ASSESSMENT OF THE CLIMATE FOR CREATIVITY IN SCHOOL AND THE LEVEL OF CREATIVE ATTITUDES OF MATHEMATICALLY GIFTED STUDENTS

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Abstract. The subject of the article is the relation between math abilities and assessment of creativity climate at school and level of creative attitudes. Main problem is included in questions about creativity meaning for expression and development of math skills. How gifted students perceive and assess climate for creativity at school (does it support creativity)? What is the level of creative attitudes of gifted students? Which factors differentiate above relations? Answers to this questions are significant for teachers who work with students talented in math. As per theoretical models, high achievements of gifted students are supported by creative talents (Renzulli, 1978). Empirical data not support this correlation enough. One of formulated thesis is that there is a conflict between high level of school achievements (abilities) and creativity (Freeman, 2012). Introduced are results of research of two groups of students: participants of math competition for middle schools (N=43) and students with highest school achievements in math (average marks and external exams results, N=62). Climate for educations means all psychosocial resources of school which supports student's creativity. Creative attitude is an active cognitive, emotional, motivational activeness toward world with will to change it. As per the conducted research school support for creative gifted students is based on positive interpersonal relations limited situations with risk and ambiguity. Students talented in math have high general creative attitudes score.

Keywords: creative attitudes, creative climate at school, mathematically gifted students

Introduction

The subject of this article is the importance of creativity for revealing and developing mathematical talents of students. According to theoretical models, the high accomplishments of gifted people are favored by the co-existence of directional and creative talents. Data from empirical studies do not fully confirm these correlations. A thesis on the conflict between the high level of school achievements (talents) and creativity is also being formulated (Freeman, 2016). Terminological and theoretical findings became the basis for research on the climate for creativity in school and the level of creative attitudes of mathematically gifted students. The results of these studies are of practical importance for the work of teachers with gifted students.

Supporting mathematical talents of students

Mathematical talents are the most studied school directional talents. This is due to the high ranking given to mathematics as a subject of instruction, but also to the deficits in mathematical education. In the report of *The High Cost of Low Educational Performance*, prepared by the Organization for Economic Cooperation and Development (OECD 2010), the authors pointed to the relation between the innovativeness of countries and the achievements of students in mathematics. It has been shown that an increase of 100 points in the international surveys of student skills (PISA) in mathematics and science leads to an increase in gross domestic product of 1.7 points. Mathematics is a compulsory subject and student competences in mathematics are assessed at all levels of school examinations. In Poland in the school year 2009/2010, after 25 years of break, mathematics was introduced as a compulsory matriculation subject. Mathematical competence is one of eight competences identified in 2006 by a decision of the European Parliament and of the Council of the European Union as a key to the development and fulfilment of people's social roles throughout their lives.

The results of mathematical education in Poland are unsatisfactory. A thesis on the crisis in mathematical education is being formulated, among others, negligence in shaping mathematical culture, imagination and creativity is being pointed out, as well as concentration on the schemes of solving tasks in terms of preparation for the final test exams (Gruszczyk-Kolczyńska 2019). This area has become a priority of education policy. Among the many activities, the need to strengthen support for mathematically gifted students was identified.

Abilities are individual differences between people, which influence the unequal effects of their activity. Authors of the latest concept on theoretical ability, the so-called Mega Model, Rena F. Subotnik, Paula Olszewski-Kubilius and Frank C. Worrell has formulated the following definition: "Abilities are a *developmental process* that is *domain-specific* and art. While the development pathway may begin with a *visible potential*, abilities must be developed and supported through exercises and interventions in domain-specific skills, programs and through the *deliberate development of the psychological and social skills* that are necessary to follow difficult new paths. The aim of this development process is to *transform potential talent* in youth into outstanding achievements and innovation in adulthood" (2015, p. 26). In the Mega Model, abilities are perceived as an Individual potential, and the priority of support is to develop them into outstanding achievements in the field of revealed talent and creative efficiency.

It is possible to talk about mathematical talents of students when they obtain above-average results in mathematics. High school achievement shows great potential, but its development is a complex process and requires support from the school environment. The dominant ways of working with students capable of accelerating and enriching the content of education. The enrichment strategy is to integrate into education a wider range and more difficult curriculum content (relating to the highest educational objectives). Typical forms of work at school are the Olympics, subject competitions and extracurricular activities (Giza 2016).

Mathematically gifted students participating in such classes are expected not only to have above-average subject knowledge, but also to have originality in solving problems. Knowledge of rules and formulas is not enough for outstanding achievements in mathematics. We need to break the patterns and heuristic thinking, which is particularly important in the face of new problems. This is consistent with the psychological classification of mathematical talents. Wadim Krutiecki (1971) pointed to productive – creative mathematical talents, leading to original solutions and unproductive – related to solving problems according to predetermined rules/algorithms.

The need to develop creative talents in working with mathematically gifted students also results from theoretical models of abilities. For example, according to Joseph Renzull's Three-Ring Conception of Giftedness, outstanding abilities are the result of three factors: cognitive abilities (intelligence or directional abilities), engagement in a task (motivation) and creative abilities. There is a structural and functional dependence between them. In working with gifted students, these relations between directional and creative talents should be taken into account.

Creativity is an activity that results in new and valuable results. Creativity can be described on four levels: fluid, crystallized, mature and outstanding (Nęcka 2001). The higher the creative level, the more complex the psychic phenomena and the social status of product increase. "Liquid" creativity appears already in young children; it occurs in people with frequency and intensity in accordance with Gauss's curve. It constitutes the basic creative potential of man, which does not have to lead to the creation of products. It can be understood as the ability to think creatively. "Crystallized" creativity is "the use of potential ideological abilities in the pursuit of a set objective or in the process of solving a problem" (Nęcka 2001 p. 217). It requires knowledge and skills in the field of solving a problem and critical thinking. Mature and outstanding creativity usually occurs only in adulthood and is shared by a few people. The term creativity is used to refer to the first two levels of creativity. Maciej Karwowski assumed that "Creativity is the personality potential of most people to achieve significant – at least on a psychological scale – results in terms of creativity. This potential is mainly related to character traits – openness, sensitivity to problems and motivation to act, hence it is justified to associate creativity with both creative attitude and creative abilities. Creativity can be treated as an initial, elementary level of creativity – characteristic for the majority of healthy people, a necessary but insufficient condition for any creative activity" (Karwowski 2009c, p. 27).

Development of creative dispositions of students is supported by two types of interactions. First of all, specialized programs and methodologies including creative thinking exercises (creativity trainings) and learning heuristics. Secondly, creating a climate at school that is conducive to students' creativity and the development of their personality traits necessary for creative activity. The concept of climate for creativity was defined on the basis of social psychology of creativity as a set of specific psychosocial variables that make up the atmosphere which inspires and maintains creative activity (Karwowski 2009a, 2009b). It is a part of the school culture. The creative school climate includes a set of specific features important for

the students' functioning, such as support for their ideas, humor, autonomy, emotional security, openness to change and challenges, clear goals and principles, motivation to be active. Research on the creative climate of schools indicates a relation between its intensity and the creative dispositions of students, but does not provide clear evidence of whether the climate affects creativity or whether creative people perceive the climate of their environment as more creative.

Research assumptions

The above theoretical findings constituted the basis for research among gifted students. They included a group of winners and finalists of the mathematics competition for junior high school students from the Świętokrzyskie Voivodeship. The respondents were aged 14-15 years. The group consisted of 43 people: 11 girls and 32 boys. They were already selected students, who made it to the last stage of the competition, after winning at lower levels. It was assumed that educational success is an indicator of the mathematical talents of these students. It was also assumed that high achievements in the competition were possible thanks to intensive exercises in solving mathematical problems, high involvement/motivation and creative predispositions. The research problem that has been formulated concerns the significance of creativity for obtaining above-average competition results. Two main questions were formulated:

1. **How do mathematically gifted students assess the climate for creativity in school?**
2. **What is the level of creative attitudes of mathematically gifted students?**

It was assumed that above-average mathematical achievements of the surveyed students will be supported by a high intensity of the climate for creativity in the schools in which they are learning and their high level of creative attitudes.

1. Climate for creativity in school in the assessment of mathematically gifted students

The research used the School Climate for Creativity Questionnaire (KKKS), constructed by Maciej Karwowski (2009a). The questionnaire has been used since 2002 and has good measures of accuracy and reliability. The KKKS contains a five-point evaluation scale and 44 statements, assigned to three climate dimensions for creativity:

- freedom and subjectivity (interpersonal sphere): includes a sense of own cause and autonomy in action. It means believing that the goals and forms of student activity are highly dependent on the students themselves.
- trust and non-conflict (task sphere): means the quality of interpersonal relations at school: students feel comfortable in their own company and trust each other, more often they cooperate than compete.
- risk and uncertainty (dynamic sphere): this dimension is in negative correlation with trust and subjectivity. It inhibits more than stimulates creative activity. Indicates that there are disputes and conflicts in classroom and school relations.

Dimensions of the climate for creativity are the main areas of institutions' functioning which have a decisive role in stimulating creative activity of people. The KKKS scores are calculated according to the key on the basis of average score and enable to distinguish three categories of schools: those with low, average and high intensity climate for creativity (Karwowski 2009a, Karwowski 2009b). Table 1 presents the research results of mathematically gifted students[1].

Table 1. *Assessment of the climate for creativity in school by mathematically gifted students (N=43)*

	Average values of KKKS dimensions		
	Trust and non-conflict (Value for schools with a high climate for creativity: **44.45**)	Freedom and subjectivity (Value for schools with a high climate for creativity: **83.60**)	Risks and uncertainty (Value for schools with a high climate for creativity: **22.31**)
Girls N=11	44,82	81,64	19,00
Boys N=32	45,31	79,78	19,81
Large city N=18	44,50	76,00	19,55
Small town N=11	45,36	83,45	20,18
Village N=14	45,07	83,21	19,21
Total N=43	**45,30**	**80,26**	**19,60**

The average values of *Freedom and subjectivity* dimensions, as well as *Trust and non-conflict* for schools in which finalists and winners of subjective competitions learn, prove the high intensity of the climate for creativity in these institutions. This is particularly true in the interpersonal sphere, where high scores are independent of the gender and abilities of students. In the task sphere, boys rate the sense of *freedom and subjectivity* at school lower than girls; between average and high levels of support for creativity. In terms of *risk and uncertainty*, the results were low and average, and did not vary according to gender or talent type. Support for the creativity of mathematically gifted students in schools can therefore be considered to be based on favorable interpersonal and task relations, while risk and uncertainty situations are reduced. On the basis of these data it can be concluded that schools in small towns are a place with a particularly favorable atmosphere for the development of talents.

[1] In another article, a comparison of these results with the evaluation of the climate for creativity in schools carried out by students with humanistic talents, winners and finalists of the Polish language competition was presented - Giza 2016.

The data presented above from research on the climate for creativity in schools prove that differences in the scope of work with students able to work in schools are worth searching for in unique systems of psychosocial variables. They allow for the support of students who are able to look at the school from a "soft features" perspective. Apart from specialized programs and methodologies, it is an atmosphere conducive to creativity, inspires creative activity and the development of talents.

Creative attitudes of mathematically gifted students

Creative attitude is an active cognitive, emotional-motivational and action attitude towards the world, expressing the need to change it or make changes in oneself. A creative attitude is a dynamic, educationally sensitive characteristic that changes with age and education type. It appears during adolescence, when adolescent students become aware of their creative abilities. A creative attitude means a type of activity in which an individual carries out new objectives and tasks in a unique and original way, enriching individual and social resources with new and valuable solutions.

The study used the version of the Creative Postures versus Recreation Scale (SPTvO) for junior high school students (Sigva 2011). The tool contains thirty statements concerning the features of creative and imitative personality, assigned to the cognitive, emotional-motivational and action sphere. Results can be presented as a sum of points or calculated on a sten scale. These results enable to assess the level of creative attitude and its spheres as low, average or high, in accordance with the key.

Distribution of the measurement results of creative attitudes in the population of all junior high school students is left-sided, which means that most of them reach a low or average level (Sigva 2011). Surveys of mathematically gifted pupils show that 73% of girls and 88% of boys achieved a high level of creative attitudes and none of the students achieved a low level of general creative attitudes (Table 2).

Table 2. *Level of creative attitudes of mathematically gifted girls and boys (N=43)*

Description of SPTvO result	Number of girls (N=11)	Number of boys (N=32)
1-4 sten; low score	–	–
5-6 sten; average score	3	4
7-10 sten; high score	8	28

In the light of the above data, it should be concluded that the creative attitude correlates with high mathematical achievements. The comparison between the age and place of residence of mathematically gifted students and the level of their creative attitudes in three spheres did not show any differences between the groups. However, gender differences were found in three spheres of creative attitudes (Table 3).

Table 3. *Level of creative attitudes of mathematically gifted girls and boys in three spheres (N = 43)*

Stens	Cognitive sphere			Emotional and motivational sphere			Action sphere		
	girls	boys	total	girls	boys	total	girls	boys	total
1-4 sten low score	3	8	11	6	8	14	4	10	14
5-6 sten average score	4	14	18	2	12	14	3	13	16
7-10 sten high score	4	10	14	3	12	15	4	9	13

Based on the above results, it can be concluded that boys are more non-conformist than girls, and are more likely to be critical and independent. The most powerful link in the creative attitudes of mathematically gifted students is the cognitive sphere. This proves their ingenuity, as well as their independence and originality in solving tasks. Students remember relevant content, associate it with a logical structure, and are inventive when solving tasks. Girls are characterized by a lower level of creative attitudes in the emotional and motivational sphere than boys. They are therefore less independent and flexible in thinking, less persistent and resistant to stress. More than half of the girls achieved a low score in this sphere, which is a proof of their imitative attitude. Such people use tried and tested examples, do not like to look for solutions, they prefer to imitate rather than discover.

Summary and conclusions

Mathematics is the area of thought genius, unique personalities and discoveries that form the basis for development of science as a whole. Excellence in mathematics requires both high directional and creative talents. At the level of compulsory education, both mathematics teaching and support for creativity are assessed as insufficient. Despite the high rank given to creativity by societies, schools are not conducive to its development. In the current system of external test exams, the results of which determine the educational chances, conventional knowledge is tested. As a consequence, this results in teaching and learning how to solve tasks on the basis of response keys. The gifted students are most affected by the contradiction between creativity and conformism because they are able to work at an above-average level. The social pressure of high achievements means that these people are less likely to be encouraged to be independent and more likely to require adjustment (Freeman 2016, p. 61).

The subject of this study were the features of school environment and individual features related to the creativity of mathematically gifted students. The results show that in the selected group, both the school environment and individual students' dispositions are conducive to their creative activity and the development of directional talents. A group of successful junior high school students in the mathematical competition was studied. This is a specific group, because

participation in the competition requires rivalry. This excludes from participation gifted youth, whose dominant motivation for the development of predisposition is perfectionism (characteristic for girls) or cognitive curiosity. This is probably the reason why there are three times as many boys as girls among the winners and finalists of the competition in question. However, these competitions have a useful role in stimulating and inspiring the development of abilities.

Results of presented research enable to draw a conclusion on the existence of mutual relations between the creative attitude and the achievement level of mathematically gifted students. Therefore, it is recommended to involve in the educational process activities developing creative attitudes and promoting originality in the thinking and functioning of students at school. In particular, it is worth to consider supporting the emotional and motivational sphere of attitudes, because it is the weakest link in the creative disposition of mathematically gifted students. It is about creating situations in which students experience the positive emotions of creative activity and at the same time compensate for the negative emotions associated with the risk of failure. Creativity liberates the potential of the learner, contributing to the development of own personality and revealing abilities.

The development of the potential of children and young people depends not only on the introduction of new content and exercises, but also on the creation of a specific climate for creativity in education. Its creator is first of all a teacher, who should have a strong creative motivation, together with students to look for original solutions to problems and experience with them positive emotions that accompany inventions. The dilemma faced by teachers is that of reconciling support for high school achievement with encouragement for talented students to have the courage to be creative and independent, and the risk of failure and defeat (Freeman 2016).

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