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DOES SELF-ASSESSMENT OF CREATIVITY AND ITS DEVELOPMENT SUPPORT THE DEVELOPMENT OF CREATIVITY?

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Abstract

Creativity is considered one of the most vital capabilities of the 21st century. Therefore, it is assumed that one of the fundamental roles of the education system is to nurture all learners' creativity. However, in general, the education system does not give it proper attention. This reality is the result of a range of circumstances, among others, the multifaceted nature of creativity, its variety of perspectives and definitions, and insufficient familiarity of teachers with the breadth of aspects associated with the nurture of creativity and its assessment. Therefore, in order to design a learning environment aimed at nurturing high school students' creativity, we have incorporated several principles inherent in the various perspectives related to the essence of creativity, and to make it easier for teachers to assess the development of their students' creativity, we utilized a designated psychometric model. The learning environment was in the field of mathematics, where students dealt with problem-posing activities as part of inquiry tasks they were engaged with. The problems that students produced constituted the "product" to be assessed in terms of creativity. Relating to the psychometric model, scores of two types can be produced: a personal score, which over time reflects each student's individual progress, and a relative score, reflecting the student's progress relative to his or her peers. Based on accumulated graphical displays of both individual and relative scores, teachers can get an idea about the strengths and weaknesses of both each student and the entire class, thus make pedagogical decisions regarding the emphases they should put, in order to nurture students' creativity. Through a process of self-assessment students can follow their own gradual change, both in relation to themselves and their colleagues.
In this paper, we present the results of a study that followed the experience of students who took part in the described learning environment. In particular, we focused on two students' perceptions of the benefits and limitations of self-assessment of their creativity and its development, using the designated model. The results indicate that self-assessment of creativity using relative scores can be beneficial for students who possess an optimal mixture of certain personal resources (e.g. motivation to study) from the outset. Such students are able to exploit this process for further developing their creativity. However, students who lack a certain degree of a threshold for some personal resources might be harmed by the process and their creativity might be suppressed.

Keywords: *Creativity, self-assessment, problem-posing.*

1. Introduction

In the 21st century, creativity is recognized as a key driver of social and economic changes as well as one of the most valuable personal skills. One might, therefore, expect that the education system would invest efforts in attempts to nurture students' creativity. However, although teachers believe that creativity can and should be nurtured at school (e.g. Shriki and Lavy, 2012), the education system scarcely encourages it. Consequently, most students do not have the opportunity to experience creative thinking and learning. This reality is a consequence of a combination of several circumstances, among them (Shriki, 2013): (i) The heavy load of teaching, and the external pressure on teachers to cover the mandatory curriculum and succeed in standardized tests leave no time for teachers to focus on nurturing skills that students are not tested on (such as creativity); (ii) Teachers were not trained to nurture their own creativity, let alone the creativity of their students, thus they do not possess the adequate pedagogy and available materials; (iii) Many teachers erroneously believe that expressions of creativity are limited to the various fields of art, and attribute creativity to giftedness, and therefore avoid implementing approaches that foster the creativity of *all* students in every discipline; (iv) There is a shortage of tools

aimed at assessing students' creativity and its continuing progress. Thus, teachers find it difficult to implement a systematic approach to develop students' creativity and observe improvement. Such monitoring could provide teachers with feedback that would help them to decide on suitable courses of action.

The learning environment we have developed, as described below, was designed to address these five factors, with the purpose of helping teachers develop learning environments aimed at nurturing the creativity of their students as part of the routine teaching of the discipline, as well as assessing its development. The learning environment that is illustrated in Section3 was adapted to teachers who teach mathematics in secondary school. In this paper, we will briefly describe the characteristics of the learning environment and focus on issues related to assessing mathematical creativity.

2. Literature background

In today's era, creativity and the capability to link objects that are seemingly unrelated are considered among the most important skills for success. For over a century, scholars have been engaged in the diverse face of creativity, its characteristics, origins, and development. These studies yielded a variety of understandings regarding the nature of creativity, its origins, manifestation, and assessment (Shriki, 2010; 2013). Review of the empirical literature in the field of creativity, in general, and mathematical creativity, in particular, reveals more than one hundred contemporary definitions of creativity as well as numerous interpretations of its essence and meaning (Mann, 2006). Due to the complexity of this field, a considerable part of these definitions and interpretations are rather vague and to date, none of the definitions has been commonly accepted. Moreover, throughout the years, creativity has been investigated from at least four perspectives: the creative process, the creative person, the creative environment and the creative product; as well as through a variety of approaches to the assessment of creativity, among them a psychometric approach (e.g. Torrance, 1974), a cognitive approach (e.g. Sternberg & Davidson, 2005), and a personal-social approach (e.g. Sternberg & Lubart, 1996). The multitude of perspectives and approaches has led, among other things, to the question of whether creativity is innate or whether it can be nurtured through appropriate education. Today, many researchers concur that creativity can be nurtured by means of suitable purposeful instruction, nevertheless, there is still no consensus as to the way it can be done (Henry, 2009).

As mentioned in the Introduction section, in most schools students do not have the opportunity to experience creative thinking and learning due to systemic aspects and teachers' perceptions and beliefs about creativity and its nurture. To address some of these constraints, we designed a learning environment that would fit into the existing set of school lessons, while developing the didactic approach and the tool for assessing creativity. In the next section, we describe the learning environment and its underlying rationale and demonstrate its implementation in the context of mathematics lessons.

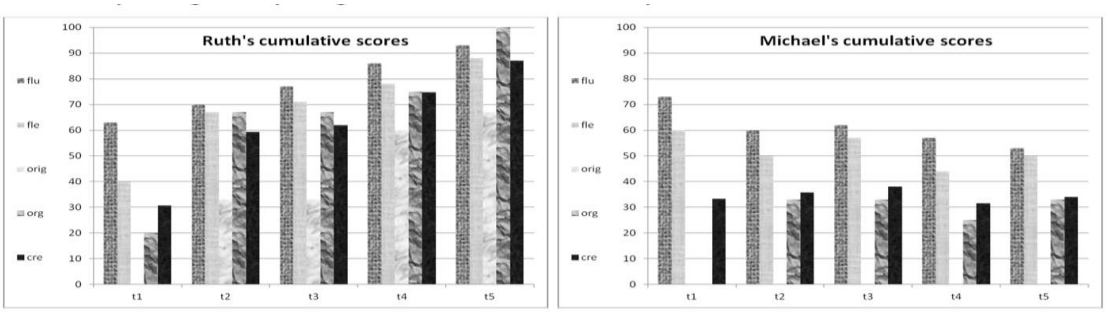
3. The learning environment

The following is the **rationale** underlying the design of the learning environment, and its adaptation to the case of mathematics teaching: (i) Among the four common perspectives for studying creativity, we chose to focus on the *product*, as it is usually easier for teachers to teach how to produce a particular product and evaluate it than to delve into issues related to processes and personality; (ii) In line with Silver (1997), we recognize the centrality of problem posing and problem solving processes in mathematics within the creative act. In particular, in the case of problem posing, Silver maintains that although mathematicians may solve problems that have been posed by others, they normally formulate their own problems based on personal experiences and interests. Therefore, the problems that are posed by students constitute "the product". It should be noted that problem-posing tasks are easy to implement and can be incorporated naturally into any math class as part of the learning process. The problem-posing approach we implemented is based on Brown and Walters' (1990) strategy, ‘What-If-Not?’ (abb. WIN). This strategy suggests that modifying the components of a given problem can yield new and stimulating problems that ultimately may result in some interesting inquiries that may lead to the uncovering of mathematic regularities; (iii) Based on our assumption that it would be easier for teachers to assess products through psychometric measures (e.g., grades), as they typically do, the assessment tool is based on Torrance's psychometric approach to measuring creativity (Torrance, 1974). Torrance's methodology uses four indices: fluency, flexibility, originality, and organization, where fluency is measured by the number of different problems posed; flexibility is measured by the number of different categories of the posed problems; originality is measured by the relative infrequency of the problems; and organization is measured by the number of problems formulated as generalizations. Then, an overall score for creativity is determined by assigning a relative weight for each index (depending on the teacher's educational goal).

Furthermore, the view of creativity as a personal trait that can be nurtured in school students requires a distinction between relative and absolute creativity (Leikin, 2009). While absolute creativity is associated with remarkable historical works of prominent mathematicians, relative creativity refers to discoveries made by a specific person within a specific reference group. Therefore, for each of the four indices, as well as for their weighting, each student receives both a "personal" score and a score that is relative to his or her classmates; (iv) Acknowledging the benefits of self-assessment of creativity and its development (Chamberlin & Moon, 2005), after every task each student receives a graphical display of his or her relative scores, as the personal scores are in fact task depended. Starting from the second task, the graphical display includes cumulative scores, so that the students are able to examine their progress/retreat relative to their classmates. Figure 1 presents two examples, a cumulative graphical display of Ruth and one of Michael for five problem-posing tasks (t1-t5). The relative scores for fluency, flexibility, originality, organization, and creativity are indicated by flu, fle, orig, org, and cre, respectively. The score for creativity was calculated so that each of the four indices received equal weight (Shriki & Lavy, 2014). Studying the graphical display of scores, the students are asked to reflect on modifications in their relative scores and try to explain apparent changes.

Further details about the learning environment and the scoring process can be found in Shriki (2013).

Figure 1. Ruth's and Michael's cumulative scores for task 1 (t1) to task 5 (t5).



4. The study

The study aimed at examining students' perceptions regarding the effect of the described self-assessment process on the development of their mathematical creativity. It should be noted that the first graphical display is given to students only after experiencing several WIN tasks and receiving a detailed explanation of the creativity indices and the meaning of relative scores. The process took place without the active involvement of the math teacher with the goal of monitoring student development independently of external guidance.

Research questions. Two research questions were derived from the research objective: How do students perceive the effect of the self-assessment process on (i) their self-efficacy as posers of mathematical problems; (ii) their development of mathematical creativity (as measured through psychometric indices).

Research participant. During the past few years, over 300 high school students participated in the study. The students studied math at various levels (low, medium, high). In each group, the study was carried out during five consecutive weeks (one problem-posing task per week), while the self-assessment process was performed between two successive tasks In this paper, we focus on two students, Ruth and Michael, whose cumulative scores are presented in Figure 1. Both were 11^{th}-grade students who studied medium-level mathematics in the same class. Ruth's and Michael's average grades in mathematics were 86 and 82, respectively. The reason for focusing on these two students is the fact that they constitute a representative example of the possible opposite effects of self-assessment of creativity in the case of relative scores.

Research tool. The graphical display was given to the study participants together with a questionnaire that included three open questions (the third question was excluded from the first questionnaire): Observing the graphical display, what can you tell about: (i) your creativity with respect to posing mathematical problems?; (ii) your ability to pose mathematical problems?; (iii) the development of your mathematical creativity. Try to explain apparent changes or lack of changes.

Data analysis. Students' responses to the questionnaires were analyzed by means of analytical induction, aiming to identify the main themes and typical patterns the emerge from the responses. This process was done by implementing open and axial coding in order to form the unifying categories and sub-categories (Strauss & Corbin, 1990).

5. Results and discussion

Ruth's and Michael's average grades in mathematics before starting the study (86 and 82, respectively) indicate that they are not considerably different in terms of their mathematics knowledge. As can be seen from Figure 1, Michael's starting point was slightly better than Ruth's, and both relative scores of total creativity were rather low. However, while Ruth's relative scores constantly increased, namely, she has improved relative to her classmates, Michael's relative position has decreased. This raises questions regarding the factors that influence the change in relative scores of the indices of creativity, and in any case, contrary to Chamberlin & Moon's (2005) findings, it indicates that self-assessment of creativity does not seem to work well with everyone.

Looking for a framework for analyzing Ruth's and Michael's responses to the questionnaires, we found Sternberg and Lubart's (1991) investment theory of creativity as suitable for this purpose. According to the theory, creativity is an interactive function of six resources– intellectual processes, knowledge, intellectual style, personality, motivation, and environmental context. Creative performance results from a confluence of these resources, thus in order to assess creativity, there is a need to look at all of them. In what follows are several quotations taken from Ruth's and Michael's responses. The brackets show the task number (t1-t5) and the question number (i-iii).

Quotations Ruth's responses. "My scores were very disappointing, but I can only blame myself for not giving it enough time…I will surely work harder on the next task" (t1, ii); "I wasn't satisfied with my scores for originality. I think that more than other scores this truly reflects creativity. So I promised myself to think 'big' next time" (t2, i); "I can see that my efforts paid off in all but originality. I think of myself as a creative person, so it's a bit annoying, but I'm not giving up" (t3, iii); "This time I changed my tactic, and it worked! I thought that if I would pose more problems, then I'll increase the chance of being original" (t4, ii); "These tasks truly gave me a chance to think differently. At first, I was afraid to think too wild, because the teacher said that the problem should be appropriate. But when I saw my scores for the three tasks I realized that if I would limit myself to simple problems I will not go far. So I really tried to think of original and generalized problems…and as you can see [the teacher], I am one of the most creative students in the class! Yeah!!!" (t5, iii).

Quotations from Michael's responses. "I tried to think of many types of problems, and I thought it would be enough. But then I saw my score of creativity and realized it wasn't enough…O.K., so I am not very original and creative, what does it say about me?" (t1, i); "I tried to prove to you [the teacher[that I can be original, but now I know I'm not…Actually, instead of getting better, I'm getting worse" (t2, iii); "It is the same as before. Perhaps I just don't know how to pose problems. We never did it in class…I'm starting not to like these tasks" (t3, i); "It is not hard to see that other students are much more creative than me, so I give up" (t4, iii); "I understand that what we did was some kind of an experiment, but you [the teacher] probably had to explain it better or tell me what I was doing wrong. If you had asked me a month ago if I could pose mathematical problems, I would definitely say "yes", but it turned out I'm not very good at it" (t5, ii).

According to the investment theory, the **intellectual resources** relate, among others, to the ability to escape the boundaries of conventional thinking, recognize which ideas worth pursuing, and willingness to invest time thinking in new ways (Sternberg, 2009). Ruth's self-testimony regarding her behavior meets these skills, and it is apparent that she takes responsibility for her achievements. Ruth realized she had to spend more time working on the tasks in order to attain the goal she set for herself: improve her relative scores, especially the score of originality (t1, t2). This goal was set as a result of perceiving originality as the essence of creativity (t2), and the fact she considered herself to be a creative person (t3). It appears that Ruth's **intellectual style**, namely, decisions about how to organize the available skills (Sternberg, 2009) and her **personality** resources, in particular, her eagerness to overcome obstacles and take risks supported her improvement. Evidently, Ruth is consciously monitoring her actions, for example- changing her strategy and posing more problems (t4), 'thinking big' (t3), and thinking of 'wild problems' (t5). Her self-efficacy as a creative person, combined with her willingness to overcome obstacles and take risks, proved to be what Ruth called 'pay off'. Clearly, these resources might not be adequate, if Ruth had no motivation. Intrinsic, task-focused motivation is essential for creativity. Nonetheless, motivation for itself is not inherent in a person but rather depends on one's decision to be motivated given a certain stimulant (Sternberg, 2009). Ruth's motivation to improve was primarily intrinsic, driven by her wish to prove to herself that she was as creative as she believed (t2-t5). Michael, on the other hand, demonstrated a different behavior of resource exploitation. At the first task, he used his **intellectual** resource for thinking of various types of problems, believing this was the right approach (t1). However, although he realized that it was insufficient for attaining high scores he did not make any attempt to escape the bounds of his conventional thinking. Michael seems to have given up quickly (t1, t3). Seemingly, Michael lacks the **personality** resources required for overcoming obstacles and taking

risks, and his low self-efficacy is expressed already after t1. Michael's utterances (t1-t4) indicate that he perceived the process as some kind of a 'competition' among his classmates, and being uncompetitive not just impeded the development of his creativity, but also harmed his self-efficacy and suppressed his intrinsic motivation. It appears that Michael's central motivation was to prove something to his teacher, rather than an intrinsic one (t2). Consequently, he 'blames' his teacher for not providing him proper conditions to succeed (t3, t5). As Sternberg (2009) noted, people may have all the essential internal resources to think creatively, however, if they do not get support from the environment, or alternatively- receive negative feedback, they will not be able to demonstrate their creativity. In t2 and t5 Michael turned directly to his teacher, wherein t5, he explicitly expressed his need for help. Unlike Ruth, who is able to resolve her conflicts by herself, Michael needs his teacher's guidance and support.

6. Conclusions

The case of Ruth and Michael suggests that self-assessment of creativity can be valuable for students who possess an optimal confluence of resources from the outset. Such students are able to advance their creativity and adapt themselves to the environment. Conversely, students who lack a certain degree of a threshold for one or more of the six mentioned resources might be harmed from this process. Further study is needed in order to understand issues related to this threshold and its relation to the self-assessment of creativity. Moreover, given the importance of environmental context, it is clear that self-assessment of creativity through the use of a graphical display of relative scores is not equally suitable for all students. Perhaps Michael could realize his creative potential if he had received his teacher's immediate support or a display of his personal scores rather than the relative ones. These two issues also need to be considered in further study.

References

Brown, S. I., & Walter, M. I. (1990). *The art of problem posing* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Chamberlin, S. A., & Moon, S. M. (2005). Model-eliciting activities as a tool to develop and identify creativity gifted mathematicians. *Journal of Secondary Gifted Education, 17*(1), 37-47.

Henry, J. (2009). Enhancing creativity with M.U.S.I.C. *The Alberta Journal of Educational Research,* 5(2), 199-211.

Leikin, R. (2009). Exploring mathematical creativity using multiple solution tasks. In R. Leikin, A. Berman, & B. Koichu (Eds.), *Creativity in mathematics and the education of gifted students* (pp. 129–145). Rotterdam, the Netherlands: Sense Publishers.

Mann, E. L. (2006). Creativity: The essence of mathematics. *Journal for the Education of the Gifted*, 30(2), 236–260.

Shriki, A. (2010). Working like real mathematicians: Developing prospective teachers' awareness of mathematical creativity through generating new concepts. *Educational Studies in Mathematics*, 73, 159–179.

Shriki, A. (2013). A model for assessing the development of students' creativity in the context of problem posing. *Creative Education*, 4(7), 430-439.

Shriki, A., & Lavy, I. (2012). Teachers' perceptions of mathematical creativity and its nurture. In Tso, T. Y. (Ed.). *Proceedings of the 36th Conference of the International Group for the Psychology of Mathematics Education (PME)*, 4, (pp. 91-98). Taipei, Taiwan: PME.

Shriki, A., & Lavy, I. (2014). Students' self-assessment of creativity: Benefits and limitations. In Nicol, C., Oesterle, S., Liljedahl, P., & Allan, D. (Eds.), *Proceedings of the Joint Meeting of PME 38 and PME-NA 36,* 5, 177-184. Vancouver, Canada: PME.

Silver, E. A. (1997). Fostering creativity through instruction rich in mathematical problem solving and problem posing. *ZDM - The International Journal on Mathematics Education*, 29(3), 75-8.

Sternberg, R. J. (2009). The nature of creativity. In J. C. Kaufman, & E. L. Grigorenko (Eds.), *The essential Sternberg: Essays on intelligence, psychology and education* (pp. 103-118). Springer Publishing Company.

Sternberg, R. J., & Davidson, J. E. (2005). *Conceptions of giftedness. Boston*, MA: Cambridge University Press.

Sternberg, R. J., & Lubart, T. I. (1991). An investment theory of creativity and its development. *Human Development, 34*, 1-33.

Torrance, E. P. (1974). Torrance tests of creative thinking. Bensenville, IL: Scholastic Testing Service.