

IBSE and Creativity Development

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ABSTRACT: Creativity plays a very important role in education. Most of educational systems support creativity as relevant competence for the 21st century. According to the findings of experts, teachers' creativity is important for the development of students' creativity. We introduce a theoretical base of creativity and styles of creativity. Based on our research, inquiry-based science education (IBSE) seems to be the appropriate way for creativity development of teachers as well as students. Every teacher and student is more or less creative and IBSE enables individual attitudes in the development of creativity. 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 basic components of creativity. Similarly, IBSE involves basic processes that give rise to creativity, which is delineated by R. Sternberg. We present reasons why IBSE is suitable for development of teachers' creativity.

KEY WORDS: creativity, IBSE, inquiry-based science education

INTRODUCTION

Since the end of the 1990s, creativity has become a growing area of interest once more within education and wider society (Craft, 1999). In the world of technological and scientific development, creativity is a critical component; human skills and creativity are key resources (Robinson, 2001). Now creativity is as important in education as literacy (Robinson, 2006) and needs to 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).

If our society legitimately expects school graduates to be not only educated, but also creative, it means that creativity is expected primarily from teachers. Most of teacher creativity is manifested in their creative work with the educational content of individual subjects; it is based on creative application of subject knowledge in instruction and it is characterized by creative didactic practices (Trna, 2012, 2013). Through their own creativity, teachers naturally affect creativity development of their students (Al-Suleiman, 2009). Creative education must be

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understood as an intentional activity, carried out using 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.) believe that cognitive styles have an impact upon thinking, problem solving, decision making and creating. School practice requires multidimensional development of teacher 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” (Huddlestone & Unwin, 1996, p. 88). Based on our research, inquiry-based science education (hereafter IBSE) seems to be the appropriate way for creativity development of teachers as well as students. Every teacher and student is more or less creative (Amabile, 1998) and IBSE enables individual attitudes in the development of creativity. IBSE is based on the fact that science learning is more than the memorization of facts and information, but it is rather about understanding and applying concepts and methods. 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 basic components of creativity defined by T. Amabile (1998). Also, the procedures proposed by R. J. Sternberg (2006) for the development of creativity, are fully consistent with IBSE.

RATIONALE

Teachers themselves should be creative people in order to be able to apply creative science education in the classroom, not only the 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 R. J. 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. Toleration 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 analysis of the available literature, we have defined several factors that are common for creativity development:

- **Suitable environment:** pupils 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 children, creative performance of parents, encouraging confidence and willingness to take risks, etc.
- **Work groups:** diverse (supportive) teams, where members share excitement, 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 children 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, children and parents, etc.
- **Hard work:** intensity and enthusiasm, finding time to work, etc.

The effective teaching strategies influencing creativity are: student-centred activities, connection 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 above mentioned factors with 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 support and development of creativity. Based on the above-mentioned ideas in our continuous professional development (hereafter CPD) program within the PROFILES project, we have developed teacher creativity using IBSE (Bolte, Holbrook & Rauch, 2012).

PROFILES CDP Program

The main objective of the project PROFILES (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science) is to promote IBSE as a component of teaching/learning. Teachers (participants) in the PROFILES project undergo a CPD program, which is described in detail in (Bolte, Holbrook & Rauch, 2012). Teachers go step by step through this CPD program in four roles: teacher as a learner; teacher as a teacher; teacher as a reflective practitioner; teacher as a leader. In our contribution, we present results from the CPD phase in which teachers acted in the role of teachers as learners and underwent education based on IBSE with the goal to develop their professional knowledge and skills as well as creativity.

Definition of creativity

It is difficult to define creativity. The field of creativity as it exists today emerged largely as a result of the pioneering efforts of J. P. Guilford (1980) and E. P. Torrance (1974). Unfortunately, most researchers that set out to examine creativity developed their own definitions of this concept. According to an analysis of published materials about creativity carried out by M. Rhodes (1961), there were more than 40 different definitions of creativity in the second half of the 20th century.

Considering that our study concerns 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. It develops itself by finding solutions that are not only correct, but also new, unusual and unexpected."

According to Czech renowned experts (Skalkova, 1999; Smekal, 2004) creativity is disposition to troubleshooting in situations, where a solution is not clear or routine solutions are not applicable. The solver is able and needs to identify the problem, can systematically search for possible solutions and is used to testing them systematically or choosing the procedure analysed as the most appropriate for the given problem and conditions. Concerning multidimensional development of teacher

professional competences we find the definition of creativity by P. 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 development of teacher creativity within IBSE.

Development of creativity

Every teacher and student is more or less creative. A lot of the creativity literature concentrates on defining and assessing the level (capacity) of problem solving and creativity. According to experts, personal creativity could be measured in different ways. To measure the level of creativity Torrance tests or their different variants are used (Torrance, 1974). Given the focus of CPD, the exact level of creativity possessed by individual teachers involved in CPD was not important. We aimed to determine whether creativity of teachers-participants in CPD was developed during the PROFILES CPD program.

Styles of creativity

Further, we tried to identify the style of teacher creativity, because researchers have discovered 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 that possess an equal level of creativity may exhibit their creativity in different ways (Puccio, 1999).

One of the most promising cognitive style theories to influence the issue of creativity is Kirton's adaptation-innovation distinction (Kirton, 1976). M. J. Kirton developed the theory of cognitive styles that is called the theory of Adaptation-Innovation (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 and appear as individual characteristics 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 the KAI theory (Kirton, 1987, 1994; Kubes, 1998). The KAI inventory was developed to measure differences in cognitive styles. According to the points individuals get in KAI it is possible to put 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 bring radical solutions to problems. Highly adaptive individuals prefer to improve things while working within the given paradigm or structure. They are characterized by precision, reliability, efficiency, discipline and conformity. They are sometimes seen as both safe and dependable in their work. Adaptors reduce problems by improvement and greater efficiency (Kubes, 1998; Puccio, 1999). To put it shortly, 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.

RESEARCH QUESTIONS AND METHODS

The research questions were phrased as follows:

1. Has there been development of teacher creativity involved in PROFILES CPD Program based on IBSE?
2. Which styles of creativity do teachers involved in PROFILES CPD Program based on IBSE possess?

Research was carried out from October 2011 to June 2012. The subjects were 25 science teachers of lower secondary schools in the Czech Republic - participants in the PROFILES CPD Program at the age from 29 to 59 years (mean age 42).

When searching for answers to the first research questions, we were creating appropriate materials for education of teachers – participants in the PROFILES CPD Program. 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, 1994).

RESULTS AND DISCUSSION

Our research resulted in the answers to our research questions about creativity development of teachers involved in the PROFILES CPD Program based on IBSE. Creating a new IBSE module is a comprehensive expression of teacher creativity. Innovative components of the PROFILES CPD Program are integrated here. 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 teacher creativity were determined by using the KAI inventory. We used Kirton's standardized questionnaire validated in research (Kubes, 1992) in the Slovak Republic and we applied it exactly according to 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 of participants of the study were between 102 and 132. Their scores were presented in Tab. 1. All 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 Czech science teachers of our CPD Program show the innovative style. In our opinion the reason of this result is that participants of the PROFILES CPD Program were excellent teachers. Our research was conceived as a pilot one and currently we are conducting research with a representative sample of Czech teachers who are going to be evaluated using statistical methods and we are going to compare our results with the available ones.

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 the point, we are presenting the results of KAI Slovak university students and Czech teachers (see Table 2). Because of differences between research groups (low number of Czech teachers and differences in the mean age, point of view of 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, individuals possess varying degrees of both styles. One teacher has shown a strong preference for innovativeness (score of KAI 132). Others possess only a slight preference for either style and exhibit characteristics of both the adaptive and innovative styles. This has been in accordance with our results of 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 CPD Program to collaborate more effectively and in the role of teachers as leaders.

CONCLUSION

We have discovered great creativity development of teachers-participants in the PROFILES 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 educate 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 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.

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