

SYNERGETIC FUNDAMENTALS OF MATHEMATICS EDUCATION

Penka Karadzhova, Dobrinka Boykina

Abstract. *An analytical overview of some basic research on synergetics as a new educational paradigm is presented. Some guidelines for the application of the synergetic approach in the education of students and university students – future teachers of mathematics, are outlined.*

Key words: synergetics, synergetic approach, educational paradigm.

Teaching as a profession faces significant challenges in recent decades. They are mostly related to the occurred changes in the attitude of the learners towards the scholastic work. In order for students to develop an interest in learning material and motivation to learn, teachers must first and foremost be their mentors and mediators. In addition, teachers need to take responsibility for their own education, to develop and improve themselves, to innovate in teaching methods, to adapt easily to changes and emerging situations, and to acquire new skills.

K. Marulevska points out that according to E. Morin education should develop the natural ability of the human mind, to contextualize and integrate [19], and very accurately notes that: “The educated person in the modern world must be able to orientate in the overloaded information and communication space, to possess global and creative thinking, to be able to use his intellectual potential for continuous personal development, as well as to solve specific problems.” [13]. According to her, in the search for adequate models of education the achievements of synergetics can be used successfully [13].

As E. Knyazeva notes [12], synergetics claims to be one of the newest independent sciences. According to the creator of this science, Hermann Haken, synergetics studies the joint action of the elements of complex, nonlinear systems, their ability to self-develop and self-organize, studies the emergence of new properties. “The main question it considers consists in this – are there general principles governing the behavior of complex systems when qualitative changes are taking place in them.” [8]. M. Busev considers that “self-organization is a process in which global external

influences stimulate the inclusion of internal for the system mechanisms, due to which certain structures occur in the system” [2].

In her monographic work “Synergetics in the scientific and educational space”, K. Marulevska interprets the new pedagogical realities from the standpoint of synergetics and devotes an important place to the application of synergetic ideas in the modern educational space. She emphasizes the application of the ideas of synergetics in the complex process of training and education and outlines the main tendencies in the application of the synergetic approach in the educational process. K. Marulevska refers to V. Budanov, who considers three areas of application of synergetics in education: synergetics for education – inclusion of synergetic knowledge in the different degrees of education; synergetics in education inclusion in various private disciplines of materials illustrating the principles of synergetics; synergetics of education – synergetics applied to the process of training and education [1].

According to E. Knyazeva and S. Kordyumov, synergetics in pedagogy should be considered in two ways: in the context of a method, i.e. as a synergetic approach, as well as for synergetic analysis of the educational and pedagogical process; in the context of the content of education training students and university students in synergetic knowledge and forming in learners a synergetic view of the world [11].

Analyzing numerous studies (of Bushev, Haken, Knyazeva, Nazarov, Nalimov, etc.), dedicated to synergetics, V. Milloushev establishes that “synergetics can be considered as a systemic reflection based on self-organization” [15]. He justifies “not only the necessity of applying a synergistic approach in education, but also to deepen researches (in methodological aspect) in that direction.” [15], for this purpose he quotes S. Grozdev: “In education ... there are a number of processes and phenomena whose internal mechanism is synergistic. Undoubtedly, it is necessary to reveal this mechanism in order for it to be understood, studied and used correctly” [5].

In this direction works V. Milloushev [16, 17, 18], coordinating the modern methodological developments with the reflexive and synergetic approaches and with the theories based on them. He considers that the characteristics of self-actualization “give an idea to develop the problem of searching for mechanisms and technologies for its implementation from the point of view of self-organization in a synergistic aspect” [15]. Considering synergetics as a systemic reflection, the author proposes a structural

model of the system “trained trainer” in the context of his newly created reflexive-synergetic approach and comes to the conclusion that: “In each of the subjects of the subsystem “trained trainer” are hidden structures-attractors for the respective perspective development ” [18].

According to V. Milloushev, “self-organization can be both explicitly (mostly for the teacher) and / or implicitly (for the student) aware on a synergetic level, i.e. it is appropriate to differentiate and consider the type of “reflexive-synergetic self-organization” [14]. In this direction also works his doctoral student N. Ivanova, which creates and approbates educational technology for the formation and development of reflexive abilities in students [9].

Based on the thesis of S. Grozdev [5, 6] that “Organization and self-organization are some of the main components in the management of the students’ potentialities, as well as in the solving problems itself.” [6], V. Milloushev came to the conclusion that “the conclusions made could be adapted and referred to the preparation of students for matriculation and entrance exams” [15].

We believe that these conclusions could be adapted to all learners entities, in particular to students, incl. and the future school mathematics teachers, who, depending on the considered context, take on the role of both learner and trainer. This is because the educational cooperation seen from a synergistic point of view, changes not only the learner but the trainer he self-develops and improve himself. In order to apply the synergetic approach in the educational process, the teacher himself needs to be a synergetically thinking person.

We agree with D. Galabova that: “The thinking person does not stop learning for the rest of his life. The main task of education is the personal orientation related to the ability of a person to maintain their own identity and constantly build themselves.” [4]. Pedagogical synergetics aims to stimulate teachers to seek and create pedagogical innovations that have a significant positive effect [4].

Correct is the conclusion of R. Gaidova that “synergetics makes an attempt to justify a new understanding of the educational process, as a movement from the synthesis of the achievements of different scientific fields and disciplines. This requires to go beyond the traditions in education, related mainly to the transmission of social and cognitive experience,

and to be performed an anticipatory-developing role with an emphasis on preparation of the human (the child, the pupil, the student).” [3]. According to her, “the application of the synergetic approach in education is a significant achievement of pedagogical science in the training of pedagogues” [3].

L. Karakasheva considers the projects method as a good opportunity for the formation of methodological competence in mathematics students and presents its synergetic model [10]. According to her “the projects method allows through resonant, i.e. small but adequate and well-organized interactions on the part of the university lecturer to awaken the creative energy in the student and to initiate the process of development, self-development and self-improvement” [10]. She justifies the usefulness of applying the synergetic approach to the development of skills in students for the implementation of “awakening” learning by presenting sample individual course and diploma projects.

K. Marulevska presents a specific option for application of the synergetic approach in education in the conditions of project-based learning activity, emphasizing the possibility to use the developing potential of the project learning activity in different stages and levels of the educational system, taking into account the specifics of implementation, “depending on the age characteristics of the learners” [13]. She points out the possibility of including synergetic ideas in the research strategy of pedagogy to create new tools and enrich its conceptual apparatus with universal synergetic images and ideas, which “will create conditions for improvement of the educational system and the educational process on the basis of forecasting the most effective ways of development” [13].

We too believe that the application of the projects method in teaching and learning mathematics affects the subject-subject relations and is the base for the formation and development of mathematical, informational, social and personal competencies in both school and university students.

Project-based learning can fit into school learning and include the application of several technologies, including computer programs, audio-visual technic and real-life research.

In conclusion, we will note that organization and self-organization, as main components of the synergetic approach, can be laid at the foundation of an educational paradigm aimed at building modern teachers having

as their credo the maxim “understand, learn, master, can, act”. Furthermore, these verbs, expressing active action by the subjects, in our study are aimed at achieving succession in mathematics education both in terms of educational content included in the different levels of the school and between different classes in the same school level, as well as succession between the particular topics in mathematics in a given class, on the one hand, and in terms of the implementation of succession in the training itself in the system “trained trainer”, on the other hand. This presupposes an appropriate didactic adaptation of the respective educational content in order for it to be meaningful for the subjects participating in the educational process so, as to achieve the above-mentioned maxim as much as possible. We set this as an “ideal goal” of methodological technology, pursuing the implementation of synergism in mathematics education and in secondary school. These ideas will be the subject of research in future publications in order to develop an upcoming dissertation work.

References

- [1] V. Budanov, *The Era of Bifurcations and Synergetics in Education – Moscow Synergetic Forum*, Theses, Moscow, (1996), (in Russian).
- [2] M. Bushev, *Synergetics; Chaos, Order, Self-organization*, “St.Kliment Ohridski” University Press, Sofia, (1992), (in Bulgarian).
- [3] R. Gaidova, Self-organization and Integration of Micro- and Macrosystems in the Preparation of Technique and Technology for Students of Pedagogical Specialties, *Scientific Papers of University of Ruse “Angel Kanchev”*, (2012), Vol. **51**, Book 6.2., ISSN: 1311-3321, (in Bulgarian).
- [4] D. Galabova, *Pedagogical Synergetics*, University of Veliko Turnovo “St. Cyril and St. Methodius”, Veliko Tarnovo, (2012), ISBN: 978-954-524-879-5, (in Bulgarian).
- [5] S. Grozdev, *For High Achievements in Mathematics: The Bulgarian Experience (Theory and Practice)*, Ruta, Sofia, (2007), ISBN: 978-954-92139-1-1, (in English).
- [6] S. Grozdev, Organization and Self-organization in the Mathematical Problem Solving, *Mathematics and Informatics*, (2002), Book 6, 51–58. ISSN: 1310-2230, (in Bulgarian).
- [7] S. Grozdev, Synergetics of Learning, *Pedagogy*, (2002), No. 7, 3–23, ISSN: 08613982 (in Bulgarian).
- [8] H. Haken, Synergetics and Some of Its Applications in Psychology

- (translated by E. Knyazeva), *Synergetic Paradigm. Non-linear Thinking in Science and Art. Progress-Traditsiya*, Moscow, (2002), 296–306, (in Russian).
- [9] N. Ivanova, *Reflexive and synergetic aspects of heuristic activity in planimetry training (in VII – VIII grade)*, Dissertation abstract, Plovdiv, (2015), (in Bulgarian).
- [10] L. Karakasheva, On the Project Method for Creating Methodological Competence in Prospective Teachers, *Anniversary International Scientific Conference “Synergetics and Reflection in Mathematics Education”*, 16–18 October 2020, Pamporovo, 71–77, (in Bulgarian).
- [11] E. Knyazeva, S. Kordyumov, *Foundations of Synergetic: Exacerbation Regimes, Self-organization, Tempo-worlds*, Alethea, Moscow, (2002), ISBN: 5-89329-517-X, (in Russian).
- [12] E. Knyazeva, 30 Years of Synergetics (Interview with H. Haken), *Pedagogy*, (2006), No. 5, 3–12, ISSN: 0861-3982, (in Bulgarian).
- [13] K. Marulevska, *Synergetics in the Scientific and Educational Space*, “Sanin Nin” Press, Blagoevgrad, (2009), ISBN: 978-954-9382-56-3, (in Bulgarian).
- [14] V. Milloushev, Reflective-synergetic Approach in Mathematics Education, *Strategies for Policy in Science and Education*, (2016), Vol. **24**, 69–85, ISSN: 1310-0270 (Print), ISSN: 1314-8575 (Online), (in Bulgarian).
- [15] V. Milloushev, Elements of the Reflexion and Synergetics in Mathematics Education, *Anniversary International Scientific Conference “Synergetics and Reflection in Mathematics Education”*, September 10–12, (2010), Bachinovo, 213–220, (in Bulgarian).
- [16] V. Milloushev, *The Triad of Activities Solving, Creating and Transformation Mathematical Problems in the Context of the Reflexive-synergetic Approach*, Abstract of a Dissertation for Awarding the Scientific Degree “Doctor of Pedagogical Sciences”, Sofia, (2008), (in Bulgarian).
- [17] V. Milloushev, About Synergetics Principles and Their Concretization in Education of Mathematics, *“Didactics of Mathematics: Problems and Investigations”* (International Collection of Scientific Works), Donetsk: DonNU, (2009), Iss. 32, 7–15, (in Russian).
- [18] V. Milloushev, The Reflective-Synergetic Approach in Education, *Scientific Papers of Plovdiv University “Paisii Hilendarski”*, (2008), Vol.

45, Book 2 – Methods of Education, 43–53, ISSN: 0861-279X, (in Bulgarian).

- [19] E. Morin, *The Well-Done Head: Rethinking Reform, Reforming Thinking*, “Polis” Press, Sofia, (2000), ISBN: 9549072827, (in Bulgarian).

Penka Karadzhova^{1,*}, Dobrinka Boykina²

^{1,2} Paisii Hilendarski University of Plovdiv,
Faculty of Mathematics and Informatics,
236 Bulgaria Blvd., 4003 Plovdiv, Bulgaria

* Corresponding author: penka_kkk@abv.bg

