ACTA DIDACTICA NAPOCENSIA

Volume 8 Number 1, 2015

AN EDUCATIONAL PROGRAM OF MATHEMATICAL CREATIVITY

Constantin Petrovici, Geanina Havârneanu

Abstract: In this article we intend to analyze the effectiveness of an educational program of mathematical creativity, designed for learners aged 10 to 12 years, which has been implemented in an urban school of Iasi, Romania. This analysis has both a psycho-educational dimension and a statistical analysis one. The psycho-educational dimension refers to the coordinates of such a program: the curriculum vision and the teleological configuration, the structure, the teaching and assessment strategies applied in this program. The statistical analysis dimension refers to the evaluation of the performance and effectiveness of this program in terms of fluency, flexibility, originality, elaboration and sensitivity to problems, the five qualities of creative thinking. This evaluation will be performed using the SPSS on the results of two mathematical creativity tests administered to an experimental group before and after the implementation of the program.Our intention is to prove, using the SPSS statistical interpretation, that such education programs of mathematical creativity, despite their difficulties, may become a rich resource in the innovation of creative teaching, which can be exploited by the teachers to improve their didactic performance.

Key words: teaching mathematics, mathematical creativity, creatological methodologies, creative skills

1. Introduction

The education programs of mathematical creativity, despite their difficulties, are a rich resource in the innovation of creative teaching, which can be exploited by the teachers to improve their didactic performance, according to the idea that the main professional competence of teachers is designing training programs or programs adapted for different age levels/training and target groups [15], because the teaching competence is about knowledge (knows what), skills (know how) and attitude (know why), and the assessment of teaching competence implies evaluating the capacity to perform a number of professional tasks using an organized ensemble of knowledge, abilities and attitudes in various contexts of professional situations[14]. Skills are about applying the basic principles and methods for solving-problem/well-defined situations, typical for the domain; adequate use of the standard criteria and assessment methods, in order to appreciate the quality and process limits of the programs, projects, concepts, methods and theories; and development of professional projects by using principles and methods specific to the domain[16].

2. Psycho-educational dimension of the mathematical creativity education program

Curriculum vision

The mathematical creativity education program that we have proposed is a tool aimed at making teaching approaches operational, starting from the configuration of modern creative methodologies of teaching mathematics that have the effect of developing divergent, creative thinking, able to process information of a different nature, under time pressure, with maximum efficiency in perceiving, understanding, interpreting and solving problems.

Teleological configuration

The activity was designed by starting from a key criterion: to stimulate students' creativity by providing a favorable microclimate which leads to creation and knowledge, and fosters creative

Received March 2015.

problem-solving skills while structuring creative skills specific to mathematics, and developing creative attitudes.

Program structure

The program, materialized as an extracurricular activity [5] (one hour per week, each class participating in the experimental group), is a creative math problem solving workshop. The items chosen are of a demo-explanatory, heuristic-creative, inventive, creative and optimization type (W. Reitman, 1965) [17], avoiding those that require calculations, to minimize algorithmic practice in finding solutions to problems [3].

The chosen curricular model [4] is a composite one, following both the valorisation valences of the curriculum as development of cognitive processes and of self-actualization, because the curriculum was designed in view of orienting learning towards building attitudes and capacities, by developing their competences in problem solving and by using participatory strategies in learning activities. In addition, the curriculum is aimed at training creative thinking, after the model developed by S. Isaksen, D. Treffinger [11], following the development of the main areas of the cognitive domain: knowledge, comprehension, application, analysis, synthesis and evaluation [1].

The educational strategies involved in achieving the program are explicit, aiming to streamline the program of activating the creative potential of each student who participates in the program. The disadvantage is that we cannot apply the default type of educational strategies pertaining to the structure and quality of education, as in the case, for example, of selected urban schools.

Teaching and assessment strategies applied in this program

According to researchers, a teacher should be oriented towards new paradigms that he/she is not yet fully accustomed to: the interaction paradigm and the learning paradigm [13]. From this perspective we decided the teaching strategies configuration of our program. Teaching and learning methods are configured after creative learning principles, opting for analogical methods (analogical relations exercise [6], the comparison method, the method based on the synthesis represented by the scheme), antithetical (crushed method, the antitext or dialectic groups "face to face" method, steps restoration in the scientific discoveries method), random (based on bissociation [12]), analytical (self-questioning, brainstorming, synectic [7], P.A.P.S.A [8]) or other methods (mathematical investigation method, the mind mapping approach to the development of inventions, morphological analysis, problematization), which provide the advantage of fostering critical, creative thinking [2].

Pedagogical efficiency was achieved by detection of the optimal methods of teaching, learning and assessment, using the group free talk method to discover which factors will favor or, conversely, inhibit students in problem solving (analysis of information in the text, mathematical knowledge, dependence settlement schemes, the courage to choose new ways of solving, making drawings that favor the discovery solution, the desire to seek more ways to solve the problems).

3. Statistical analysis dimension of the mathematical creativity education program

Sample

Participants in the program are non-voluntary students of classes IV, V and VI of an urban school in Iasi. The sampling method used is that of stratified sampling with simple random selection (stratification variables as class, gender). In addition, because we intended to highlight the change in the selected population we used the investigation of fixed samples (panel) repeatedly, at regular intervals (general creativity test [18], mathematical creativity test [9]).

Yield of the program

The yield of the program, calculated by dividing the score achieved growth (after retesting) to the possible increase (to obtain maximum score) ranged between 14.95% and 23.17%. The lower yield is justified by the fact that many students showed reluctance to the program (52%), and among those who expressed interest in integrating active learning activities, only 60% showed enthusiasm, emulation, genuine critical and creative spirit (see Figure 1.).

On the whole experimental group, the yield program was 17.98%, which reveals its low efficiency. Some cases may be distinguished: a negative attitude to the idea of work done outside school hours, after the school program (either on the grounds that the curriculum is overloaded or because the usefulness of such a program was not understood), the rather low background of learners (which led to a slow evolution of those involved in learning activities), lack of interest in an activity that involves problem solving, lack of intrinsic and extrinsic motivation for extra work that is not rewarded by formal assessment or other material form of extrinsic motivation, lack of education for novelty, lack of responsiveness to the school's educational offer.

Risk ratio of the program

The risk ratio of the program is calculated by dividing the negative differences to the positive differences, by which we mean the number of students who have regressed relative to the number of students who have progressed. As any student who sat all tests did not regress, it can be considered that the risk coefficient of the program is 0.

Program effectiveness

The effectiveness of the program is to be analyzed globally, holistically so as to assess to the extent to which a real development of mathematical creativity could be achieved objectively, depending on the age group studied (grades IV-VI), age-specific particularities and peculiarities of the group which was the subject of analysis, and the specificities of the Romanian educational system, which are implicitly involved in influencing academic progress, the student's intellectual development and restructuring the creative component of each student's personality. The statistical interpretation of the experimental group results on the development of creativity, reveals that although the yield of the program was low, however, its effectiveness has been relatively high, as it clearly facilitated students' progress in the field of mathematical creativity, meaning that about 80% of the pupils obtained higher scores on the second test, and of these, about 10% made significant progress.

Analysis of program efficiency on creative thinking components

The statistical interpretation of the results of the experimental group on each component of mathematically creative thinking reveals that progress is manifested primarily by the uneven development of creative skills components.

Fluidity level

As regards fluidity it should be noted that a rate of 0.96% of pupils regressed, 49.04% stalled, 31.73% had a medium evolution, 13.46% performed well and 4, 81% showed a very positive development (see Figure 2.).

Flexibility level

At the level of flexibility results show that a rate of 0.96% of pupils regressed, 40.38% stalled, 39.42% had a mean evolution, 14.42% performed well, 3.85% had a very positive development and 0.96% had a particularly good development (see Figure 3.).

It should be noted that fourth graders demonstrated the most measurable improvements as regards fluidity and flexibility because at this age vocabulary development, and the acquisition of declarative knowledge are obvious, and last but not least, age-specific interest and curiosity made them more receptive to the learning activities proposed, which led to a rapid development of creative thinking components related to their participation in the program.

Originality level

As far as originality is concerned, results show that a rate of 1.92% of pupils regressed, 58.65% stalled, 11.54% had a mean evolution, 16.35% performed well, 4, 81% had a very positive development, 5.77% made obvious progress and 0.96% had a very good development (see Figure 4.).

Fourth graders had the most surprising developments. On the one hand, because their overall progress was significantly higher than that of students in other age groups, on the other hand, because there was a turnaround, namely, the class with the lowest fluidity and flexibility scores (IV B) with a score lower

on cognitive background compared to the parallel class, obtained significantly higher scores in the sphere of originality, which shows once again that the profound, intimate mechanisms of how the original idea is born are not fully known, but certainly not exclusively related to the individual's background. At the level of originality mention must be made of the remarkable progress of students in grade 6B; they showed the greatest enthusiasm and interest in learning activities structured on modern methodologies in the proposed program.

Elaboration level

In the elaboration level we can observe that a rate of 1.92% of pupils regressed, 7.69% stalled, 42.31% had a mean evolution, 25.96% had a good evolution, 12, 5% had a very good evolution and 9.62% had a particularly good development (see Figure 5.).

It should be noted that the progress at the elaboration level was felt at all age groups, and significantly so, less with fifth graders, where the development was important, but not significant, as they consistently showed disinterest in the program. In addition, it is noted that the elaboration level of mathematical creativity is dependent on the cognitive background, which is explained by the fact that if the resolvent approach is an enigma for the student, obviously, on the one hand they will not be able to translate it mentally in detail and, on the other hand, they will not manifest the joy of explaining it in minute detail.

Sensitivity to issues

At the level of sensitivity to issues results showed that a rate of 3.85% of pupils regressed, 17.31% stalled, 50.96% had a mean evolution, 21.15% performed well, 3.85% had a very positive development, 1.92% had a particularly good progress and 0.96% had a very good development (see Figure 6.).

It should be noted that the progress referring to sensitivity to problems was felt especially in the sixth grade, probably because age-specific psychological development allows them to fully express curiosity in different registers depending on their interests at a particular moment, and to exercise their imagination, which now becomes extremely rich and based on logical elements, because they begin to perceive the hypothetical dimension of things, and thinking becomes abstract.

Error! Not a valid link.

Figure 1. Yield of the program as regards classes

Error! Not a valid link. Figure 2. Evolution of the fluidity level

Error! Not a valid link. Figure 3. Evolution of the flexibility level

Error! Not a valid link. Figure 4. Evolution of the originality level

Error! Not a valid link. Figure 5. Evolution of the elaboration level

Error! Not a valid link. Figure 6. Evolution of the sensitivity to issues level

4. Conclusion

A deep analysis of changes in the two trials that fall diachronically the proposed and implemented mathematical creativity education program, emphasizes that as long as the educational factors, formal or informal, do not act convergently, by constantly focusing on the development of creativity, as it happens in the selected urban schools, creativity does not increase significantly after some sequential activities, organized at school level.

The conclusion that can be drawn is that without the involvement of all educational stakeholders, both at school (teachers, teachers, head teachers, principals) and family levels, the fate of extracurricular

activities is uncertain. This has a direct impact on the yield of such a program, which cannot be entirely successful. The involvement of educational factors serves to facilitate initially extrinsic motivation of students for participation in learning activities of the mathematical creativity education program, to create the material necessary for properly conducting the activities involved in such a program by providing an emotional environment involving the idea of constructive competition between participating students, the idea of disseminating the results obtained by students and of popularizing the best creations of students (most ingenious solutions to problems can be presented in the school magazine, which will impact the entire school population), through active involvement in coordinating learning activities, in the strategic and creative diversification of learning activities, in empowering students participating in the program.

References

[1] Bloom, B. S., (1963), *Raport on creativity research by the Examiner"s Office of the University of Chicago*, apud Taylor, C. W., Barron, F., *Scientific Creativity its recognition and development*, New York, Wiley

[2] Chiş, V., Ionescu, M., (1992), *Strategii de predare şi învăţare*, Editura Ştiinţifică, Bucureşti

[3] Chiş, V., Şerdean, Gh., Chiorean, M., (2001), *Gidul profesorului de matematică*, Editura Dacia, Cluj-Napoca,

[4] Creţu, C., (1998), *Curriculum diferentiat si personalizat*, Editura Polirom, Iaşi

[5] Creţu, C., (2000), *Teoria curriculum-ului şi conţinuturile educaţiei,* Editura Universităţii „Al. I. Cuza", Iaşi

[6] Fustier, M. et B., (1976), *Pratique de la créativité*, Librairies Techniques, Entreprise Moderne d'Édition, ESF, Paris

[7] Havârneanu, G., (2010), Tehnica GORDON / SINECTICA, în *Simpozion Naţional KREATIKON*, Editura PIM, Iaşi, , p. 61-63

[8] Havârneanu, G., *(*2009), Aplicaţiile metodei P.A.P.S.A. în predarea matematicii, în *Simpozion Naţional KREATIKON*, Editura PIM, Iaşi, p. 127-130

[9] Havârneanu, G., (2013), *Stimularea creativităţii prin predarea matematicii*, Editura Institutul European

[10] Havârneanu, G., (2014), *Evaluarea gândirii creative matematice*, Editura Performantica

[11] Isaksen, S., Treffinger, D., (1985), *Creative Problem Solving: The Basic Course*, Bearly Limited, Buffalo, New York,

[12] Koestler, A., (1965), *Le cri d'Arhimède*, Editura Calmann-Levy, Paris

[13] Masari, G.A., Petrovici , C., (2014), *A Critical Perspective Regarding Pre-service Teacher Training and Competences Needed of Kindergarten Teachers from Romanian Education System*, Procedia-Social and Behavioral Sciences 146, p. 22-27

[14] Petrovici , C., Masari, G.A., (2014), *Aligning the Academic Teacher Training Curriculum for Preschool and Primary School Education to the Requirements of the RNCIS*, Procedia-Social and Behavioral Sciences 142, p. 731-737,

[15] Petrovici , C., Masari, G.A., (2014), *Content Analysis of Syllabus for Students of Kindergarten and Primary School Pedagogy according to the Professional Competences*, Procedia-Social and Behavioral Sciences 146, p. 28-33

[16] Petrovici , C., (2014), *Professional and Transversal Competences of Future Teachers for Preschool and Primary School Education*, Procedia-Social and Behavioral Sciences 142, p. 724-730

[17] Reitman, W. R., (1965), *Cognition and thought. An information processing approach*, New York: John Wiley & Sons, Inc., p. 312

[18] Stoica-Constantin, A., Caluschi, M., (2005), *Evaluarea creativităţii*, Editura Performantica, Iaşi

Authors

Constantin Petrovici, Al. I. Cuza University, Iasi (Romania), cpetrovici@psih.uaic.ro

Geanina Havârneanu, Al. I. Cuza University, Iasi (Romania), havi@uaic.ro