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COMPETENCIES OF SCIENCE TEACHERS: COMPARATIVE ASSESSMENT

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Recently, competencies have become a priority area of discussions. Acquiring appropriate competencies in higher school is a guarantee of successful pedagogical work. Therefore, accurate defining of competencies as well as their content and structure is very important. It should be taken into consideration that the majority of competencies gained during studies at university level will be developed in comprehensive schools i.e. achieving competencies is not a finalized process as it lasts long - the whole time of active pedagogical activities. For example, such teachers' strengths as the ability to individualize educational content, the ability to teach how to learn and communicate with other people, the ability to purposefully apply the learning strategy and different methods in the teaching/learning process for collaboration purposes, the ability to apply varying methods evaluating students' achievements and progress in the educational process etc. are absolutely crucial points.

It is clear that conveying knowledge, broadening students' world outlook and establishing a positive relationship with an immediate environment (natural and social) are outstanding qualities. Different international research (SAS, ROSE, TIMSS, etc.) shows that motivation and increased interest in sciences play a fundamental role. The teachers of sciences interdependently coordinate their activities, maintain a close interdisciplinary-integrated relationship and look for new more efficient educational methods and activities. Thus, they can achieve highly positive results (in terms of students' knowledge level and value-based maturity).

Experience gained during the process of training foreign teachers of sciences is very relevant. Within the framework of the carried out IQST project the experts from the project-partner countries prepared the lists of competencies.

First, it should be noticed that the experts from different countries singled out a number of different competencies of science teachers. The majority of competencies necessary for teachers were mentioned by the respondents from Turkey and Bulgaria. Considering the meaning, some of the presented competencies are very close, for example *organizing educational process* (Lithuania), *practical pedagogical activity* (The Czech Republic), *general pedagogical abilities* (Turkey), *general pedagogical competence* (Bulgaria). Some of those are very exceptional, for example solving problems and critical thinking (Lithuania), safety and

welfare (The Czech Republic), general intellect (Bulgaria), modelling the process of cognitive conflict (Cyprus) (Table 1).

Table 1. Competencies of science teachers singled out by the experts.

Country	Competencies *									
	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**
Lithuania	Critical thinking	Organizing educational process	Problem solving	Creativity and innovativeness	Communication	Use of ICT	Information and knowledge management	Value-based attitudes	Researching	Content of the taught subject
The Czech Republic	Perceiving the core of science	Perceiving science development	Researching	Practical pedagogical activity	Content of the taught subject	Evaluation	Safety and welfare	Professional improvement	-	-
Turkey	Perceiving the core of nature and science	Professional activity	Researching	General pedagogical abilities	Content of the taught subject	Evaluation	-	-	-	-
Bulgaria	Perceiving the core of science	General intellect	General pedagogical	Didactics of the taught subject	-	-	-	-	-	-
Cyprus	Modelling the process of cognitive conflict	-	-	-	-	-	-	-	-	-

***** further in the article, competencies are expressed by the symbols representing the singled out original competence indicated by the experts of every country. The meaning of a symbol can be established using Table 1: a letter is a symbol of a country and a figure shows competence itself, for example B2 is *Competence of general intellect* learned by the experts from Bulgaria.

The content of competencies revealed that the experts from different countries highlighted the same elements of competencies using various methods of combining them into certain units. The content of individual competencies includes components that in terms of semantics reach the notional framework of other competencies. For example, Lithuanian experts established that the teachers of sciences should demonstrate *information and knowledge management* – (L7) (Table 1). The component of the competence *able to self-sufficiently increase professional qualification* semantically agrees with the content of competence *professional improvement* (Č8) singled out by the experts from the Czech Republic. Another component of the same competence *perceives knowledge of science* conforms to the content of competence *perceives the core of science* – (Č1; T1; B1) named by the Czech, Turkish and Bulgarian experts. It is worth mentioning the competence *modelling the process of cognitive conflict* specified by the colleagues from Cyprus. The content of the latter competence consists of 20 integrated parts embracing the aspects of *pedagogical activity, evaluation, problem solving, ensuring safety and creativity*. Therefore, a thorough assessment of competence content disclosed that the experts from different countries identified the following competencies required for science teachers-constructivists:

- perceiving the core of science;
- perceiving science development (historical aspect);
- content of the taught subject;
- critical thinking;
- evaluation;
- problem solving;
- researching;
- practical pedagogical activity;
- modelling the process of cognitive conflict;
- creativity and innovativeness;
- communication;
- professional improvement;
- information and knowledge management;
- safety and welfare;
- value-based attitudes.

As it was mentioned before, depending on the meaning, the individual components of the content of some competencies agree with a few competencies. Thus, the integrated elements of different competencies cover the majority of the above introduced competencies (Table 2).

Table 2. Proportion of the integrated elements of competence content to the singled out competencies

Integrated elements of competencies	**Competencies**				
Perceiving the core of science	L7		T1; T2	B2; B3	
Perceiving science development (historical aspect)	L7	Č2		B1	
Content of the subject taught	L10	Č5	T5	B4	K1
Critical thinking	L1			B1; B2	
Evaluation	L3	Č6	T2; T6	B2; B3	K1
Problem solving	L3				K1
Researching	L9	Č3	T3	B1; B2; B4	
Practical pedagogical activity	L2; L6	Č4	T4	B2; B4	K1
Modelling the process of cognitive conflict					K1
Creativity and innovativeness	L4		T6	B3	K1
Communication	L5	Č8	T2	B2	
Professional improvement	L5; L7	Č8	T2; T6	B2	
Information and knowledge management	L7	Č8	T2	B1; B2; B4	
Value-based attitudes	L8				
Safety and welfare		Č7			K1

Science teacher's competence to be a teacher should be confirmed by his/her gained knowledge, developed abilities and formed value-based orientation. These are the main points to be considered discussing competencies necessary for teachers of sciences. An assessment of the competence list demonstrates that the experts from different countries emphasize the following competencies focusing on knowledge:

- content of the taught subject;

- perceiving science development;
- perceiving the core of science;
- modelling the process of cognitive conflict;

The following competencies are focused on ability development:

- professional improvement;
- evaluation;
- solving problems;
- critical thinking;
- researching;
- modelling the process of cognitive conflict.

Very few students' value-based competencies have been singled out:

- value-based competence;
- safety and welfare.

A more thorough assessment reveals that the integrated elements of competence content make different groups of competencies concentrating on knowledge, abilities and value-based attitudes (Table 3). Practical abilities (22 positions) rather than knowledge (16 positions) are devoted more attention. Only 3 positions on value-based attitudes show scant attention to the latter aspect of competencies.

Table 3. Competence distribution considering knowledge, abilities and value-based attitudes.

Content of competencies		
Knowledge	**Abilities**	**Value-based attitudes**
L7; L9; L10; Č2; Č3; Č5; Č8; T1; T2; T3; T5; B1; B2; B3; B4; K1	L1; L2; L3; L4; L5; L6; L7; L9; Č3; Č4; Č6; Č8; T2; T3; T4; T6; B1; B2; B3; B4; K1	L8; Č7; K1

The table illustrates that due to the variety of separate content elements the same competence frequently focuses on knowledge as well as on practical abilities, for example *information and knowledge management* (L7), *professional and practical activity* (T2), *researching* (T3).

All indicated competencies focus either on the taught subject or on practical pedagogical activity (Table 4):

Table 4. Competence distribution considering the taught subject and pedagogical activity.

Competencies in a taught subject	Competencies of practical pedagogical activity
L6; L7; L8; L9; L10; Č1; Č2; Č3; Č5; Č7; T1; T3; T5; B1; B4; K1	L1; L2; L3; L4; L5; Č4; Č6; Č8; T2; T4; T6; B2; B3; K1

The table shows that almost there is a balance between the competencies concentrating on the taught subject and those focusing on practical pedagogical activity. The former competencies are slightly predominating (positions 16 to 14).

Along the undertaken assessment, a comparison of competence subdivision into the taught subject and pedagogical activity sections focusing on knowledge, abilities and attitudes has been made (Table 5).

Table 5. Competence subdivision into the sections focusing on knowledge, abilities and attitudes

	Taught subjects	Pedagogical activities
Knowledge	➢ content of a taught subject; ➢ perceiving science development; ➢ perceiving the core of science; ➢ modelling the process of cognitive conflict (separate elements)	
Focus on knowledge and abilities	➢ information and knowledge management; ➢ researching; ➢ perceiving the core of science; ➢ didactics of the taught subject; ➢ applying ICT.	➢ professional and practical activity; ➢ professional improvement; ➢ general intellect; ➢ general pedagogical.
Abilities		➢ critical thinking; ➢ organizing educational process; ➢ problem solving; ➢ creativity and innovativeness; ➢ communication; ➢ practical pedagogical activity; ➢ evaluation; ➢ professional improvement; ➢ modelling the process of cognitive conflict (separate elements)
Attitudes	➢ value-based attitudes; ➢ safety and welfare (separate elements)	➢ safety and welfare (separate elements)

Table 5 clearly discloses that competencies in the taught subjects are aimed at knowledge whereas those in pedagogical practical activity are fixed for abilities. An assessment of competence content disclosed that some competencies focused on knowledge as well as on abilities (highlighted in the table).

A summary of the findings of the carried out research reveals the possibility of modeling a list of competencies of an ideal science teacher organizing the educational process on the basis of the principles of constructivistic teaching/learning. Such a programme could help the teachers intended to follow the above introduced educational principles with self-evaluation of personal abilities and achievements and prefigure the fields to be improved in the future (Table 6).

Table 6. The list of the competencies of science teacher organizing the educational process through the constructivistic approach.

Sections of competencies	Competencies	Content of competencies
1. Competencies in the taught subject	**1. Information and knowledge management**	➢ knows the basic facts of science evolution; ➢ knows the history of science knowledge development of the taught subject; ➢ knows and identifies the most important science theories, laws and regularities maintained in different situations; perceives the value of scientific information; ➢ able to understand and process scientific information; ➢ knows preconditions necessary for creating scientific knowledge; ➢ able to efficiently apply the gained knowledge training the young generation;

		➢ understands and is able to provide the possibilities of applying a scientific knowledge in every day practice for the students; ➢ analyzes and perceives the public alterations encouraged by the rise of a scientific knowledge, technological progress and personal and community development in different cultures worldwide; ➢ able to compare science with other methods of acknowledging the reality; ➢ able to use different information sources and to regularly update a personal knowledge.
	2. Content of the taught subject	➢ knows the objectives and tasks of science education and the content of the taught subject i.e. knowledge that needs to be acquired by the secondary school students; ➢ knows the content and didactical attitudes of general science education standards; ➢ able to identify events and phenomena that should increase students' interest, help with perceiving disagreements between the ideas of science and real phenomena, assist in creating the situations of cognitive conflict; ➢ able to choose training aids efficient at solving cognitive conflict.
	3. Didactics of the taught subject	➢ knows and optimally apply specific forms, methods and models of science education; ➢ able to outstandingly develop the process of science education in secondary school i.e. to plan cognitive and research activity involving students, to raise real teaching goals and tasks and to suitably choose training material and resources required for teaching.
	4. Researching	➢ understands the core of scientific research; ➢ knows the main methods of scientific research; ➢ able to successfully plan research, be charged with implementing it in practice, to prepare research report and evaluate results; ➢ understands and is able to use mathematical procedures when analyzing research data; ➢ understands and is able to use research data in daily work dealing with the problems of different format;
	5. Use and application of ICT	➢ able to use ICT i.e. has computer literacy skills allowing to make the educational process more diverse; ➢ able to efficiently apply ICT in the educational process optimally using the Internet, broadens the possibilities of teaching/learning, stimulates educational alterations; ➢ able to apply ICT for the purposes of science education.
	6. Value-based attitudes	➢ perceives nature as a value; ➢ able to identify the possibilities of natural science education in secondary school in the context of other subjects taught.
	7. Safety and welfare	➢ knows and perceives teacher's ethical and legal responsibility for students' physical safety during the classes in sciences; ➢ able to properly/safely arrange, look after and apply different material during the classes in sciences; ➢ encourage students to follow necessary safety rules in the classroom, ensure safety of equipment devoted to the teaching process and guarantee safety of students' activity during the classes in sciences; ➢ knows requirements for exemplary behaviour with animals; safely, humanely and ethically behave with animate organisms in the classroom;
	1. Critical thinking	➢ knows classical and modern concepts of science education, understands the main differences between them, perceives the qualities and drawbacks of classical and modern concepts of science education; ➢ knows situation in science education at national, European and worldwide level; able to rationally make profit on experience of

2. Pedagogical practical activity		other countries; ➢ acknowledges the alternative methods of reality perception; ➢ accepts learning as students' individual efforts to develop personal thinking, build and broaden personal knowledge rather than a process of conveying knowledge;
	2. Practical pedagogical activity	➢ able to optimally combine classical and modern concepts of science education in practice and to prefigure the effective measures of an educational impact; ➢ able to organize the teaching/learning process through communication and collaboration, initiate productive students' social interaction building personal knowledge through collaboration; ➢ manages to identify student groups able to use the most optimal strategies to resolve cognitive conflict; ➢ able to conform to alterations; in order to develop different student abilities, frequently changes activities, teaching strategies and methods; ➢ able to create a learning environment stimulating the development of students' ideas; ➢ perceives the importance of meta-cognitive abilities; able to develop both cognitive and meta-cognitive abilities.
	3. Modeling the process of cognitive conflict	➢ flexible about creating problematic situations; able to individualize the above mentioned situations depending on student cognitive abilities, the style of dealing with problems, sex and social and cultural experience; ➢ able to identify the students experiencing cognitive conflict; offers support in resolving the introduced conflict, making decisions; ➢ able to attract students to the process of cognitive conflict.
	4. Problem solving	➢ able to quickly and effectively deal with the issues of science education and the questions of the quality of students' educatedness; able to initiate qualitative alterations in science education.
	5. Creativity and innovativeness	➢ able to create original ideas; announces initiatives; is innovative. ➢ able to create suitable, interesting problematic situations attracting students to cognitive conflict.
	6. **Communication**	➢ able to foster a positive relationship with the community; ➢ able to collaborate and to do teamwork; ➢ able to disclose and present the achievements in sciences and science education to society; ➢ able to defend an individual position with considerable self-respect;
	7. Evaluation	➢ able to notice alteration in student activity, to identify learners' achievements and progress and to regularly evaluate the self/educational process; ➢ able to identify an agreement between students' achievements and science education standards at national level; able to establish the evaluation criteria of achievements; ➢ uses different evaluation methods and forms; ➢ able to provide valuable and purposeful feedback information encouraging the development of students' scientific thinking; ➢ on the basis of the evaluated data, advances the process of science education making the impact on the results of teaching/learning;
	8. Professional improvement	➢ able to individually raise professional qualification (seeks for regular advancement, participates in the events of teacher training, is interested in the latest methodical and scientific information on the issues of science education, adequately evaluates and apply it in practice); ➢ able to take over good experience of colleagues, advisers and students and use it to change individual abilities;

		➢ benevolently accepts advice from the colleagues having wider experience; ➢ able to share good individual experience with those who are less experienced.
	9. Safety and welfare	➢ able to stimulate positive students' abilities such as interest, the feeling of psychological safety etc. ➢ able to reduce negative students' emotions such as fear, distrust, anxiety etc.

It is clear that complete unification will hardly be reached; moreover, the latter project is not aimed at achieving these objectives. This principled and weighty question should be seriously considered in common European space. Such a need directly reflects the problems of today's school. Novelties and financial support are received and information communication technologies should improve students' abilities in schools; however, research carried out at national and international level in different countries show that not all learners improve their results. The tendency that the results achieved by the teachers using modern technologies in the classroom are worse can be noticed. The teachers of sciences are not always effective users of ICT as they frequently feel lack of competencies in this field. Nevertheless, students' involvement in sciences is tendentiously decreasing (in the classes of upper-secondary school in particular), there is shortage of attractive science teaching and learning material etc. based on reality-based problems and ICT. Therefore, a baseless thing is an over-focus on teacher's competencies linked with modern ICT. In this case, researcher's competence remains one of the most important points. The ability to plan, organize and conduct various investigations involving students is certainly one of the most important competencies. Natural sciences have been, are and carry on staying an experimental area. The process of science education, which is too much theoretical and remote from reality, determined the situation that the interest in sciences and technologies reached a very low level in developed countries.

Hence, a crucial point is to highlight what model of competencies should be applied by universities in order to train teachers of sciences able to effectively act in present conditions.