Discovering the Creativity in Informatics

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Abstract. In this paper we scrutinize various aspects of creativity in education and namely in school informatics. We have reviewed many literature sources looking for definition of creativity in informatics and the result was not satisfactory. We decided to build a definition and theory about various aspects of creativity in informatics using the qualitative research methods and grounded theory approach. The emerging theory is compared with literature. In the paper we present early version of our findings.

Keywords: informatics, education, creativity, digital technology

1 Introduction

We are living in a creative society, where new ideas and original solutions are becoming more and more valuable. In today´s fast changing world we need to prepare our pupils for uncertain future which is neither possible to imagine nor to define key competencies and skills for living in the world in twenty or even ten years.

We need to prepare pupils for their lives and future professional careers. What will they definitely need is the ability to quickly adapt to new circumstances, to communicate, to cooperate in team and *"think and act creatively"* [1].

In the last three years (since the national school reform in 2008) discourse about creativity in education has become more important in Slovakia. The National Curriculum in Slovakia highlights the importance of fostering creativity in schools and in informatics as well.

Although The National Curriculum emphasizes fostering creativity in informatics in various contexts, the explicit definition of creativity as well as ways how to support it are missing. We need to find a key characteristic of creativity to define this concept and determine relevant factors, which can influence creative process in schools. Since digital technologies (when properly used) can facilitate creative process we are trying to focus on them and characterize digital tools that support creativity.

2 Creativity in Education

Although creativity is often and widely discussed on popular and academic levels, there is still no consensus on explicit definition of creativity. The term creativity is used frequently and with different meanings – there are various perspectives for studying creativity and many different definitions of creativity in the psychology. There are two essential attributes in almost every definition of creativity – **novelty** and **value** [2].

Today we know that creativity is not exclusive to the geniuses or extraordinarily gifted people. Everyone is creative at some level and we should develop pupil´s creative skills during the educational process as one of the key competencies for living in 21st century. Creativity is a complex capacity, not only general ability [3] which requires three variables to appear [4]:

- domain-relevant skills,
- creativity-relevant skills,
- and task motivation.

The definition of creativity applicable to the educational process is one in the NACCCE report, which defines creativity as: *"Imaginative activity fashioned so as to produce outcomes that are both original and of value"* [5]. But what does it mean to produce something original and valuable in the school setting? Banaji et al. [6] refer to two key implicit distinctions in this definition – *"it distinguishes between imagination and purposeful imagination and defines originality as new to the child, not necessarily the world"*.

For better understanding of creativity we need to distinguish between two types or levels of creativity. Boden [7] describes historical creativity (h-creativity or eminent creativity, also labeled Big-C creativity) and psychological creativity (p-creativity, also labeled little-c creativity). Whilst Big-C creativity appears exceptionally and brings historically novel and original ideas which are fundamental in the field and nobody has had them before, little-c creativity is typical for everyday creative experiences that help to express ideas, solutions, emotions or opinions in original way. This type of creativity is also called everyday creativity and brings novelty which is relevant and meaningful for a certain group of people [3], for example classmates.

Beghetto & Kaufman [4] broaden conception of creativity and describe mini-c creativity, which is typical and essential for learning process, when pupils construct their personal knowledge and understanding. Although the problem solution may be well-known or introduced in the textbook, it can be new and original in relation to pupil´s previous work and knowledge, if he or she explores this solution by himself/herself. The main distinction between little-c and mini-c creativity is in judgment - whilst both Big-C and little-c creativity *"rely on interpersonal and historical judgments of novelty"*, mini-c creativity produces something novel and meaningful to the individual which is intrapersonally evaluated [4].

2.1 Creative teaching

The role of the teacher is crucial to promote creativity and facilitate creative activities within the classroom. They establish conditions and atmosphere which support the creative process, conduct creative learning activities, actively engage pupils and through their thinking and acting represent a role model of creative behaviour.

Feldhusen & Treffinger [8] and QCA [9] provided recommendations for establishing atmosphere which stimulates pupil´s creativity and give advice to the teacher how to promote creativity within the classroom:

- teacher should appreciate and foster unusual ideas, solutions and responses of students. It is important to perceive failures or mistakes positively as a part of the creative process,
- teacher should provide the pupils with various resources, prompts and support, enable them to reflect and concentrate,
- teacher should be open to pupils' ideas or interests and adapt them into lesson plan if possible. Unexpected events can motivate and stimulate pupils to work creatively, it´s allowed to put aside lesson plan and 'go with the moment',
- time is very important in the creative endeavor, pupils need sufficient time to think about creative ideas and explore them, that might not occur immediately or spontaneously,
- teacher should encourage pupils to solve divergent problems which support lateral thinking, encourage pupils to ask questions, make connections, work imaginatively, ask open-ended questions such as "What if...?" to explore various perspectives,
- teacher should establish a confidence building approach where pupils can take risk and freely present, communicate and share their ideas within the classroom. Atmosphere in which pupils feel safe is key factor for stimulating creativity,
- teacher should have fun and laugh with pupils, respect them, value what pupils do and say, reward originality and imagination,
- teacher should participate in creative activities, act and think creatively as a role model. Demonstrating that he or she is still learning can help to establish an opened atmosphere,
- teacher should create conditions for teamwork, where pupils can cooperate with classmates or even with pupils from a different age group.

2.2 Digital technologies that support creativity

Digital technologies (DT) have the potential in supporting creativity and creative process. Loveless [10] describes four key features that digital technologies provide for creative process:

- **provisionality** – they provide easy way to make changes or make step back during the performance, to try alternatives, to make drafts or to trace of the thinking process and development of ideas,

- **visualization and interactivity** – DT can provide dynamic, reasonable and immediate feedback on decisions or actions currently made, they can simulate or visualize processes or realities and enable manipulation of variables or changing conditions, so users can better understand and make connections and relations,
- **capacity and range** in which DT provide access to information from all over the world in any time, it's also wide range of tools that digital technologies enable us to use in thinking and problem solving process,
- **speed and automatic functions** which enable users to store, transform, transmit and especially analyze, synthesize, interpret, share and communicate information and ideas more effectively or more intelligibly.

Greene [11] and Schneiderman [12] analyze properties and characteristics of digital tools that support creativity. They define some requirements that DT should fulfill to facilitate creativity:

- DT should support *"pain-free explorations and experimentations",*
- enable users to move back (return to previous steps) or forward, work continuously and step-by-step,
- there should be no big penalties for errors or mistakes and success should be rewarded with meaningful response,
- there should be *"immediate and useful feedback for one´s action"*,
- user should have sense of control over actions and processes,
- DT should support meaningful visualization of data and processes for better understanding and exploring relationships and connections,
- enable explore various alternatives and solutions through 'what-if' scenarios and simulations,
- provide access to large databases of resources and digital libraries to find inspiration and gather knowledge,
- let users to disseminate their outcomes, products or artifacts to gain reputation and broaden databases of accessible resources.

Programmable media [13] (which enable users to create animations, interactive games, stories, simulations etc.) should let users customize their projects in an easy way – change backgrounds, objects, choose from available libraries or make own figures, scenes or pictures up to personal style and preferences.

2.3 Valuing creativity

"To Understand Is To Invent."
J. Piaget

If we want to think about the evaluation of creativity, first we need to answer the raising questions concerning value and originality in creative efforts and results.

Beghetto & Kaufman [4] emphasize creativity as a dynamic process. They propose that a creative process is more important than a creative product. Boden [7] assumes

that everyone is creative at some level. Rather than asking if the idea is creative, she proposes to ask how creative the new idea or artifact is and in which way.

The NACCCE [5] proposes three different categories of originality: individual, relative and historical. **Historical originality** is involved in Big-C creativity and such outcomes are uniquely creative in the field. **Relative originality** is a part of little-c creativity and produces outputs, which are original in relation to the classmates or to a particular peer group. Mini-c creativity involves **individual originality** which produces outcomes that are *"original in relation to his or her own previous work"* [15].

In the school setting it is the little-c and mini-c creativity, which are most likely to occur. The mini-c creativity is typical in a situation when pupils construct their knowledge by themselves – in such situation it is very likely that new findings will be original and meaningful for them. This type of creativity is the most important in the learning process and a teacher should be aware of such efforts and reward them. Moreover, the teacher should suggest normative standards, authorities and positive role models in the field.

Runco [14] claims that the creative expression is often *"personal and not easily compared with normative standards"*. The results of the creative effort are novel or original for classmates *"but not in comparison with some larger norms"*. Hence Runco recommend to focus attention on a creative potential *"rather than unambiguous creative performance"* [14].

Nevertheless, it is important to encourage pupils in self-evaluation and critical reflection on their own and others´ work. Craft et al. [15] present some thoughts on how to judge creativity and to overcome the subjectivity of this judgment:

- *"determine clear criteria for excellence"* and requirements for the tasks,
- be flexible in the judging (be opened to various solutions even the surprising ones),
- get variety of evaluative methods (teacher's evaluation, peer review, self-evaluation),
- failure in creative process should not be judged negatively.

3 What Do Teachers Think About Creativity in Informatics?

In this chapter we analyze the data gathered via several interviews with teachers. Our goal is to identify core themes in this context and propose a definition of creativity in informatics. For this purpose we chose a qualitative approach heavily relying on grounded theory methodology (though at this point of research not all the criteria are met and some strategies of the grounded theory have not been used yet).

Sampling - we combined several types of purposive sampling [16] and we chose teachers from primary and secondary schools that we knew are active, innovative and think critically about teaching and learning processes. For the future sampling an exact method on how to choose those teachers is needed (e.g. a questionnaire that would estimate their fit for our research).

Data collecting and preparation - with four participants we digitally recorded the interviews and then transcribed them into digital text form. The interviews were unstructured. We began with general questions about teaching and school life and

then we moderated the interview to creativity related topics. Other three participants responded to seven open-ended questions via e-mail (e.g. Are there some lessons you consider to be the creative ones? If so, how are they organized, what is the teacher's role? Are they different form less creative lessons? Describe the activities the pupils do.). Once we collected the data we printed and organized them by type (interview, questionnaire responses).

Coding process - in first reading we explored the data looking for emerging patterns and themes (this partially happened already by interviewing and transcribing). Then we applied open coding and broke text into segments, labeling each of them with code. By axial coding we refined the categories and looked for more accurate relationships among them. The result is a detailed map which depicts the categories and their relations (simplified version is in the Fig. 1.). We describe our findings in the following chapters.

This research is not finished. We are aware that data has not been saturated yet (we need to interview more teachers as well as enhance the methods on choosing them). More detailed selective coding is needed to reduce the categories and their properties. Only then we would be able to state the resulting theory on creativity in informatics. There are also several emerging questions that are interesting to examine closer. We plan to interview more teachers and reinterview the participants we already had and ask them more specific questions.

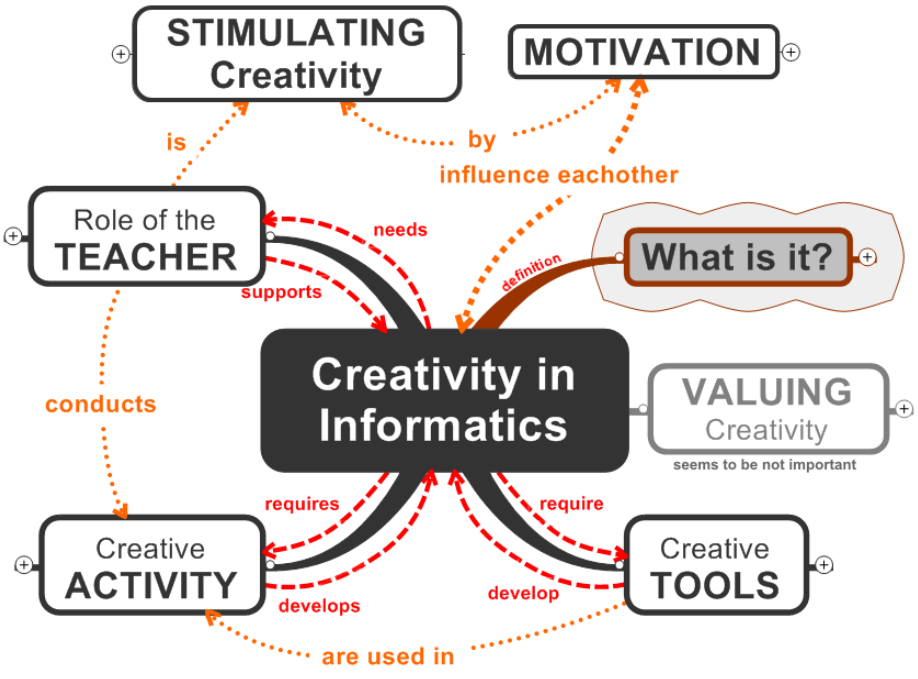

Fig. 1. Map of main themes (categories) emerging around the creativity in informatics.

The **main themes (categories)** that represent creativity in informatics are:

- definition of creativity,
- characteristics of creative activities,
- role of the teacher in this process and it's connection to motivation and means of supporting creativity,
- features of creative tools.

3.1 What is Creativity in Education and Informatics

We have identified **five domains** in which creativity is present in the context of school informatics (and generally in education). Creativity means

- **to have ideas** - ability to come up with something new, different, original, innovative and imaginative,
- **to make things happen** - to do more than the instructions asked for, to work independently,
- **to know how to** use tools and knowledge acquired at school, to know how to connect things together,
- **to discover** solutions, be able to find more than one solution,
- **to react** in different situations, to process various inputs.

As the most important the teachers marked the **ability to creatively use the tools which were a subject of the informatics education** (usually they meant software applications such as graphic editors but some also mentioned this in the context of programming and by tool they meant some programming structure such as a loop).

All teachers implicitly spoke about 'little C' or 'mini C' creativity. They were aware of the fact that their pupils usually did not come up with any revolutionary inventions. They readily appreciated if children discovered something that is new only to themselves or in the classroom environment.

Teachers also identified various aspects of creativity. They mentioned **visual**, **algorithmic** and **literary** creativity. This categorization is not final since only some teachers admitted that solving algorithmic problem might be creative. We suspect that many teachers do not find programming to be the core topic in school informatics and they focus much more on the user skills with various applications (editors).

Other classification of creativity regarded the **creativity of a process** and **creativity of a product**. Again this topic is seen differently - some teachers observe and appreciate both types of creativity, some of them endorse only the product, others only the process. We plan to investigate more what the reason for this disagreement is.

3.2 Creative Tools and Digital Technology

So far we have identified several features that are common for creative educational tools (programming languages and environments, educational software, microworlds, software applications, etc.):

- **simplicity** - tool must be easy to use and to get familiar with, complicated interface restricts the creativity,
- **wide walls** - tool must have many possibilities and wide range of use,
- **visual elements** - this feature relates to motivation, teachers believe that children like working with visual tools, it also links to the visual (or artistic) type of creativity,
- **interactivity** - again interactivity is a feature popular with children and stimulates their motivation and thus also creativity,
- **orientation on the product** - tool has to produce something (so the creativity of product might appear), the product should be interesting, entertaining or useful.

3.3 Creative Activities

The teachers pointed out that any activity in the classroom **has to meet the educational objectives**. Creative activities often jeopardize their fulfillment. A teacher has to ensure educational objectives are met and this is often very difficult to manage. They stated that **creative activities are demanding** and a teacher has to be very flexible. However, during the activity the role of the teacher is minimized and the focus is on the **learner who works on his own**. We assume that during such creative activity a teacher 'teaches less' but the nature of this teaching is much more demanding than during regular lessons.

The teachers often described **improvised activities** they prepare *"only in their head"* due to lack of time or will to prepare them beforehand. Some teachers do this on purpose and improvising is their modus operandi. Regardless of the reason these activities are reported to be very successful. Teachers perceive them as creative (we suspect this relates more to the teacher's creativity than to the learner's creativity).

The most important feature of a creative activity is its **open-ended nature**. Teachers characterized it as

- without given output,
- proposing wide theme,
- the learner has freedom to choose (theme, solving strategy, methods, ...),
- has various solutions.

Examples of such activities:

- the child has to make up its own task (*"make up your own"*) and solve it (e.g. to make up their own picture a turtle should draw, or to make up a new function for the project they programmed at previous lesson),
- the child adds a new feature to existing solution (e.g. to the program),
- multimedia projects (creating movies, clips, music videos, books, radio broadcast - this activities often include writing a scenario, working with DT, using editing software and teachers regard them as fairly difficult to finish).

Convergent activities are perceived as restricting the creativity - it can emerge only in the process not in the product (since it is given in the instructions). Some teachers do not recognize the process as creative and thus convergent activities are not creative either.

3.4 Role of the Teacher

As hinted in previous section the role of the teacher is to **manage the class**. Ensuring the educational objectives are met is important. Other positions involve

- **giving ideas**, stimuli and prompts,
- **interacting with the learner** - the teacher is flexible, is able to continue the lesson in various directions, finds benefits in every situation that appears, he also helps the learner if they go astray from the lesson objectives.

Stimulating Creativity

Most of the teachers admitted that they **do not support creativity on purpose**; it is more of a by-product of other objectives. However, they were able to identify some strategies for supporting creativity:

- give ideas and other extrinsic stimuli,
- conduct open-ended activities,
- give enough space for learner's ideas,
- do not restrict, only guide,
- recognize, appreciate and present learner's creativity.

None of the teachers had a strategy for grading creativity. They either did not know how to evaluate it or did not even feel the need to evaluate it since creativity is not their primary goal of education. Although they stated that recognition and appreciation is needed to maintain the creative environment.

Creativity and Motivation

Motivation is understood as a crucial factor in the process of learning. Motivation and creativity go hand in hand, they influence each other and they both enable a child to learn new things. Most teachers identified the personality of the teacher himself as a core factor for extrinsic motivation. They mentioned '**atmosphere**' of the class created by the teacher, group of learners, environment and 'school spirit'. This atmosphere has to be favouring creativity to stimulate it.

The teachers recognize also an intrinsic motivation of children, but some think they are not able to develop it and take it as a given property of the child. Others think they can work also with intrinsic motivation by giving appropriate prompts.

Valuing Creativity

The teachers do not grade creativity - they do not consider creativity to be their educational objective and therefore grading it is not their goal. They grade only the correctness of the solution. Some of them recognize only the visual (artistic) creativity and since they are not educated in this field they do not feel entitled to judge the originality.

They were not able to word any methods how to value creativity, though they stated they could recognize if a child is creative or not. They also emphasized that creativity should be rewarded - verbally or by presenting before the class. They feel that promoting creativity is important but they have no systematic methods to find out if creativity is occurring in the classroom or not.

4 Conclusion

The data collected from the teachers show that their understanding of creativity is similar to the theory we have learnt from literature. Even if literature heavily recommends focusing on the creative process some teachers do not recognize this process as part of creative performance and they value only the product. The teachers defined creativity in informatics mostly as an ability to effectively use the (digital) tools they mastered in the class, to discover solutions and to work on their own.

Teachers defined creative activities as open-ended, where pupils can modify the instruction, choose theme or make up their own task. They also stated that work with multimedia is creative.

The role of the teacher in the creative process is to facilitate creativity, provide ideas and focus the activity on the pupils. These activities are perceived as more demanding for the teachers because they need to react flexibly in unexpected situations. Important in this process is motivation that supports creativity and vice versa. Appreciating creativity and creating a creative atmosphere in the classroom is equally important. Teachers do not have systematic methods to judge creativity and do not feel entitled to do so.

Our early analysis opened several interesting question we haven't considered before (e.g. what does it mean that some teachers do not recognize creative in the process, why is creativity often limited only to the visual aspect, how should creativity be valued in classroom). We plan to investigate them in greater detail and look for possible explanations.

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