PREPARATION OF FUTURE MATHEMATICS AND INFORMATICS TEACHERS FOR COMPETENCY-BASED EDUCATION

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Abstract. *In recent years, the implementation of Competency-Based Education (CBE) has become a key priority for the Bulgarian educational system, representing a critical stage in the preparation of future teachers. Although these students have not been educated under the new paradigm themselves, with appropriate pedagogical preparation and methodological support they can effectively and rapidly apply its principles in school practice. This article analyzes the main challenges related to the teaching and implementation of CBE and presents a system developed and piloted in the training of mathematics and informatics students. The proposed approach integrates adapted task design and teaching methodologies aligned with the competence model. It supports interdisciplinary integration and the practical application of competencies, thus bridging education with the real needs of the labor market and ensuring learning outcomes consistent with professional standards and requirements.*

Key words: Competency-Based Education, Teacher Training, Interdisciplinary Integration, Professional Competences, Project-Based Learning, Labor Market Relevance.

Introduction

The implementation of Competency-Based Education (CBE) represents a strategic necessity for the modernization of the Bulgarian educational system with the preparation of future teachers being crucial for its successful realization. Similar trends are observed globally, where CBE is regarded as a response to digital transformation and the need to develop key 21st-century skills [13, 17].

In the European Qualifications Framework (EQF) [19], competence is viewed as a combination not only of knowledge and skills, but also of the degree of responsibility and autonomy that individuals demonstrate in their application. Overall, CBE entails a shift in the educational paradigm—from an emphasis on knowledge transmission toward the formation of abilities for effective action in real-life contexts [2, 10]. Such education focuses the learning process on the active role of the learner, who applies acquired knowledge in authentic situations, demonstrates behavior based on understanding, and develops reflection and self-regulation as integral elements of learning.

This change in perspective aligns with the constructivist view of learning, which posits that knowledge is actively constructed by the learner rather than passively received – a concept formulated by Piaget [11] and further developed by von Glasersfeld [16]. Competencies are formed through the integration of knowledge, skills, and attitudes, supported by effective pedagogical design and reflective strategies [1, 13].

Similar to the EQF, Eleazier [6] defines competence as the ability of an individual to mobilize knowledge, skills, attitudes, and values within a specific context in order to achieve effective and responsible action. He emphasizes that competence is not a static set of abilities but a dynamic adaptive process, in which personal qualities—such as empathy, flexibility, reflection, and commitment—play a decisive role in the successful application of knowledge in real situations.

In this context, future teachers are the first learners exposed to the new paradigm of competency-based education. Their preparation is of particular importance, as they are expected to become agents of change in school practice and mediators of the competency model's transfer into real educational environments. University programs are gradually integrating courses such as Competency-Based Approach and Innovation and STEM-oriented modules designed to develop analytical, research, and innovative pedagogical thinking [15]. For students, this represents a new learning experience that requires not only theoretical understanding but also practical mastery of the model through the design of competency-based tasks, learning modules, and projects [1, 13]. As a result, professional readiness, responsibility, and reflective capacity are cultivated [13], shaping the profile of the competent teacher in the context of contemporary education.

Analysis of the Challenges in Student Training

In the process of preparing future teachers for the implementation of Competence-Based Education (CBE), several key challenges can be identified:

- First, students generally lack personal experience with this type of learning, since their own educational background has taken place in a traditional, knowledge-centered environment. This necessitates the development of new pedagogical models and strategies that actively engage learners in competence-oriented activities.

- Second, although CBE focuses on the development of professional competences, job descriptions in most sectors still do not contain clearly defined competence requirements. An exception is the IT sector, which

has already provided strategic recommendations for reforming the Bulgarian educational system and has developed specific competence profiles [15].

- Third, CBE implies integration across disciplines and the application of knowledge in real-world contexts. This requires a transformation of the teacher's role – from a traditional lecturer to a facilitator of the learning process who supports students' autonomy and reflection [13].

Therefore, a phased approach to the implementation of CBE is recommended—initially within a single university course, and after mastering the methodology and philosophy of the approach, through integration with other subjects in an interdisciplinary project. Such a model supports the gradual transformation of teaching practice and creates conditions for the sustainable development of professional and pedagogical competences among future teachers.

Approach to the Implementation of CBE

The training involves students from the degree programs Information Technologies, Mathematics and Educational Management, Mathematics, Informatics and Information Technologies, and Biology and English Language. The proposed approach is applicable across all academic disciplines, which constitutes a core characteristic of its conceptual framework. Given the pilot nature of the study, it is implemented within the aforementioned programs. Upon successful implementation, it is envisaged that the approach will be expanded and applied in an interdisciplinary context. The overarching aim is for the training to evolve into a holistic model encompassing all areas of key competences. The learning format includes lectures, discussions, and practical sessions aimed at transforming the traditional model of instruction into a competence-based one [10]. It is emphasized that CBE does not reject traditional education but rather builds upon it by focusing on the practical application of acquired knowledge and skills, the ability to assume responsibility, and the transferability of learning across new contexts [6, 17, 19].

The training aims to promote deep learning rather than surface learning—knowledge is not reduced to the reproduction of facts, theorems, or postulates but is grounded in comprehension and critical understanding. Learning is viewed as a dynamic cognitive and reflective process in which the student not only memorizes information but also analyzes, synthesizes, and evaluates the relevance and applicability of what has been learned.

In this sense, the concept of "retention of knowledge" evolves into a

higher-order category that implies deep understanding and flexible application – an ability to transform knowledge in novel situations [13, 14]. Competence thus manifests itself as the capacity to adapt and creatively apply acquired knowledge to solve real-world problems, where learning becomes the foundation for conscious, purposeful, and responsible behavior [6, 17, 19].

During the practical sessions, students are trained and assessed through a system of tasks developed in accordance with the CBE framework (Table 1). This system encourages self-reflection, critical thinking, and innovation in pedagogical practice. The goal is not only to facilitate the acquisition of academic knowledge but also to develop the ability to solve real-life problems. Students become familiar with the principles of CBE and analyze the core components of the competence-based learning model.

Table 1. System of Competency-Based Tasks for Pre-Service Teachers

Grade	**Evaluation Example Task**	**Developed Knowledge, Skills, and Competencies**
3	Describe, with examples, the difference between knowledge, skill, and competence.	Understanding the core concepts of CBE. [4]
4	Design a short lesson in mathematics/informatics that includes the application of up to three basic operations in solving a task.	Application of knowledge and formation of basic skills. [9]
5	Analyze a mathematics/informatics lesson and propose improvements to achieve competency-based outcomes.	Analysis and synthesis of information, planning, and evaluation. [14]
6	Develop an interdisciplinary project (e.g., "Modeling an ecosystem through programming") that includes a real social context.	Interdisciplinary synthesis, teamwork, critical thinking, and taking responsibility. [15]

Through this system, students are trained to design CBE-oriented sets of learning tasks, which constitute the core of this educational approach. Tasks within the competence-based model are situated in real-life or professional contexts, often articulated in the terminology of the applied domain (for example, "How can we optimize the school's energy consumption?"). The objective is to develop the ability to translate practical problems into scientific inquiry. The learner must be able to identify an applied problem and "translate" it into the language of science, employing relevant concepts, principles, and laws.

Such tasks (or problems) require the integration of knowledge and skills from multiple disciplines—e.g., mathematical modeling, programming, and environmental analysis. They also aim to foster the development of social competences [1]: higher levels of mastery (levels 5 and 6) presuppose confidence,

responsibility, and teamwork.

When designing and selecting tasks within the system, the cognitive level should be explicitly reflected in accordance with goal-setting taxonomies, and each task should be aligned with the Bulgarian six-point grading system.

Each task should:

- be formulated using active verbs denoting observable actions [7];
- be situated within a real-life or professional context;
- integrate knowledge and skills from more than one subject area;
- create conditions for the development of responsibility and teamwork.

Methodological Framework for Designing Competency-Based Learning Tasks

Table 2 presents the requirements that the tasks in the CBE-oriented systems developed by Pre-Service Teachers must meet, as well as an illustrative correspondence with the traditional grading system.

Table 2. Requirements for the system of tasks developed by Pre-Service Teachers

Grade	Competence Level	Observed Behaviour	Type of Activity	Expected Outcome
3	Knowledge, Understanding, and Immediate Application	Reproduction and explanation of basic concepts; single-operation skills	Answering questions, providing examples	Demonstrates basic understanding and direct application [4, 9]
4	Application Requiring Basic Analysis	Using knowledge in familiar situations involving 2–3 operations	Solving standard tasks	Shows conscious application of acquired knowledge [5, 8]
5	Analysis and Synthesis (in a Familiar Context)	Integrating knowledge from different sections; conscious selection of strategy	Solving complex problems	Demonstrates analytical, planning, and reasoning skills [12, 14]
6	Creation (Interdisciplinary Synthesis)	Solving real-world problems through integration of multiple disciplines	Project-based and teamwork activities; creative approach	Exhibits competent behaviour through integration of knowledge and skills [13, 15, 17]

The proposed system has a dual nature: students learn to design lessons and tasks for the implementation of CBE, while their own learning and assess-

ment are carried out within the same framework. In line with the CBE concept, the Competence-Based Approach and Innovations course requires students to apply this framework, at least partially, during their teaching practicum.

With regard to the students' future professional realization as teachers and the necessity to develop curricula for elective classes, the formation of skills related to curriculum design was established as a minimum requirement within the training. The curriculum was expected to build upon and extend the competences embedded in the compulsory curriculum. In this context, students were assigned the task of developing a sample competence-oriented curriculum for elective classes, integrating additional areas of key competences.

The training addressed topics such as recalculating quantities in cooking recipes; comparing times in sports competitions with precision to hundredths; selecting an optimal subscription plan offered by service providers; determining the moment when two buses arrive simultaneously by applying the least common multiple (LCM); developing an eco-plan for recycling through the calculation and analysis of percentages; organizing a mini sports tournament involving the calculation of points and number of matches; and creating a timeline of events by calculating differences between years and centuries.

Discussion

The introduction of Competence-Based Education (CBE) in the training of future teachers is still at an early stage, which means that both students and instructors are learning and adapting in the process [15]. Implementing CBE requires coherence with other pedagogical domains, posing challenges in the alignment of curricula and the coordination between university-level and school-level education. It is essential to maintain the principle of systematization and continuity, ensuring that new knowledge is built upon previously acquired concepts and experiences [3, 18].

CBE-based training holds dual value: by designing systems of learning tasks, students both acquire the methodology and create practical tools for school application. Thus, the process simultaneously develops professional competences and generates real resources for the gradual implementation of CBE in secondary education.

Conclusion

The implementation of competency-based education (CBE) in the preparation of future teachers represents not merely a methodological change but a profound transformation in the way learning itself is understood and enacted.

The methodology developed within the course "Competency-Based Approach and Innovations" demonstrates how a system of tasks can serve as an effective tool for developing and assessing the professional competencies of future teachers. It is based on clearly defined criteria for observable behavior, types of activities, and expected outcomes, providing opportunities for learners to demonstrate different levels of competence.

The proposed approach has a dual value. Through the creation of task systems, students simultaneously demonstrate and further develop their pedagogical competencies while generating practical tools for applying CBE in the school environment. A high student assessment reflects not only the degree of professional mastery of the approach but also the quality and applicability of the task system created by the student for real classroom use. In this way, the process of university training becomes a source of resources for school practice, ensuring synergy between the education of future teachers and the sustainable implementation of the competency-based model in the educational system.

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