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REVIEW OF POLICY ENVISIONS AND REQUIREMENTS FOR STEM TEACHERS IN BULGARIA

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Abstract. The article precents a review of the normative framework in Bulgaria related to the development of STEM teachers' competences. It studies explicitly defined requirements: pedagogical, academic, administrative and communicative competences, as well as implicitly defined ones, integrated in National Educational Standards and students' curricula: research, team work, ICT, work on a project, management of inquiry-based learning, etc.

The authors identify dimensions and aspects of STEM teachers' competences, set out the major issues for consideration in providing teachers' training, and formulate six Key messages to providers of STEM teachers' trainings and policy makers, related to forms, content, approaches and responsibilities of institutions.

The goal of the research is for the results to be used in European computer-assisted blended learning teacher trainings. They provide requirements to the training design as well as to the software platforms for implementations of trainings.

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1. Introduction. During the last decades, Bulgaria faced the need of dramatic changes in the educational system and regulatory framework. The low level of functional literacy of Bulgarian students, the high percentage of drop-out students, old and cumbersome regulatory framework in education, economics development, labour market and business needs, etc., are just some of the factors determining the need of educational reform in the country.

The reform started in 2010 and as of 2016 it is in effective use. The recent Law on pre-school and school education speaks of education as a national priority. It keeps the balance between regularity and autonomy (authority) of the players. It delegates more rights to the schools, teachers, parents and students to take decision and respective responsibility for their relationships. The simpler framework guarantees the transparence and predictability of the policies in the educational system.

The main goals of the educational reform are:

- change of the educational system;
- increasing the quality of general education;
- defining new educational levels and providing possibilities for more students to graduate;
- possibility to separate students who would like to go to the labour market after their 16th year from those who would like to prepare for university education;
- increasing the quality of teaching and possibilities for career development of the teachers.

The Law on pre-school and school education offers new understanding of educational standards focused on the achievement of the educational goals and outcomes, national qualification framework and competences which should be developed at pre-school and school age, regulation of inclusive education as a part of the human educational rights, etc.

The Law provides more flexibility and freedom in curricula, providing autonomy to schools to develop their own curricula for extensive and extracurricular learning courses. It also governs the validation of competences developed by an informal or non-formal educational process. The Law

guarantees a possibility for implementing individual, distance or blended forms of education.

The law pays special attention to qualification and career development of the teachers. It introduces:

- mandatory qualification for in-service teachers (48 academic hours per attestation period), measured by ECTS credits;
- mandatory internal institutional qualification (16 academic hours per year);
- an attestation period of 4 yours for all pedagogical specialists;
- possibility for professional development for all pedagogical specialists;
- opportunities to attract young people to work as teachers by introducing new positions: trainee-teacher and mentor teacher.

Within the frame of the Law on pre-school and school education there were developed 19 National standards and other sub-law regulatory documents. The main ones, related to the general and STEM education, are:

- Ordinance on National requirement for acquiring the professional qualification of teacher, which formulates the teachers' competences and defines a model for career development of teachers.
- Ordinance #12 on the status and professional development of teachers, headmasters and other pedagogical specialists. It pays special attention on:
    - teachers' competences;
    - teachers' career development;
    - stimulating teachers' research;
    - stimulating application of innovative methods of teaching.
- Ordinance on inclusive education.
- National Educational Standards on the expected results of STEM education, focused on the development of the key competences. As a consequence, the new curricula for each school subject and each grade, containing subject learning content description as well as recommendations for appropriate teaching approaches.

2. Dimensions and aspects of (STEM) teachers' competences according to the policy documents. The national policy documents, based on relevant European policy documents, provide evidence for requirements for covering each of the three key dimensions of teachers' competences—knowledge and understanding; skills; dispositions.

2.1. Knowledge and understanding. The basic aspect of required knowledge is the deep knowledge in the subject matter: *… as a minimum, teachers should have a specialist knowledge of the subject(s) they teach* [4]. The requirement reflects on the main national policy document ORDINANCE #12 of 1 September 2016 on the status and professional development of teachers, headmasters and other pedagogical specialists [13], which defines the National Standard for the requirements to and qualification of pedagogical staff, as well as the path of career development of teachers, headmasters, and other pedagogical specialists. The requirements for taking up a position as a teacher are explicitly defined—the initial degree that the candidate must have graduated with and, in some special cases, additional courses or continuous professional development (CPD) for every specific learning discipline. For STEM teachers the requirement is to have a bachelor's or master's degree in one of the following: science (mathematics, informatics, physics, chemistry, biology, etc., according to the subject taught), pedagogy of education in... (specific subjects), or engineering. The same document defines the types of qualification of a pedagogical specialist: *…2. long-life—directed to professional and personal development… through: short-term training courses dedicated to periodical actualisation of subject knowledge, to development of skills to teach key competences, to knowing and applying innovative approaches in education… etc.*

Special attention in the policy documents is paid to **inclusive education**. *Equal access to high-quality education, inclusion of every student and child* is a priority defined in the Law on pre-school and school education [6]. During the educational reform, a National Standard about inclusive education [11] was developed. The standard defines principles and conditions for students' inclusion in educational process independently of their individual characteristics, special educational needs, ethnic and cultural specifics, etc. The standard recommends that teachers should be able to *apply differentiated pedagogical*

approaches in accordance with interests and stimulating the motivation of the child and the student, adapted to the age and social changes in his/her life and adapted to his/her ability to apply the acquired competencies in practice, which means that at least they should have a theoretical basis on the specific educational needs and a variety of pedagogical approaches for differentiated education. The issues of inclusion and diversity are also a subject matter of the National requirement of the teaching profession: the teacher's responsibility is *planning and conduction of educational process in accordance to: … encouraging achievements and providing the necessary support and assistance for their (the students') full integration into the educational and social environment according to their specific needs.*

In Bulgaria the use of **ICTs in education**, reported in the Science Education in Europe: National Policies, Practices and Research, Figure 3.4 [3, 72] and Key Data on Learning and Innovation through ICT at School in Europe 2011 [2, 69], became a good tradition in the last 10 years. These good practices are kept in recent policy documents—as is written above, the National requirements for teacher qualification includes at least 30 academic hours of study of the use of ICTs and digital environment in teaching process [10].

Current policy documents also focus the attention on the use of **innovative teaching methods** in all teaching disciplines. Ordinance #12 [13] states that *the position of a teacher includes the following features … use of effective methods of teaching….* It stimulates teachers to gather knowledge on different modern innovative educational methods not only through formal education but also by participation in large teachers' networks (national general or thematic, Scientix, etc.), teachers forums, conferences, experience exchange events. There are many initiatives, led by the Bulgarian Academy of Sciences and universities, providing interactive teachers' events as well as handbooks and tutoring in the local language on active participation in the Europe-wide teachers' community [5].

Another aspect of teachers' competences is focused on knowledge and understanding of the key role of **evaluation and assessment** methodologies and techniques. The policy documents comment on different aspects of the evaluation process:

- students' assessment—formative and summative;

- teachers' assessment in relevance to career development;
- educational process/system evaluation at macro level.

Ordinance #11 [12] describes the National Educational Standard on assessing students' achievements. It determines the components, types and forms of assessment of students' educational achievements; the terms and procedure for organizing external evaluation and maturity exams; recognition of skills in arts and sports; etc. The document precents the different forms and types of assessments, the role and expected responsibilities of teachers, the importance of formative assessment in tracking students' progress, as well as the role of summative assessment for diagnostics, monitoring and future improvement of educational policies.

The assessment of teachers' proficiency is discussed in ORDINANCE #12 [13], where the attestation card is provided. The document treats teachers' knowledge, understanding and skills for self-assessment as crucial for his/her career development.

Far fewer teachers are involved in evaluation of the educational process—mainly in conduction of the evaluation procedure at operational level.

2.2. Skills. All the policy documents treat teachers' **academic and pedagogical** competences as a whole—all the knowledge listed above is accompanied by relevant skill for design, conduction and evaluation of the teaching process.

For in-service teachers, the **pedagogical competences: planning, teaching, evaluation and assessment, class/group management** take a special place in the procedure for teachers' attestation [13].

In addition, the teachers' assessment card in ORDINANCE #12, Appendix #2 [13] defines two more groups of teachers' competences: **communicative competence** and **administrative competence**.

Communicative competence includes **team working skills**—partnership with other pedagogical specialists and school managers, didactical support and mentoring of newly recruited teachers, leadership skills and skill for taking decisions at school policy level and corresponding responsibility, participation in institutional, out-of-school, cultural and social activities; and **skills for collaborating with parents and other stakeholders**—including

parents in educational process, support and stimulation of the parents of children with special educational needs, etc.

Administrative competence relates to familiarity with the National Educational Standards and skills to apply them, ethics in work with children, privacy of personal information, work with policy documents.

Not least, the teacher is expected to act as a **researcher** in the classroom and to develop sustainable competences in the field [13]: *The qualification of pedagogical specialist... is: ... 2. long-life—directed to professional and personal development... through: participation in* ***research***, ***inquiry*** *and* ***creative*** *activities.*

2.3. Disposition, beliefs, attitude. The Law on pre-school education pays special attention to **commitment to promoting learning to all students**. One of the main principles there is *Equality and non-discrimination when conducting pre-school and school education* [6]. The principle is expressed in:

- equal access and inclusion of every child and student;
- humanism and tolerance;
- safety of cultural diversity and inclusion through the Bulgarian language.

The Ordinance on inclusive education [11] regulates the public relations relating to the provision of Inclusive education of children and pupils in the pre-school system, school education, as well as the activities of the institutions in this system on providing support for the personal development of children and students. It requires:

- unique support of the personal development of each pupil in accordance with his/her special educational needs;
- differentiated pedagogical approaches in accordance with the personal interests and motivators of the student, age and social life and changes;
- acceptance of and respect to the uniqueness of each child and pupil—individual needs and opportunities, personal qualities, knowledge, skills and interests to which the educational institution must respond in such a way that the children or pupils can maximize their potential;

- a systematic and holistic approach in the organization and collaboration of educational institutions; etc.

The ordinances accompanying the recent law contain special dispositions to **change, flexibility, ongoing learning and professional improvement, including study and research**. According to the Ordinance #12: *47. Organizational forms of long life qualification are: … (6) forums (conferences, contests, planers, etc.) in accordance to precent research results, studies, best practices, innovative practices or achievements* [13].

- Principles:
    - humanity and tolerance;
    - the preservation of cultural diversity and inclusion through the Bulgarian language.
- Goals:
    - acquisition of competences needed for successful personal and professional development and active civic life in modern communities;
    - acquisition of competences for understanding and application of principles, rules, responsibilities and rights arising from EU membership.

The Law is supported by a special Ordinance on civic, health, ecological and intercultural education [9], which states that *Civic education is aimed at forming civic consciousness and civic virtues and involves knowledge about the formation of a democratic society, the rights and obligations of the citizen, and skills and readiness for responsible civic behavior.*

3. Dimensions and aspects of STEM teachers' competences evident in teacher training curricula/documents in the country. The Law on pre-school and school education and accompanied regulatory framework is quite new—it has been in effect since 2016. At this moment the institutions responsible for teachers' education and development are in process of developing new educational plans and curricula in order for schools to be able to implement the recent regulation in the beginning of the 2017/2018 academic year. This is the reason for the lack of

information about how the universities and other institutions will respond to the new rules in teachers' development. Moreover, not only the universities, but also the separate faculties (preparing teachers in different disciplines) have their academic autonomy in deciding what subjects to teach, by what curricula, to what depth and what content to include.

The main regulatory framework in teachers' development is provided by the Ordinance on National requirements for acquiring the professional qualification of teacher. The other main aspect of the required teachers' knowledge and understanding is in the field of **pedagogy and educational technologies** as well as the field of **psychology**. The knowledge of how to teach in general and how to teach a specific subject are crucial for the teaching profession in Europe: *Initial teacher education is an intensive experience that requires student teachers to be both learners and teachers simultaneously – being supported in learning how to teach, and supporting pupils in how to learn* [1]. In correspondence with this need, the Ordinance on National requirements for acquiring the professional qualification of teacher [10] suggests the minimal academic hours pre-service teachers have to learn:

- Pedagogy: 60;
- Psychology: 60;
- Pedagogy in... (specific subject): 90;
- Inclusive education: 15;
- ICT in education and work in digital environment: 30.

The policy document defines the minimum of academic hours for studying basic disciplines, but it does not provide any requirements for the learning content. That is the responsibility of the training providers.

The Ordinance defines who can teach specific school subjects. For STEM teachers it is expected to have a stable base in a **specific content** (they should have a basic bachelor's or master's degree in the field) and to have taken additional or parallel courses in **pedagogy and psychology**. The experience at Sofia University and discussion and forums with other teachers' training institutions shows a gap between subject matter education and pedagogical education—usually both groups of disciplines are led by professors

with very different expertise without any competition. The relationship between both groups of subjects is the responsibility of departments of pedagogy in the specific subject.

The main organizations that are eligible to prepare STEM teachers are universities. Most of them train dual subject teachers—biology & chemistry, physics & mathematics, physics & chemistry, mathematics & informatics, chemistry & informatics, etc. There is a good practice at Sofia University to share disciplines between pre-service teachers from faculties of chemistry, physics and mathematics and informatics. In this specific case, the IBL is taught in parallel with ICT in education.

In addition to main teachers' training providers, other institutions can also provide (usually short-term) teacher training courses—Bulgarian Academy of Science (BAS), special departments for teachers' CDP, NGOs, etc. Since 2016 the National register of teachers' qualifications programs [8] has been developed. All the courses are approved by the Ministry of Education and Science and provide corresponding ECTS credits which are required for the teachers' attestation and professional development. Unfortunately, only a brief annotation of the course is publicly accessible. According to it, the main directions of **STEM teachers' courses** are:

- subject matter courses dedicated to the new curricula in a specific subject and class;
- innovative methods of teaching;
- application of ICTs in specific subject education.

It is a good practice that some of organizations provide proven courses at European level developed under European research projects. For STEM teachers' a special place has been taken by **Inquiry-based learning courses** related to the corresponding EU projects and networks: Mascil (BAS), weSPOT (Sofia University), Scientix (BAS).

4. Dimensions and aspects of STEM teachers' competences that are implicitly evident from students STEM curricula. The Bulgarian educational systems defines two types of schools: general schools and professional schools. STEM subjects are compulsory in

both schools until graduating from the first level of secondary school. In general schools, the second level of secondary school, there is a National standard for profiled education in STEM subject. The standards and the corresponding curricula are used by the schools which have chosen to offer profiled education in the field.

The National standards for STEM education acknowledge the necessity for a STEM teacher to be very familiar with the **subject matter**. The second level, whose goal is to prepare pupils for universities, requires these teachers to have much more academic knowledge than those teaching at the first level. The National standards for first and second level of STEM learning also reveals additional teachers' competences, implicitly described there.

The National standard about learning content [7], App#3—mathematics, informatics and ICTs specify the following goals for the basic education (grade 5–7):

- forming logical thinking, combinability, observability and mathematical competence;
- empirical formation of part of the geometric knowledge for the first level (grades 8–10):
- developing the ability and desire of the individual to use mathematical methods of thinking and presentation—by means of formulas, models, constructions, graphs, diagrams—in general, "working with data";
- taking responsibility for independent completion of tasks as well as showing an attitude and choice of decision and behavior according to specific problems and circumstances.

The goals implicitly show that the teacher should be able to lead the **Inquiry-based learning (IBL) process** as well as to form the different levels of the student's **research skill**. The same requirement is much more explicitly stated in the National Standards in Human and Nature, Biology and Health Education, Chemistry and Environment, Physics and Astronomy, where the next goals are described:

- Ambient world (grades 1–4): Forming skills to study of environment changes through discovery of data, facts, and by observatory of processes and phenomena

- Human and Nature (grades 5–7):
    - Stimulating curiosity towards nature...
    - Forming skills for researching objects, processes and phenomena in nature
    - Using primary (observation, experiment) and secondary (schemes, charts, graphics, models, etc.) sources of information, related to organisms, solids, substances, natural phenomena and processes.
- Biology and Health Education (grades 5–7, 8–10):
    - Forming practical skills for working with laboratory instruments, appliances and apparatuses, observation and study of objects of the nature.
    - Development of curiosity towards wildlife.
    - Forming practical skills for observation and study of different levels of organization of live matter.
- Physics and Astronomy (grades 8–10): Development of practical skills for preparation and conduction of observations and experiments, use of physics' instruments and apparatus, measuring physical magnitude, and verification of physical laws.
- Chemistry and protection the environment (grades 5–7, 8–10):
    - Forming skills for observation and comparison of objects, noticing causal links; explaining properties of substances through their construction, aggregation of information; formulating conclusions.
    - Developing skills for autonomous learning by exploring information presented through text, tables, charts, patterns, diagrams, including using ICT; discussing the impact of the studied substances on the environment and people.

The same standard and the STEM curricula implicitly reveal also the teachers' competences in the development of **critical thinking**, **creativeness**, **team-work skills**, and **project work skills**:

Critical thinking:

- ICTs (I level): development of informational culture, critical and responsible attitude to the information.
- Biology and Health Education (grades 8–10): Forming of critical thinking and rationalising one's position in solving specific cases and problems related to one's own and one's relatives' health and the protection of the environment.

Creativeness:

- ICTs: Creative use of the possibilities of the modern technologies for processing information, solving problems and communication.

Team working skills:

- ICTs: Working online in team on a common problem.

Work on a project:

- ICTs: Forming skills for team work in development, presentation and documenting of a group project.

The requirement of the STEM curricula on the interdisciplinarity of the learning process means that the teacher should have a good base on other STEM subject as well as to act as a **team member** in a local teachers' community:

- Mathematics (II level): developing an ability for application of mathematical thinking and reasoning in solving problems in other disciplines learned.
- Informatics (I level): modelling objects of the real world.
- Ambient world (elementary): developing integrated knowledge about the ambient world.

A very important teacher's competence is to use ICTs in the teaching process, as in Bulgaria students use ICT in class *and* for complementary activities (homework, projects, research) in Mathematics and Science at all grades [2] (Figure C3: Student use of ICT by subject area according to official steering documents in primary and general secondary education, p. 46).

5. Conclusions. The review of the National policy documents from the perspective of the requirements for development of STEM teachers' competences leads to the major issues for consideration in terms of design, organization, delivery and conduction of STEM teachers training courses, formulated below as *Key messages* to the providers of teacher training.

The educational reform defines a new profile of the teacher as a main actor in the educational process. Although there is strong experience in the experiences collected a few decades ago [14], the change of the in-service teachers' knowledge, skills and attitudes, as well as professional life habits and behavior in parallel with accepting a new understanding of teachers' responsibilities, is a big challenge not only for the teachers themselves but also for supporting institutions—Ministry of Education and Science, Regional Management Centers of Education, teacher training institutions and schools. Only working together, they can react to:

Key message 1: The academic, pedagogical, communicative and administrative teachers' competences needed to be developed and supported all together.

Key message 2: Teachers needs to act as a researchers and innovation providers in the classroom.

Just a few years ago the schools were strongly advised to follow the national directions on management, internal organization of school life, and development strategies according to the school type. Today they have more autonomy and freedom for decisions, and accordingly more responsibilities.

Key message 3: Schools and teachers are more flexible to reflect to the users' expectations and economy changes, and they needs to manage their own strategy, curricula and approaches to teaching.

The teachers' training institutions face the challenge to prepare new curricula, corresponding to the new requirements for teachers. At the same time they should support in-service teachers in developing their competences according to recent rules and methodology of teachers' assessment, providing relevant courses for CPD in appropriate forms, duration and places.

Key message 4: The teacher training institutions needs to respond to the new requirements of schools and teachers with new curricula and updated learning content, and to be flexible for permanently changing requirements.

The educational reform opens the doors for business companies and NGOs to provide short-term teachers' trainings. These give possibilities for publishers to participate in the teachers' competence development process, familiarizing them with new students' textbooks and learning resources, for business companies to prepare teachers to develop particular professional skills in professional schools, for NGOs to provide support and training in inclusive education issues, etc.

Key message 5: Institutions and organizations eligible to provide short-term thematic training courses need to be prepared for their new role and understand this responsibility.

The students' curricula demonstrated the need for STEM teaches' to be able to stimulate the pupils' natural curiosity to science and nature, and to develop students' inquiry skills—to organize different levels of experiments, to observe a variety of phenomena, to make conclusions and to rationalise them. In addition, teachers are required to act as pedagogical researchers in the classroom, to share their experimental results, and to be able to evaluate the innovative experience of other teachers in a critical way.

Key message 6: The application of IBL in STEM subject teaching should be interwoven in the development of competences, curricula, training and practice on all levels and in all institutions.

All of these key messages are not only a challenge for all the stakeholders but they also provide a set of possibilities for a new way of communication and collaboration between institutions. The real educational reform is possible only with a common effort of all sides.

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