Enhancing Learning in Teaching via e-inquiries

Intellectual Output 2

Context-based indicators for evaluating STEM teachers' competence development

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ELITe. Enhancing Learning in Teaching via e-inquiries

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Intellectual Output:	O2: Context-based indicators for evaluating STEM teachers' competence development
Output description:	The aim of this document is to provide evaluation tools for testing the ELITe's project assumption, namely that STEM teachers' professional learning through IB methodology supports the development of teachers' competences. Towards this end presented are outcome indicators (and sub-indicators relevant to the national context of Greece, the Netherland, Bulgaria and Spain), which aim to serve as a tool to evaluate the impact of the training activities on competence development. In addition, presented are process indicators aiming to provide information and context to facilitate the interpretation of outcomes. These serve as an evaluation tool to indicate whether an IB skill or competence has been practiced by learners when performing the ELITe's professional learning activities. The proposed indicators will facilitate the collection of evidence on the outcome and the processes of the project's learning in teaching approach. In subsequent project activities, the results from the evaluation will lead the development of an evidence-based framework for STEM teachers' competence development via inquiry methodology aiming to inform curriculum design for STEM secondary teachers' continuous professional development and learning.
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Introduction

There is a wide range and wide complexity of competences required for teaching in the 21st century: teachers are asked to teach in increasingly multicultural classrooms, integrate students with special needs, use ICT for teaching effectively, engage in evaluation and accountability processes and involve parents in schools (OECD, 2009). Furthermore, it is expected that they help students develop ways of thinking (creativity, critical thinking, problem-solving, decision-making; ways of working (communication and collaboration); use tools for working (ICT); and skills around citizenship and career (OECD, 2011). Teaching nowadays is more than a task and requires complex combinations of knowledge, skills, understandings, values and attitudes leading to effective practice. Supporting teachers' professional learning for competence development is, therefore, not just a need but a must!

The growing demand for Science, Technology, Engineering and Mathematics (STEM) education and people that possess STEM competence also underlines the need for supporting STEM teachers inquiry-based learning (IBL) professional development. Scientific inquiry answers the question of how phenomena are related: why things do happen. It is about cause-consequence relations, which can principally be tested in experiments. It is not about believes but about empirical evidence. Inquiry based learning is learning, which starts from a project idea and follows the rules of scientific inquiry. It leads finally to structure knowledge about a domain and develops skills and competences about how to carry out research which is efficient, scientifically sound and which can be communicated. Inquiry skills and competences are needed to carry out scientific research. Many more competences and skills are necessary to carry out meaningful inquiry.

Against this background, the overall goal of the ELITe project is to support teachers' professional learning for competence development, targeting specifically in-service educators in the STEM domain. The ELITe's approach for professional learning propagates the adoption of the inquiry-based (IB) methodology in professional learning activities, under the assumption that teachers' training via IB methodology supports the development of teacher competences. The main tangible outcome of the project will be the development of an evidence-based framework for STEM teachers' competence development via inquiry methodology aiming to inform curriculum design for STEM secondary teachers' continuous professional development and learning. Teacher leaning activities -that inform the development of the framework- take place in 4 countries of the ELITe consortium, namely: Greece, the Netherlands, Bulgaria and Spain, through an online platform, which facilitates personal and collaborative inquiry learning.

For addressing the overall goal of the project, identified are the following challenges and the according implicit requirements:

1) From a conceptual perspective, wide variety prevails across European countries, in the current approaches to teachers' competences (EC, Education and Training, 2013). General guidelines about the competences required for teaching are usually embedded in the national curricula and autonomy is then left to university or college providers to develop and apply detailed competence requirements in teacher education programs accordingly. Therefore the ELITe approach advocates that efforts to stimulate teachers' competence development through professional learning opportunities need to be place-based, taking into consideration the various interpretations and understandings not only among the different EU educational systems, but also among different stakeholders in each country.

2) From a methodological perspective, current prevailing approaches in initial and continuous training programs focus on subject knowledge, pedagogy and "practice"(classroom-based training) (EC, Education and Training, 2015). Such approaches, fail to recognize that teachers' dispositions towards learning and teaching - and as a consequence their practice - are highly influenced by the way teachers have received training themselves. Knowledge and skills on/about teaching is developed by teachers themselves, as they use theory and research to reflect upon their practices in professional learning communities (Hagger &McIntyre, 2006). In addition, formal and traditional forms of in-service training such as courses, workshops and conferences currently prevail in most educational systems. However, many

teachers either do not find suitable professional development or cannot attend due to conflicting work schedules (OECD, 2009). ELITe argues that there is a need for providing flexible professional development opportunities in which the training methodology has a prevailing role, embedded on the concept of "change as professional learning perspective", which sees teachers as reflective practitioners, responsible for their own learning.

3) From a domain specific perspective, STEM education is currently defined as 'creative education to foster the future needs of society (Sutcliffe, 2011). STEM educators – under the Responsible Research and Innovation (RRI) policy agenda- are expected to equip students as future citizens to understand socio-scientific issues, applying science knowledge, ethical values and inquiry skills to form evidence based opinions (EC, 2015). In addition there are expected to aspire science related careers to students and support students develop positive attitudes towards science. Therefore, the thematic of the professional learning activities for STEM in-service teachers need to reflect current policy orientations under the RRI agenda on the role of STEM education and help teachers to model key competences required (knowledge, skills and attitudes) in order to help students to acquire them.

Bearing in mind the identified implicit requirements for achieving the project's goal, the ELITe Strategic partnership seeks to address the following objectives:

- 1st objective: To deepen understandings on the requirements for STEM teachers competence development at national levels, as conceptualized and expressed by policy makers, policy mediators and practitioners;
- 2nd objective: To develop, deploy and evaluate the effectiveness of an innovative methodology - based on inquiry-based (IB) methodology - for STEM teachers flexible and reflective professional learning
- 3rd objective: To support the uptake of the proposed innovative professional learning methodology by teacher training curriculum stakeholders, for better alignment of policy envisions relating STEM education to actual practice.

Previous work conduced within the project addressed the first project objective, i.e. to enhance understandings on policy envisions and requirements for STEM teachers' competence development in Greece, the Netherlands, Bulgaria and Spain. The national contexts were reviewed through documentary analysis (of policy documents, STEM teachers training curricula and students' STEM curricula in each country), under the scope of identifying the space of intervention for supporting STEM teachers' professional learning. The review provided insights on the dimensions and aspects of competences (knowledge & understanding, skills, dispositions and attitudes) that are explicitly and implicitly evident at policy, policy mediation and teaching practice levels in each country (presented in the form of national reports in the report O1 "*Policy envisions and requirements for STEM teachers' competence development: the case of Greece, Netherlands, Bulgaria and Spain"*, in Appendix 1[1]). As an outcome of the review of the national contexts, prominent issues for consideration in each country were identified and presented concisely (see the above mentioned report, Appendix 2[2]).

This work reported in O1 served as the basis of subsequent project activities, which aim at addressing the second project objective, namely the development, deployment and evaluation of the ELITe's learning in teaching approach for STEM teachers' competence development. Among these activities is the identification of context-based indicators for evaluating STEM teachers' competence development - which is the focus of this document.

[1] See pages 17-55 of the Intellectual Output O1: "Policy envisions and requirements for STEM teachers' competence development: the case of Greece, Netherlands, Bulgaria and Spain" available here http://www.learning-in-teaching.eu/images/docs/EN/IO1/IO1.pdf

[2] See pages 56-77 of the above mentioned report

The aim of the report and its role within the project

This document reports on the processes and outcomes of the synthesis of the national reports on policy envisions and requirements for STEM teachers competence development in Greece, the Netherlands, Bulgaria and Spain (presented in the Intellectual Output O1), and their mapping into EU policy envisions relating teachers' competence development - as evident in EC (2013) framework. The scope of work is to identify indicators for evaluating the impact of ELITe's learning in teaching approach.

First, presented are the outcomes of the synthesis of the national reports, aiming to provide comparative insights on aspects of STEM teachers' competences required in Greece, the Netherlands, Bulgaria & Spain. Then, presented are outcome indicators and sub-indicators for evaluating the impact of initiatives for STEM teachers' competence development, covering the dimensions of STEM teachers' knowledge and understanding, skills and dispositions and attitudes. Information is also provided in relation to the national context (of Greece, the Netherlands, Bulgaria and Spain) to which each sub-indicator is relevant to, both explicitly (as evident in national policy documents and curricula) and implicitly (as evident in students STEM curricula). Finally, reported in this document are process indicators for IBL skills development, which aim to serve as a tool in the course of evaluating the project's training activities.

Outcomes of the work reported in this document aim to inform subsequent project's activities relating to the development and the evaluation of the ELITe's "learning in teaching" approach for STEM teachers' competence development:

From the perspective of the development of the project's training approach, the comparative insights on the aspects of STEM teachers' competences required explicitly and implicitly in the national contexts will allow to orient the project's training approach towards expected teachers' learning outcomes which are most relevant for each national context.

From an evaluation perspective, the identified outcome indicators and sub-indicators will serve as a tool to evaluate the impact of the project's teachers' learning activities on the development of competences (in the dimensions of teachers' enhancing knowledge and understanding, of developing skills, and of developing dispositions and attitudes). On the other hand, the presented process indicators will serve as a tool to identify the IBL skills practiced by teachers through their engagement in the projects IBL based training activities. A correlation of the results in relation to teachers development of competences and in relation to the IBL skills being practiced, will allow to test the assumption on which the project is based: namely, that teachers' training via IB methodology supports the development of teacher competences.

The work reported in this document contributes to the accomplishment of the overall goal of the project, by providing tools under which the project's learning in teaching approach via e-inquiries will be evaluated. Results from the evaluation will lead the development of an evidence-based framework for STEM teachers' competence development via inquiry methodology aiming to inform curriculum design for STEM secondary teachers' continuous professional development and learning.

STEM teacher's competences required in Greece, the Netherland, Bulgaria and Spain: Comparative insights

In previous work conducted in the frame of the project, the national contexts of Greece, the Netherlands, Bulgaria and Spain in terms of STEM teachers' competence development were reviewed through documentary analysis (of policy documents, STEM teachers training curricula and students' STEM curricula) in each country - see the report "*Policy envisions and requirements for STEM teachers' competence development: the case of Greece, Netherlands, Bulgaria and Spain*", accessible here: http://www.learning-in-teaching.eu/images/docs/EN/IO1/IO1.pdf.

A synthesis of the review of the national contexts is presented here below, providing comparative insights at the levels of policy envisions and requirements (macro-level), teacher training curricula (meso-level) and students STEM curricula (micro-level).

Comparative insights at macro level (policy envisions & requirements at policy level)

In Greece, the Netherlands, Bulgaria and Spain STEM teachers' competence development is currently a prominent issue in the policy agenda as a warrant of quality in education, in line with the priorities of the EU policy agenda for education and training. In specific:

In the Greek context the issue of improving teachers' competences is inscribed in both the rhetoric of contemporary political discourse on education (expressed for example in the frame of the establishment of the "*Certificate of pedagogical & teaching competency for secondary teachers*"), and the recent attempted reform initiatives (New school and Social school reforms). Major aspects of competences (knowledge and understanding, skills and dispositions and attitudes) that are identified in the Greek reform for teachers' initial training and professional development include:

Knowledge & Understanding:

- Subject matter knowledge is less emphasised as it is considered as a prerequisite for attending the Programme for acquiring the "Certificate of pedagogical & teaching competency for secondary teachers";
- Most focus is given on building "professional knowledge", constituting of PCK, Pedagogical knowledge and curricula knowledge; issues of inclusion and diversity.

Skills:

- Most emphasis is given on:
  - using, developing and creating research knowledge to inform practices;
  - reflective, metacognitive and interpersonal skills for learning individually and in professional learning communities;
  - inquiry skills, collecting, analyzing and interpreting evidence and data for teaching/learning improvement;
  - using teaching materials and new technologies.
- Less emphasis is given on collaboration and negotiation skills with colleagues and parents.

Dispositions, beliefs and attitudes:

- Most emphasis is given on:
- dispositions to change, ongoing learning;
- critical attitudes to one's own teaching;
- transferable skills;
- epistemological awareness.
- Some emphasis is given on collaboration and team-working.

In the Dutch context, recently the teacher competence framework (first established in 2006) has been updated, and formulated three generic competence areas/pillars: subject matter, teaching and pedagogical expertise. For each pillar relevant knowledge and skills are defined. In specific:

In terms of knowledge:

- Up-to date domain knowledge;
- relations with adjacent areas;
- learning and instructional theories;
- development and behavioural sciences;
- instructional psychology;
- learning sciences;
- pedagogical science;
- inclusive education;
- personalised learning.

In terms of skills:

- can explain, give an overview, demonstrate and present both the theoretical frameworks as practical applications;
- can position and relate to other disciplines within the curriculum;
- can make links to daily practice and possible further educational trajectories;
- can give feedback;
- can explain content;
- can stimulate learners to learn actively;
- can realize outcome-based learning;
- can lead, monitor, steer group process;
- can win trust;
- can create safe pedagogical climate;
- can create a climate that stimulates learning, including making mistakes.

As for dispositions and attitudes, emphasized are disposition:

- to reflect on one's own knowledge,
- to learn from each other in school and outside, individually and in teams.

Specifically for secondary education in STEM disciplines the teacher competence framework lays emphasis on:

- design and development perspective including the ability to effectively utilize existing curricular resources to design instruction and to interact with tools and resources;
- making sense of and using tools/resources to design and enact instruction and to adapt curricula, resources, and learning environments to new insights and new teacher roles as coaches and facilitators of learning.

In the Bulgarian context, the national policy documents, influenced by relevant European policy documents provide evidence for requirements for covering each of three key dimensions of teachers' competences - knowledge and understanding, skills, dispositions and attitudes. In specific:

In relation to *knowledge & understanding*:

- The basic aspect of required knowledge is the deep knowledge of subject matter.
- Special attention in the policy documents is dedicated to inclusive education;
- The use of innovative teaching methods in all teaching disciplines is also emphasised.

- Another aspect evident is knowledge and understanding of evaluation and assessment methodologies and technics.

In relation to required *skills*:

- Planning, teaching, evaluation and assessment, class/group management skills are emphasized.
- Among required skills are communicative skills (including team working skills and skills for collaborating with parents and stakeholders) and
- Administrative skills.

In relation to teachers' *dispositions and attitudes*:

- Current legislation pays special attention to the commitment to promoting the learning to all students.
- The ordinances accompanying the new law emphasises teachers dispositions to change, flexibility, ongoing learning and professional improvement, including study and research.
- The promotion of students' attitudes and practices as European citizens is also part of the national policy agenda.

In the Spanish context, competence-based education is supported by law in all level of compulsory education and baccalaureate. Key competencies are part of the evaluation of the effectiveness of the educational system. Furthermore, the Spanish reform recommends methods to facilitate methodological strategies that allow for classroom competencies work. Major aspects of competences (knowledge and understanding, skills and dispositions and attitudes) that are identified in the Spanish reform for teachers' initial training and professional development include:

In terms of *knowledge & understanding*:

- Subject matter knowledge;
- Pedagogical & curricular knowledge;
- Issues of inclusion and diversity;
- Developmental psychology;
- Issues on evaluation and assessment.

In terms of skills, emphasis is placed on:

- Planning, managing and coordinating teaching;
- Using teaching materials and technologies;
- Managing students and groups;
- Monitoring, adapting and assessing teaching/learning objectives
- Using research knowledge to inform practices;
- Metacognitive and reflective skills;
- Adapting to education contexts.

In terms of dispositions and attitudes, emphasised aspects are:

- Dispositions to change and professional improvement;
- Commitment to promoting learning for all students;
- Critical attitudes towards own teaching practices.

Comparative insights at meso level (mediating mechanisms-STEM teacher training curricula)

In the Dutch and the Spanish contexts policy frameworks for teachers' competence development are in place from 2006 and have recently been updated. However, while in the Netherlands the regulatory framework has been adopted and implemented by teacher education institutes, in Spain there is a lack of consensus on the acceptance of the new policies among regions, local authorities and educational councils and as such implementation is being challenged.

In the Dutch context, dimensions and aspects of STEM teachers' competences evident in teacher education curricula in the country are:

In relation to knowledge:

- Discipline specific subjects, educational science and pedagogy, pedagogical content knowledge;
- In-depth domain specific knowledge, knowledge of educational science;
- Pedagogical content knowledge;
- Design aspects for STEM-subjects.

In relation to skills (a large component of all curricula) – in-service or internship at schools.

- Development of reflective and inquiry habit of mind (a new emphasis);
- Profession related skills are trained during internships in schools.
- *Education design skills* – develop, apply and evaluate.
- *Research skills*: developed and demonstrated through a Master thesis, an independent research project conducted in the educational practice.

In relation to dispositions:

- Professional dispositions (functioning in a team, in the school as a professional organization and acting as an academically trained professional;
- Critical thinking.

In the Spanish context, currently universities have undergone an important challenge on creating Master programs (Masters' degree in secondary education) under a competence oriented approach (focusing on learners' promotion of knowledge, skills and attitudes). Competences emphasized in the Inter-University Masters' Degree programs for teachers' accreditation in STEM-related subjects are:

In terms of *knowledge and understanding*:

- subject matter knowledge;
- pedagogical knowledge;
- curricular knowledge;
- educational science foundations;
- contextual, institutional, organizational aspects of educational policies;
- issues of inclusion and diversity;
- effective use of technologies in learning; developmental psychology;
- learning theories and motivational issues;
- evaluation and assessment.

In relation to *skills*, emphasized aspects are:

- planning, managing and coordinating teaching;
- using teaching materials and technologies;
- managing students and groups;
- using, developing and creating knowledge to inform practice; reflective, metacognitive skills;
- adapting to educational contexts.

In relation to *dispositions and attitudes*:

- epistemological awareness;
- teaching skills through content;
- disposition to change, flexibility;
- commitment to promote learning of all students;
- dispositions to promote students democratic attitudes;
- dispositions to team working.

In Greece and Bulgaria, on the other hand, the establishment of a regulatory framework for teacher education under a competence development orientation is a part of very recent reform initiatives; as such, currently there is uncertainty on how providers of teacher education and training will respond to and implement the new regulatory framework.

Comparative insights at micro level (teaching practice-students STEM curricula)

In all national contexts, a high level of coherence is evident between teacher competences required/envisions by policy and the skills that students are aimed to develop via STEM studies.

In Greece, major skills emphasised in students curricula under the current education intended reform are:

- Lifelong learning skills;
- Skills for Responsible citizenship;
- Reflective and metacognitive skills;
- Critical thinking;
- Creativity;
- Problem solving skills;
- Risk estimation;
- Decision making ;
- Team working;
- Digital skills.

Identified aspects of teachers' competences implicitly required in teaching practice –as evident in STEM curricula- are:
In relation to *knowledge and understanding*:

- subject matter knowledge;
- pedagogical content knowledge;
- pedagogical knowledge;
- issues of inclusion and diversity;
- effective use of technologies;
- developmental psychology;
- group processes & dynamics, learning theories, motivational issues;
- evaluation and assessment.

In relation to *skills*:

- planning, managing and coordinating teaching;
- using teaching materials and technologies;
- managing students and groups;

- collecting, analyzing, interpreting evidence and data for professional decisions and learning/teaching improvement.

In relation to *dispositions and attitudes*:

- teaching skills through content;
- commitment to promote learning of all students;
- dispositions to promote students' democratic attitudes and practices as European citizens.

In ***the Netherlands***, at the classroom/students' curricula level, in the context of teacher competence development the following developments are relevant: the introduction of "Studiehuis", guided and independent (project based) learning in the lower secondary school with the teacher positioned as a coach instead of the exclusive source of knowledge and "a sage on the stage"; "Tweede fase", or the second (upper) school phase curriculum innovation with a focus on development of generic skills, cross-disciplinary and higher order skills like information problem solving and research skills in secondary school curricula and examination & assessment programs. As a consequence, a mayor applied task of conducting an independent inquiry or design project has become a constituent part of the final examination program and school curriculum. Both developments implied mayor shifts in the organization of the teaching process from instruction and knowledge transmission to guidance of independent and group work and monitoring student learning within school disciplines and in cross-discipline learning activities, including stimulating independent learning (inquiry) skills in children. A STEM-specific development concerns the curriculum of Technasium with high requirements for both domain knowledge and pedagogical and didactical skills of the teachers. Thus, the core subject of Technasia, R & D, requires besides in-depth discipline related knowledge, the ability to design project-based activities and design skills and organization of curriculum. Functioning in regional networks requires social networking skills.

In Bulgaria, at the classroom/students' curricula level, in the context of teacher competence development, the national standards for STEM education require STEM teachers to be very well familiarized with the subject matter. *Skills* implicitly evident in students' curricula relate to teachers' ability to lead inquiry based processes so as to facilitate the development of research skills to the students. Teachers' competences implicitly evident in students' curricula are also critical thinking, creativeness, team working skills and work on a project skills.

In Spain, at a teaching practice level, the Educational law to enhance the quality of the educational system, emphasizes the development of students' competences. Competences are present in the curriculum development and assessment of all educational levels and modalities. Moreover, the Law states that cognitive abilities must be accompanied by students' acquisition of transversal competences such as critical thinking, management of diversity, creativity and communication skills. In 2007 basic competences were introduced for the first time in the Spanish National Curriculum for Secondary education, bearing strong similarities with those set in the European Reference Framework (European Commission, 2008): linguistic communication, mathematic competence, competence in knowledge and interaction with the physical world, digital and information processing competence, social and citizenship competence, cultural and artistic competence, learning to learn, and personal autonomy and initiative. Tthe following aspects of teachers' competences are implicitly required by STEM teachers in the country:

In relation to *Knowledge & Understanding*:

- Pedagogical Content Knowledge;
- Issues of inclusion and diversity;
- Effective use of technologies in learning.

In relation to *skills*:

- Collecting analyzing, interpreting evidence and data for teaching/learning improvement;
- Using, developing and creating research knowledge to inform practices.

In relation to *Dispositions & Attitudes*:

- Dispositions to promote students' democratic attitudes and practices as European citizens (including appreciation of diversity and multiculturality);
- Dispositions to team working, collaboration and networking.

Concluding, at macro level (policy), major aspect of teacher competences (knowledge & understanding, skills, dispositions & attitudes) as defined in EC (2013) framework are emphasised in all national contexts. At meso level (mediating mechanisms) disparities are evident among the countries: In the Netherlands, the regulatory framework has been long been in place and has been adopted and implemented by teacher education institutes; in Spain, there is a lack of consensus on the acceptance of the new policies among regions, local authorities and educational councils and as such implementation is being challenged; in Greece and Bulgaria, on the other hand, currently there is uncertainty on how providers of teacher education and training will respond to and implement the new regulatory framework. At micro-level, in all national contexts, a high level of coherence is evident between teacher competences required/envisions by policy and the skills that students are aimed to develop via STEM studies. The above indicate that in the national contexts of Greece, Bulgaria and Spain the main challenge identified in respect of STEM teachers' competence development lays on the grounds of policy mediation, i.e. on how teacher education institutions and providers implement policy envisions and requirements. In the Dutch context, on the other hand, given that the regulatory framework for teachers' competence development has long been established and implemented by mediating mechanisms, the main issue identified for further exploration and discussion is on the impact of teacher learning for competence development on the school practice.

An overview of aspects of STEM teachers competences explicitly and implicitly evident in the national contexts

The information provided in the national reports of O1 was mapped into EC (2013) framework for teachers' competence development, providing an overview on the dimensions and aspects of competences (knowledge & understanding, skills, dispositions and attitudes) that are explicitly and implicitly evident in in Greece, the Netherlands, Bulgaria and Spain (see Table 1).

Aspects *explicitly* evident refer to evidence as demonstrated in the national policy documents and the curricula for STEM teachers' training. Aspects *implicitly* evident refer to evidence as demonstrated in students' STEM curricula.

Table 1: *An overview of STEM teachers' competences (knowledge & understanding, skills, dispositions & attitudes) that are required (explicitly as evident in policy documents and teacher training curricula and implicitly as evident in students STEM curricula) in Greece, the Netherlands, Bulgaria and Spain.*

	Aspects of **knowledge & understanding** required in the national contexts of:							
	Greece		Netherlands		Bulgaria		Spain	
	Explicitly	Implicitly	Explicitly	Implicitly	Explicitly	Implicitly	Explicitly	Implicitly
Subject matter knowledge		✓	✓		✓		✓	
Pedagogical content knowledge		✓	✓		✓			✓
Pedagogical knowledge	✓	✓	✓		✓		✓	
Curricular knowledge	✓		✓		✓		✓	
Educational science foundations	✓		✓		✓		✓	
Contextual, institutional, organizational aspects of educational policies	✓		✓		✓		✓	
Issues of inclusion and diversity	✓	✓	✓	✓	✓		✓	✓
Effective use of technologies in learning	✓	✓	✓	✓	✓	✓	✓	✓
Developmental psychology	✓	✓	✓		✓		✓	✓
Group processes and dynamics, learning theories, motivational issues	✓	✓	✓	✓	✓		✓	
Evaluation and assessment		✓	✓		✓		✓	

	Aspects of **skills** required in the national contexts of:							
	Greece		Netherlands		Bulgaria		Spain	
	Explicitly	Implicitly	Explicitly	Implicitly	Explicitly	Implicitly	Explicitly	Implicitly
Planning, managing and coordinating teaching	✓	✓	✓	✓	✓	✓	✓	
Using teaching materials and technologies	✓	✓	✓	✓	✓	✓	✓	
Managing students and groups		✓	✓	✓	✓	✓	✓	
Monitoring adapting and assessing teaching/learning objectives and processes	✓		✓	✓	✓		✓	
Collecting, analyzing, interpreting evidence and data for professional decisions		✓	✓	✓	✓			✓
Using, developing and creating research knowledge to inform practices	✓		✓	✓	✓		✓	✓
Collaborating with colleagues, parents and social services			✓		✓			
Negotiation skills (social and political interactions with multiple educational stakeholders, actors and contexts)								
Reflective, metacognitive, interpersonal skills for learning individually and in professional communities	✓			✓	✓		✓	
Adapting to educational contexts				✓	✓		✓	

	Aspects of **dispositions & attitudes** required in the national contexts of:							
	Greece		Netherlands		Bulgaria		Spain	
	Explicitly	Implicitly	Explicitly	Implicitly	Explicitly	Implicitly	Explicitly	Implicitly
Epistemological awareness	✓				✓	✓	✓	
Teaching skills through content		✓	✓		✓		✓	
Transferable skills				✓	✓			
Dispositions to change, flexibility, ongoing learning and professional improvement, including study and research	✓			✓	✓		✓	
Commitment to promoting the learning of all students	✓	✓	✓		✓		✓	
Dispositions to promote students democratic attitudes and practices as European citizens	✓	✓	✓	✓	✓			✓
Critical attitudes to one's own teaching	✓		✓	✓	✓		✓	
Dispositions to team working , collaboration and networking	✓		✓	✓	✓			✓
Sense of self-efficacy								

The comparative insights on the aspects of STEM teachers' competences required explicitly and implicitly in each national context provided above aim to inform project activities in two respects: on the one hand, they aim to allow to orient the project's training approach towards expected teachers' learning outcomes which are most relevant for each national context. On the other hand, they aim to inform project work relating to the identification of indicators for evaluating the impact of the projects teacher learning activities, presented in the following section of this document.

Outcome indicators for evaluating the impact of ELITe' s learning in teaching activities

Outcome (or output) indicators reflect the quantity of outcomes produced, including immediate measurable results, and direct consequences of activities implemented to produce such results (Burke, 1998). The defining feature is quantity or numerical amount, and the quality of these numbers is almost entirely disregarded because quantitative performance indicators do not demonstrate quality of education, but rather quantities of its outcomes (Burke et al, 2002). In the frame of the ELITe project we developed qualitative outcome indicators for evaluating the project's learning in teaching approach for competence development.

Methodology

The methodological steps followed for the development of outcome indicators were the following:

- First, defined were the expected outcomes of the ELITe's teaching in learning approach, on the basis of Deakin & Crick (2008) definition of competences as requirements for teaching and learning;
- Then, identified were outcomes indicators for the ELITe's learning in teaching activities, by clustering the aspects of competences defined in EC (2013) framework for competence development and translating the formulated clusters into indicators for evaluating the expected outcomes
- Finally, the aspects of competences in each cluster were translated into sub-indicators; using information provided in Table 1 (outcome of the synthesis of the national reports and their mapping into the EC (2013) framework) we identified the national contexts (from Greece, the Netherlands, Bulgaria & Spain) in which each sub-indicator is relevant to.

In specific:

Defining the expected outcomes of the ELITe's learning in teaching activities

Currently, international scholarly consensus seems to converge on Deakin & Crick (2008) definition of competences as requirements for teaching, articulated in knowledge& understanding, skills and dispositions and attitudes. According to Deakin & Crick (2008) a competence is best described as *'a complex combination of knowledge, skills, understanding, values, attitudes and desire which lead to effective, embodied human action in the world, in a particular domain*'. Such a definition focuses on the potentialities of continuous development and achievement, associated with aims and objectives in a lifelong learning perspective. The dimensions of teachers' competences (knowledge & understanding, skills, dispositions & attitudes) served as the basis for the definition of the expected outcomes of STEM teachers' participation in initiatives for competence development within ELITe. As illustrated in the figure below, through the participation in ELITe's continuous professional learning initiatives, STEM teachers are expected to: develop knowledge & understanding on learning and teaching; develop skills for learning and teaching; and develop positive dispositions and attitudes on learning and teaching, i.e. come to value learning and teaching (see figure 1).

Figure 1: *Defining the expected outcomes of the ELITe's professional learning approach, on the basis of Deakin & Crick (2008) definition of competences*

			Expected outcomes
Dimensions of teachers competences	Knowledge & Understanding	⇨	Develop knowledge & understanding on learning and teaching "I have knowledge and understanding on this"
	Skills	⇨	Develop skills for learning and teaching "I can do this"
	Dispositions & attitudes	⇨	Come to value learning and teaching – develop positive dispositions and attitudes "This is important to me"

Identifying outcomes indicators for the ELITe's learning in teaching activities

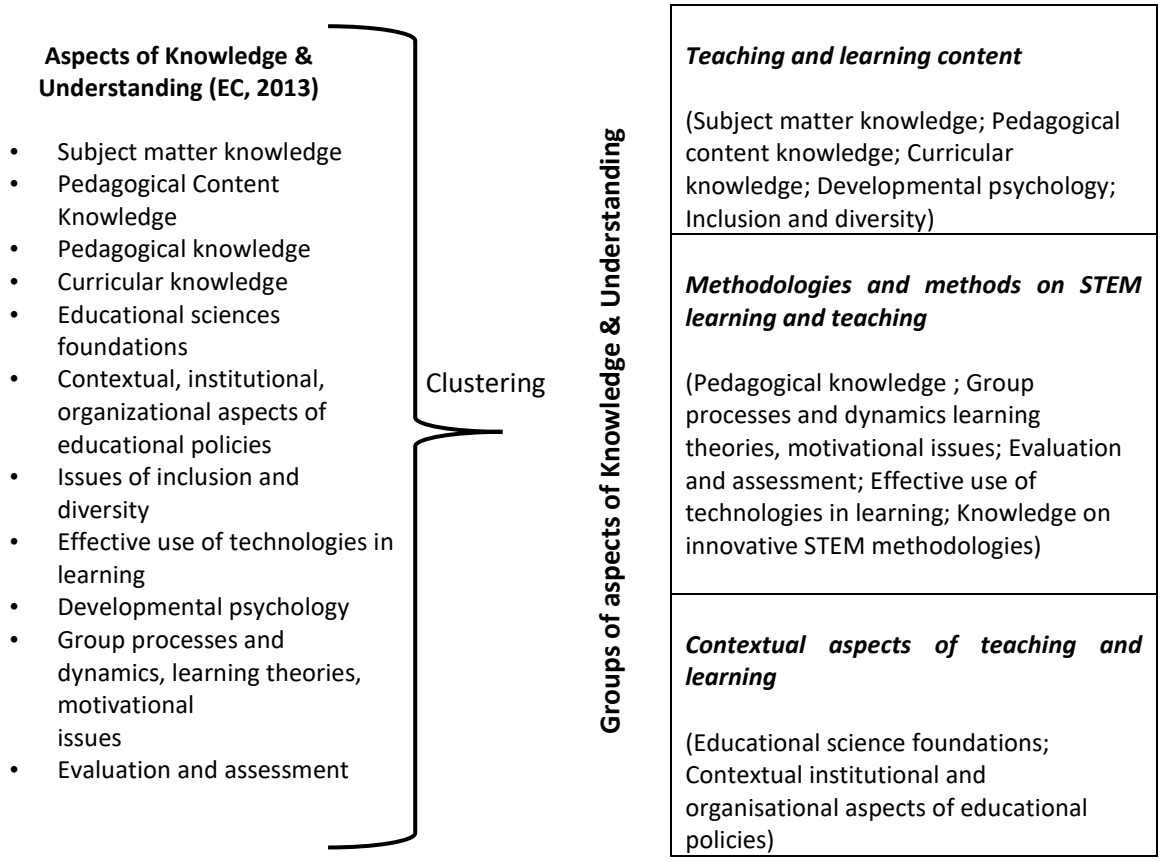
In order to identify indicators for evaluating the expected outcomes of STEM teachers' participation in ELITe's learning in teaching activities, we draw on EC (2013, p45-46) framework. The framework defines aspects in each of the three dimensions of competences (knowledge & understanding, skills, and dispositions & attitudes). These encompass perspectives from policy and research and have been proposed under the scope of being "*useful references for a shared discourse between stakeholders and experts, as well as a starting point for further developments in international arenas of educational policy and practice* - as suggested in the Commission Staff Working Document 'Supporting the Teaching Professions for Better Learning Outcomes' ". The breaking down of teacher competences – which are essentially dynamic and holistic - into separate areas and components only serves the analytical purpose of understanding the implications and assumptions that underlies them.

The proposed aspects of the EC (2013) framework were clustered in groups. For the dimension of "Knowledge & Understanding" three groups of aspects were formed, namely:

- aspects relating to knowledge and understanding of the *teaching and learning content*;
- aspects relating to knowledge and understanding on *methodologies and methods on STEM learning and teaching*;
- aspects relating to knowledge and understanding on contextual aspects of teaching and learning

(see figure 2 below for the aspects of knowledge and understanding that fall in each group).

Figure 2: ***Clustering aspects of Knowledge & Understanding of the EC (2013) framework***

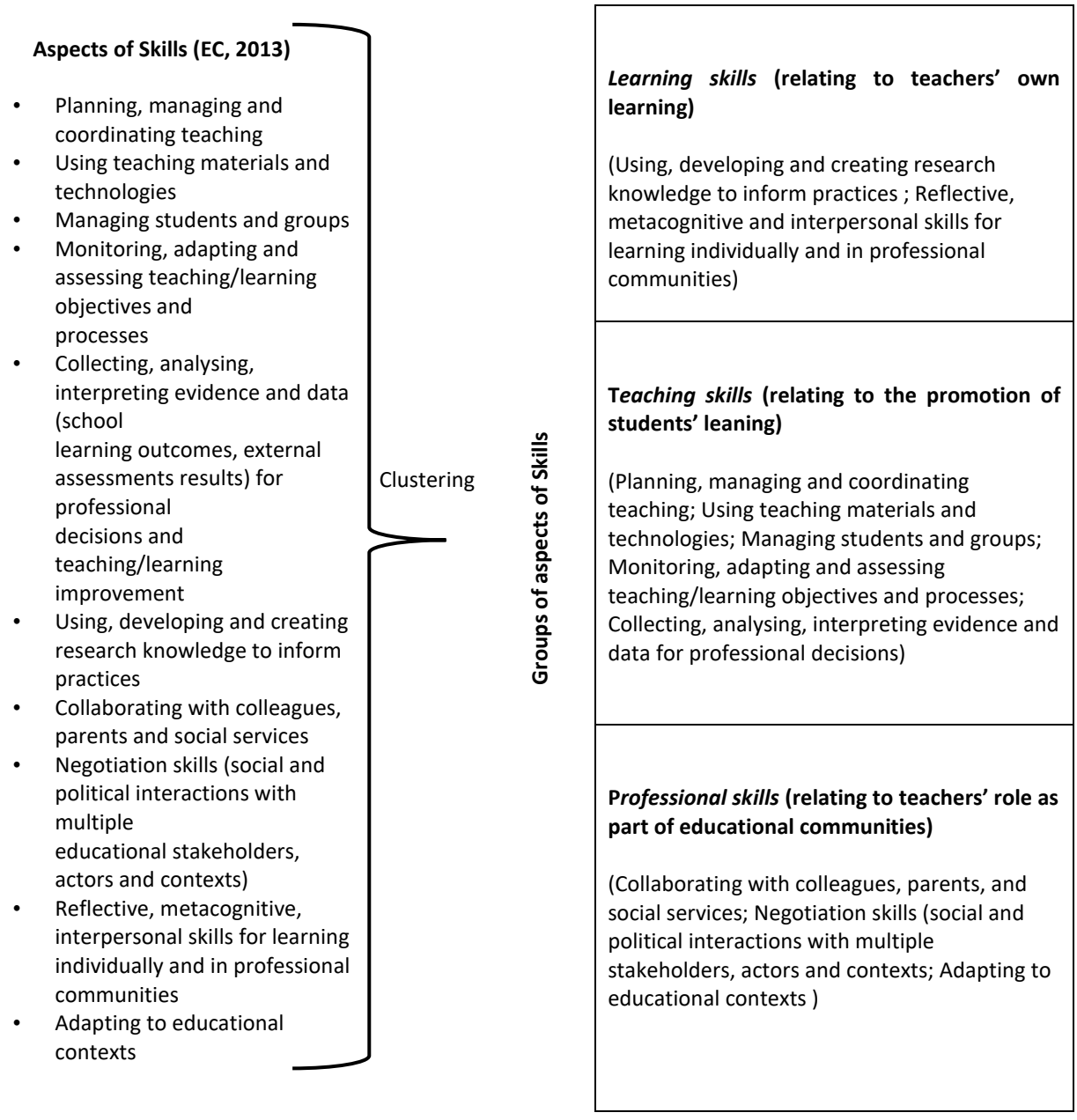


Aspects of skills of the EC (2013) framework were clustered in three groups, namely:

- learning skills (relating to teachers' own learning);
- teaching skills (relating to the promotion of students' leaning);
- professional skills (relating to teachers' role as part of educational communities)

(see figure 3 below)

Figure 3: ***Clustering aspects of Skills of the EC (2013) framework***

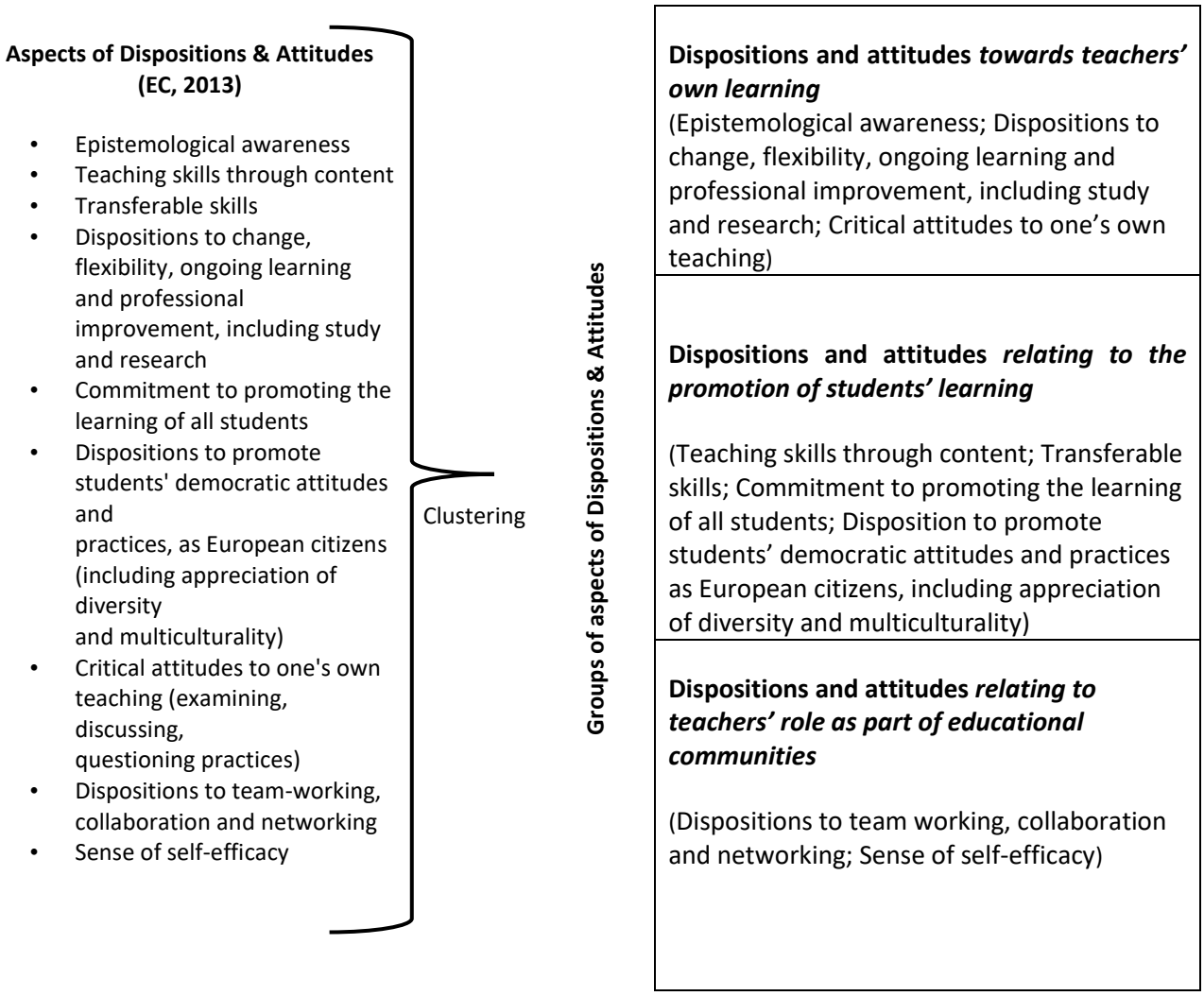


Aspects of dispositions and attitudes of the EC (2013) framework were clustered in three groups, namely:

- dispositions and attitudes towards teachers' own learning;
- dispositions and attitudes relating to the promotion of students learning;
- dispositions and attitudes relating to teachers' role as part of educational communities

(see figure 4 below)

Figure 4: ***Clustering aspects of Dispositions & Attitudes of the EC (2013) framework***



Translating the aspects of competences in each cluster into sub-indicators

The formulated clusters of knowledge & understanding, skills, dispositions & attitudes presented in Tables X. Y Z above, allowed the identification of indicators for evaluating the impact of initiatives on STEM teachers' competence development towards the expected outcomes (outcomes indicators).

As illustrated in figure 5 below, in relation to the expected outcome "Development of knowledge and understanding on learning and teaching", we identified three outcome indicators, namely demonstration of:

- enhanced knowledge and understanding on STEM related teaching and learning content;
- enhanced knowledge and understanding on methodologies and methods relating to STEM learning and teaching, and

- enhanced knowledge & understanding on contextual aspects of learning and teaching.

In relation to the development skills for learning and teaching, we propose that STEM teachers participating in initiatives for competence development should demonstrate:

- enhanced learning skills, relating to the promotion of teachers' own learning;
- enhanced teaching skills, relating to the promotion of students' learning, and
- enhanced professional skills, relating to teachers' role as part of educational communities

In relation to the expected outcome "Come to value learning and teaching-dispositions and attitudes" identified were three indicators, namely demonstration of:

- positive dispositions and attitudes relating to teachers' own learning;
- positive dispositions and attitudes relating to promoting students' learning, and
- positive dispositions and attitudes relating to teachers role as part of educational communities.

Figure 5: *Translating the formulated clusters of aspects of the EC (2013) framework into indicators for evaluating the expected outcomes of the ELITe's professional learning activities*

				Outcome indicators ***STEM teachers participating in initiatives for their competence development should demonstrate:***
Clustering of aspects of teachers' competences of EC(2013) framework	Knowledge & Understanding	STEM related teaching and learning content	⇨	Enhanced knowledge and understanding on STEM related teaching and learning content
		Methodologies and methods relating to STEM teaching and learning	⇨	Enhanced knowledge and understanding on methodologies and methods relating to STEM learning and teaching
		Contextual aspects of learning and teaching	⇨	Enhanced knowledge & understanding on contextual aspects of learning and teaching
	Skills	Learning skills (relating to teachers' own learning)	⇨	Enhanced learning skills, relating to the promotion of teachers' own learning
		Teaching skills (relating to the promotion of students' STEM learning)	⇨	Enhanced teaching skills, relating to the promotion of students' learning
		Professional skills (relating to teachers' role as part of educational communities)	⇨	Enhanced professional skills, relating to teachers' role as part of educational communities
	Dispositions & Attitudes	Dispositions and attitudes relating to teachers' own learning	⇨	Positive dispositions and attitudes relating to teachers' own learning
		Dispositions and attitudes relating to promoting students; learning)	⇨	Positive dispositions and attitudes relating to promoting students' learning
		Dispositions and attitudes relating to teachers; role as part of educational communities	⇨	Positive dispositions and attitudes relating to teachers role as part of educational communities

For each outcome indicators, sub-indicators were identified, on the basis of the aspects of competences of the EC (2013) framework that fall in each cluster (see figure 6 below).

Figure 6: *Translating the aspects of competences in each cluster into sub-indicators for evaluating the expected outcomes of the ELITe's professional learning activities*

Aspects of competences in each cluster				**Outcome sub-indicators** ***STEM teachers participating in initiatives for their competence development can demonstrate the following types of evidence:***
	STEM related teaching and learning content	Subject matter knowledge	⇨	Demonstration of enhanced STEM knowledge (knowledge in specific content areas)
		Pedagogical content knowledge	⇨	Demonstration of enhanced Pedagogical Content Knowledge (knowledge of tasks, learning contexts & objectives; knowledge of students' prior knowledge & subject specific learning difficulties; strategic knowledge of instructional methods & curricular materials)
		Curricular knowledge	⇨	Demonstration of enhanced Curricular Knowledge (knowledge of STEM curricula-e.g. the planned and guided learning of subject specific contents)
		Developmental psychology	⇨	Demonstration of knowledge on issues pertaining to developmental psychology
		Inclusion and diversity	⇨	Demonstration of knowledge on issues of inclusion and diversity
	Methodologies and methods relating to STEM teaching and learning	Pedagogical knowledge; Group processes and dynamics learning theories; motivational issues	⇨	Demonstration of enhanced Pedagogical knowledge (knowledge of teaching and learning methodologies & processes; group processes & dynamics; learning theories & motivational issues)
		Evaluation and assessment	⇨	Demonstration of knowledge on innovative STEM methodologies (e.g. inquiry based learning and teaching)
		Effective use of technologies in learning	⇨	Demonstration of knowledge on evaluation and assessment (processes and methods)
		Knowledge on innovative STEM methodologies	⇨	Demonstration of knowledge on new technologies (and their affordances as a tool for more effective learning)
	Contextual aspects of teaching and learning	Educational science foundations	⇨	Demonstration of knowledge on educational sciences foundations (intercultural, historical, philosophical and sociological knowledge)
		Contextual institutional and organisational aspects of educational policies	⇨	Demonstration of knowledge on contextual, institutional & organizational aspects of educational policies
	Learning skills	Using, developing and creating research knowledge to inform practices	⇨	Demonstration of ability to using, develop and create research knowledge to inform practices
		Reflective, & metacognitive skills	⇨	Demonstration of reflective & metacognitive skills during owns learning
		Interpersonal skills	⇨	Demonstration of interpersonal skills for learning individually and in professional communities
	Teaching skills	Planning, managing and coordinating teaching	⇨	Demonstration of ability to plan, manage and coordinate teaching
		Using teaching materials and technologies	⇨	Demonstration of ability to use teaching materials and technologies
		Managing students and groups	⇨	Demonstration of mastery in managing students and groups
		Monitoring, adapting and assessing teaching/learning objectives and processes	⇨	Demonstration of ability to monitor, adapt and assess teaching/learning objectives and processes
		Collecting, analysing, interpreting evidence and data for professional decisions	⇨	Demonstration of collecting, analysing, interpreting evidence and data skills for professional decisions and teaching/learning improvement

	Professional skills	Collaborating with colleagues, parents, and social services	⇨	Demonstration of collaboration skills (with colleagues, parents and social services)
		Negotiation skills (social and political interactions with multiple stakeholders, actors and contexts	⇨	Demonstration of negotiation skills (social and political interactions with multiple educational stakeholders, actors and contexts)
		Adapting to educational contexts	⇨	Demonstration of ability to adapt to educational contexts
		Life and career skills	⇨	Demonstration of Life and Career skills (Flexibility and adaptability; Initiative and self-direction; Productivity; Leadership and responsibility)
	Dispositions and attitudes towards teachers own learning	Epistemological awareness	⇨	Demonstration of epistemological awareness
		Dispositions to change, flexibility, ongoing learning and professional improvement	⇨	Demonstration of positive dispositions to change, flexibility, ongoing learning and professional improvement (including study and research)
		Critical attitudes to one's own teaching	⇨	Demonstration of critical attitudes to one's own teaching (examining, discussing, questioning practices)
	Dispositions and attitudes towards promoting students; learning	Teaching skills through content	⇨	Demonstration of teaching skills through content
		Transferable skills	⇨	Demonstration of transferable skills
		Commitment to promoting the learning of all students	⇨	Commitment to promoting the learning of all students
		Disposition to promote students' democratic attitudes and practices as European citizens	⇨	Dispositions to promote students' democratic attitudes and practices, as European citizens (including appreciation of diversity and multiculturality)
	Dispositions and attitudes relating to teachers' role as part of educational communities	Dispositions to team working, collaboration and networking	⇨	Dispositions to team-working, collaboration and networking
		Sense of self-efficacy	⇨	Sense of self-efficacy

Results

Information from Table 1 allowed to identify the national context (from Greece, the Netherlands, Bulgaria and Spain) in which each sub-indicator is relevant to. The following table (Table 2) provides an overview of the outcomes of the above-mentioned methodological processes.

Presented in Table 2 are the expected outcomes of the ELITe's learning in teaching activities, aligned to indicators and sub-indicators for evaluating the expected outcomes. Information is also provided in relation to the national context in which each sub-indicators is relevant to.

Table 2: *Indicators and sub-indicators relevant to the national contexts of Greece, the Netherlands, Bulgaria & Spain for evaluating the expected outcomes of the ELITe's learning in teaching activities.*

Outcome Through the participation in initiatives for STEM teachers' competence development, STEM teachers are expected to :	**Outcome Indicators** STEM teachers participating in initiatives for their competence development should demonstrate:	**Sub-indicators** STEM teachers participating in initiatives for their competence development can document the following types of evidence:	**National contexts** in which the sub-indicators are relevant to:	
			Explicitly	Implicitly
Develop **knowledge & understanding** on learning & teaching  **"I have knowledge & understanding on this"**	**Enhanced knowledge and understanding on STEM related & teaching and learning content**	***Demonstration of enhanced STEM knowledge*** *(knowledge in specific content areas)*	NL,BG,ES	GR
		Demonstration of enhanced Pedagogical Content Knowledge (knowledge of tasks, learning contexts & objectives; knowledge of students' prior knowledge & subject specific learning difficulties; strategic knowledge of instructional methods & curricular materials)	NL,BG	GR, ES
		Demonstration of enhanced Curricular Knowledge *(knowledge of STEM curricula- e.g. the planned and guided learning of subject specific contents)*	GR,NL,BG,ES	
		Demonstration of knowledge on issues pertaining to developmental psychology	GR,NL,BG,ES	GR,ES
		Demonstration of knowledge on issues of inclusion and diversity	GR,NL,BG,ES	GR,NL,ES
	Enhanced knowledge and understanding on methodologies and methods relating to STEM learning and teaching	***Demonstration of enhanced Pedagogical knowledge*** *(knowledge of teaching and learning methodologies &* processes; group processes & dynamics; learning theories & motivational issues)	GR,NL,BG,ES	GR,NL
		Demonstration of knowledge on innovative STEM methodologies *(e.g. inquiry based learning and teaching)*	NL,BG	NL
		Demonstration of knowledge on evaluation and assessment *(processes and methods)*	NL,BG,ES	GR
		Demonstration of knowledge on new technologies *(and their affordances as a tool for more effective learning)*	GR,NL,BG,ES	GR,NL,BG,ES
	Enhanced knowledge and understanding on contextual aspects of learning and teaching	***Demonstration of knowledge on educational sciences foundations (****intercultural, historical, philosophical and sociological knowledge****)***	GR, NL, BG, ES	
		Demonstration of knowledge on contextual, institutional & organizational aspects of educational policies	GR, NL, BG, ES	

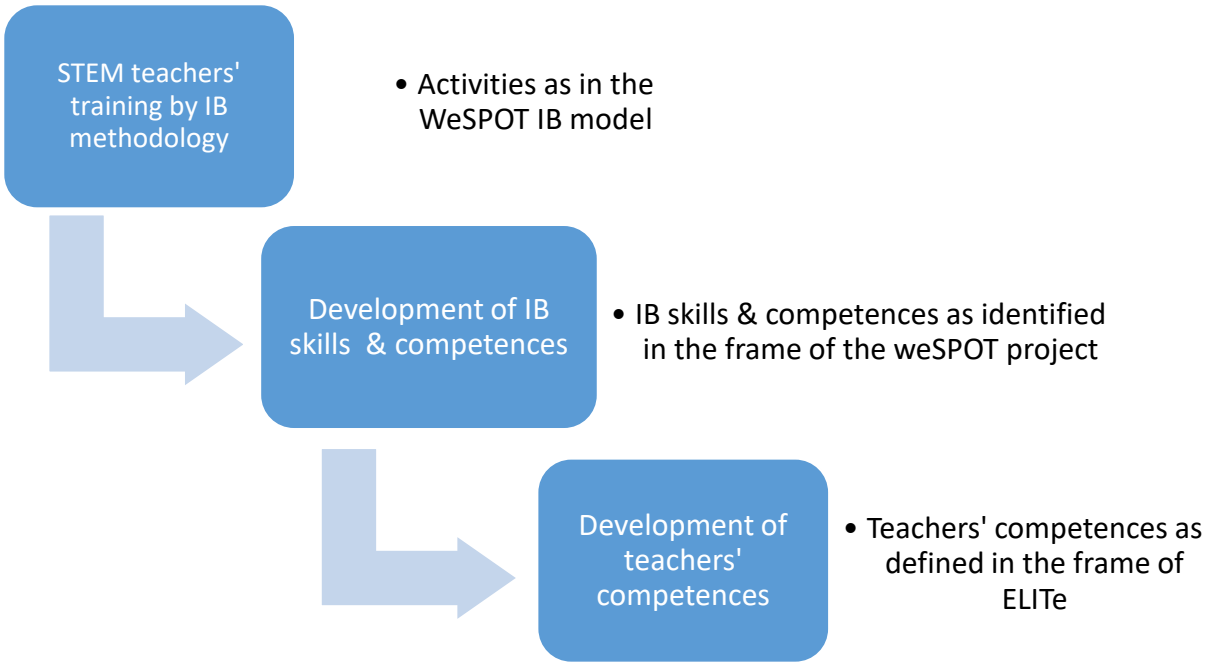
Outcome Through the participation in initiatives for STEM teachers' competence development, STEM teachers are expected to :	**Outcome Indicators** STEM teachers participating in initiatives for their competence development should demonstrate:	**Sub-indicators** STEM teachers participating in initiatives for their competence development can document the following types of evidence:	**National contexts** in which the sub-indicators are relevant to:	
			Explicitly	Implicitly
Develop **skills** for learning & teaching  **"I can do this"**	**Enhanced learning skills -relating to the promotion of teachers' own learning**	***Demonstration of ability to using, develop and create research knowledge to inform practices***	GR,NL,BG,ES	NL,ES
		Demonstration of reflective & metacognitive skills during owns learning	GR,BG,ES	NL
		Demonstration of interpersonal skills for learning individually and in professional communities	GR,BG,ES	NL
	Enhanced teaching skills –relating to the promotion of students' learning	***Demonstration of ability to plan, manage and coordinate teaching***	GR,NL,BG,ES	GR,NL,BG
		Demonstration of ability to use teaching materials and technologies	GR,NL,BG,ES	GR,NL,BG
		Demonstration of mastery in managing students and groups	NL,BG,ES	GR,NL,BG
		Demonstration of ability to monitor, adapt and assess teaching/learning objectives and processes	GR,NL,BG,ES	NL
		Demonstration of collecting, analysing, interpreting evidence and data skills for professional decisions and teaching/learning improvement	NL,BG	GR,NL,ES
	Enhanced professional skills- relating to teachers' role as part of educational communities	***Demonstration of collaboration skills (****with colleagues, parents and social services)*	NL, BG	
		Demonstration of negotiation skills *(social and political interactions with multiple educational stakeholders, actors and contexts)*		
		Demonstration of ability to adapt to educational contexts	BG	NL,ES
		Demonstration of Life and Career skills *(Flexibility and adaptability; Initiative and self-direction; Productivity; Leadership and responsibility)*		BG

Outcome Through the participation in initiatives for STEM teachers' competence development, STEM teachers are expected to :	**Outcome Indicators** STEM teachers participating in initiatives for their competence development should demonstrate:	**Sub-indicators** STEM teachers participating in initiatives for their competence development can document the following types of evidence:	**National contexts** in which the sub-indicators are relevant to:	
			Explicitly	Implicitly
Come to value learning and teaching- **dispositions & attitudes**  **" This is important to me"**	**Positive dispositions and attitudes relating to teachers own learning**	***Demonstration of epistemological awareness***	GR,BG	BG
		Demonstration of positive dispositions to change, flexibility, ongoing learning and professional improvement *(including study and research)*	GR,BG,ES	NL
		Demonstration of critical attitudes to one's own teaching *(examining, discussing, questioning practices)*	GR,NL,BG	NL,
	Positive dispositions and attitudes relating to the promotion students learning	***Teaching skills through content***	NL,BG,ES	GR
		Transferable skills	BG	NL
		Commitment to promoting the learning of all students	GR,NL,BG,ES	GR
		Dispositions to promote students' democratic attitudes and practices, as European citizens *(including appreciation of diversity and multiculturality)*	GR,NL,GR	GR,NL,ES
	Positive dispositions and attitudes relating to their role as part of educational communities	***Dispositions to team-working, collaboration and networking***	GR,NL,BG	NL,ES
		Sense of self-efficacy		

Process indicators in ELITe's inquiry based professional learning

The ELITe's approach for STEM teachers' professional learning foresees teachers training activities taking place via the inquiry based (IB) methodology, by the use of an on-line platform for facilitating personal and collaborative inquiry learning. The platform is embedded on an inquiry based learning model developed in the frame of the weSPOT project. The assumption underlying this approach is that STEM teachers training through IB methodology facilitates practicing of IB skills which in turn supports the development of teacher competences. An overview of the ELITe's approach/assumption to STEM teachers' professional learning is presented in figure 7.

Figure 7: *The ELITe's approach/assumption to STEM teachers' professional learning*



In order to provide empirical evidence on whether training by IB methodology supports the development of teacher competences (i.e. test the project's assumption), we need to gain insights on:

a) the outcomes of the ELITe's learning activities on teachers' competence development, and

b) the processes of teachers' learning activities that lead to the observed outcomes.

The work presented in the previous section of this document (on outcome indicators) facilitates to gain insights on the outcomes of the ELITe's learning activities, by defining the expected outcomes of the teachers' training activities and by proposing aligned to them indicators and sub-indicators, under which the outcomes will be evaluated.

In this section presented are the processes and outcomes of the activities relating to the development of process indicators that aim to provide information and context to facilitate the interpretation of the observed outcomes. First, we present outcomes of the weSPOT project that have informed current work: we outline the weSPOT IB model and the related to it learning activities, we present IB skills & competences that are practiced through learning activities by the weSPOT model, and we outline the linkage of the IB skills and competences to the learning activities. Then, presented are process indicators, linked to the IB skills & competences and to learning activities, and therefore can indicate is a skill is present or not, depending on the activity performed by learners.

Background

The weSPOT IB model on which ELITe's training activities are based

The weSPOT model moves on from the simplistic cyclical models steps required for good research, steps described in scientific literature (Crawford & Stucki, 1990; Hunt & Colander, 2010) such as, data collection, data analysis, hypothesis forming, communication and dissemination of findings etc. and it is closely related to the inquiry model by Mulholland et al. (2012). It shares many of the phases that Mulholland et al. (2012) described in their model, such as create a question or a hypothesis, collect data, analyse data, share finding etc., but it is more elaborate regarding the sub-phases providing a detailed description of things that teachers and students should consider when doing inquiry.

The weSPOT inquiry-based learning model presented in figure X, consists of six phases, placed within the context, that mirror the phases that researchers need to go through in order to conduct their research, since inquiry is an integral feature of science. Each phase also consists of a number of activities ranging from six to eleven. Activities in each phase are outlined here below:

Problem/Topic

- Embedding
- Existing knowledge
- Mental representation
- Language/definitions
- Field of research
- Ethics
- Empirical meaning
- Discussion/Argumentaion
- Question
- Hypothesis
- Reflection

Operationalisation (realisation of idea with the aim to measure)

- Indicators
- Predictions
- Resources
- Methodology (of data collection and processing)
- Ethics (Ethical issues)
- Discussion/Argumentaion
- Reflection

Data collection

- Information foraging
- Systematic observation
- Experimentation
- Tools
- Simulation
- Data storage
- Data security
- Documentation
- Discussion/Argumentaion
- Reflection

Data Analysis (processing)

- Quantitative analysis (Statistical methods/analysis)
- Qualitative analysis
- Tools
- Visualisation
- Discussion/Argumentaion
- Reflection

Interpretation

- Embedding (Embedding into existing theories/results/domain knowledge (classification))
- Confirmation/falsification (of the initial question/hypothesis)
- Relevance (of the results)
- Discussion/Argumentation
- Reflection

Communication

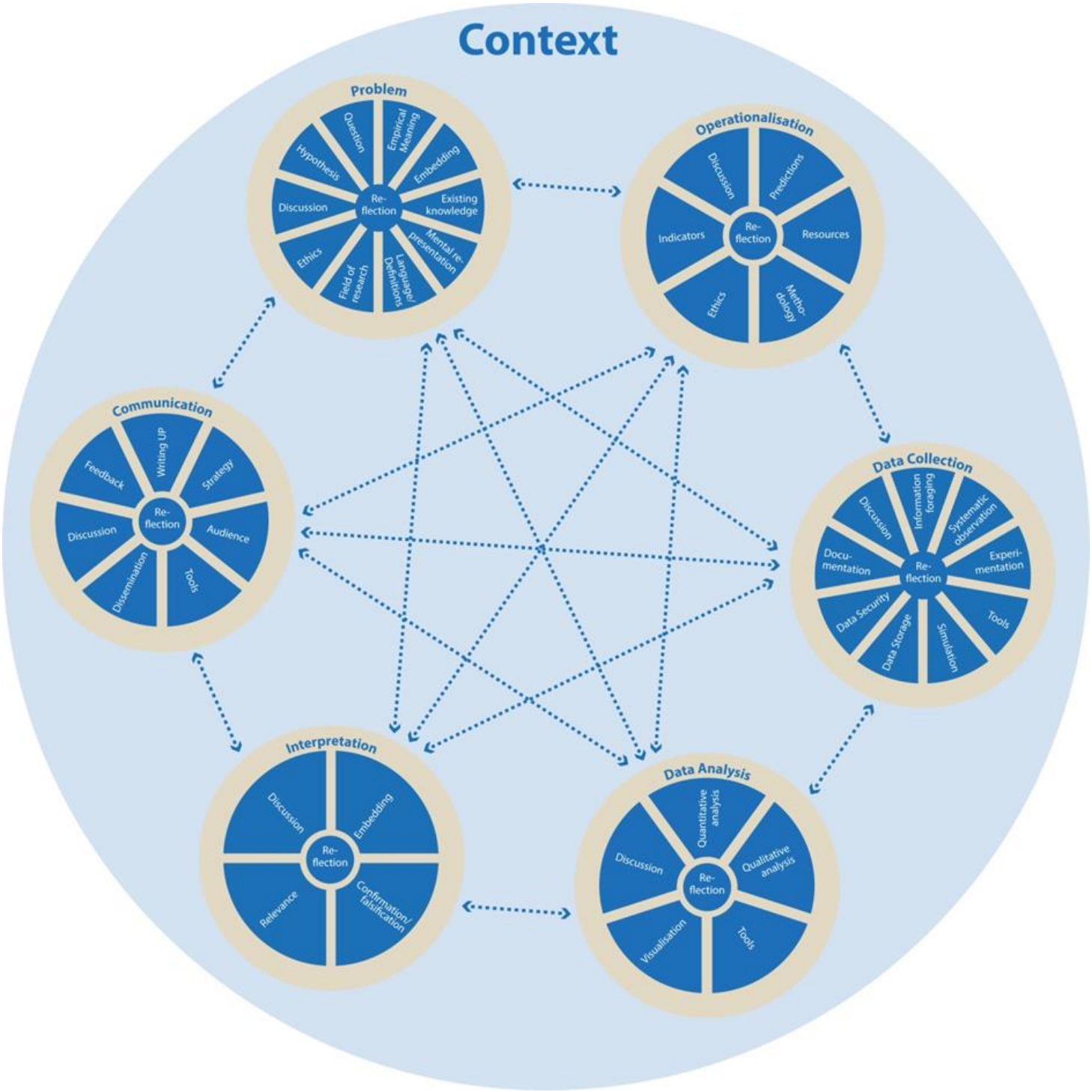
- Strategy
- Audience
- Tools
- Dissemination (Events/Presentation/Publication)
- Discussion/Argumentaion
- Feedback (Receiving and reacting)
- Writing up
- Reflection

All the IBL model phases are placed in the context where the different aspects of inquiry can take place.

The weSPOT inquiry-based learning model places reflection at the centre of each inquiry phase, see it as an integrated process throughout the inquiry activity and not as an independent phase that comes at the end of the process. The reason is that reflection is vital at every stage of the process even at the very beginning when the student needs to develop a question or a hypothesis. He/she needs to reflect upon the question, and evaluate it before they decide to proceed. The evaluation can either be individual or collaborative.

Additionally, there is bidirectional communication between the different inquiry phases, meaning that students and teachers can move from one phase to the next depending on their needs and their focus without needing to complete a phase. A more detailed description of the model can be found on the report: Deliverable D2.3.1: Pedagogical and Diagnostic Framework (available in: http://wespot.net/).

Figure 8: *The weSPOT IB model on which the ELITe professional learning activities will be based on*



IB skills & competences practiced through weSPOT IB learning activities

Skill is seen as a goal oriented and well organised behaviour which is developed through practice and gradually becomes automated. Skill is a much narrower term compared to competence and focuses on the ability to use the knowledge to accomplish a task. **Competence** on the other hand is defined as a set of observable performance dimensions, including individual knowledge, skills, attitudes, and behaviours, as well as collective team, process, and organizational capabilities, that are linked to high performance.

Skills related to the IB learning activities as identified in the WeSPOT project -and adopted by the ELITe project - are the following:

- Analytical skills to research a topic, develop a project plan and timeline, and draw conclusions from research results.
- Science skills to break down a complex scientific system into smaller parts, recognize cause and effect relationships, and defend opinions using facts.
- Comprehension, read and understand scientific and technical materials.
- Experimentation skills to know the different methodologies and processes required.
- Mathematic skills for calculations and measurements.
- Attention to detail to follow a standard blueprint, record data accurately, or write instructions.
- Technical skills to troubleshoot the source of a problem, repair a machine or debug an operating system, and computer capabilities to stay current on appropriate software and equipment.
- Presentation skills
- Cooperation skills to listen to others needs or interact with project partners.
- Creative skills/abilities to solve problems and develop new ideas.
- Leadership skills to be able to lead a team.
- Organization skills to keep track of lots of different information.
- Metacognitive skills

Competencies related to the IB learning activities as identified in the WeSPOT project -and adopted by the ELITe project - are the following:

Research competence: To have research competence one should be able to apply a variety of analytical skills, mathematical and technical skills, experimentation skills and knowledge, sometimes to apply creative skills to obtain a solution, presentation skills, collaboration and communication skills especially if working within a team and so on.

Problem solving: Problem solving is a competence that requires several skills, knowledge and behaviours to be performed well. For example, to solve problems effectively one must have the skill to define the problem, have knowledge of all possible solutions, and exhibit behaviour that enables him or her to make a decision. Problem solving competence can be applied to technical as well to non-technical tasks/areas.

Communication: Communication is really a competency that relies on a combination of certain skills, behaviour and knowledge. To communicate effectively, for example, a person may need to understand cultural diversity, have advanced language skills, behave with patience have technical skills regarding different presentation media etc.

Critical thinking: Critical thinking includes a wide range of cognitive skills and intellectual dispositions needed to interpret, analyse, and evaluate arguments, problems and systems, and then to synthesize, evaluate, and explain an appropriate response. This response may be innovative and go beyond standard conventions.

Linking learning activities of the weSPOT IB model with IB skills and competences

The table below indicates the weSPOT IBL model phases with its sub-phases, its related activities and the associated skills and competences. For instance, in the phase "Problem/Topic" there is a sub-phase called "Wonder moment", then the relevant activities have defined accompanied by the relevant technology in the learning platform that a teacher will have to use to produce such an activity. Then the associated skill/competence is provided to serve as guidance for the development of such skill/competence. All the IB model phases and sub-phases have been linked to the relevant activities and their associated skills/ competence.

Table 3: Linking IB skills & competences with weSPOT model learning activities

Phase	Sub phase	Activities	Technologies/ widgets	Skills & Competences
Phase 1 – Problem/topic	Wonder moment	Providing a wonder-moment, a 'My theory is' (Idea)	Questions	critical thinking (+comprehension)
	Specify context	Conducting a search for sources / literature research	Notes	research (+observation)
	Existing knowledge	Literature research/ describing 'What we (already) know'	files[*1]	information literacy (existing knowledge, learning, argumentation)
	Concept map	Concept mapping	mindmaps	critical thinking (comprehension), metacognitive
	Definitions of concepts	Concept defining	notes	critical thinking (comprehension, argumentation), information literacy (existing knowledge, learning, argumentation), communication (language)
	Need to know	Describing 'What we (still) need to know'	questions	critical thinking, analytical
	Phase 1- reflection	Understanding different kinds of scientific questions and examining and evaluating this aspect of the learning experience thinking (evaluation)	Reflection	critical thinking, metacognitive, critical

Phase 2 - Operationalisation	Indicators for measuring	Coming up with resources and ways how to measure/ instruments (qualitative and quantitative)	Discussion	information literacy (existing knowledge, learning)
	Prediction	Coming up with indicators for concepts that can be measured to develop or test ideas [and relationships among them]	notes	information literacy (existing knowledge, learning, argumentation)
	Planning the method	Formulating hypotheses and coming up with alternative hypotheses	hypothesis	critical thinking (+inferring), analytical
	Methodology	Setting up experiments to test hypotheses or set up other inquiry procedure	Files[*2]	critical thinking, research (observation)
	Ethical concerns	Showing ethical concern within research setup	Discussion	information literacy (existing knowledge, learning)
	Phase 2 - reflection	Discussing the phase in a critical manner (e.g. implications, limitations of approach, lessons for future studies) by providing arguments	Discussion	critical thinking, analytical thinking, information literacy
Phase 3 - Data collection	Collect information	Collecting data with (measurable) indicators to develop or test ideas/beliefs	data_collection	information literacy (exisiting knowledge, learning), computer/technical, research (scientific)
	Description of experiment	Testing a hypothesis/ideas	files[*3]	research (+experimentation)
	Systematic data collection	Using authoritative resources, systematic measuring of qualitative and quantitative measures (controlling the experiment to minimize alternative influences)	discussion	research (+observation, +experimentation)

	Description of data collection tool	Using appropriate tools to collect data with	files[*4]	computer/technical
	Evidence	Collecting evidence	files	computer/technical
	Inquiry discussion (data privacy)	Taking privacy of data into consideration	discussion	computer/technical
	Followed data collection methods	Careful record keeping of methods and findings	files[*5]	communication (+language, +writing), computer/technical
	Phase 3 - reflection	Reflecting on what knowledge was gained and what has not been collected yet, and examining and evaluating this aspect of the learning experience	reflection	critical thinking (+evaluation), metacognitive
Phase 4 - Data analysis	Calculations done on data	Processing measures taken	notes	analytical (+quantitative analysis, +mathematical), analytical (statistical)
	Procedure of categorizing data	Processing the measured perceptions of phenomena, e.g. extracting theme's, clustering	notes	analytical (+statistical, +mathematical, +qualitative analysis)
	Analysed data	Using data analysis tools, like spreadsheets, tables	files	computer/technical
	Graph/visualisation of data	Using graphs or other visualisations	files	critical thinking (comprehension), computer/technical
	Phase 4 reflections	Checking the analyses and coming up with alternatives, and examining and evaluating this aspect of the learning experience	reflection	critical thinking (+evaluation), metacognitive

Phase 5 - interpretation	Fit of findings with existing knowledge	Interpreting findings in light of previous knowledge	discussion	critical thinking (+comprehension, + inferring), information literacy (existing knowledge, learning), analytical (classification)
	Counterevidence	Judging evidence and counterevidence	discussion	critical thinking (evaluation), research (experimentation), analytical (+statistical, +mathematical)
	Relevance of results to problem	Making sure the results are relevant to the problem	files[*6]	critical thinking, analytical
	Phase 5 reflections	Checking the interpretation (process) and coming up with alternatives, and examining and evaluating this aspect of the learning experience	reflection	critical thinking (+evaluation), metacognitive
Phase 6 - communication	Conclusion	Presenting the findings in clear, written form	conclusions	communication (language), communication (writing)
	Impact, stakeholders	Considering impact, content, routes and stakeholders	discussion	research (+planning, +organisation)
	Describe the kind of audiences you will present your findings to	Determining the audience and adjusting presentation mode accordingly	notes	analytical (+classification), research (+planning)
	Which technical tools can we use to communicate our results?	Using technical tools for communicating results	notes	computer/technical
	Implications, limitations, lessons learned	Discussing the findings in a critical manner (e.g. implications, limitations of approach, lessons for future studies)	discussion	communication, critical thinking
	Feedback	Providing feedback on findings of others	files[*7]	communication

	Phase 6 reflection	Checking the method of communication and coming up with alternative approaches, and examining and evaluating this aspect of the learning experience	reflection	critical thinking (+evaluation), metacognitive,

The work presented in table 3, has been developed in the frame of the weSPOT project (see report D2.23.2. Revised pedagogical and diagnostic framework available in http://wespot.net/) and serves as the basis for the development of process indicators for the ELITe's learning in teaching activities, that aim to provide information and context to facilitate the interpretation of the observed outcomes.

Methodology

Process indicators are the indicators which include the means used to deliver educational programmes, activities and services within the institutional environment (Burke, 1998). These measurements look at how the system operates within its particular context, accounting for institutional diversity, a common confounding factor in inter- and intra-institutional comparison. Process indicators allow the collection of qualitative information on aspects of teaching and learning quality; such as policies and practices related to learning and teaching, performance management and professional development of staff, quality of curriculum and the assessment of student learning, and quality of facilities, services and technology. Process indicators have been identified by empirical research to be the most practical, useful and appropriate measures of quality teaching and learning within higher education institutions (Chalmers, Cunningham & Thomson, forthcoming) and are the indicators commonly reviewed through institutional audit. They provide an understanding of current practice and the quality of that practice. This has been shown to be effective in informing further initiatives and policy decisions (Kuh, Pace & Vesper, 1997), leading to quality enhancement. They are an invaluable source of information on teaching and learning quality because they investigate the core of the learning experience (e.g. quality of teaching, curriculum, assessment, services and facilities).

The ELITe process indicators aim to provide information and context to facilitate interpretation of outcome indicators. They aim to serve as an evaluation tool to indicate whether an IB skill and competence has been practiced by learners when performing IB activities. The methodological steps followed for the development of process indications were the following:

- First, the activities of the weSPOT IB model performed by learners were clustered in groups on the basis of the IB skills and competences to which they relate (based on information from Table 3)
- Then, the activities of the weSPOT model were translated into indicators that enable to identify whether the activity has been performed, and as such the aligned to it skill/competence has practiced.

Results

Table 4 below outlines the outcomes of the above mentioned methodological processes. Presented are the ELITe process indicators, linked to the weSPOT IBL skills, phases and activities and therefore can indicate, if a skill is present or not depending on the activity performed by the teacher.

Table 4 : *Process indicators for the ELITe learning in teaching activities*

IB skill - competence	Activities of the weSPOT IB model		Process indicators (Indicating whether an IB skill /competence has been practiced by learners when performing IB activities)
Critical thinking (argumentation skills, comprehension skills, evaluation skills and inferring)	Problem/Topic Phase– Wonder moment	⇨	Providing a wonder moment
	Problem/Topic Phase– Concept map	⇨	Developing a concept map
	Problem/Topic Phase – Definition of concepts	⇨	Concept defining
	Problem/Topic Phase- Need to know	⇨	Describing what we still need to know
	Problem/Topic Phase – Phase 1 reflection	⇨	Understanding different kinds of scientific questions and examining and evaluating this aspect of the learning experience thinking (evaluation)
	Operationalisation- planning the method	⇨	Formulating hypothesis
	Operationalisation-Methodology	⇨	Set up inquiry procedure
	Operationalisation- phase 2 reflection	⇨	Discussing the phase in a critical manner (e.g. implications, limitations of approach, lessons for future studies) by providing arguments
	Data collection – phase 3 reflection	⇨	Reflecting on what knowledge was gained and what has not been collected yet, and examining and evaluating this aspect of the learning experience
	Data analysis – phase 4 reflection	⇨	Checking the analyses and coming up with alternatives, and examining and evaluating this aspect of the learning experience
	Interpretation – fit the findings with existing knowledge	⇨	Interpreting findings in light of previous knowledge
	Interpretation – counterevidence	⇨	Judging evidence and counterevidence
	Interpretation – phase 5 reflection	⇨	Checking the interpretation (process) and coming up with alternatives, and examining and evaluating this aspect of the learning experience
	Communication – implications, limitations, lessons learned	⇨	Discussing the findings in a critical manner (implications, limitations, lessons learned)
	Communication- phase 6 reflection	⇨	Checking the method of communication and coming up with alternative approaches, and examining and evaluating this aspect of the learning experience
Information literacy (existing knowledge and learning)	Problem/Topic phase- Existing knowledge	⇨	Describing what we already know
	Problem/Topic Phase – Definition of concepts	⇨	Concept defining
	Operationalisation- indicators for measuring	⇨	Coming up with resources and ways how to measure
	Operationalisation- prediction	⇨	Coming up with indicators for concepts that can be measured to develop and test ideas
	Operationalisation- Ethical concerns	⇨	Showing ethical concern with inquiry set up
	Interpretation – fit the findings with existing knowledge	⇨	Interpreting findings in light of previous knowledge

IB skill - competence	Activities of the weSPOT IB model		Process indicators (Indicating whether an IB skill /competence has been practiced by learners when performing IB activities)
Analytical skills (classification, quantitative & qualitative analysis and statistical skills)	Problem/Topic Phase- Need to know	⇨	Describing what we still need to know
	Operationalisation- planning the method	⇨	Formulating hypothesis
	Data analysis – procedure of clustering	⇨	Clustering data
	Interpretation – relevance of results to the problem	⇨	Making sure the results are relevant to the problem
Communication skills (presentation, language, writing skills)	Problem/Topic Phase – Definition of concepts	⇨	Concept defining
	Data analysis – visualization of data	⇨	Using various types of visualization
	Communication – conclusion	⇨	Presenting findings in clear written form
	Communication – technical tools	⇨	Using technical tools for communicating results
	Communication – feedback	⇨	Discussing the findings in a critical manner (implications, limitations, lessons learned
	Communication – implications, limitations, lessons learned	⇨	Providing feedback on findings of others
Digital skills	Data collection-description of data collection tool	⇨	Using appropriate tools to collect data
	Data collection – evidence	⇨	Collecting evidence
	Data collection – data privacy	⇨	Taking privacy of data into consideration
	Data collection – followed data collection methods	⇨	Careful record keeping of methods and findings
	Data analysis –analyzed data	⇨	Using data analysis tools

IB skill - competence	Activities of the weSPOT IB model		Process indicators (Indicating whether an IB skill /competence has been practiced by learners when performing IB activities)
Metacognitive skills	Problem/Topic phase- Concept map	⇨	Developing a concept map
	Problem/Topic Phase – Phase 1 reflection	⇨	Understanding different kinds of scientific questions and examining and evaluating this aspect of the learning experience thinking (evaluation)
	Operationalisation – phase 2 reflection	⇨	Discussing the phase in a critical manner (e.g. implications, limitations of approach, lessons for future studies) by providing arguments
	Data collection – phase 3 reflection	⇨	Reflecting on what knowledge was gained and what has not been collected yet, and examining and evaluating this aspect of the learning experience
	Data analysis – phase 4 reflection	⇨	Checking the analyses and coming up with alternatives, and examining and evaluating this aspect of the learning experience
	Interpretation – phase 5 reflection	⇨	Checking the interpretation (process) and coming up with alternatives, and examining and evaluating this aspect of the learning experience
	Communication- phase 6 reflection	⇨	Checking the method of communication and coming up with alternative approaches, and examining and evaluating this aspect of the learning experience
(other) Research skills (experimentation, observation, organisation and planning skills)	Problem/Topic phase – Specify context	⇨	Conducting a search for resources/literature research
	Operationalisation-Methodology	⇨	Set up inquiry procedure
	Data collection – collect information	⇨	Collecting data to develop/test ideas
	Data collection –description of inquiry	⇨	Testing hypothesis/ideas
	Data collection – systematic data collection	⇨	Using authorities resources
	Communication –impact	⇨	Considering impact, content, routs and stakeholders

Conclusions

The primary aim of this document was to provide evaluation tools for testing the ELITe's project assumption, namely that STEM teachers' professional learning through IB methodology supports the development of teachers' competences. Towards this end presented were outcome indicators (and sub-indicators relevant to the national context of Greece, the Netherland, Bulgaria and Spain), which aim to serve as a tool to evaluate the impact of the training activities on competence development.

The proposed outcome indicators and sub-indicators will facilitate exploring the following research questions (RQ):

- RQ1a: What are the outcomes of the ELITe's learning in teaching activities on *enhancing STEM teachers' knowledge and understanding on teaching and learning*?
- RQ1b: What are the outcomes of the ELITe's learning in teaching activities on *STEM teachers' development of skills for learning and teaching*?
- RQ1c: What are the outcomes of the ELITe's learning in teaching activities on *STEM teachers' depositions and attitudes on learning and teaching?*

An overview of the identified indicators and sub-indicators relevant to each of the above-mentioned research questions is presented here below:

RQ1a: What are the outcomes of the ELITe's learning in teaching activities on *enhancing STEM teachers' knowledge and understanding on teaching and learning*?

Indicators		Demonstration of enhanced knowledge and understanding on STEM relating to *teaching and learning content*	Demonstration of enhanced knowledge and understanding on *methodologies and methods relating to STEM learning and teaching*	Demonstration of enhanced knowledge and understanding on *contextual aspects of learning and teaching*
Sub-indicators relevant explicitly or implicitly to the national context of:	**Greece**	*Explicitly relevant:* Demonstration of • enhanced Curricular Knowledge • knowledge on issues pertaining to developmental psychology • knowledge on issues of inclusion and diversity *Implicitly relevant*: Demonstration of • enhanced STEM knowledge • enhanced Pedagogical Content Knowledge • knowledge on issues pertaining to developmental psychology • knowledge on issues of inclusion and diversity	*Explicitly relevant:* Demonstration of • enhanced Pedagogical • knowledge on new technologies *Implicitly relevant*: Demonstration of • enhanced Pedagogical knowledge • knowledge on evaluation and assessment • knowledge on new technologies	*Explicitly relevant:* Demonstration of • knowledge on educational sciences foundations • knowledge on contextual, institutional & organizational aspects of educational policies

	The Netherlands	*Explicitly relevant:* Demonstration of • enhanced STEM knowledge • enhanced Pedagogical Content Knowledge • enhanced Curricular Knowledge • knowledge on issues pertaining to developmental psychology • knowledge on issues of inclusion and diversity *Implicitly relevant:* Demonstration of: • knowledge on issues of inclusion and diversity	*Explicitly relevant:* Demonstration of • enhanced Pedagogical knowledge • knowledge on innovative STEM methodologies • knowledge on evaluation and assessment • knowledge on new technologies *Implicitly relevant:* Demonstration of: • enhanced Pedagogical knowledge • knowledge on innovative STEM methodologies • knowledge on new technologies	*Explicitly relevant:* Demonstration of • knowledge on educational sciences foundations • knowledge on contextual, institutional & organizational aspects of educational policies
	Bulgaria	*Explicitly relevant:* Demonstration of: • enhanced STEM knowledge • enhanced Pedagogical Content Knowledge • enhanced Curricular Knowledge • knowledge on issues pertaining to developmental psychology • knowledge on issues of inclusion and diversity	*Explicitly relevant:* Demonstration of • enhanced Pedagogical knowledge • knowledge on innovative STEM methodologies • knowledge on evaluation and assessment • knowledge on new technologies Implicitly relevant: Demonstration of: • knowledge on new technologies	*Explicitly relevant:* Demonstration of • knowledge on educational sciences foundations • knowledge on contextual, institutional & organizational aspects of educational policies
	Spain	*Explicitly relevant:* Demonstration of: • enhanced STEM knowledge • enhanced Curricular Knowledge • knowledge on issues pertaining to developmental psychology • knowledge on issues of inclusion and diversity *Implicitly relevant*: Demonstration of: • enhanced Pedagogical Content Knowledge • knowledge on issues pertaining to developmental psychology • knowledge on issues of inclusion and diversity	*Explicitly relevant:* Demonstration of • enhanced Pedagogical knowledge • knowledge on evaluation and assessment • knowledge on new technologies *Implicitly relevant*: Demonstration of: • knowledge on new technologies	*Explicitly relevant:* Demonstration of • knowledge on educational sciences foundations • knowledge on contextual, institutional & organizational aspects of educational policies

RQ1b: What are the outcomes of the ELITe's learning in teaching activities on *STEM teachers' development of skills for learning and teaching*?

Indicators		Demonstration of enhanced *learning skills* -relating to the promotion of teachers' own learning	Demonstration of enhanced *teaching skills* –relating to the promotion of students' learning	Demonstration of enhanced *professional skills*- relating to teachers' role as part of educational communities
Sub-indicators relevant explicitly or implicitly to the national context of:	**Greece**	*Explicitly relevant:* Demonstration of • ability to using, develop and create research knowledge to inform practices • reflective & metacognitive skills during owns learning • interpersonal skills for learning individually and in professional communities	*Explicitly relevant:* Demonstration of • ability to plan, manage and coordinate teaching • ability to use teaching materials and technologies • ability to monitor, adapt and assess teaching/learning objectives and processes • collecting, analysing, interpreting evidence and data skills for professional decisions and teaching/learning improvement *Implicitly relevant*: Demonstration of • ability to plan, manage and coordinate teaching • ability to use teaching materials and technologies • mastery in managing students and groups • collecting, analysing, interpreting evidence and data skills for professional decisions and teaching/learning improvement	
	The Netherlands	*Explicitly relevant:* Demonstration of • ability to using, develop and create research knowledge to inform practices *Implicitly relevant:* Demonstration of: • ability to using, develop and create research knowledge to inform practices • reflective & metacognitive skills during owns learning • interpersonal skills for learning individually and in professional communities	*Explicitly and implicitly relevant:* Demonstration of • ability to plan, manage and coordinate teaching • ability to use teaching materials and technologies • mastery in managing students and groups • ability to monitor, adapt and assess teaching/learning objectives and processes • collecting, analysing, interpreting evidence and data skills for professional decisions and teaching/learning improvement	*Explicitly relevant:* Demonstration of • collaboration skills *Implicitly relevant:* Demonstration of • ability to adapt to educational contexts

	Bulgaria	*Explicitly relevant:* Demonstration of: • ability to using, develop and create research knowledge to inform practices • reflective & metacognitive skills during owns learning • interpersonal skills for learning individually and in professional communities	*Explicitly relevant:* Demonstration of • ability to plan, manage and coordinate teaching • ability to use teaching materials and technologies • mastery in managing students and groups • ability to monitor, adapt and assess teaching/learning objectives and processes • collecting, analysing, interpreting evidence and data skills for professional decisions and teaching/learning improvement *Implicitly relevant:* Demonstration of: • ability to plan, manage and coordinate teaching • ability to use teaching materials and technologies • mastery in managing students and groups	*Explicitly relevant:* Demonstration of • collaboration skills • ability to adapt to educational contexts *Implicitly relevant:* Demonstration of: • life and career skills
	Spain	*Explicitly relevant:* Demonstration of: • ability to using, develop and create research knowledge to inform practices • reflective & metacognitive skills during owns learning • interpersonal skills for learning individually and in professional communities *Implicitly relevant*: Demonstration of: • ability to using, develop and create research knowledge to inform practices	*Explicitly relevant:* Demonstration of • ability to plan, manage and coordinate teaching • ability to use teaching materials and technologies • mastery in managing students and groups • ability to monitor, adapt and assess teaching/learning objectives and processes *Implicitly relevant*: Demonstration of: • collecting, analysing, interpreting evidence and data skills for professional decisions and teaching/learning improvement	*Implicitly relevant:* Demonstration of • ability to adapt to educational contexts

RQ1c: What are the outcomes of the ELITe's learning in teaching activities on *STEM teachers' depositions and attitudes on learning and teaching?*

Indicators		Demonstration of positive dispositions and attitudes relating to *teachers own learning*	Demonstration of positive dispositions and attitudes relating to the *promotion of students learning*	Positive dispositions and attitudes relating to their *role as part of educational communities*
Sub-indicators relevant explicitly or implicitly to the national context of:	**Greece**	*Explicitly relevant:* Demonstration of • epistemological awareness • positive dispositions to change, flexibility, ongoing learning and professional improvement • critical attitudes to one's own teaching (examining, discussing, questioning practices)	*Explicitly relevant:* Demonstration of • Commitment to promoting the learning of all students • Dispositions to promote students' democratic attitudes and practices, as European citizens (including appreciation of diversity and multiculturality) *Implicitly relevant*: Demonstration of • Teaching skills through content • Commitment to promoting the learning of all students • Dispositions to promote students' democratic attitudes and practices, as European citizens (including appreciation of diversity and multiculturality)	*Explicitly relevant:* Demonstration of • disposition to team-working, collaboration and networking
	The Netherlands	*Explicitly relevant:* Demonstration of • critical attitudes to one's own teaching (examining, discussing, questioning practices) *Implicitly relevant:* Demonstration of: • positive dispositions to change, flexibility, ongoing learning and professional improvement • critical attitudes to one's own teaching (examining, discussing, questioning practices)	*Explicitly relevant:* Demonstration of • Teaching skills through content • Commitment to promoting the learning of all students • Dispositions to promote students' democratic attitudes and practices, as European citizens (including appreciation of diversity and multiculturality) *Implicitly relevant:* Demonstration of • Teaching skills through content • Transferable skills • Dispositions to promote students' democratic attitudes and practices, as European citizens (including appreciation of diversity and multiculturality)	*Explicitly and implicitly relevant:* Demonstration of • disposition to team-working, collaboration and networking

	Bulgaria	*Explicitly relevant:* Demonstration of: • epistemological awareness • positive dispositions to change, flexibility, ongoing learning and professional improvement • critical attitudes to one's own teaching (examining, discussing, questioning practices) Implicitly relevant: • epistemological awareness	*Explicitly relevant:* Demonstration of • Teaching skills through content • Transferable skills • Commitment to promoting the learning of all students • Dispositions to promote students' democratic attitudes and practices, as European citizens (including appreciation of diversity and multiculturality)	*Explicitly relevant:* Demonstration of • disposition to team-working, collaboration and networking
	Spain	*Explicitly relevant:* Demonstration of: • positive dispositions to change, flexibility, ongoing learning and professional improvement	*Explicitly relevant:* Demonstration of • Teaching skills through content • Commitment to promoting the learning of all students *Implicitly relevant*: Demonstration of • Dispositions to promote students' democratic attitudes and practices, as European citizens (including appreciation of diversity and multiculturality)	*Implicitly relevant:* Demonstration of • disposition to team-working, collaboration and networking

In addition, presented in this document were process indicators aiming to provide information and context to facilitate the interpretation of outcomes. They aim to serve as an evaluation tool to indicate whether an IB skill or competence has been practiced by learners when performing the ELITe's professional learning activities.

The proposed process indicators will facilitate exploring the following research questions (RQ):

- RQ2a: Have critical thinking competences been practiced by learners and if yes by which IB activities?
- RQ2b: Have information literacy skills been practiced by learners and if yes by which IB activities?
- RQ2c: Have analytical skills been practiced by learners and if yes by which IB activities?
- RQ2d: Have communication skills been practiced by learners and if yes by which IB activities?
- RQ2e: Have digital skills been practiced by learners and if yes by which IB activities?
- RQ2f: Have metacognitive end reflection skills been practiced by learners and if yes and by which IB activities?
- RQ2g: Have other research skills been practiced by learners and if yes and by which IB activities?

An overview of the process indicators relevant to each of the above-mentioned research questions is presented here below:

RQ2a: Have *critical thinking competences* been practiced by learners and if yes by which IB activities?

Process indicators	**Related activities of the weSPOT IB model**
Providing a wonder moment	Problem/Topic Phase– Wonder moment
Developing a concept map	Problem/Topic Phase– Concept map
Concept defining	Problem/Topic Phase – Definition of concepts
Describing what we still need to know	Problem/Topic Phase- Need to know
Understanding different kinds of scientific questions and examining and evaluating this aspect of the learning experience thinking (evaluation)	Problem/Topic Phase – Phase 1 reflection
Formulating hypothesis	Operationalisation- planning the method
Set up inquiry procedure	Operationalisation-Methodology
Discussing planning method in a critical manner (e.g. implications, limitations of approach, lessons for future studies) by providing arguments	Operationalisation- phase 2 reflection
Reflecting on what knowledge was gained and what has not been collected yet, and examining and evaluating this aspect of the learning experience	Data collection – phase 3 reflection
Checking the analyses and coming up with alternatives, and examining and evaluating this aspect of the learning experience	Data analysis – phase 4 reflection
Interpreting findings in light of previous knowledge	Interpretation – fit the findings with existing knowledge
Judging evidence and counterevidence	Interpretation – counterevidence
Checking the interpretation (process) and coming up with alternatives, and examining and evaluating this aspect of the learning experience	Interpretation – phase 5 reflection
Discussing the findings in a critical manner (implications, limitations, lessons learned)	Communication – implications, limitations, lessons learned
Checking the method of communication and coming up with alternative approaches, and examining and evaluating this aspect of the learning experience	Communication- phase 6 reflection

RQ2b: Have *information literacy skills* been practiced by learners and if yes by which IB activities?

Process indicators	**Related activities of the weSPOT IB model**
Describing what we already know	Problem/Topic phase- Existing knowledge
Concept defining	Problem/Topic Phase – Definition of concepts
Coming up with resources and ways how to measure	Operationalisation- indicators for measuring
Coming up with indicators for concepts that can be measured to develop and test ideas	Operationalisation- prediction
Showing ethical concern with inquiry set up	Operationalisation- Ethical concerns
Interpreting findings in light of previous knowledge	Interpretation – fit the findings with existing knowledge

RQ2c: Have *analytical skills* been practiced by learners and if yes by which IB activities?

Process indicators	**Related activities of the weSPOT IB model**
Describing what we still need to know	Problem/Topic Phase- Need to know
Formulating hypothesis	Operationalisation- planning the method
Clustering data	Data analysis – procedure of clustering
Making sure the results are relevant to the problem	Interpretation – relevance of results to the problem

RQ2d: Have *communication skills* been practiced by learners and if yes by which IB activities?

Process indicators	**Related activities of the weSPOT IB model**
Concept defining	Problem/Topic Phase – Definition of concepts
Using various types of visualization	Data analysis – visualization of data
Presenting findings in clear written form	Communication – conclusion
Using technical tools for communicating results	Communication – technical tools
Discussing the findings in a critical manner (implications, limitations, lessons learned	Communication – feedback
Providing feedback on findings of others	Communication – implications, limitations, lessons learned

RQ2e: Have *digital skills* been practiced by learners and if yes by which IB activities?

Process indicators	**Related activities of the weSPOT IB model**
Using appropriate tools to collect data	Data collection-description of data collection tool
Collecting evidence	Data collection – evidence
Taking privacy of data into consideration	Data collection – data privacy
Careful record keeping of methods and findings	Data collection – followed data collection methods
Using data analysis tools	Data analysis –analyzed data

RQ2f: Have *metacognitive end reflection skills* been practiced by learners and if yes and by which IB activities?

Process indicators	**Related activities of the weSPOT IB model**
Problem/Topic phase- Concept map	Problem/Topic phase- Concept map
Problem/Topic Phase – Phase 1 reflection	Problem/Topic Phase – Phase 1 reflection
Operationalisation – phase 2 reflection	Operationalisation – phase 2 reflection
Data collection – phase 3 reflection	Data collection – phase 3 reflection
Data analysis – phase 4 reflection	Data analysis – phase 4 reflection
Interpretation – phase 5 reflection	Interpretation – phase 5 reflection
Communication- phase 6 reflection	Communication- phase 6 reflection

RQ2g: Have *other research skills* been practiced by learners and if yes and by which IB activities?

Process indicators	**Related activities of the weSPOT IB model**
Conducting a search for resources/literature research	Problem/Topic phase – Specify context
Set up inquiry procedure	Operationalisation-Methodology
Collecting data to develop/test ideas	Data collection – collect information
Testing hypothesis/ideas	Data collection –description of inquiry
Using authorities resources	Data collection – systematic data collection
Considering impact, content, routs and stakeholders	Communication –impact

A correlation of evaluation results in relation to teachers development of competences (RQ1a,d,c) and in relation to the IBL skills being practiced (RQ2a,b,c,d,e,f,g), will allow to test the assumption on which the project is based: namely, that teachers' training via IB methodology supports the development of teacher competences. Results from the evaluation will lead the development of an evidence-based framework for STEM teachers' competence development via inquiry methodology aiming to inform curriculum design for STEM secondary teachers' continuous professional development and learning- which is the main tangible output of the ELITe project.

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