carried out using certain methods, including setting conditions to make these methods effective. Recently researchers have examined the relationship between creativity and cognitive styles.

Many researchers (Guilford, 1980; Kirton, 1976 etc.) think that cognitive styles have an influence on thinking, problem solving, decision making and creating. Current school practice requires a multidimensional development of a teacher's professional competences including creativity. The teacher does not solve a single problem, but a series of tasks. Teachers are now seen as "managers of learning" involved in a range of activities which "stretch beyond the day-to-day business of teaching in a classroom or workshop" (Huddleston & Unwin, 1996, p. 88). The findings of our research suggest that inquiry-based science education (hereinafter IBSE) seems to be the appropriate way for the development of creativity of teachers as well as students. Every teacher and student is creative to a greater or lesser degree (Amabile, 1998) and IBSE enables individual attitudes in the development of creativity as well as creating and supporting a creative classroom environment. IBSE is based on the fact that science learning is more than the memorisation of facts and information, but it is rather about understanding and applying concepts and methods. It provides a forum for asking questions and seeking answers through students' own way of inquiry. The core principles of IBSE such as student activities, linking information into a meaningful context, developing critical thinking, promoting positive attitudes towards science and motivation correspond to the basic components of creativity defined by Amabile (1998). Also, the procedures proposed by Sternberg (2006) for the development of creativity are fully in accordance with ideas of IBSE.

CREATIVITY IN SCIENCE EDUCATION

For the above mentioned reasons, it is clear that the creativity of students and teachers is an important factor influencing science education. It is necessary that teachers have enough knowledge about creativity in order to be able to develop creativity in a suitable way.

Definition of creativity

There is not only one definition of creativity because it is difficult to define creativity. The creation of theoretical foundations of creativity is connected with the pioneering efforts of Guilford (1980) and Torrance (1974). Unfortunately, most researchers dealing with creativity developed their own definitions of this concept. According to an analysis of published materials about creativity carried out by Rhodes (1961), there were more than 40 different definitions of creativity in the second half of the 20th century.

Considering that our study relates to Czech teachers, we quote definitions of Czech experts, reflecting how creativity is perceived in the Czech Republic. In the pedagogical dictionary by Czech authors (Prucha, Walterova, & Mares, 1998, p. 264), creativity is defined as "mental ability based on cognitive and motivational processes where, however, an important role is played by inspiration, imagination, and intuition. Creative solutions are not only correct, but also new, unusual and unexpected."

Other renowned Czech experts on creativity (Skalkova, 1999; Smekal, 2004) say that it prevails when troubleshooting in situations where a solution is not clear or routine solutions are not applicable. The solver has to be able identify the problem, systematically search for possible solutions, test them systematically and choose the solution procedure which was analyzed as the most appropriate for the given problem and conditions. Concerning the multidimensional development of teacher professional competences we find the definition of creativity by Zak (2004) the most comprehensive. He defines creativity as:

- a) *Ability*: to imagine or invent something new, which does not mean creating something out of nothing; to generate ideas, solutions, pieces of work, using combinations, changes, replications of existing ideas.
- b) *Individual approach characterized by*: agreement, acceptance of changes and news, willingness to play with ideas and thoughts, flexibility in perspective.
- c) *Process characterized as*: hard work, continuous mental activity to generate solutions, space for improvisation, order.

We have proceeded from this definition of creativity because it seems to be appropriate for the monitoring and determining of the development of teacher creativity within IBSE.

Development of creativity

Most of the creativity authors concentrate on defining and assessing the level (capacity) of problem solving and creativity. Every teacher and student is creative to a greater or lesser extent. According to experts, personal creativity could be measured in different ways. Very often Torrance tests or different variants are used to measure the level of creativity (Torrance, 1974). Given the focus of continuous professional development (hereinafter CPD) of teachers, the exact level of creativity possessed by individual teachers involved in CPD was not important. Because the purpose of CPD was to increase creativity we aimed to determine whether the creativity of teachers-participants in CPD was developed during the PROFILES CPD programme.

Styles of creativity

Researchers have uncovered that individuals not only differ in the level (capacity) of creativity, but they also differ in their style of creativity. It is obvious that how well one can solve a problem (level) is not the same as in what way it is done (style). Therefore, individuals who possess an equal level of creativity can demonstrate their creativity in different ways (Puccio, 1999). The style of creativity of team members influences the results of the whole team's work. The style of creativity of individual team members has an impact on the work of the team as a whole. Considering that teachers usually work in a team, we tried to identify the style of teacher creativity which can influence teacher cooperation at school.

Style of creativity is connected with cognitive style theories. One of the most important is Kirton's adaptation-innovation distinction (Kirton, 1976). M. J. Kirton developed the theory of cognitive styles called Kirton's Adaptation-Innovation theory (hereinafter KAI). The KAI theory is concerned with differences in creative processes, problem solving and decision-making (Kubes, 1998). Cognitive styles are relatively stable over time in contrast to the level (capacity) of creativity (Kirton, 1994).

Kirton's Adaptation-Innovation Inventory

Kirton's Adaptation-Innovation Inventory is a measurement tool of KAI theory (Kirton, 1987, and 1994; Kubes, 1998) that was developed to measure differences in cognitive styles. On the grounds of the number of points which individuals get in KAI it is possible to classify each of them into two groups, adaptors and innovators (Kirton, 1994). Everyone can be located on a continuum ranging from highly adaptive to highly innovative. Highly innovative individuals prefer to do things differently, to challenge the paradigm or structure. They are sometimes seen as undisciplined, thinking tangentially, and as approaching tasks from unexpected angles. They like radical solutions to problems. Highly adaptive individuals prefer to do things within the given paradigm or structure. They are characterized by precision, reliability, efficiency, discipline and conformity. They are sometimes seen as both responsible and dependable in their work. Adaptors reduce problems by improvement and greater efficiency (Kubes, 1998; Puccio, 1999). To put it briefly, innovators "do things differently" and adaptors "do things better" (Kirton, 1987; Puccio, 1999). Individuals possess a share of each style; however,

each of us prefers one style to the other (Gregorc, 1979). Each style possesses its own strengths and weaknesses. One style is not better than the other; both styles are useful.

Creative classroom environment

The influence of classroom environment on outcomes of education is confirmed by research. Analogous research (de Souza Fleith, 2000) confirms the influence of classroom environment on the development of creativity. The purpose of this research was to investigate teachers' and students' perceptions about characteristics which either encourage or inhibit the development of creativity in the classroom environment. The findings suggest that both teachers and students believe that a classroom environment, which enhances creativity, provides students with the possibility of choices, accepts different ideas, boosts self-confidence, and focuses on students' strengths and interests. On the other hand, in an environment which inhibits creativity, ideas are ignored, teachers are controlling, and excessive structure exists.

CREATIVITY INFLUENCES IN SCIENCE EDUCATION

Teachers should be creative people themselves in order to be able to implement creative science education in the classroom, not only using appropriate science content. They should know how to improve creativity in science education, support divergent thinking in students; they should pay attention to students' original, innovative and unusual ideas and encourage them to become creative individuals (Robinson, 2006). According to Sternberg (2006) our creativity is largely determined by our will. He defined 12 basic processes that give rise to creativity:

1. The ability to define a problem differently
2. Analysis of our own ideas
3. Presentation of ideas
4. Understanding of knowledge in context
5. Overcoming barriers
6. Acceptance of acceptable risks
7. Desire to improve ourselves
8. Belief in ourselves
9. Tolerance of ambiguity
10. Search for our own interests
11. Finding time to work
12. Error tolerance

Experts interested in creativity development explore the factors that influence creative teaching and try to find out effective strategies for this kind of school instruction (Jeffrey & Craft, 2004; Starko, 2010; de Souza Fleith, 2000; Esquivel, 1995; Nickerson, 1999; Horng, Hong, ChanLin, Chang, & Chu, 2005; Neber & Neuhaus, 2013). Based on the research findings and the analysis of the available literature, we have defined several factors that are common for creativity development:

- *Suitable environment*: students feel safe, not afraid to ask questions and make mistakes; cultivating, supporting and rewarding environment for creativity, humour, etc.
- *Personality traits of the teacher*: persistence, willingness to develop, acceptance of new experiences, self-confidence, sense of humour, curiosity, depth of ideas, imagination, etc.
- *Family factors*: open and tolerant ways of teaching students, creative performance of parents, encouraging confidence and willingness to take risks, etc.
- *Work groups*: diverse (supportive) teams, where members share enthusiasm, willingness to help and recognize each other's talents, brainstorming among classmates, information sharing, collaboration, etc.
- *School administration*: curriculum supporting creativity; resources – such as time, money, space for teacher creativity; attitudes of school management to creativity of students and teachers, freedom to choose means of achieving goals, etc.
- *Experience of life and education*: inquiry, creativity-solving problems, exploring multiple options, self-created games and stories; creating things, etc.
- *Motivation*: especially intrinsic motivation of teachers, students and parents, etc.

- *Hard work*: intensity and enthusiasm, finding time to work, etc.

The effective teaching strategies influencing creativity are: student-centred activities, link between teaching contents and real life, management of skills in class, open-ended questions, encouragement of creative thinking and use of technology and multimedia.

If we compare effective teaching strategies influencing creativity and the above mentioned factors with the basic principles of IBSE (especially stimulating environment, connection with problems of everyday life, instruction based on inquiry, team work, strong motivation, etc.) we come to the conclusion that IBSE can be considered a suitable method for the support and development of creativity. Based on the above-mentioned ideas in our continuous professional development (hereafter CPD) programme within the PROFILES project, we have developed teacher creativity using IBSE (Bolte, Holbrook, & Rauch, 2012).

IMPLEMENTATION OF CREATIVITY IN TEACHER TRAINING

It is clear that the implementation of creativity in teacher training is a very important part of CPD, especially in science education.

Research questions and methods

The research questions were phrased as follows:

1. *Has there been a development in science teacher creativity after participation in the PROFILES project CPD programme founded on IBSE?*
2. *Which styles of creativity do science teachers involved in the PROFILES project CPD programme founded on IBSE possess?*

The research was carried out from October 2011 to June 2012. The research sample consisted of 25 science teachers from lower secondary schools in the Czech Republic - participants in the PROFILES project CPD programme aged from 29 to 59 years (mean age 42).

When searching for answers to the first research questions, during CPD we applied the above mentioned factors for creativity development and we created appropriate creative materials for the education of teachers – participants in the PROFILES project CPD programme. Based on intensive work with these teachers, observation of their outcomes and inspection of their portfolio, we decided to determine the development of their creativity by using pedagogical qualitative research methods such as observation, content analysis of data, structured interviews with teachers etc. We used the definition of creativity as the basis for determining whether there was any development of creativity at all. In accordance with the definition we compared their ability, individual approach and process. To determine their style of creativity, we used a standardized method, Kirton's Adaptation-Innovation Inventory (KAI) (Kirton, 1987, and 1994).

RESULTS AND DISCUSSION

The findings of our research suggest that the creativity of science teachers involved in the PROFILES project CPD programme founded on IBSE has developed. This statement is supported by the following facts:

- teachers created new original IBSE modules, which is a comprehensive expression of teacher creativity. Innovative components of the PROFILES CPD Programme are integrated here
- teachers changed their style of teaching - they assert more student-centred activities, links between teaching contents and real life, open-ended questions, encouragement of creative thinking
- teachers created a suitable classroom environment increasing creativity; they provide students with the possibility of choices, accept different ideas, boost self-confidence, and focus on students' strengths and interests.

According to our observation, content analysis of data and structured interviews, each participant improved in accordance with the definition of creativity (Zak, 2004) his/her abilities (all participants created new materials),

individual approach (teachers changed worksheets etc.) and process (teachers worked very hard, improvised, etc).

Styles of science teacher creativity were established by using the KAI inventory. We used Kirton's standardized questionnaire validated in research (Kubes, 1992) in the Slovak Republic and we used it exactly according to the instructions described in Kubes (1992). There are 32 items in the KAI measurement. Each item is scored from one to five points. The theoretical measurement interval is between 32 and 160. As a result of the administrations by the researchers, the scores were generally found to vary between 46 and 145. The average score is 96 (Kirton, 1987, 1994, 1999). A person with an adaptive cognitive style will score in the 60-90 range. Someone with an innovative style will score between 110 and 140 (Mudd, 1996). The points for the participants of the study were between 102 and 132. Their scores were presented in Tab. 1. All the scores of the Czech teachers were higher than the average score (96) presented in literature. Their average score was 113.8. According to Mudd, (1996) only five persons were not in the interval (110 – 140) for the innovative style, but their scores were above the interval (60-90) for the adaptive style. We can conclude that the Czech science teachers in our CPD Programme exhibit the innovative style. In our opinion the reason for this result is that participants of the PROFILES project CPD programme were excellent science teachers. Our research was conceived as pilot and currently we are conducting research with a representative sample of Czech science teachers (see Tab. 1) who are going to be evaluated using statistical methods and we are going to compare our results with the available ones presented in literature.

Table 1: Scores of the KAI (SKAI) inventory of Czech teachers (n = 25)

SKAI	102	106	110	111	113	115	117	120	104
SKAI	108	110	112	113	116	118	124	105	110
SKAI	111	112	115	116	120	124	132		
Average score	113.8								

To illustrate we are presenting the results of KAI Slovak university students and Czech teachers together (see Tab. 2.). Because of the differences between research groups (low number of Czech teachers and differences in the mean age, point of view, gender) we did not carry out statistical comparisons.

Table 2: Scores of the KAI inventory of Czech teachers and Slovak university students

Population	Country	N	Mean	Standard deviation	Author (year)
University students - men	Slovak Republic	124	98.7	16.4	Kubes (1992)
University students - women	Slovak Republic	95	91.7	16.6	Kubes (1992)
Teachers (men + women)	Czech Republic	25	113.8	6.7	Trnova (2013)

According to experts, individual persons possess varying degrees of both styles. In accordance with this statement only one teacher has shown a strong preference for innovativeness (score of KAI 132), while the others possess only a slight preference for either style and exhibit characteristics of both adaptive and innovative styles. This finding was confirmed by the results of our pedagogical qualitative research methods. Findings about creativity styles are important for team work (Kirton, 1994). KAI is beneficial to cooperation with others in the task of problem solving. In order to communicate effectively, individuals must understand the tendencies and potential of other team members. This knowledge helped participants in the PROFILES project CPD programme to collaborate more effectively and manage in a better way.

CONCLUSION AND IMPLICATIONS

We have discovered great development of creativity of teachers-participants in the PROFILES project CPD, which is very important for students, because creativity is one of the most important factors for their lifelong learning and future success. According to experts, however, only a creative teacher can bring up a creative student. According to our findings, IBSE is a suitable method for the development of creativity. We found out that IBSE is a suitable method for the development of creativity because it is mainly based on student-centred activities, connection between teaching contents and real life, open-ended questions and encouragement of creative thinking. There is an overlap between factors supporting creativity and core principles of IBSE. Because teamwork currently plays a significant role in creativity, it is important to involve knowledge about the KAI theory and information on how to determine creativity styles of team members in teacher training.

We identified overlap between creativity factors and IBSE characteristics. Our research results verify that implementation of creativity factors in the framework of IBSE into science education is beneficial for science education. The international dimension of the PROFILES project CPD programme provides an opportunity for the development and dissemination of ideas and curricular materials among science teachers. The teachers involved in this CPD express their opinion that IBSE is effective educational technology leading to the upgrading of science education and creativity development. Creative teaching/learning methods have a positive influence on students and science teachers. We have implemented our research results into pre-service and in-service science teacher training.

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