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Handbook with guidelines for STEM teachers' inquiry and reflective practice

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Enhancing Learning in Teaching via e-inquiries

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Intellectual Output:	O6: Handbook with guidelines for STEM teachers' inquiry and reflective practice
Output description:	This document aims to support teachers changing practice towards competence development. It provides guidelines for good practice towards developing knowledge, skills and attitudes for effective STEM teaching. It also provides guidelines for effective participation in the professional learning community exchanging and communicating about good practice. The document (in English) is accompanied by a concise "key-messages" document (both in English and in the 4 country's languages).
Activity Leading Organisation:	UNISOF
Participating Organisations:	FORTH, OUNL, UB, DLEARN, EPA
Authors:	Nikolina Nikolova, Fotini Chaimala
Contributors:	Olga Firssova, Mario Barajas, Paolo Modica & Eszter Salamon
Project coordinator:	Kathy Kikis-Papadakis (FORTH) Email: katerina@iacm.forth.gr

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PREFACE

The ***ELITe (Enhancing Learning in Teaching via e-inquiries)*** project is dedicated to supporting teachers' professional learning for competence development, specifically targeting in-service educators in the Science, Technology, Engineering and Mathematics (STEM) domain. Higher Education and Research Institutions from Greece, the Netherlands, Bulgaria, Spain and Germany, an EU association and a network, collaborate in the project in order to develop, deploy, evaluate and disseminate an innovative approach for STEM teachers' professional learning via an inquiry-based learning methodology.

Current prevailing approaches in initial and continuous training programs focus on subject knowledge, pedagogy and 'practice' (classroom-based training). Such approaches fail to recognize the relevance of inquiry based approaches for teacher practice and are highly influenced by the way teachers have received training themselves. Knowledge and skills on/about teaching are developed by teachers themselves, as they use theory and research to reflect upon their practices in professional learning communities. 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 opportunities or cannot attend such events due to conflicting work schedules. In the ***ELITe*** project we provide flexible professional development opportunities in which the training methodology (asking questions, looking for answers, instead of consuming content) has a prevailing role, embedded in the concept of ***change as a professional learning perspective***, that considers teachers as reflective practitioners, responsible for their own learning.

As an outcome, the ELITe team has developed a framework for teacher's competence development, having the following characteristics:

- Teachers leaning activities take place via an **inquiry-based learning (IBL) methodology**, by the use of an **online platform** for facilitating **personal** and **collaborative** inquiry-based learning.
- The learning activities of teachers are structured around **themes** and **scenarios** that reflect the needs and interests of teachers: dealing with diversity and inclusion, fostering student achievement, teaching cross-curricular skills, student career guidance, teacher-parent relationships and approaches to individualized learning.

The **Handbook with guidelines for STEM teachers' inquiry and reflective practice** provides guidance for teacher educators and teachers on the application of the ***ELITe (Enhancing Learning in Teaching via e-inquiries)*** methodology.

Teacher educators and respective **teacher education institution** representatives will find here:

- Information about the **IBL approach and reflective teacher training practices** as well as their effectiveness when they are implemented together.
- A **tool** for self-evaluating **competences** and **needs in initial teacher training**.
- A set of **thematic areas** for teacher trainings, extracted by the study of national policies in four European countries: Greece, the Netherlands, Bulgaria and Spain
- A **model,** and **corresponding tools** for **designing** and **implementing** competence development teacher trainings, based on IBL & reflective teachers' practices
- A set of basic teacher training **scenarios** in the provided thematic areas.
- **Examples** of different interpretations and adjustment of the basic scenarios according to the national contexts and trainings conditions.
- **Good practices** examples for teacher training implementation.
- A **free online tool** for designing and implementing an ELITe teacher competence development training.

Teacher educators may apply the whole set of tools together to implement the (full) *ELITe* approach for efficient and effective teacher trainings. They may also choose some of the tools, ideas and practices, and integrate them in other teacher training practices.

For practicing **STEM teachers** the Handbook offers:

1) Information, helping them to get a sense how effective it is to combine **IBL & reflective practices** in teacher trainings.
2) **Key characteristics** of the ELITe approach and teacher training courses, implementing IBL & reflective practices.
3) A **self-evaluation tool**, aiming at identifying their specific needs in terms of professional competence development, and supporting them to choose the most appropriate course.
4) An environment supporting inquiry and reflective practice as a base for change of attitudes towards participating in non-traditional learning using **innovative learning methods**.
5) Orientation about the important **thematic areas** for teacher competence development in 4 EU countries.
6) Promotion of the value of **IBL & reflective practice**
7) Preliminary preparation for full participation in an *ELITe* course, feeling free to **share** any insights and thoughts.
8) **Ideas and insights** from the best *ELITe* practice examples.

9) Possibility for tracking/evaluating their own professional development during and after a course, using the **self-evaluation tool** as well as **group** and **personal reflections**.
10) Guidelines for the use of a **free online tool** for IBL training design, that they can also use in their own classroom.

As an added value, the Handbook aims at teachers to get acquainted with the **weSPOT IBL model** and enabling them to use it in their classrooms.

The ***ELITe*** methodology guidelines are illustrated by a set of examples of **good practice**, by experience of ELITe team members.

The **Handbook with guidelines for STEM teachers' inquiry and reflective practice** is accompanied by a **Key Messages** document, containing a summary of the main guidelines.

INTRODUCTION

THE AIM OF 21ST CENTURY STEM EDUCATION

To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science.

Albert Einstein

Science, Technology, Engineering and Mathematics (STEM) education has a key role in contemporary economic growth. According to resent reports by the Organisation for Economic Co-operation and Development (OECD) only innovation-driven growth has a potential to create value-added jobs and industries (Corlu, 2014). An in-depth research by Corlu, Capraro & Capraro shows that innovation is largely derived from advances in STEM and an increasing number of jobs at all levels require STEM knowledge. As innovation involves the integration of diverse STEM competences and transcends disciplines, and it is a highly interactive and multidisciplinary process tightly connected to life, the importance of STEM education increases dramatically for today's economics and life. STEM adheres to the development of scientific, technological and mathematical insights, concepts and practices and how to use and apply them in practice in order to solve complex questions or real-life challenges. In addition, it develops analytical and critical thinking as well as inquiry competences – crucial for raising the current generation with innovative mindsets.

According to a recent Report by the European Commission (EC) (European Commision, 2015) – *Science Education for Responsible Citizenship* – STEM education is vital in the 21st century in order to:

- Promote a culture of scientific thinking and inspire citizens to use evidence-based reasoning for decision making;
- Ensure citizens have the confidence, knowledge and skills to participate actively in an increasingly complex scientific and technological world;
- Develop the competencies for problem-solving and innovation, as well as analytical and critical thinking that are necessary to empower citizens to

lead personally fulfilling, socially responsible and professionally-engaged lives;

- Inspire children and students of all ages and talents to aspire to careers in science and other occupations and professions that underpin our knowledge and innovation-intensive societies and economies, in which they can be creative and accomplished;
- Enable public, private and third-sector organisations, based in Europe, to find appropriately skilled and knowledgeable people and to promote and nurture an innovative Europe wide environment where companies and other stakeholders from around the world want to invest, work and live;
- Empower responsible participation in public science conversations, debates and decision-making as active engagement of European citizens in the big challenges facing humanity today.

In short, STEM education has the potential to enable young people and future citizens to interpret and understand our world, to manage risk and put uncertainty into perspective, to guide technological development and innovation, and to make forecasts and plan for the future. It has the potential to improve job prospects, cultural awareness and ability to act as well-informed citizens in solidarity with citizens around the world.

THE CHANGING ROLE OF STEM TEACHERS IN 21ST CENTURY EDUCATION

The key role of STEM education establishes the need to strengthen teachers' competences enabling them to respond to the demands of the new digital innovation-driven era. Teaching in the 21st century is more than a task confined in classroom frames and it demands more than the acquisition of content, pedagogical knowledge and technical skills. Teachers nowadays need the competence to innovate and adapt to opportunities emerging from the new digital era. This includes having critical, evidence-based attitudes to available resources, enabling them to respond to student outcomes, evaluating new evidence from inside and outside classrooms, and engaging in professional dialogue, in order to adapt their own practice for better students' learning outcomes (European Commission., 2013). Teachers, therefore, need to be supported in their new role as reflective practitioners, responsible for their own learning.

> *Teachers can change lives with just the right mix of chalk and challenges*
>
> *Joyce Meyer*

STEM teachers nowadays need to help students not only to acquire knowledge and skills, but also to open their mind as 21st century citizens, provisioning them with:

Fig. 1. STEM teachers' responsibilities

More than ever before STEM teachers face the challenge of facilitating students to *acquire the necessary knowledge of and about science to participate actively and responsibly in, with and for society, successfully throughout their lives* (European Commission/EACEA/Eurydice, 2015). That is why one of the most important requirements for teachers' competence development is to ensure **learning to learn** skills and competences.

In the course of the ELITe project and on the basis of the EC (2013) framework for teachers' competence development we have identified that, for effective 21st century teaching, STEM educators need to develop and practice a range of competences under their roles as **learners themselves**, as **facilitators of students' learning** and as **members of educational communities**:

Teachers **as lifelong learners** need to develop/practice

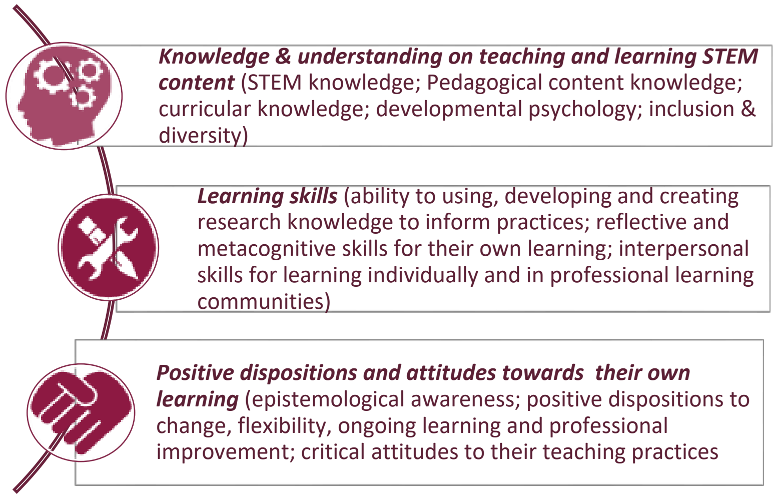

Fig. 2 Teachers as lifelong learners

We as educators speak often about creating lifelong learners, but if we aren't buying into it ourselves, then our students don't stand a chance.

Wolpert-Gawron (2009)

Teachers as **facilitators of students' learning** need to develop/practice

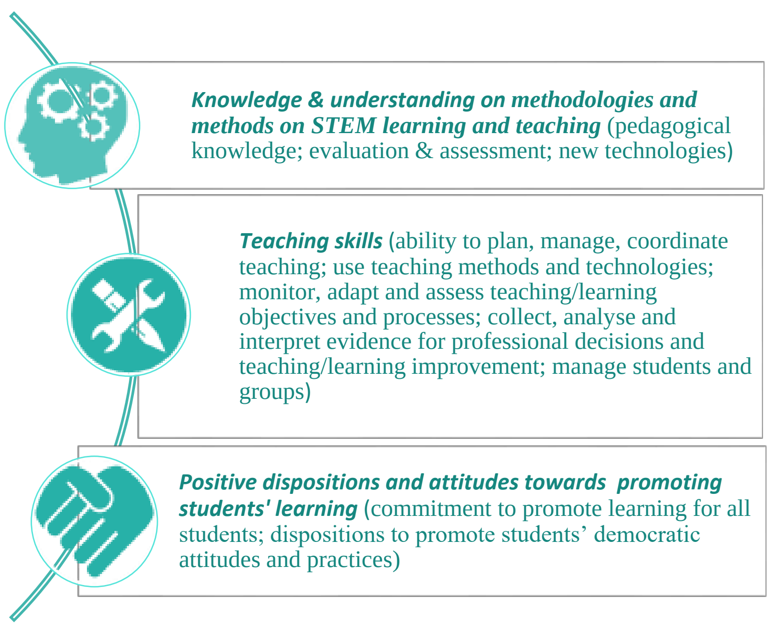

Fig. 3. Teachers as facilitators

Now as it is believed that knowledge is constructed by learners from experience, the instructor needs to 'be a guide on the side, rather than a sage on the stage'. If teaching is a professional job, facilitating is the role of the teacher

Giri (2011)

Teachers as **members of educational communities** need to develop/practice

Teaching as a practice maintained in isolation is replaced by collaboration. Essentially, what defines a professional community is a shared commitment to work together to create an effective learning environment.

Earp (2017)

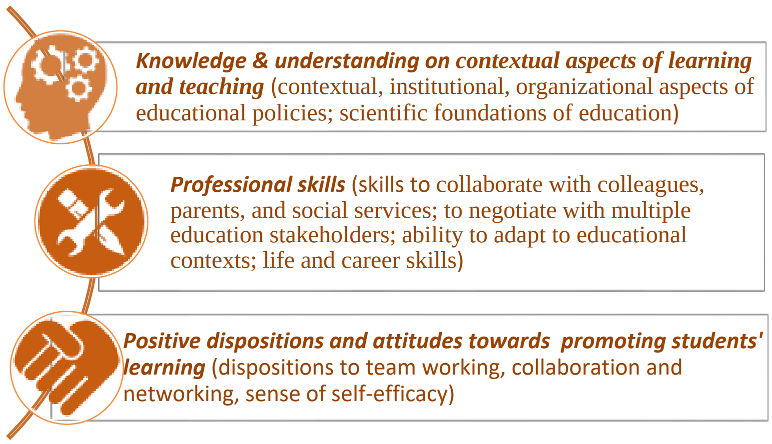

Fig. 4. Teachers as members of educational communities

READ MORE

On the processes and outcomes of ***EC (2013) framework adaption for the case of STEM teachers' competence development conducted in the frame of the ELITe project***, as reported in the project's Intellectual Output IO1: https://goo.gl/QethDA

AN OVERVIEW OF THE ELITE PROJECT'S APPROACH TO FACILITATING STEM TEACHERS' INQUIRY AND REFLECTIVE PRACTICES

The underlying concern of the ELITe project is to support STEM teachers develop knowledge, skills and attitudes for inquiry and reflective practice, so that that they can effectively address their roles as lifelong learners, facilitators of students' learning and members of educational communities.

The project's approach to STEM teachers' professional learning (*Learning in Teaching via e-inquiries*) foresees ***inquiry and reflective skills practiced through an inquiry-based learning (IBL) methodology*** supported by digital means, ***as a way to facilitate teachers' competence development***.

The implementation of the IBL methodology in teachers' competence development courses will provide them with real situation experience and know-how as well as with a reflection from 'students point of view'

Major concepts embedded in the approach are the ones of inquiry and reflective practice. The approach is based on the principle that ***a teacher teaches in such a way that he/she was taught.*** Inquiry-based learning (IBL) has been identified as one on the most powerful innovative teaching approaches, providing opportunities

The teacher teaches in such a way in which he/she was taught.

to develop scientific literacy of all learners. At the same time, teachers meet difficulties to implement it in the classroom due to missing experience in it as teachers' professional development courses are usually conducted in a traditional way via lectures.

The main assumption of the ELITe project is that ***the implementation of an IBL methodology in teachers' competence development courses will provide them with real situational experience and know-how as well as with a reflection from a 'students' (learners') point of view'***.

The IBL has a very poor explored potential as an effective teacher training method, which can contribute for effective STEM teachers' competence development

ELITe's approach to STEM teachers' professional learning has been deployed and evaluated in the course of the project in 4 EU national contexts, namely in: Greece, the Netherlands, Bulgaria and Spain. Outcomes of the evaluation aim to inform curriculum development in STEM professional learning activities, by providing evidence on the links between inquiry skills practice and teachers' competence development.

The ELITe teacher training approach is designed to face the current challenges and implicit requirements on STEM teachers' professional learning (PL) for competence development.

Table 1 Challenges and implicit requirements that informed the development of ELITe's professional learning approach to STEM teachers' competence development

		Challenges	Implicit requirements
Perspectives	Contextual	Teacher competence requirements among and within EU countries	Place-based approach, consistent with national policy requirements and practice needs
	Methodological	Teachers' practice depends on the way it is developed by trainings	Modernisation of teacher training methodology
	Content related	Thematics addressing broader STEM aims	Relevance of the thematics to broader STEM education aims
	Outcome related	Evidence of the impact of competence-based frameworks on teachers' professional learning	Need for an evidence-based framework for STEM teachers' competence development

On the basis of the above-mentioned challenges and implicit requirements, the ELITe project's approach to STEM teachers' professional learning includes the following elements that should be interpreted as assumptions underpinning the approach:

- Adopts a **place-based** approach for STEM teachers' professional learning, taking into consideration **national policy requirements and practice needs**
- Promotes the **adoption of an inquiry-based learning (IBL) methodology in professional learning activities**, under the assumption that STEM teachers' training via IBL methodology supports the development of teacher competences
- Proposes such thematic **content areas for STEM teachers' professional learning that reflect current policy orientation on the broader aims of STEM education,** so as to facilitate teachers to model key competences required (knowledge, skills and attitudes) in order to help students to acquire them
- Is oriented towards facilitating the development of an **evidence-based framework** for teacher's competence development through IBL methodology

*Good practice increasingly views both teachers and students as **lifelong learners:** teachers should in the same time **'learn how to teach'** and **'teach how to learn'***

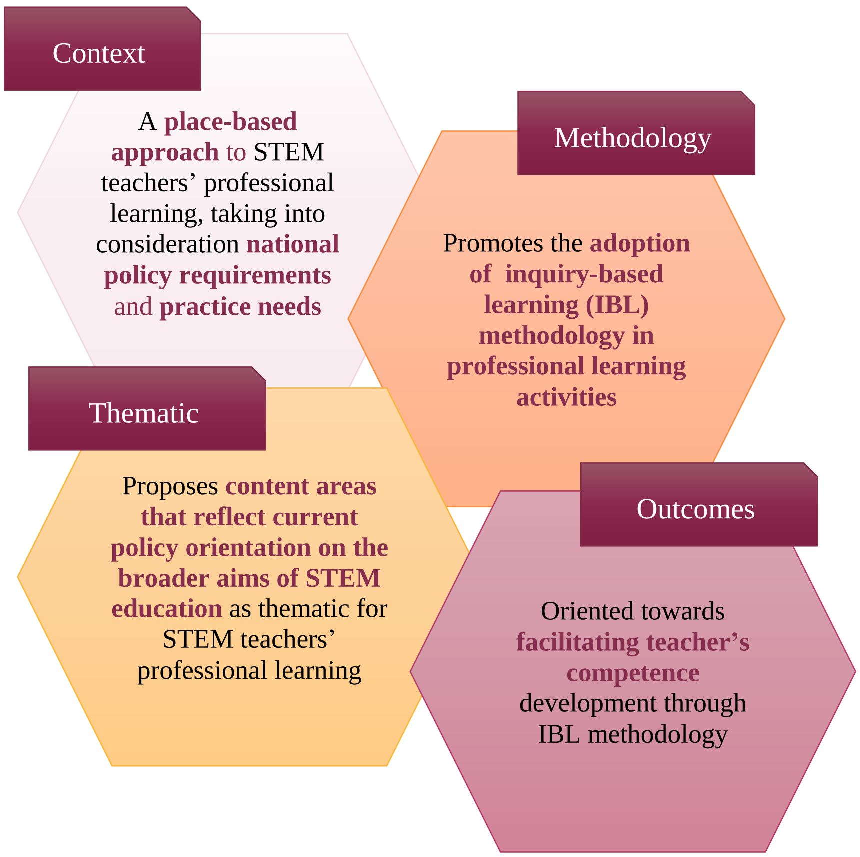

Fig. 5. Overview of the ELITe's approach for supporting STEM teachers' inquiry and reflective practice in professional learning activities

READ MORE

On the ELITe projects ***"Learning in Teaching via e-inquiries"*** approach to STEM teachers' professional learning: https://goo.gl/5TktbL

THE PURPOSE OF THIS HANDBOOK

The handbook is intended for teachers and teacher educators.

It aims to **facilitate development of knowledge, skills and attitudes of STEM teachers necessary to tackle requirements/challenges for STEM practice under their roles as learners, facilitators of students learning and members of educational communities**. This is supported by providing them with guidelines for inquiry and reflective practice, informed by the piloting processes of the ELITe project ***Learning in Teaching approach via e-inquiries***.

On the other hand, the handbook also aims **to facilitate STEM teacher educators structuring learning/training environments that support STEM teachers' inquiry and reflective practice**. This is supported by providing them with guidelines for structuring learning/training environments and good practices for effective STEM teacher participation in professional learning communities.

TOWARDS DEVELOPING STEM TEACHERS' INQUIRY AND REFLECTIVE PRACTICE

WHAT IS INQUIRY AND REFLECTIVE STEM TEACHER PRACTICE? INSIGHTS FROM LITERATURE

REFLECTIVE PRACTICE

Reflective practice has its historical roots in education – we still use the term 'Socratic method' meaning a form of reflective questioning, leading to a deep understanding of a given case or problem. Currently, there are many definitions of *reflective practice* in education but all of them have common points based on:

> ***Reflection as a learning process:*** *Examining current or past practices, behaviours, or thoughts in order to make conscious choices about future actions.*
>
> (Barnett & O'Mahony, 2006)

- Looking back to your own practice and thinking about the experience and possibilities for improvement or going closer to a desired state
- Exploring possible solutions and alternatives
- Making evidence-based decision
- Evaluating results of its implementation that forms the first stage of the new reflective cycle

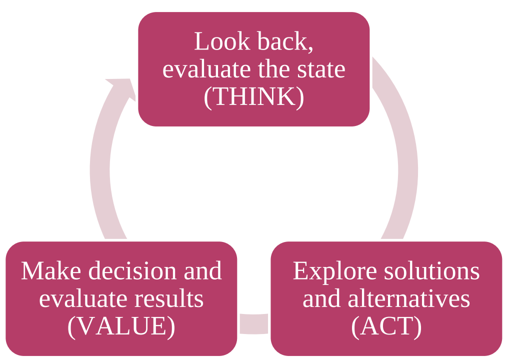

Fig. 6. Reflective practice spiral

According to Kerry Earl & Bill Ussher, the phrase 'reflective practice' can be understood in two ways. It can be used to refer to a habit of people, such as teachers, who reflect on their own practices, or it can refer to a style of practice as in 'teaching as reflective practice' – the practice of the teacher here referring to *teaching* not to *reflection*. (Earl & Ussher, 2016). They also share Dewey's understanding that having an experience does not necessarily lead to learning, but reflective practice in 'working with' our experience helps us to build knowledge and understanding that we can draw on in the future.

In this Handbook, we will use the term 'reflective practice' as a synonym of 'reflection', defied by Barnett & O'Mahony: learning process *examining current or past practices, behaviours, or thoughts in order to make conscious choices about future actions*. This definition implies that reflection is the combination of **hindsight**, **insight**, and **foresight** (Barnett & O'Mahony, 2006).

INQUIRY PRACTICE

Research or inquiry is a reflective practice of professional development. Its special feature is its publicity. *An inquiry process, along with learning from this process, is intentionally designed to be shared* (Earl & Ussher, 2016). It covers a variety of qualitative pedagogical research methods – self-study, auto-ethnography, action research, teaching as inquiry, and spiral of inquiry, with the following purpose:

- **Self-study**, for examining one's own practice to gain self-knowledge and professional growth with consequential expected lessons (learnt in ractice) study and improvement in practice.
- **Auto-ethnography**, for attention on social, cultural and political issues through a personal lens.
- **Action research**, for identifying 'new' actions, individually, as a team or in an organisation, to implement and evaluate for shifts in the consequences of our changes.
- **Teaching as inquiry**, for focusing directly on levels of student achievement that are higher than defined by centralised standards.
- **Spiral of inquiry**, for the exploration of hunches, involvement of students, and development of innovative practices to change the way in which things have been done previously for learners by teachers.

The common feature of all these inquiry methods is the focus on **understanding human beings in a social world** where human beings are the educators/teachers and the social world is the school and/or classroom setting.

INQUIRY & REFLECTIVE PRACTICE

As it is shown, inquiry and reflective practices go together as inquiry practice is a form of reflective professional development in teachers' practice. Their relationship is clearly described by David Kolb's **"What? So what? Now what?"** model.

To facilitate educational practitioners – teachers and teacher educators, Barnett and O'Mahony (Barnett & O'Mahony, 2006) adapt the model, inserting the terms of 'socialisers', 'reflectors', 'analysers' and 'doers'.

The essence of the model is the following three short, but meaningful questions:

Kolb's model of reflection:

☑ *What*?
Report the facts and events of an experience, objectively

☑ *So What*?
Analyse the experience

☑ *Now what*?
Consider the future impact of the experience on you and the community.

- When recounting an event (concrete experience, reflective observation), individuals must consider what happened prior to and during this event: ***What***?
- As individuals attempt to understand why the event transpired (abstract conceptualization), they determine what they have learned about the situation: ***So what***?
- To anticipate future actions and consequences (planning for implementation, active experimentation), individuals determine what they will do similarly and/or differently: ***Now what***?

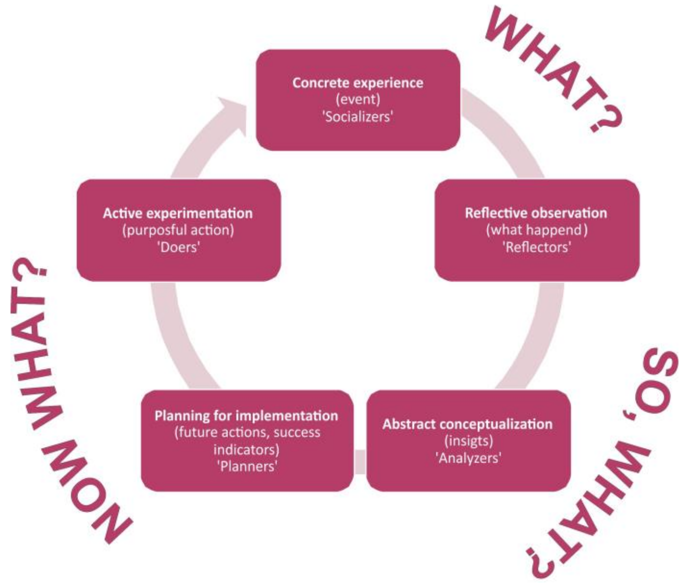

Fig. 7 Kolb's adapted model

WHY ARE INQUIRY AND REFLECTIVE PRACTICE IMPORTANT?

Critical reflection allows us to learn from our mistakes, examine our actions, evaluate them against prescribed norms, alter them for success, repeat successes, revise and plan continually (Krishnamurthy, 2007).

By reflexivity, past and present events are reviewed in the light of possible futures

As the teaching context is changing permanently – in terms of wide and national policies, generational differences, new technologies development, etc., practicing teachers need to be given opportunities for professional development in and during their practice through critical inquiry reflection. By reflexivity, past and present events are reviewed in the light of possible futures.

In addition, critical reflection promotes developing networking opportunities, making friends, building confidence and self-esteem, enhancing team-working skills and developing leadership skills. These benefits form a basis for ensuring lifelong teacher support by the professional community, so that each teacher feels free to reveal their weaknesses and express their fears, taking support by their own experience as well as of community members'.

The inquiry & reflective practices result in systematic assessment, quality improvement, and openness to growth

Eliason & Holmes (2010)

Inquiry & reflective practices help participants to illustrate their willingness to share materials and resources they used, ways they might change them in different contexts – according to student specifics, ways of delivery, etc.

THE ELITE'S PATH TO DEVELOPING STEM TEACHERS' INQUIRY AND REFLECTIVE PRACTICE

The ELITe approach to STEM teachers' professional learning for developing inquiry and reflective practice considers four levels: teacher educators' teaching practice, and STEM teachers' learning, teaching and professional practice.

Teacher educators' inquiry & reflective **teaching** practices

Teachers' inquiry & reflective **learning** practices

Teachers' inquiry & reflective **teaching** practices

Teachers' **professional** practice

Fig. 8. Levels of inquiry & reflective practices

Four levels of inquiry & reflective practice in Learning in Teaching via e-inquiries approach:

- ☑ **Teacher educators'** inquiry & reflective **teaching** practices
- ☑ Teachers' inquiry & reflective **learning** practices
- ☑ Teachers' inquiry & reflective **teaching**
- ☑ Teachers' **professional** practice

Teacher educators' teaching inquiry & reflective practice takes place in a preliminary phase – studying implicit and explicit requirements for teacher competences; during the design of the course, in terms of reflecting on these requirements and also providing a meta-course design that could be used as a model by teachers in their teaching practice; during the delivery of teacher trainings as a facilitating method; and as a post-reflection after teacher training – to be aware of what was learnt during the course and how the next issue could be improved.

STEM teachers' practice, on the other hand, considers teachers' roles as lifelong learners (learning practice), as facilitators of students' learning (teaching practice) and as members of educational communities (professional practice). Teachers' inquiry & reflective learning practices help teachers to become aware of lessons learnt from their self-experience and from constructive team work and shared experience of other colleagues. It is integrated in each phase of the *ELITe Inquiry-Based Learning (IBL)* model for teacher competence development in the form of discussions, reflections and ongoing feedback by and among participants. The ELITe Learning in Teaching via e-inquiries approach encourages teachers to work with self-reflection during their practice, so that they will be able to identify problematic aspects and act as learners choosing relevant courses. The ELITe project provides them with tools for pre- and post- self-assessment as a reliable method for measuring the result of a teacher professional development course. For teachers' inquiry-based & reflective teaching practice, communication is also an integral part of the Learning in Teaching via e-inquiries model of teachers' development.

The ELITe **path** to developing STEM teachers' inquiry and reflective practice at the above-mentioned levels has been informed by Kerry Earl & Bill Ussher (2016) and Kolb's models for reflection and the weSPOT inquiry based learning model, and foresees three key stones: **THINK**; **ACT**; **VALUE**.

KEY STONE 1: THINK is a reflection stage on the national context (national requirements, challenges and needs).

KEY STONE 2: ACT relates to inquiry-based learning action.

KEY STONE 3: VALUE calls for a self-reflection on lessons learnt.

KEY STONE 1: **THINK** – REFLECTION ON NATIONAL REQUIREMENTS, NEEDS AND CHALLENGES

CONTENT FOR REFLECTION

Requirements and challenges for STEM teachers' competence development: The case of Greece, the Netherland, Bulgaria and Spain

There seems to be a variety of approaches to the requirements of teacher competences in national educational policies in the EU, ranging from a 'light touch' definition of broad competence sets in competence frameworks to prescriptive lists, linked with professional standards and career advancement (Caena, 2011). However, major aspects of teacher competences as defined in the European commission framework (European Commission., 2013) are more or less evident in national STEM teachers' professional development frameworks.

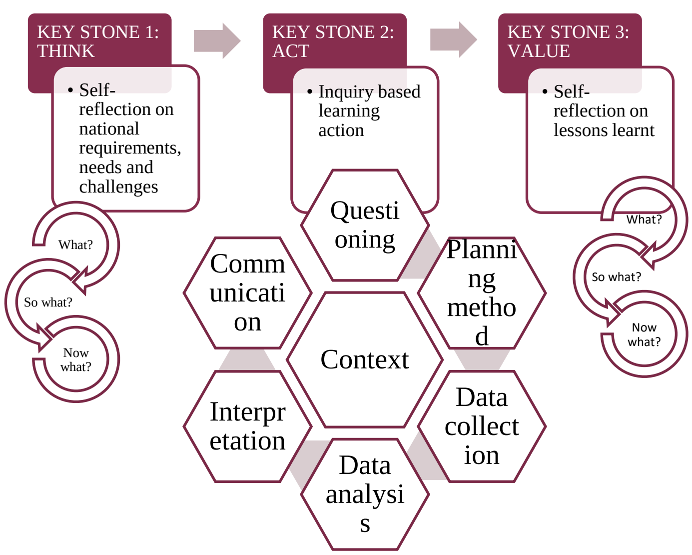

Fig. 9 Key Stones in the ELITe path to developing STEM teachers' inquiry and reflective practice

In the course of the ELITe project, we reviewed the ***national contexts of Greece, the Netherlands, Bulgaria and Spain in terms of STEM teachers' competence development***, through document analysis (of policy documents, STEM teacher training curricula and students' STEM curricula) in each country – study reference year 2017.

Provided below is ***a comparative overview of required STEM teacher competences in the national contexts of Greece, the Netherlands, Bulgaria and Spain, under their roles as lifelong learners themselves, as facilitators of students' learning and as members of educational communities*** (see Tables 2, 3 and 4).

Considered are three dimensions of competences (knowledge & understanding, skills, dispositions & attitudes), while aspects in each dimension explicitly evident refer to evidence as demonstrated in the national policy documents and the curricula for STEM teacher training; aspects implicitly evident refer to evidence as demonstrated in students' STEM curricula.

Table 2: Comparative insights on policy requirements for STEM teachers' competence development under their role as lifelong learners in Greece, the Netherlands, Bulgaria and Spain - explicitly (as demonstrated in the national policy documents and the curricula for STEM teachers' training) and implicitly (as demonstrated in students' STEM curricula)

STEM teachers **as lifelong learners** are required by national policies to develop, practice, demonstrate:		**Knowledge & Understanding of STEM related teaching and learning content**						**Learning skills, relating to the promotion of teachers own learning**			**Dispositions & Attitudes relating to teachers own learning**	
		STEM knowledge	Pedagogical Content knowledge	Curricular Knowledge	Developmental psychology	Issues on Inclusion and diversity	Use, develop, create research knowledge	Reflective, metacognitive skills	Interpersonal skills	Epistemologica l awareness	Flexibility, ongoing learning	Critical attitudes on own learning
GR	*Explicitly*			☑	☑	☑	☑	☑	☑	☑	☑	☑
	Implicitly	☑	☑		☑	☑						
NL	*Explicitly*	☑	☑	☑	☑	☑	☑	☑	☑			☑
	Implicitly					☑	☑				☑	☑
BG	*Explicitly*	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	Implicitly									☑		
ES	*Explicitly*	☑		☑	☑	☑	☑	☑	☑		☑	
	Implicitly		☑		☑	☑	☑					

Table 3: Comparative insights on policy requirements for STEM teachers' competence development under their role as facilitators of students learning in Greece, the Netherlands, Bulgaria and Spain - explicitly (as demonstrated in the national policy documents and the curricula for STEM teachers' training) and implicitly (as demonstrated in students' STEM curricula)

STEM teachers **as facilitators of students' learning**	**Knowledge & Understanding of methodologies and methods relating to STEM learning and teaching**	**Teaching skills, related to the promotion of students' learning**	**Dispositions & Attitudes, related to the promotion of students learning**

are required by national policies to develop, practice, demonstrate:		Pedagogical knowledge	Innovative STEM methodologies	Evaluation and assessment	New technologies	Plan, manage, coordinate teaching	Use teaching materials & technologies	Manage students & groups	Monitor, adapt & assess teaching objectives	Collect, analyse, interpret evidence	Teaching skills through content	Transferable skills	Promote learning of all students	Promote democratic attitudes & practices
GR	*Explicitly*	☑			☑	☑	☑		☑				☑	☑
	Implicitly	☑		☑	☑	☑	☑	☑		☑	☑		☑	☑
NL	*Explicitly*	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑
	Implicitly	☑	☑		☑	☑	☑	☑	☑	☑		☑		☑
BG	*Explicitly*	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
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ES	*Explicitly*	☑		☑	☑	☑	☑	☑	☑		☑		☑	
	Implicitly				☑					☑				☑

Table 4: Comparative insights on policy requirements for STEM teachers' competence development under their role as members of educational communities in Greece, the Netherlands, Bulgaria and Spain - explicitly (as demonstrated in the national policy documents and the curricula for STEM teachers' training) and implicitly (as demonstrated in students' STEM curricula)

STEM teachers **as members of educational communities** are required by national policies to develop, practice, demonstrate:		**Knowledge & Understanding of contextual aspects of learning and teaching**		**Professional skills, relating to STEM teachers' role as part of educational communities**				**Dispositions & Attitudes relating to STEM teachers' role as part of educational communities**	
		Educational Science foundations	Contextual, institutional and organizational aspects of educational policies	Collaboration skills	Negotiation skills	Ability to adapt to educational contexts	Life and career skills	Dispositions to team-working, collaboration and networking	Sense of self-efficacy
GR	*Explicitly*	☑	☑					☑	
	Implicitly								
NL	*Explicitly*	☑	☑	☑				☑	
	Implicitly				☑	☑		☑	
BG	*Explicitly*	☑	☑	☑		☑		☑	
	Implicitly						☑		
ES	*Explicitly*	☑	☑						
	Implicitly					☑		☑	

READ MORE

On STEM teachers' competences required in GR, NL, BR, ES: Comparative insights in the ELITe's project Intellectual Output IO2: http://tiny.cc/mkx94y

How are national policy frameworks for STEM teachers' competence development are interpreted and implemented at meso (teacher training) and micro (school practice) levels?

Despite the existence of national policies on/for STEM teachers' competence development, it should be noted that *the presence of teacher standards seems to be no guarantee of actual quality standards, since "**the devil is in the interpretation**" (Conway et al., 2010; Koster & Dengerink, 2008; Mahony & Hextall, 2000)* (Caena, 2011).

Comparative insights from document analysis during the review of national contexts of Greece, the Netherlands, Bulgaria and Spain in terms of STEM teachers' competence development indicate that:

- ***At meso level*** (mediating mechanisms) disparities are evident among the countries: In the Netherlands, the regulatory framework has 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 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 about 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.

Overall, as evident from the document analysis, ***in the national contexts of Greece, Bulgaria and Spain the main challenge identified with respect to STEM teachers' competence development is on 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***.

READ MORE

On STEM teachers' competence requirements in GR, NL, BR, ES: in the ELITe's project Intellectual Output IO1: http://tiny.cc/dsw94y

What are the needs/challenges in STEM teachers' competence development in the 4 countries?

In the frame of ELITe, the results of exploring nation contexts through document analysis were discussed with more than 30 education stakeholders in each country (policy makers, responsible for STEM teacher training and STEM teachers). On the one hand this discussion process validated the results of our document analysis, and on the other hand allowed us to gain insights from education stakeholders on means of supporting STEM teachers' professional learning for competence development in each national context more effectively.

Main outcomes of the multiplier events in relation to **thematic**, **methodology** and the **forms** of STEM teachers' trainings include:

In Greece, in relation to the thematic of teacher training courses, participants recommended that the focus should be on interdisciplinary topics; innovative teaching methods; differentiation; opening up schools to communities; assessment issues. In relation to methodology and forms of delivery of training courses participants recommended blended learning opportunities; communities of practice; training methodologies offering innovative teaching methods that teachers themselves are asked to implement in classrooms.

In the Netherlands, input collected from the workshop pointed out to several specific themes that are of interest as anchors in professional learning events for teachers interested in innovative pedagogies such as inquiry-based learning. There is interest in new concepts and tools while the relevance of application of the new knowledge in the classroom, in one's professional practice can be seen as a predictor of whether professional learning events introducing such tools and approaches will effectively contribute to teacher competence development in general and in STEM-related disciplines in particular. Specifically, challenges STEM teachers face on integrating inquiry-based learning methodologies in their classrooms – which is a prominent issue for consideration in the Dutch context - as emerged from the negotiation process include: 1) for teachers: dealing with diversity; personalized teaching, differentiation; monitoring process, getting all students participate; acting as a coach, assessment of outcomes at different levels for different students skills; 2) for students: collaboration, planning, inquiry-mindedness, self-regulation; formulating good learning questions; discovering what is possible, going beyond the given task, getting from idea to results; working with technology. Professional learning activities that aim to tackle the above-mentioned challenges are of prominent importance according to the event participants.

In Bulgaria, in relation to the thematic of teacher training courses, participants recommended that the focus should be on: STEM subject matter/new science achievements; interdisciplinary topics; innovative teaching methods; inclusive education; working with parents and local communities; assessment and evaluation. In relation to the methodology and forms of delivery of training courses participants recommended: blended learning opportunities; online courses as immediate support and as an archive for long term use; balance between learning at work place (school) and out-of-school courses.

In Spain, the need of application of active teaching and learning methods is of prominent importance. Special attention is dedicated to the inquiry-based and project-based learning methods that are emerging in Spanish schools and are required to develop STEM competences in an integrated way. For STEM learning disciplines, there is a special need for teachers to be trained on how to design, deliver and conduct attractive STEM resources. Inclusive education is still a challenge that Spanish teachers are facing. Aspects of fighting gender stereotypes in STEM are considered important. The role of parents' associations in the school is very important. In relation to the modalities of teacher training, there is a need for developing communities of practice of STEM teachers, something that can be done both face-to-face and online, especially given the limitations of teachers in terms of schedule and geographical distribution. Discussing teaching methodology, all stakeholders shared the belief that teacher training should be based on the same innovative learning methods that are expected for teachers to apply in the classroom, as opposed to the traditional lecture-based teaching, which is less and less popular in Spain.

READ MORE

- Supporting STEM teachers' professional learning for competence development: Insights on the space for intervention in GR, NL, BG, ES: https://goo.gl/Q9TdRL

QUESTIONS FOR REFLECTION

For STEM teacher educators:

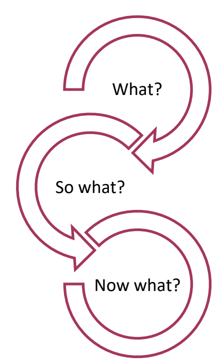
- ***What?*** Consider requirements for STEM teachers' competence development in your national context. How are they aligned with the expected outcomes of your training courses?
- ***So what?*** Consider needs/challenges for STEM teachers' competence development in your country. What are the implications of what you have learnt on your practice?

For STEM teachers:

- ***What?*** Consider requirements for STEM teachers' competence development and STEM teachers' needs for professional learning in your national context. How are they aligned with the expected outcomes of training courses you have participated at?
- ***So what?*** What are your needs for professional development? What opportunities and challenges are there for professional learning in your national context?

KEY STONE 1: THINK

- Self reflection on national requirements, needs and challenges



- ***Now what?*** Anticipate consequences (planning for implementation, active experimentation) and determine future actions.
- ***Now what?*** Anticipate consequences of what you have learned and determine future actions

KEY STONE 2: **ACT** – INQUIRY-BASED LEARNING ACTION

THEORETICAL BACKGROUND: THE WESPOT INQUIRY-BASED LEARNING MODEL

The ELITe ***Learning in Teaching via e-inquiries*** teacher competence development approach builds on the weSPOT IBL cyclic model, designed especially for successful inquiry-based learning supported by free ICT tools.

It 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 below (Fig. 10):

- **Problem/Topic**: Embedding; Existing knowledge; Mental representation; Language/definitions; Field of research; Ethics; Empirical meaning; Discussion/Argumentation; Question; Hypothesis; Reflection
- **Operationalisation** (realisation of idea with the aim of measuring): Indicators; Predictions; Resources; Methodology (of data collection and processing); Ethics (Ethical issues); Discussion/Argumentation; Reflection
- **Data collection:** Information foraging; Systematic observation; Experimentation; Tools; Simulation; Data storage; Data security; Documentation; Discussion/Argumentation; Reflection
- **Data Analysis (processing):** Quantitative analysis (Statistical methods/analysis); Qualitative analysis; Tools; Visualisation; Discussion/Argumentation; Reflection
- **Interpretation**: Embedding (into existing theories/results/domain knowledge (classification)); Confirmation/falsification (of the initial question/hypothesis); Relevance (of results); Discussion/Argumentation; Reflection
- **Communication**: Strategy; Audience; Tools; Dissemination (Events/Presentation/Publication); Discussion/Argumentation; Feedback (Receiving and reacting); Writing up; Reflection

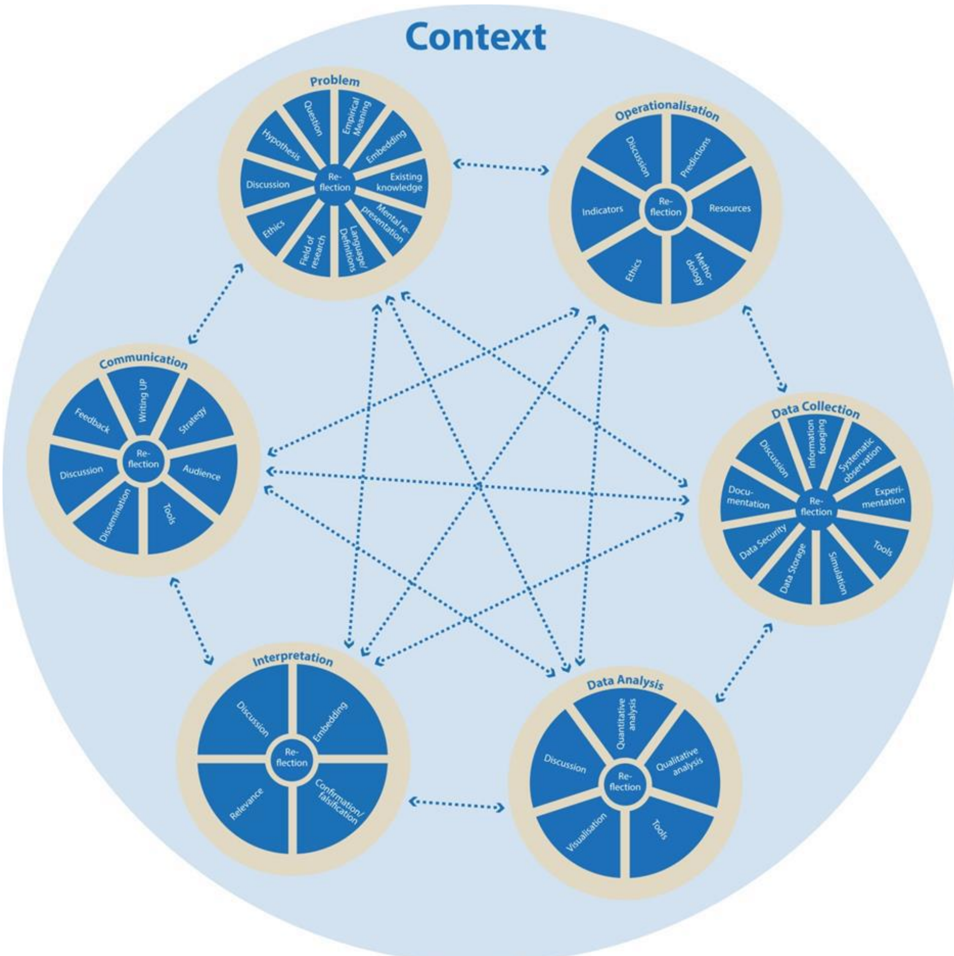


Fig. 10. The weSPOT IBL model on which the ELITe professional learning activities are based on

The model creates an environment for practicing inquiry skills & competences. **Skill** is seen as a goal-oriented and well-organised behaviour developed through practice, which gradually becomes automatic. Skill is a much narrower term than competence and focuses on the ability to use 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.

Competences, developed by weSPOT IBL model:

- ☑ **Research competence**
- ☑ **Problem solving**
- ☑ **Communication**
- ☑ **Critical thinking**

Skills, related to IBL, developed by the weSPOT model:

- 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 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 ICT skills to stay up-to-date 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.
- Organisation skills to keep track of lots of different information.
- Metacognitive skills

Competences, related to IBL, developed by the weSPOT model:

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, to sometimes 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 them to make a decision. Problem solving competences can be applied to technical as well to non-technical tasks/areas.

Communication: Communication as a competence 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 necessary to interpret, analyse, and evaluate arguments, problems and systems, and then to synthesise, evaluate and explain an appropriate response. This response may be innovative and go beyond standard conventions.

Additianally, the weSPOT model builds on reflective practice – each phase contains sub-stages for discussion, reflection and feedback, that makes it a really effective model for inquiry & reflective teacher competence development practice.

GUIDELINES TO TEACHER EDUCATORS FOR STRUCTURING STEM PROFESSIONAL LEARNING SCENARIOS THROUGH IBL METHODOLOGY

Key processes of development of ELITe ***Learning in teaching approach via e-inquiries*** STEM teacher competence development scenarios are structured and implemented around the questions:

1. **In what context?**
2. **What for?**
3. **Which content areas?**
4. **How to structure and implement?**
5. **How to ensure evidence on the value?**

The main questions, leading key processes of the ELITe scenario development:

- ☑ **In what context?**
- ☑ **What for?**
- ☑ **Which content areas?**
- ☑ **How to structure and implement?**
- ☑ **How to ensure evidence on the value?**

Formed in such a way, process-objective oriented methodology follows a continuous improvement approach that involves development, review, implementation, evaluation & improvement of teacher competence development scenarios. Each scenario can be conducted as a separate teacher competence development course or as a module of a more complex continuous professional development course. The process of each particular scenario's development is based on the results of building *Learning in teaching via e-inquiry approach*.

Tasks leading to the production of IO4[1] modules' scenarios were:

- **Consideration of policy requirements**, most relevant to each national educational context, based on IO1 and IO3 (corresponding to Key process 1).
- **Definition of the modules' objectives** in terms of IO2 results (corresponding to Key process 2).
- **Selection of inquiry skills leading to the specific teacher competence development**, based on IO2 (corresponding to Key process 2)
- **Selection of particular content areas**, based on IO3 (corresponding to Key process 3)
- **Defining the expected learning outcomes**
- **Structuring the learning activities** under the weSPOT IBL model (corresponding to Key process 4 and selected inquiry skills to be developed)
- **Selection of assessment methods and tools** (corresponding to Key process 5)
- **Selection of relevant and appropriate learning materials** according to the particular content area and specified target group
- **Structuring e-learning content and tools** corresponding to e-learning activities and assessment methods

[1] IO is the abbreviation of Intellectual Output and the numbers reference the different IOs of the ELITe project, in order of production

PROPOSED THEMATIC AREAS & SAMPLE SCENARIOS

Exploring the national policy requirements and challenges and opportunities, shared by stakeholders in the four piloting countries - Greece, the Netherlands, Bulgaria and Spain, ***nine thematic areas*** relating to current challenges for STEM professional teaching and learning were identified:

- ***Dealing with inclusion and diversity***
- ***Teaching STEM for skill development***
- ***Incorporating RRI in STEM education***
- ***Innovative STEM methodologies (IBL & project work, self-directed learning, computational thinking)***
- ***Opening up school science***
- ***Assessment challenges in STEM***
- ***ICT enhanced STEM learning and teaching***
- ***Answering challenges of new curricula***
- ***Enhancing teacher-parent collaboration***

The thematic areas by each country show common problems and gaps in STEM teachers' professional development in different countries.

The chosen thematic areas by each country show common problems and gaps in STEM teachers' professional development in different countries, as they are listed in the table below:

Thematic areas / Country	**Scenarios in each thematic area in the national contexts of**			
	GR	**NL**	**BG**	**ES**
Inclusion and diversity	Reflective practice for tackling inclusion and diversity issues in STEM classrooms		***Neither sees nor hears, but succeeds*** /researchers with SEN in school/ Creating a learning design for successful learning through IBL approach of pupils with SEN	Dealing with diversity in education: gender differences, learning styles, personalisation, etc.
Teaching STEM for skills development	Promoting students' achievement in STEM: Changing perspectives from knowledge acquisition to skills development	Learning to design inquiry-based learning with DojoIBL: an exploration		Design of good IBL activities based on DojoIBL for teaching and learning

Thematic areas / Country	Scenarios in each thematic area in the national contexts of			
	GR	NL	BG	ES
RRI in STEM education	Dealing with controversial socio-scientific issues in contemporary science			Strategies for introducing socio-scientific issues in the classroom: dilemmas, controversies, conversations.
Innovative STEM methodologies (IBL & project work, self-directed learning, computational thinking)	Design and delivery of an interdisciplinary STEM project	Self-directed learning for professionals in Education. An online master-class for teachers, teacher educators and MSc students in Educational Science interested in the topic of self-directed learning Computational thinking in the (STEM) classroom and beyond	***Detectives in the classroom*** IBL approach in STEM disciplines (how to design, deliver, conduct and evaluate IBL education in STEM)	Overcoming key difficulties of inquiry-based learning for STEM teachers
Opening up the STEM classroom	Opening up science education: taking advantage of the potential of informal science education	Learning and teaching in a seamless way (combining classroom learning with learning in the outside world: an introduction (**part 1**) and designing seamless learning experiences (**part 2**)	***Open air lessons – myth or not…*** Design of open air, field IBL education in STEM	Approaching STEM in collaboration with science centres and museums, and other local institutions.
Assessment challenges in STEM	Confronting challenges of IBL from an implementation and assessment perspectives	Assessment of 21st century skills with technology: how to do it in practice? Viewbrics, a tool for assessment of 21st century skills	***Measure three times, cut once*** Assessment for success (methods, techniques and tools for assessment IBL project work and team work)	

Thematic areas / Country	Scenarios in each thematic area in the national contexts of			
	GR	NL	BG	ES
ICT enhanced STEM learning and teaching		Challenges of inquiry-based learning and how to tackle them using DojoIBL. A design-oriented course for teachers of secondary vocational education (in STEM related domains)	***Dream or Reality***: Combining *dreams* (online tools, virtual reality, augmented reality and others) and *reality* (real places for educational visits	Emerging ICT technologies in STEM education: computational thinking, robotics, and game-based learning Open Science resources: use, adaptation and design of digital resources for the STEM classroom.
Answering challenges of new curricula			***Challenges of the new ICT curriculum for 8-th grade*** The scenario is dedicated to familiarize trainees with new, related challenges and to prepare them for teaching under its framework	
Enhancing teachers-parents collaboration	Overcoming personal bad experiences of parents for STEM success of their children			
	Supporting gender-neutral approaches to STEM at home			

The mapping of the scenarios' thematic areas outlined common issues in teachers' professional development that became a basis for collaborative discussions about weak competences, their origin and how they are presented in different countries. Its result is the development of the ELITe teacher training scenarios, having common points, but reflecting the specific audience, needs and situation in each country.

Taking a more general look, the mapping table is a basis for formulating an assumption that there are Europe-wide issues, related to STEM teachers' professional development, the ELITe project can successfully contribute to addressing. Moreover, as the scenarios deal with complex issues, detailed elaboration of the scenarios' objective, goals and workflow are suitable for

They are Europe-wide common issues, related to STEM teachers' professional development outlining much more common issues among participating countries regardless the difference in policy documents and experience.

STRUCTURING SCENARIOS IN THE DIGITAL PLATFORM AND SUPPORTING AN ONLINE COMMUNITY

DojoIBL cloud system (http://dojo-ibl.appspot.com), developed under the weSPOT project and covering all levels and phases of the weSPOT and other inquiry-based models, was chosen as the basic IBL online platform. The system helps teacher educators and teachers to implement collaborative learning processes like e.g. inquiry-based learning or problem-based learning. It provides a very simple, but powerful interface. Teachers/facilitators can create (or reuse) inquiry structures and arrange multiple groups of students working on them. The students/learners can collaborate and make use of the different functionalities to keep track of group progress and have an overview of the project. The user interface is translated into the languages of the four ELITe countries. In addition, each country can integrate the DojoIBL content in other e-learning systems, specific for the institution implementing the teacher competence development scenario, and include a variety of ICT tools appropriate for specific activity and / or skill development.

To use the Dojo IBL platform, each user should log in using a Google account or registering an account via email.

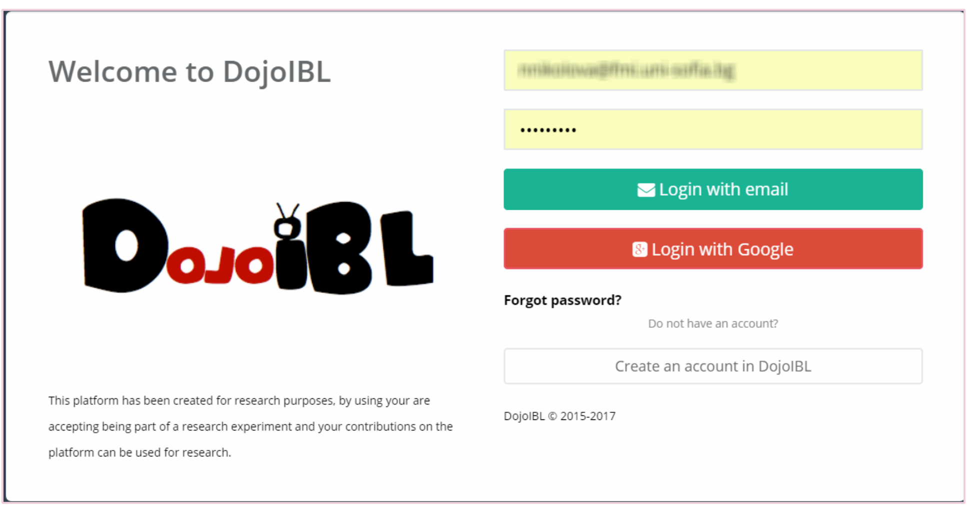


Fig. 11. Logging into DojoIBL

Reusing a scenario template

To reuse an implemented in DojoIBL ELITe competence development scenario, a teacher educator has to be the ‘owner’ or to have administrator rights on somebody else’s project. There are two ways to reuse a project:

1) To clone the project and adapt it
2) To create a new working group and join / invite teachers there.

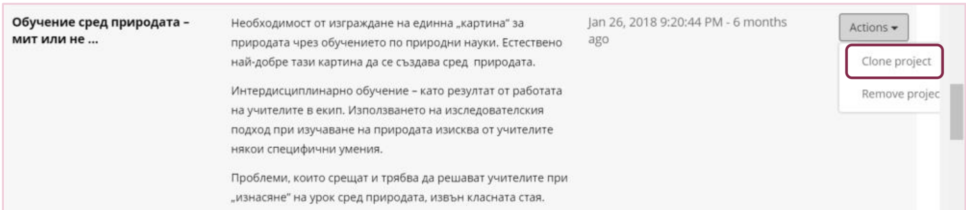


Fig. 12 Cloning a project

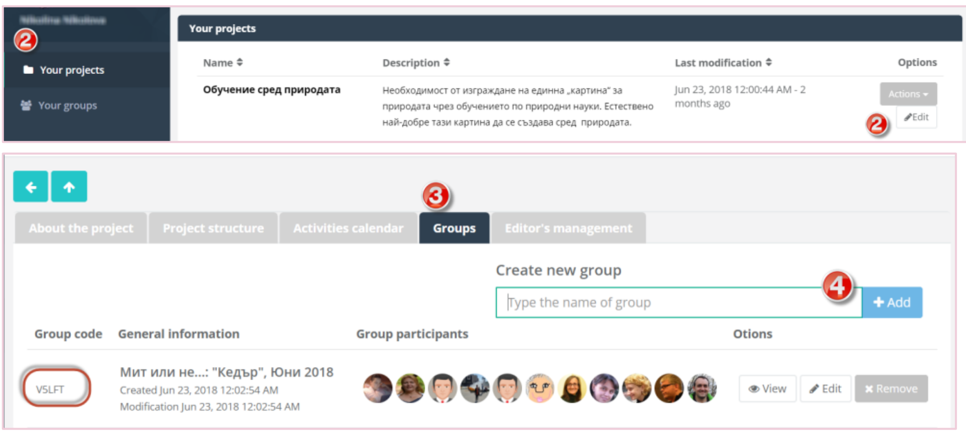


Fig. 13. Creating working group

Participants can join the group entering an assigned **Group code**.

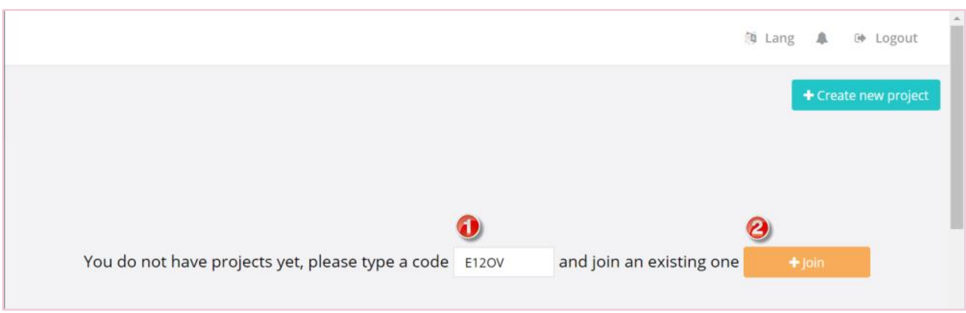


Fig. 14. Joining a group

Creating your own scenario based on the ELITe IBL model

An own scenario can be created in three easy steps:

1) Use the Create new project button in the project menu

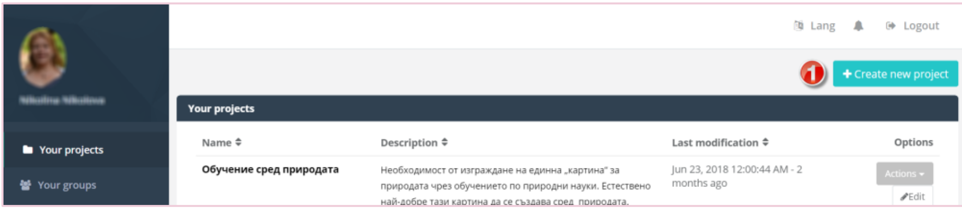


Fig. 15. Creating a project in DojoIBL

2) Choose the weSPOT IBL model template

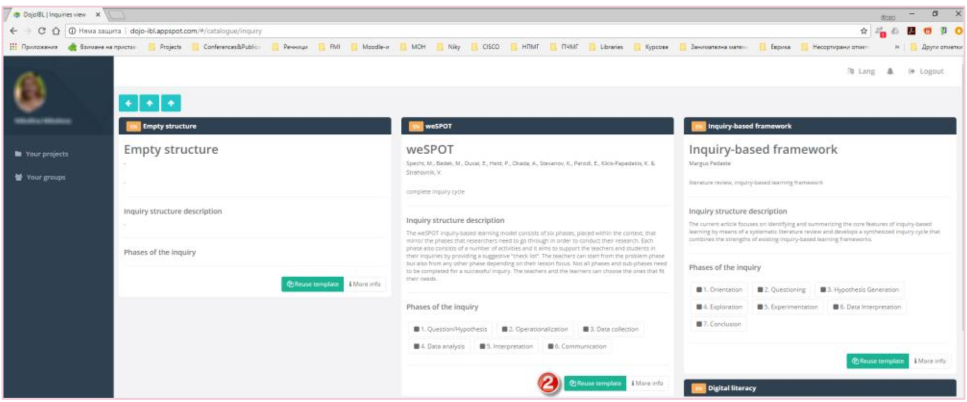


Fig. 16. Choosing a template for new project

3) Define activities and add resources according to ELITe ***Learning in teaching approach via e-inquires*** or use sample scenario phases and sub-phases(described in the next section).

READ MORE

- IO4. Sample digital scenarios for STEM teachers' competence development via inquiry methodology: https://goo.gl/qQsUUH
- Digital Scenarios per country – full description (in local language) and access codes for DojoIBL implementation:
  - Greece: https://goo.gl/HP6GHT
  - The Netherlands: https://goo.gl/SdcR42
  - Bulgaria: https://goo.gl/EFkfxM
  - Spain: https://goo.gl/MasjAP

GOOD PRACTIC EXAMPLES ON/FOR TACKING STEM LEARNING AND TEACHING CHALLENGES

The ***Learning in teaching approach via e-inquires*** methodology, developed under the ELITe project, was piloted trough teacher competence development scenarios presented below.

Based on teachers' and teacher educators' reflection and feedback, a set of *good practice* examples were selected. Selected cases represent different thematic areas of intervention, or different interpretations corresponding to the national context of implementation in a same thematic area, but in different countries.

These examples provide a model for a way of delivery of the training modules. They are described in a reflective way by teacher educators. Inspirations and concepts extracted show the power of reflective learning practices, provide feedback about the value of education and insights about its improvement or development of new teacher competence development scenarios.

Scenario descriptions of the presented good practice cases are available in the APPENDIX.

Thematic area: teaching STEM for skills development

Case: *How to design a good STEM activity based in IBL with DojoIBL*: Spain

In principle, this training is face-to-face, with a duration of 4 hours, with the aim of forming a cohesive working group that, will be able to work more easily online forming a team on the DojoIBL platform.

They began with personal introductions of participants, each of them presented and explained a brief description of their current training and profession, as well as their interest and expectations for the course.

The training started with the presentation of the DojoIBL platform. Afterwards, each participant registered their profile on a computer on the DojoIBL platform, then they were able to enter the course and carry out the planned tasks jointly, working as a team.

In order to create teams that work online on the DojoIBL platform, it is recommended to meet in person or to get to know each other personally, since we have proven that this makes it easier to work later at a distance

This module works as a meta-course, since the main objective is to teach (through understanding the working of the platform) so that the teacher can design a good STEM activity using the DojoIBL platform.

There were moments, very important for a good development of the course, of a plethora of ideas and wrapping up. In this case, the fact that the course is done face-to-face did facilitate oral communication. The participants also made an effort to use the platform's data to check whether the exchange of ideas and individual proposals could be solved virtually, as well as the space to make comments, with the aim of responding to the demands of each participant to the tasks.

With this module, the participants were able to design their own STEM activity based on IBL. They started posing the question they did agree on: how many students of this school are necessary to make a pillar (a castle) to reach the moon?

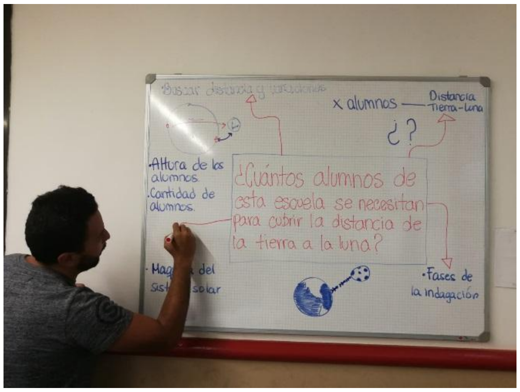


Fig. 17. Sharing of knowledge aiming at designing the structure of the inquiry phases (and tasks) in order to respond to the question posed

Next, following the instructions of the module, participants investigated how to design a series of tasks that may allow their hypothetical students to learn some contents about the planetary system, the estimation and calculation of large distances, etc., in the path of their research to answer the question, previously discussed and agreed.

Thus, the participants did create their own course with the DojoIBL platform, that they can implement with their students at the time when they follow the tasks of the module. The participants finished the course online in the days following the face-to-face meeting.

Teachers' reflections / inspiration

- The participants supported each other to give answers to questions of each phase of the investigation proposed in the course.
- When teachers had to agree on a research question, considering their secondary school students, they had to evaluate the possibility of visiting web pages to activate their ideas and think of questions that can be asked to motivate their students.
- The consensus sessions allowed us to improve and adjust the questions that should be the driving force of the students' inquiry.
- The tasks foreseen in the course of each phase of the investigation, especially the ones that promote reflection on the work done and the work to be done were highly valued by teaching staff, since they facilitate the organization of team work, and also highlight the weaknesses and strengths of what was done. This made it possible to start again to improve it or to foresee strategies to improve the work of the following phases of the module.

Teacher educators' reflections / inspiration

- The DojoIBL platform is a great way to organize learning, since it helps to structure a series of tasks in a chronological way that will help the students to develop skills and competences while they carry out activities to answer the question they are researching, and it motivates them.
- In order to create work teams or "research teams" that work online on the DojoIBL platform, it is recommended to meet in person or to get to know each

other personally, since we have proven that this makes it easier to work remotely later.

- Commenting in the platform on the requirements of each task of each phase of the module promotes participants' reflection, interaction, while contrasting points of view (since they have to agree on what to write), the ability to make decisions (and therefore to be more critical), and the consolidation of their knowledge.
- It is important that at the end of each session the participants have to answer questions that focuse on the objective of the session and engage them into synthesising and highlighting the lessons learned. It is important that they do not ask too many questions, as in such cases some questions remain to be un-answered.

Thematic area: Responsible Research & innovation in STEM education

Case: *Dealing with controversial socio-scientific issues in contemporary science*: Greece

Nowadays, STEM teachers need to equip students for making sense of cutting-edge technology and science that affects our lives and understanding how scientific research is developed. This is highly challenging, as it requires a shift from teaching scientific facts to equipping students to discuss socio-scientific issues by applying science knowledge, ethical values and inquiry skills. STEM teachers need to develop pedagogical know-how and practice to help learners to integrate science knowledge with ethical values for evidence-based thinking.

Students are more motivated to learn because topics are relevant to everyday life

All these considerations have guided the development and the implementation of the training scenario “Dealing with controversial socio-scientific issues in contemporary science” under the ELITe project’s “Learning in teaching via e-inquiries” teacher training methodological approach. The training scenario targeted secondary STEM teachers. It aimed to facilitate them to adopt/adapt good practices & methodologies and to enhance positive dispositions and attitudes on/for incorporating socio-scientific issues in their classrooms.

During the distance-learning implementation, participants shared opportunities and challenges they face when dealing with socio-scientific issues in STEM classrooms from personal, school-related, curricular, educational system related perspectives; defined their research question on the topic on the basis of challenges they face; reviewed literature and resources on socio-scientific issues developed in the frame of the ENGAGE project; and reflected and communicated with the team about lessons learnt from their learning experience.

Teachers’ reflections / inspiration

- Socio-scientific topics based on dilemmas are highly relevant for students’ everyday life and as such these are topics that can easily motivate all students to engage in the learning process. As per teachers’ reflections/comments during the training session, by incorporating socio-scientific topics in teaching/learning process: *students are more motivated to learn because topics* *are relevant to everyday life* and *students are encouraged to formulate their thoughts and opinions and cultivate the capacity for discussion and argumentation. All this I believe will make the lesson attractive, alive and inclusive*.

- Prominent challenges that teachers face in implementing lessons based on socio-scientific issues and dilemmas include:
  - Challenge to design a lesson on socio-scientific issues (*designing such a lesson is a challenge for every teacher, as there is no support for such methods from the curriculum*)
  - Challenge to implement a lesson on socio-scientific issues (*time restrictions"; "students are not very familiar with learning/teaching methods such as inquiry-based methods or discovery learning that are most relevant to deal with such issues*; *we as teachers need to practice more IBL and get experience and knowledge on how to deal with students' group discussions*)
  - Challenge to assess a lesson on socio-scientific issues (*which are the learning objectives of such a course and how do I assess them?*)
- How could the challenges be confronted as per teachers' reflections and communication process in the course of the scenario implementation?
  - Get inspiration from Open Education Resources available on the web, for example the ENGAGE project resources (*In my opinion, lessons such as those in ENGAGE is a rich library for the teacher to choose what he thinks fit for students of his/her class*)
  - Practice, insist and collaborate with colleagues (*I think it may initially seem difficult to the educator, but with practice and faith in the approach it will soon become easier*; *collaboration and implementation of similar techniques involving pupils and other colleagues in the same school so that students can better 'get involved' in these different ways of approaching the different themes*)
  - Use self-evaluation and peer-evaluation techniques (*by self-assessment of students. I would encourage them to compare their initial views with those they formed after the end of the lesson*; *the learning outcomes that could be evaluated are teamwork and learning products such as video creation by students about the subject under discussion in which to formulate their views*)

We, as teachers, need to practice more IBL and get experience and knowledge on how to deal with students' group discussions

Teacher educators' reflections / inspiration

The 'planning the method' phase might need special attention of teacher educators. It might be the case that some teachers are not familiar with making their 'research plan' explicit and concrete at the beginning of their inquiry process.

A **KWHL grid** (what I know; what I want to know; how I will find out; what I have learnt) could be a useful tool in this respect.

KWHL grid

What I know on the topic….

What I want to know…	How I will find out…	What I have learnt…

Case *Strategies for introducing socio-scientific issues in the classroom: dilemmas and conversations*: Spain

The training duration was three hours in person, with a closed group of people, and with another person working online on the DojoIBL platform from her office.

They began with personal introductions of participants, because they were new to each other. Each of them presented and explained their current training and profession briefly, as well as their interest and expectations for the course.

As usual, the training began with a brief presentation of the DojoIBL platform. Afterwards, each participant registered their profile on a computer on the DojoIBL platform, and then they were able to enter the course and carry out the planned tasks. They could share their ideas and their doubts talking to each other face-to-face, but also by the chat with the person working online.

Fig. 18. Participants working in teams with the platform DojoIBL

We could observe that activities of this Module are truly inspiring and very motivating to the participants because of the core theme of the module. The didactic aspects of scientific dilemmas had been quite unknown for the participants who were really interested.

With this module, the participants were able to design their own activities based on introducing scientific questions and dilemmas following the IBL methodology. They started with sharing their existing knowledge about the methodology (dilemmas, debates, inquiry, etc.) and they were collecting information by videos and presentations available via links in the activities on DojoIBL.

They thought about good issues and questions for teaching by dilemmas in their classrooms. Some questions were raised (the end of the plastic bag, consequences of choosing the sex of future children, etc.) and they debated about choosing the best ones.

They debated about how to design, plan and manage the sessions to teaching socio-scientific questions of this kind. They also talked about how to link the subjects of the official curricula with this kind of open questions.

The participants finished the course online in the days following the face-to-face meeting.

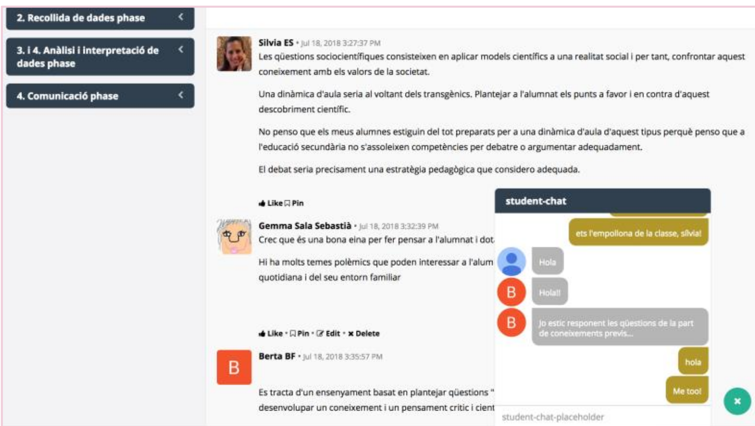


Fig. 19. Participants interacting on the platform DojoIBL in the first phase by comments and by the chat

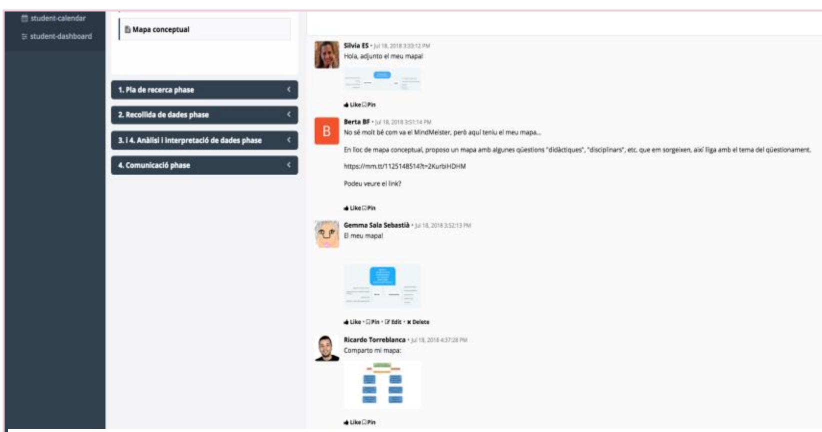


Fig. 20. Screenshot of the conceptual map activity

Teachers' reflections / inspiration

- They agreed that students could be motivated for tackling socio-scientific questions that are related to their immediate context.
- Students could develop critical thinking, scientific and communication skills.
- They think classroom management is very important in this type of teaching activity but it could be very difficult, too.

Teacher educators' reflections / inspiration

- The participants showed deep interest in the teaching methodology in this module.
- They are not confident about their abilities to deal with this methodology in their classrooms. They perceived themselves as incompetent to moderate a debate that involves their students in order to focus the discussion in curricular themes.
- The participants didn't trust in their students' communications skills and they believed that it is of key importance in this kind of methodology of teaching and learning.

Thematic area: Innovative STEM methodologies

Case: *Self-Directed Learning for Professionals in Education*: The Netherlands

Being able to learn in a self-directed way is important in our rapidly changing knowledge-based society, in which there is an increasing demand for flexible thinking and acting. Teachers are therefore encouraged to incorporate self-directed learning into their teaching. Tools and support is, however, missing.

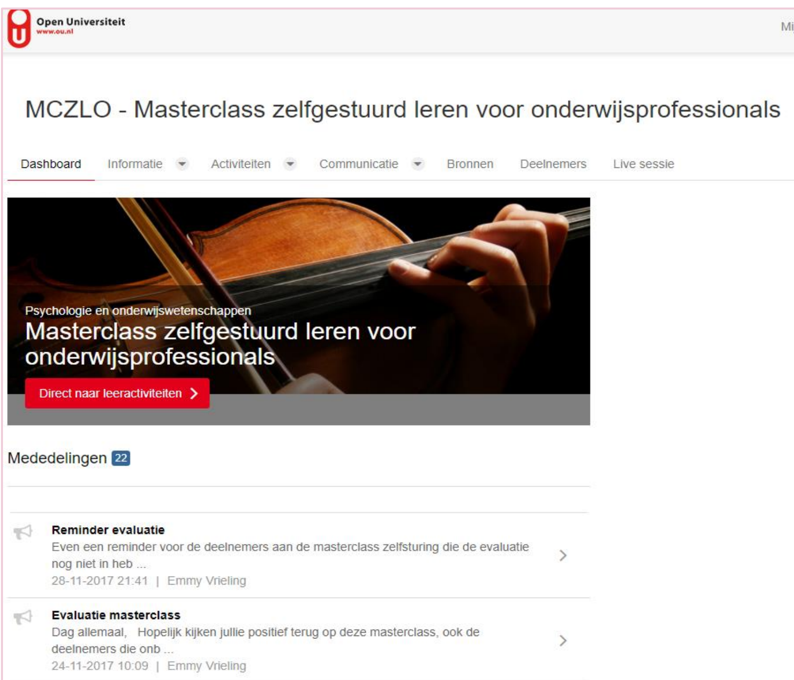


Fig. 21 The starting page of the online course

Open University Netherlands designed and realized a learning scenario on self-directed learning for teachers to offer them guidance on this topic by combining theoretical findings with practical insights.

This learning scenario had the form of an online masterclass entitled Self-Directed Learning for Professionals in Education. It was implemented by the Open University Netherlands in collaboration with Iselinge Hogeschool and the University of Maastricht. The duration of the masterclass was 4 weeks and the study load was estimated to be 28 hours. The target group were primary and secondary school teachers, students in teacher education and master students in Educational Science interested in studying the theme of self-directed learning in greater depth.

My goals are now more specific: I want to know what are the next steps for my school in helping schoolchildren to learn more

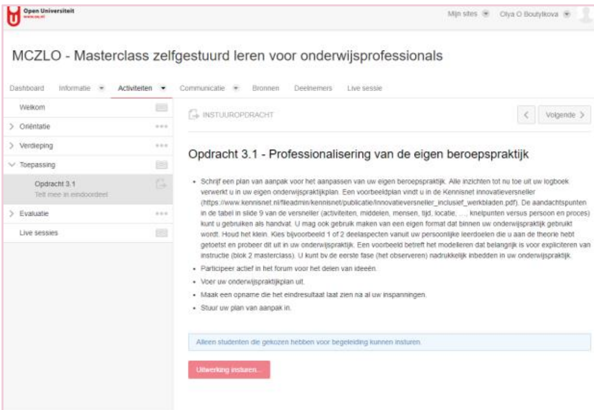


Fig. 22. Instructions

The master class consisted of online learning activities based on the study of selected materials, independent inquiry activities and discussions with other learners asynchronously, and two live online sessions in which learners could ask experts questions through the chat function in real time. The focus of the online masterclass was on defining self-directed learning, applying this concept in school practice and curricula, assessment of self-directed learning and sustainability of self-directed learning in school curricula.

Living what you are learning can be a strong learning tool

Participants' own learning objectives formed the point of departure in their inquiries and a substantial part of the learning trajectory, thus learning was explicitly tailored to their personal learning situation and needs, and teachers reflected on directing their own learning as part of theireducation.

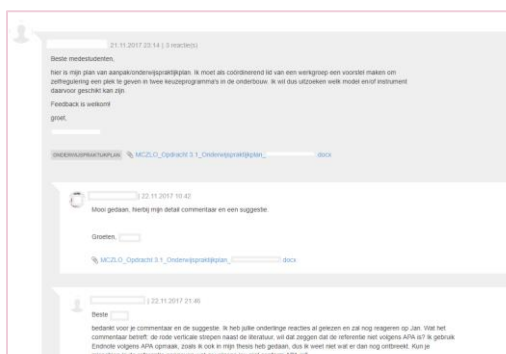


Fig. 23. Online discussion and reflection

The set-up of the masterclass included a sequence of five phases: (1) orientation on the topic, learning goals formulation and planning actions; (2 & 3) in-depth knowledge acquisition through literature study and interaction with experts during live sessions and consequent adjustment of personal learning goals; (4) goals attainment through realization of the planned actions (5) reflection on goals, their attainment and process through essay writing.

Exchanges with other learners were strongly encouraged and supported with tools such as a Google Drive folder for exchanging resources, a discussion forum and chat. Expert feedback on the original plan and assessment of plan realisation constituted important features of this learning scenario.

Teachers' reflections / inspiration

Having one's own practice as a point of departure and the requirement to explicitly formulate learning objectives and reflect on them, adjusting, if relevant, upon the contact with experts, reflection on the realized objectives increased the awareness of participants of the complexity of and ambiguities related to the topic of self-directed learning in school practice, in particular on the implications for teacher role in steering self-directed learning and teacher professional needs.

"*My original learning goal was getting insights in the implications of sdl (self-directed learning) for the curriculum (on the ways the curriculum integrates sdl skills, on what types of innovation are necessary to increase sdl skills of schoolchildren, etc.) and teacher professional learning on sdl in general (getting better insights in the implications for teacher knowledge and skills needed to support sdl of schoolchildren). Having followed the masterclass live sessions and doing literature study made me realise that my initial learning goals were much too ambitious. My goals are now more specific: I want to know what are the next steps for my school to help schoolchildren learn more actively and based on self-awareness.*"…My outcome is a step-by-step plan that I can use as a concept for discussion with my school team to develop a long term strategy together".

"*It became clear to me that students need to understand how they can direct themselves and their learning using strategies. Reflecting on this, I realised that neither I nor my colleagues model such behaviour, there are no concrete materials within the school to support pupils*".

Teacher educators' reflections / inspiration

Formulating personal learning goals and objectives is an iterative process and not a single activity. Going back to your own learning goals equipped by new insights and reflecting on them, helps to specify them and attain them.

Living what you are learning can be a strong learning tool. Participants came to the masterclass to learn a new concept and its possibilities for educational practice. The online masterclass provided a hands-on immersive experience of actively and consciously self-directing and self-regulating their learning against the academic background and producing an academic artefact of their learning.

Thematic: Opening up the STEM classroom

Case: *Seamless Learning – an introduction*: The Netherlands

People learn in increasingly different (physical and social) settings with less effort than 50 years ago, as both technological and physical infrastructures allow them to do so. Learners easily move from one 'place' to another and create their own learning 'spaces', e.g. by using mobile devices and cloud-technology. Learners' mobility and control on what, when, where (Chan et al., 2006) and how they want to learn is still increasing every day, allowing learners to choose from a wide variety of formal (e.g. schools, universities) as well as non-formal (e.g. museums, 'on the job', MOOC's) learning experiences. Seamless Learning (Wong, Milrad, & Specht, 2015) looks at the 'gaps' that currently exist between these varied learning settings and how learning across these different settings can be fostered by making transitions as smooth as possible (Looi et al., 2010) with innovative technology and pedagogy, in order to make learning more meaningful, transferable, effective, continuous and fun for learners.

Connecting classroom learning to outside world learning and working together with a variety of partners on realising seamless learning reflects the societal needs in new generation equipped with 21st century skills and competences. However, integrating real life experiences in classroom learning can be challenging and demand other skills and competences from the teachers that they may lack. Collaboration with specialists from a variety of disciplines is necessary and instructional design skills may also be needed. Foremost, teachers need to have an idea of what seamless learning entails and what opportunities it offers. Furthermore, they need to understand the possible challenges and be aware that effort might be necessary in tackling them.

I agree that contexts are not yet used as open and dynamic interactive systems for learning

The focus of this learning scenario is on the concept of seamless learning and the pre-requisites of integrating seamless learning (projects) into formal school curricula and into STEM education, in particular. Learners (teachers, e.g. teachers in STEM disciplines) are introduced to the concept and are invited to brainstorm and reflect on the added value, opportunities and challenges or barriers to linking classroom learning to learning in the real world.

This learning scenario is realized as an open online course that can be followed separately or as preparation for a one-day live conference on the topic. The online course is delivered in an open online learning environment for MOOCs, Open Edx (edia.ou.nl).

Phase 1, Introduction to the topic with initial knowledge acquisition and questioning took place in this environment.

The concept of seamless learning was introduced with an example (a trigger of attention) and an introductory part that included several assignments and a concise theoretical introduction. In the trigger-assignment, learners were prompted to generate examples of outside-of-classroom learning, examples of learning-rich contexts (triggers for wonder moments) and to reflect on the theoretical introduction in relation to their own practice. Furthermore, they were prompted to reflect on the benefits and challenges of combining classroom learning with outside-of-classroom learning and generate ideas on seamless learning experiences. As a final online task, learners were invited to think of a theoretical seamless learning scenario for their own practice and formulate a question they would/could answer based on new knowledge. DojoIBL (https://dojo-

Theoretical assignments that could open new perspectives of viewing the presented problems were barely "consumed" by participants leaving no visible traces of learning in the environment

ibl.appspot.com) was offered for the purpose. In this tool one group for each educational domain (primary education, secondary education etc.) both for STEM-related domains and not-STEM domains was established. Learners were invited to choose a DojoIBL group based on the domain they have affinity with and formulate a question and proceed with looking for answers in a structured way individually or in collaboration with others.

Furthermore, learners were invited to participate in a one-day live conference on the topic of seamless learning after the online course. During the conference a hands-on session on seamless learning design scenarios was offered in three variations: participants were invited to design a prototype of a learning environment based on one of the three exemplary contexts that were provided. The hands-on session was concluded with final presentations of the (groups) participants about their design ideas and scenarios of seamless learning.

Teachers' reflections / inspiration

Introduction by concrete examples stimulated active participation in the online part of the course. Discussion groups were actively used by participants to share experiences and examples, ask questions and provide answers to each other. Reflections of the participants were related to the assignments provided, cases they considered interesting or relevant for their educational practice.

- *The museum addresses inventing and experiencing on your own* (on the provided case of learning in a museum). This implies that you as a learner are gathering (informal) knowledge. Different levels of thinking are addressed that is a huge step forward as compared to traditional classroom learning"
- *Once a year I take my students to the Binnenhof (parliament) in the Hague. ProDemos offers a programme called "Dutch Parliament in a nutshell". One part of this programme is related to the use of tablets to make quizzes.* Currently *no attempts are made to connect learners who are busy with their own quizzes, to support shared knowledge construction. I agree with X who says that contexts are not yet used as open and dynamic interactive systems for learning* (on the invitation to share seamless experiences from one's own instructional practice).

Teacher educators' reflections / inspiration

While stimulating course participants to share their concrete experiences and contribute to a shared overview of possible applications of seamless learning, theoretical assignments that could open new perspectives of problems presented were barely "consumed" by participants leaving no visible traces of learning in the environment.

Neither did the invitation for independent inquiry in DojoIBL. These activities need coaching and personal contact with the teacher /expert.

Case: *Open air lessons – myth or not…*: Bulgaria

The training was organized in two sessions:

- Face-to-face: meta-training, applying IBL approach in open air lessons, and reflection
- Distance-learning session for self-inquiry-based learning and preparation of final product.

The fun during the training is a powerful tool for overcoming bad attitude to the non-traditional learning methods

The face-to-face session took place in a holiday camp called 'Cedar' (the name was integrated in the next tasks). The teachers were grouped in three competitive teams, assigned to the following tasks:

- To find hidden parts of a crossword puzzle in the camp garden, to assemble and solve the crossword puzzle. A common map was provided.
- To calculate the area of the garden.
- To research bio-diversity in the garden, calculating different kinds of flowers, shrubs and trees per square meter. The teams should be ready to provide artefacts proving their results.
- To contribute to the promotion and / or saving the holiday village, creating advertisement, tables, etc. from natural material found in the garden.

Settings:

- The teams were allowed to use mobile phones, sheets of paper, pens and natural materials found in the garden but not harming nature
- In this case, it was lightly raining during the training.

The teams had one hour for completing their tasks and an hour for a group reflection on it. The results showed different approaches to the tasks (measurement by feeds, using mobile apps – maps, calculators, internet, etc.) and creativity – not only in art tasks, but also in reaching results in other tasks. The face-to-face session finished with a summary on what is necessary to be learnt before organising open-air lessons, what normative documents shall be prepared, what potential constrains shall be considered and how to include all student even if some of them have some kind of disability or cannot participate in person.

I realize my need to learn more and more. We may be afraid of open-air lessons because they are complex and we are not sure we are competent enough

During the distance session teachers continued working in teams, studying good practices provided through the DojoIBL platform, preparing documents required by Regional Management Centres of Education, sharing resources, developing lesson plans, looking for appropriate places for one-day or longer educational activities. At the end, each team published their own design, resources and related documents for open-air learning. The training finished with reflection, feedback and evaluation.

Fig. 24. Map exploration

Fig. 25. Joint team efforts on-task

Fig. 26. Field research

Fig. 27. Reporting results and providing reasoning

Teachers' reflections / inspiration

- At the beginning, some of the teachers were frustrated by bad weather (cold wind and light rain). Regardless, they completed the task and they shared afterwards that then they realised how important fun was during learning. Running in the garden having fun and competing with other teams were evaluated as a real motivation-providing environment for invisible learning processes.
- The reflection reveals a deeper understanding of teachers that people learn in different ways, and open-air learning and a combination of inquiry and creative tasks provide the necessary conditions for people with different learning styles to perform well.
- *I realise my need to learn more and more. We may be afraid of open-air lessons because they are complex and we are not sure we are competent enough (or even as competent as students in some aspects – for example using mobile devices)* (Vyara)
- *Actually, a classroom cannot provide such atmosphere and environment that enables students not only to learn, but to feel the deepness of relationship across different STEM disciplines. But you need a very strong team of other STEM teachers to be able to design such learning process.* (Ivo)

- *We are used to being 'right'. But this funny competition showed us that even we, teachers, shall be more critical of our knowledge and skills. Applying the same approach with students, we can manage it in order to developed students' critical thinking* (Tanya)

Teacher educators' reflections / inspiration

- To experience the same style of teaching that is expected from teachers to apply has a very high added value – they understand not only of the teaching methods, but also different constrains related to the design and implementation.
- The fun during training is a powerful tool for overcoming bad attitude to non-traditional learning methods.
- Teacher trainings are as powerful as the level trainers are able to transfer their own energy and attitude to the learning process to their trainees at.
- Forming a strong professional community during the training is the responsibility of the teacher trainers. Succeeding in this leads to a long-lasting learning effect and continuous community support to the trainees.

Thematic: Enhancing teacher-parent collaboration

Case: *Overcoming personal bad experiences of parents for STEM success of their children*: International

The starting point should be for teachers to spend time with parents

Traditionally, STEM subjects are considered 'difficult' and in public discourse it is considered natural that a student struggles with STEM subject, while arts subjects are considered differently. This is based on anecdotal, experiential parental approaches, mostly based on their own schooling experiences. The use of innovative teaching methodology and technology can help counterbalance this on two preliminary conditions: teachers' awareness of this phenomenon and tools to change parental mindsets and attitudes.

In the training activity designed and implemented the first phase is awareness raising. This is based on teachers' personal experiences as well as their students' interpretation of their parents' attitudes and supportiveness. It is also part of the building of a working hypothesis and designing a local own research to follow public discourse, popular literature and mass media. Research clearly shows that parental attitudes towards school and school subjects has a major impact on student success and learning outcomes. It is also clear that the positive impact does not depend on the parents' ability to actually help children with homework and studying at home (Perera 2014.), so for teachers it is of utmost importance that they have the support of parents in motivating students to engage in STEM. It is also clear from research that parents' attitudes towards STEM is mostly influenced by their own schooling experiences: while parents with higher education or, most importantly, income levels often indicate the 'STEM is difficult' attitude by hiring private tutors as if school would not be enough, parents with lower income simply validate lower grades and even failures by telling their children they had similar experiences.

In the framework of the training, implementing the IBL methodology, the communication phase is based on Flecha's Successful Educational Action Plan methodology and Epstein's six types of parental involvement like the other parent scenario.

School partnerships were valued high for overcoming disadvantages coming from parents' previous experiences

Participants' reflections / inspiration

When we implemented the training scenario in the framework of EPA, all participants were very positive about the topic and found it important to get all parents on board. Everybody shared experiences with parents who had a negative attitude towards STEM based on their own schooling experiences.

During the workshop several possible actions were suggested by participants. They agreed that the starting point should be for teachers to spend time with parents, when starting teaching a certain group/class, introducing their subject and teaching methodology in a clear and simple way. Most participants found it useful to introduce 'champions' to both parents and students: successful people coming into school, talking about their journeys, especially ones coming from low socio-economic status families.

School partnerships – collaboration of primary or even pre-school and secondary – were also valued high for overcoming disadvantages coming from parents' previous experiences. It was considered especially useful to implement such partnerships in a way that makes it possible for parents to engage in playful STEM learning experiences on their own or together with their children. Another successful action can be partnerships between schools and non-formal learning providers (youth organisations, technical museums, etc.) and encourage parental participation in non-formal learning activities.

Case: *Communication with parents*: Bulgaria

The training started with face-to-face role-play, continued by distance learning and finished with a short face-to-face plenary session.

We have a chance to experience, together with other teachers, real-life cases from our own practice

During the initial session the participants were divided into two groups of equal size: one of them assigned the role of STEM teachers, the other one the role of parents. Then they were re-grouped into teacher-parent pairs. Each pair had the task of dealing with the following case:

> *A student has found an open social network profile of another student in the computer lab. This student has used the situation to write messages and post in the name of the owner, violating his reputation online and crossing the border of his privacy.*

The teacher's task was to invite the parent to a personal meeting, to explain the situation, the role and importance of ICT as school subject, safety and ethical issues of working on internet. They, teacher and parent together, should come to a common solution on how to deal with student and class management.

After the role-play, participants reflected on the communication during the game and if the pair came to a common solution, how, or why not.

At the beginning, I was afraid that too much reflection is required by us during the distance phase. Actually, starting to share experiences, resources and opinions in the reflection tool, I struggled to read others' opinion and point of view, to explore different aspects, and... to share again

During the distance phase, they were provided with scientific material about different types of parents. They elaborated on them and each participant had to identify the type of parent in the pair, to compare the result with his partner's opinion, and together to revise communication issues and how they can be overcome in the specific context. The next steps were distance communication with the roles changed, and the parent type was preliminary known for parents, and teachers presented a case form their own STEM practice.

The last stage was related to the research of scientific resources on successful communication between school and parents, to prepare a strategy for regular communication with the parent' community as well with different types of parents individually.

The training finished with a 2-hour face-to-face plenary session for summary and reflection.

Fig. 28. Individual 'teacher-parent' meeting

Fig. 29. Group moderated reflection

Fig. 30. Group life discussion

Fig. 31. Plenary reflection and evaluation

Teachers' reflections / inspiration

- Teachers have a high esteem for the method of 'wearing each other's shoes' as a way of development understanding of and empathy for parents as well as to look for good practices of communication with parents
- They shared that their research practices on parents' types and successful communication technics were much more focused and critical after the role-play than usual.
- *We have a chance to experience, together with other teachers, real-life cases from our own practice – to share difficulties, worries, etc. I was excited to see that my problems are not 'mine' personally. And, while I'm feeling alone and lost in the situation at my workplace, discussing and reflecting with colleagues reveal lots of approaches to the solution, I have a sense of security and support from the professional community*.
- *At the beginning, I was afraid that too much reflection required by us during the distance phase. Actually, starting to share experiences, resources and opinions in the reflection tool, I struggled to read others' opinion and point of view, to explore different aspects, and… to share again.*

Teacher educators' reflections / inspiration

- The power of IBL in the presented case is in focusing on self-directed teachers' inquiry in a relevant direction.
- Work shared online saves teachers' time by elaborating various resources, evaluating their reliability and appropriateness. It makes filtering resources useful in practice easy.
- Regular reflection during the training carry a potential for revealing diversity of point of view and approaches to looking for solutions of a given problem.
- An initial face-to-face stage is a pre-requisite for creating trust and a sense of community that, in turn, leads to good communication and effective training during the remote phase

Case: *Supporting gender-neutral approaches to STEM at home*: International

Gender bias in STEM is a well-known and well-researched topic. It can be conscious, based on beliefs and traditions, but unconscious gender bias also exists. Research also clearly shows that a supportive family environment is inevitable for good learning outcomes, so the parents and family should be the primary ally for any teacher. While the direct impact of parents on learning outcomes falls behind the impact of peers by secondary school age, it is still of utmost importance (Desforges 2003.). For successful STEM teaching in secondary school it is also important to know how STEM was approached and received by the student in primary school when parental impact was the most important. Gender bias in STEM starts at a very early age, and by the time students reach secondary level, it

However, the planning phase was difficult to carry out because of one participant who deeply believed in natural separation between boys and girls, that girls are 'created' for arts and boys for STEM can have a deep impact on their attitudes and openness towards STEM, and it has a major impact on the daily work of teachers (Gonyea 2017.).

We have developed and implemented a training scenario aiming at mapping the level and depth of gender bias by parents and developing an action plan addressing the issue. During the IBL activity, participants were invited to explore the state of art in the field of attitudes towards STEM by looking at popular examples, discussing their experiences with parents and analysing their own parenting practices and possible bias. Based on this, trainees were asked to develop a research on the topic in their own class/school environment. Based on the outcomes, participants were developing a so-called ‘Successful Education Action Plan’ – using the methodology developed by Ramon Flecha at al. in the IncludED project (2005-2009) – considering different groups among parents in their local setting. The planning is based on Epstein’s typology of parental involvement and should consider that parents will be involved in different levels according to their personality, availability and connection to the school of their children.

In the framework of EPA we have implemented the training scenario in order to validate that gender bias is a major issue in school. The assumption was more than validated, all participants of the workshop agreed that indeed it is an existing phenomenon. Most participants were aware of programmes promoting STEM to girls, but there was ample criticism against them mentioning that boys’ learning outcomes are declining all over Europe, so there would rather be a need for a truly equal approach, encouraging both girls and boys to engage in STEM more.

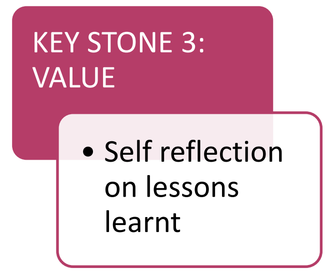
Participants’ reflections / inspiration

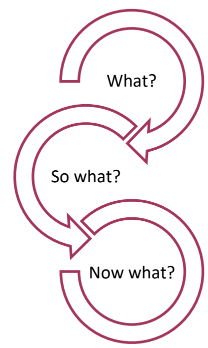
Some participants agreed that it is not a desirable situation, and good personal examples of equal treatment of sons and daughters were shared. Everybody agreed that this issue is best addressed from an early age, so in the case of secondary school teachers it is desirable that they try to reach into the family, especially if there are younger siblings, and try to have an impact on early or earlier years’ practices.

However, the planning phase was difficult to carry out because of one participant who deeply believed in natural separation between boys and girls, that girls are ‘created’ for arts and boys for STEM. As opposed to other participants who were open to exploring the underlying reasons for conscious and unconscious gender bias, were empathic to the biased ones, the natural separation believer was aggressively trying to convince everybody and was not open to any discussion. This was an interesting phenomenon that could be useful for other contexts. When planning any action, you need to be aware of the possibility of having such people in your target group of parents and you need to be prepared for that.

KEY STONE 3: **VALUE** – SELF-REFLECTION ON LESSONS LEARNT

QUESTIONS FOR PROMPTING REFLECTION ON LESSONS LEARNT





For STEM teacher educators:

- ***What?*** Consider the impact of the delivered activity in terms of: *relevance* (of the content, methodology, objectives of modules to participants' needs); *usefulness* of the course to participants; *accomplishment* of the expected learning outcomes.
- ***So what?*** What are the implications of what you have learnt for your practice? Consider implications in terms of STEM teachers' competence development.
- ***Now what?*** Anticipate consequences (planning for implementation, active experimentation) and determine future actions.

For STEM teachers:

- ***What?*** What have you gained from participating in the delivered professional learning activity?
- ***So what?*** What are the implications of what you have learnt for your practice? Consider implications in terms of your competence development and in relation to your professional learning needs.
- ***Now what?*** Anticipate consequences of what you have learnt and determine future actions

GUIDELINES TO TEACHER EDUCATORS FOR DEVELOPING A SELF-EVALUATION TOOL FOR STEM INQUIRY AND REFLECTIVE PROFESSIONAL LEARNING ACTIVITIES

The ELITe ***Learning in teaching approach via e-inquiries*** evaluation tool has a double role:

On the one hand, it aims to facilitate teacher educators evaluate the impact of professional learning activities on teachers' competence development; and evaluate the course in the dimensions of: relevance (of the content, methodology, objectives of modules to participants' needs); usefulness of the course to participants; accomplishment of the expected learning outcomes.

On the other hand, it aims to facilitate STEM teachers to reflect on their expectations, on the learning experience and on what they have gained from it.

The development of the tool draws input from ELITe's proposed indicators and sub-indicators for evaluating the impact of initiatives of STEM teachers' competence development, presented in the following tables.

Table 5 Indicators and sub-indicators for evaluating knowledge & understanding

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. 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	***Demonstration of knowledge on educational sciences foundations*** *(intercultural, historical, philosophical and sociological knowledge)*	GR, NL, BG, ES	

	aspects of learning and teaching	***Demonstration of knowledge on contextual, institutional & organizational aspects of educational policies***	GR, NL, BG, ES	

Table 6 Indicators and sub-indicators for evaluating skills

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 - related to the promotion of teachers' own learning**	***Demonstration of ability to use, develop and create research knowledge to inform practices***	GR, NL, BG, ES	NL, ES
		Demonstration of reflective & metacognitive skills during your own learning	GR, BG, ES	NL
		Demonstration of interpersonal skills for learning individually and in professional communities	GR, BG, ES	NL
	Enhanced teaching skills related 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 related 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 different education 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

Table 7 Indicators and sub-indicators for evaluating dispositions & attitudes

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	**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 of 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
"This is important to me"		***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		

READ MORE

On indicators and sub-indicators for evaluating the impact of initiatives of STEM teachers' competence development: in the ELITe's project Intellectual Output O2, accessible here: http://tiny.cc/obqa5y

Guidelines for facilitating teachers' educators are provided below to structure an evaluation tool for inquiry and reflective STEM teachers' professional learning activities.

Table 8 Guidelines for structuring evaluation tool

<table>
<tr><th>Aim of the tool item</th><th>Dimensions</th><th>Example of tool item</th></tr>
<tr><td>To provide data for evaluating course assumptions</td><td>- Relevance of the thematic to participants' needs

- Relevance of learning through IBL methodology

- Relevance of expected lear-ning outcomes</td><td>How relevant are the following to my professional learning needs
(1: not at all – 5: to a great extent)

<table>
<tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>Thematic of the module</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Learning through inquiry methodology</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Expected learning outcomes as in the module outline</td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>To provide insights on participants' needs and expectations</td><td></td><td>What is your motivation for participating in this course? What do you expect to gain from taking part in it?

{open question}</td></tr>
<tr><td rowspan="2">Evaluating the impact:

To provide us with data on teachers' competence development</td><td>Knowledge & understanding</td><td>Note: Refer to outcome indicators and sub-indicators from table 5 → dimension knowledge & understanding

Example:

My knowledge and understanding on {indicative: implementing and assessing inquiry-based learning}:

(1:very poor – 5: very good)
<table>
<tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>Before the course was ...</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>After the course is ...</td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Skills</td><td>Note: Refer to outcome indicators and sub-indicators from table 6 → dimension Skills</td></tr>
</table>

<table>
<tr>
<td></td>
<td></td>
<td>
Example:
My ability to {indicative: use and adopt existing research knowledge to inform my practices}:
(1:very poor – 5: very good)
<table>
<tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>Before the course was …</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>After the course is …</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
<tr>
<td></td>
<td>Dispositions & attitudes</td>
<td>
Note: Refer to outcome indicators and sub-indicators from table 7 → dimension Dispositions & attitudes

Example:
How important it is for me
(1: not at all – 5 to a great extent):
<table>
<tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>{Indicative :To have critical attitudes to my own learning and teaching practice }</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>{indicative: To work in teams, collaborate and network with colleagues}</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
<tr>
<td>To provide data on the IBL skills developed in the course aligned to IBL activities</td>
<td></td>
<td>
During the course, I believe that I used the following skills
(1: not at all – 5 to a great extent):
<table>
<tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>Critical thinking</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Information literacy</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Analytical skills</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Communication skills</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Digital skills</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Metacognitive and reflection skills</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Other research skills</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
<tr>
<td></td>
<td>Activities that the learner contributed to</td>
<td>
During the course, I contributed to the following activities
(1: not at all – 5 to a great extent):
<table>
<tr><th>{indicative}</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>Formulating the question</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Planning the method</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Review and analysis of data</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Hands-on activity</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Communication</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>….</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
<tr>
<td>Evaluation of the course</td>
<td>Usefulness</td>
<td>How useful were the following course elements to me?
(1: not at all – 5 to a great extent):</td>
</tr>
</table>

<table>
<tr><td></td><td></td><td>
<table>
<tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>Learning through inquiry</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Self-regulated learning</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Leaning with peers</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Hands-on learning</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Reflection & metacognition</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td></td><td>Learning outcomes</td><td>
Overall, where do I believe I am in relation to my learning outcomes? Please tick
<table>
<tr><th></th><th>This is new information/experience for me and I need some time to process it</th></tr>
<tr><td></td><td>I have connected new information to my previous learning</td></tr>
<tr><td></td><td>I understand now how this new information fits into the bigger picture</td></tr>
<tr><td></td><td>I am ready to share my new learning with others</td></tr>
<tr><td></td><td>I can explain new information to others and help them understand it</td></tr>
</table>
</td></tr>
</table>

Self-evaluation tool example

An example of a self-evaluation tool that has been developed in the course of the professional learning activity implemented for the Greek context is provided below.

Table 9 Example of a scenario on which the self-evaluation tool is applied

Scenario Title	**Reflective practice for tackling inclusion and diversity issues - opportunities and challenges in STEM classrooms**
Rationale	Inclusion typically refers to the integration of children with special needs into mainstream schools and classrooms; however, the idea of inclusive education in current discourse expands that concept to any child with varying abilities, who are at risk of school failure or dropping out, as well as from various minority groups and cultures. The challenge for inclusive education is of prominent relevance to the Greek context: Greek educators nowadays are asked to teach in increasingly multicultural classrooms as well as integrate students with special educational needs. STEM teachers are especially called to deal with gender issues among other things given the different dispositions and attitudes on STEM subjects and STEM studies among boys and girls. This module aims to facilitate STEM teachers' reflective practice for tackling diversity issues in their classrooms and for addressing the challenge of inclusive education. Opportunities and challenges for dealing with inclusion specifically in STEM teaching and learning will be negotiated. Effective school practices and teaching approaches will be presented as examples of good practice and as a ground for reflection and inspiration for own practice.
Training objectives	This module aims to enhance teachers': • *knowledge* on teaching strategies for dealing with inclusion and diversity;

	• interpersonal *skills* and ability to adapt to educational contexts; • critical *attitudes* towards their own teaching practices and positive *dispositions* on promoting students' democratic attitudes.
Learning outcomes	Having completed the course, participants are expected to be able to: • use research knowledge, and adopt/adapt good practices for dealing with the challenge of inclusive education in STEM classrooms; • demonstrate critical attitudes towards their own teaching practices – examining, discussing & questioning practices – in respect to inclusion and diversity issues

The Self-evaluation tool developed for this activity is presented on Table 10:

Table 10 Example of using the self-evaluation tool

How relevant are the following to my professional learning needs?	Thematic of the module	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Learning through inquiry methodology	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Expected learning outcomes as in the module outline	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
What do you expect to gain from taking part in this module?			Open question
My knowledge and understanding on **issues pertaining to inclusion and diversity** Before the course was…		1	very poor
		2	poor
		3	medium
		4	good
		5	very good
		1	very poor
		2	poor

My knowledge and understanding on **issues pertaining to inclusion and diversity** After the course is…		3	medium
		4	good
		5	very good
My ability to **use pedagogical strategies in STEM to deal with issues on inclusion and diversity** Before the course was…		1	very poor
		2	poor
		3	medium
		4	good
		5	very good
My ability to **use pedagogical strategies in STEM to deal with issues on inclusion and diversity** After the course is…		1	very poor
		2	poor
		3	medium
		4	good
		5	very good
My ability to **design learning activities that tackle diversity issues in the classroom** Before the course was…		1	very poor
		2	poor
		3	medium
		4	good
		5	very good
My ability to **design learning activities that tackle diversity issues in the classroom** After the course is…		1	very poor
		2	poor
		3	medium
		4	good
		5	very good
How important for me is…	To have critical attitude to my own learning and teaching practice	1	very poor
		2	poor
		3	medium
		4	good
		5	very good
	To promote learning for all students	1	very poor
		2	poor
		3	medium
		4	good
		5	very good
During the course, I contributed to the following activities:	Questioning	1	not at all
		2	to a small extend
		3	to some extend

		4	o a moderate extend
		5	to a great extend
	Planning methods	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Review data	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Analize and interpret data	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Communication	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
During the course, I believe that I practices the folowing skills:	Critical thinking	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Information literacy	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Aanlytical Skills	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend

		5	to a great extend
	Communication skills	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Digital skills	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Metacognitive reflection skills	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Other research skills	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
How useful were the following course elements to me?	Learning through inquiry	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Self-regulated learning	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Learning with peers	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend

	Hands-on learning	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
	Reflection & metacognition	1	not at all
		2	to a small extend
		3	to some extend
		4	o a moderate extend
		5	to a great extend
Overall, where do I believe I am in relation to my learning outcomes? Please, tick.		1	This is a new information / experience to me and I need some time to process it
		2	I have connected the new information to my previous learning
		3	I understand now how this new information fits into the bigger picture
		4	I am ready to share my new learning with others
		5	I can explain the new information to others and help them to understand it

ELITE *LEARNING IN TEACHING VIA E-INQUIRIES* APPROACH: KEY MESSAGES

THE *ELITE LEARNING IN TEACHING VIA E-INQUIRIES* APPROACH

The ***ELITe (Enhancing Learning in Teaching via e-inquiries)*** approach supports STEM teachers' professional learning for competence development through and inquiry-based methodology. It builds on the principle that ***teachers teach in such a way that they were taught***.

As opposed to traditional lecture-style, subject-oriented teacher trainings, it provides learner-oriented, flexible professional development embedded in the concept of ***change as professional learning perspective***, which considers teachers as reflective practitioners, responsible for their own learning.

The ELITe training methodology follows **inquiry and reflective skills practiced through inquiry-based learning (IBL)** and provides opportunities for professional development to take place by the use of a free **online platform, DojoIBL**, facilitating **personal** and **collaborative** inquiry-based learning. The assumption is that implementing the IBL methodology in teachers' competence development courses will provide them with real situational experiences and know-how as well as with a reflection from a 'students' (learners') point of view'.

Teachers' learning activities are structured in learning **scenarios** reflecting the needs and interests of teachers. The scenarios are designed for particular **thematic areas**, representing fields of the teachers' professional development: dealing with diversity and inclusion, fostering student achievement, teaching cross-curricular skills, career guidance for students, teacher–parent relationships and approaches to individualized learning.

The **Handbook with guidelines for STEM teachers' inquiry and reflective practice** provides guidance to:

- **teacher educators** on how to design, deliver and conduct ***ELITe*** teacher professional development trainings;
- **teachers** on how to identify needs and corresponding courses, and how to participate effectively and evaluate the results of an ***ELITe*** training.

B**est practice examples** are aiming at facilitating both groups in understanding and following the ELITe methodology as **teacher trainers**, **teachers** and **learners**.

ELITE LEARNING IN TEACHING VIA E-INQUIRIES PROCESS

The ***ELITe (Enhancing Learning in Teaching via e-inquiries)*** process follows the **reflective practice** cycle **THINK – ACT – VALUE**, looking at reflection as a combination of **hindsight**, **insight**, and **foresight**. It applies **inquiry practice** of professional development – a reflective practice, covering variety of qualitative pedagogical research methods – self-study, auto-ethnography, action research, teaching as inquiry and spiral of inquiry. The inquiry and reflective practice results in critical evaluation of the fast-changing teaching context and provides flexibility in professional development during practice in such a fast-changing context. It provides support also by offering networking opportunities, leading to self-esteem and enhanced team working skills.

The ELITe approach considers four levels of inquiry & reflective practice:

- **teacher educators'** *teaching* practice
- STEM **teachers'** *learning* practice
- STEM **teachers'** *teaching* practice
- STEM **teachers'** *professional* practice.

The ELITe **path** for developing STEM teachers' inquiry and reflective practice foresees three key stones: **THINK**; **ACT**; **VALUE**.

KEY STONE 1: **THINK** is a reflection stage on the national context (national requirements, challenges and needs).

KEY STONE 2: ACT relates to inquiry-based learning action.

KEY STONE 3: VALUE calls for a self-reflection on lessons learnt.

KEY MESSAGES

KEY STONE 1: THINK

- ELITe's STEM teacher training **design *incorporates interdisciplinary IBL activities for teachers***. Its IBL STEM nature gives flexibility to answer different national policy and stakeholder requirements.
- The ELITe **self-evaluation tool** is a powerful instrument:
    - For teachers – to evaluate their competences in advance and to choose the most appropriate course. At the end of the training it provides them with a clear picture of their achievements.
    - For teacher educators and teacher training providers – to evaluate participants' initial professional competences and to adjust the training design in such a way, so as to meet the trainees' needs in a most efficient way.

KEY STONE 2: ACT

- The strength of ELITe's STEM teacher training is based on **meta-design** developed, involving teachers in the IBL process. The full power of this method is reached for teacher educators only when IBL is followed by facilitated reflection.
- DojoIBL provides an appropriate **online environment** for effective inquiry and reflective practice for teachers' competence development. Moreover, it plays a powerful role as a source of implemented examples.

KEY STONE 3: VALUE

- **Self-reflection** facilitated by the ELITe tool is a reliable training assessment method for IBL STEM teacher training.
- The ELITe ***Learning in teaching approach via e-inquires*** IBL & reflective approach provides environment and conditions for reasonable development of the teachers' researcher skills. As an added value, the participation in an ELITe course leads also to development of self-confidence of trainees that they not only cover the training goals but can also act as researchers in their classroom.

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APPENDIX: GOOD PRACTICES – SCENARIO DESCRIPTIONS

Scenario Title	**Design of good IBL activities based on DojoIBL**
Country	Spain
Type	General teaching / learning thematic
Rationale	This course is addressed to teachers who would like to learn the basic principles of organising and orchestrating learning according to inquiry-based methodology. Central concepts of IBL will be included. Learners will be able to experience working and learning in their individual or group IBL environments using DojoIBL, a project management online learning environment free of charge. Furthermore, they will obtain an in-depth understanding of the rationale of using particular components of DojoIBL for the purposes of inquiry-based learning.
Training objectives	A. Knowledge A1. Develop teachers' pedagogical knowledge in terms of underlying concepts belonging to STEM domains, insights in learning and teaching according to IBL methodology A2. Develop teachers' knowledge on new technologies and their affordances as a tool for more effective lesson planning *and orchestration of this learning* B. Skills B1. Carry out an inquiry to learn about designing an inquiry-based learning activity involving reflection on learning and exchange with peers B2. Plan, manage and coordinate an IBL lesson [in an online learning environment] C. Attitudes C1. Develop critical attitudes to one's own learning C2. Disposition to promote students' IBL skills as a useful way to participate in scientific and technological development C3. Transferrable skills
Learning outcomes	A1a. Suitable pedagogies for STEM teaching A1b. Phases of an IBL lesson A1c. Learning resources for IBL lessons A1d. Role of the teacher and the learner in an IBL lesson A2a. Principles of orchestrating learning A2b. Affordances and functionalities of DojoIBL B1a. Follow all the steps of the inquiry successfully B1b. Reflect on one's learning B1c. Interact with peers B2a. Select and use teaching materials and technology B2b. Configure student groups to achieve learning outcomes B2c. Plan assessment strategies for an IBL scenario B2d. Plan a student feedback collection strategy to improve teaching

	C1a. Examining one's teaching practices C1b. Discussing, one's teaching practices C1c. Questioning one's teaching practices C2a. Develop a positive attitude towards learners driving the learning process C2b. Accept that the results of the lesson might not be the ones initially planned C3a. Disposition to team-working, collaboration and networking C3b. Sense of self-efficacy
Scenario Title	**Dealing with controversial socio-scientific issues in contemporary science**
Country	Greece
Type	STEM-related issues
Rationale	Currently, STEM teachers need to equip students for making sense of cutting-edge technology and science that affects our lives and understanding how scientific research is developed. This is highly challenging as it requires a shift from teaching scientific facts to equipping students to discuss socio-scientific issues by applying science knowledge, ethical values and inquiry skills. STEM teachers need to develop pedagogical know-how and practice to help learners to integrate science knowledge with ethical values for evidence-based thinking.
Training objectives	This activity aims to enhance STEM teachers': • pedagogical *knowledge* on teaching methodologies for dealing with socio-scientific issues in their classrooms; • *teaching skills* for learning through content • *dispositions* and *attitudes* on incorporating socio-scientific issues in classrooms
Learning outcomes	Having completed the course, participants are expected to be able to: • adopt/adapt good practices & methodologies for incorporating socio-scientific issues in their classrooms; • demonstrate critical attitudes towards their own teaching practices – examining, discussing & questioning practice
Scenario Title	**Strategies for introducing socio-scientific issues in the classroom: dilemmas and conversations**
Country	Spain
Type	General teaching / learning thematic
Rationale	This module is useful for STEM teachers who have some awareness and knowledge of teaching about socio-scientific issues and want to learn more about its applicability in the classroom. In this module, teachers will increase their awareness and knowledge about pedagogical strategies to teach about socio-scientific issues, namely dilemmas and conversations. They will also develop their skills on planning, implementing and reflecting on its application in the classroom. Finally, they will develop attitudes about their role and the role of students in this type of learning scenarios.

Equipped with his five senses, man explores the universe around him and calls the adventure Science."

Edwin Powell Hubble

Training objectives	STEM teachers are expected to develop knowledge, skills and attitudes about two pedagogical strategies supporting the teaching of socio-scientific issues in the classroom, namely dilemma and conversation. More specifically, they will develop: A. Knowledge: A1. Develop teachers' knowledge about curricular goals related to active citizenship A2. Develop teachers' awareness, knowledge & understanding about the pedagogical strategy known as an inquiry-based learning scenario with a dilemma to teach about socio-scientific issues B. Skills: B1. Select a socio-scientific issue to apply in the classroom B2. Design and implement a data collection strategy to learn about how to implement socio-scientific issues in the classroom C. Dispositions & attitudes: C1. Understand the nature of science as a process in which several social actors are involved, not only scientists C2. Be comfortable with the idea of the teacher as a facilitator C3. Think of students as drivers of their own learning process
Learning outcomes	A. Knowledge: A1a. Goals and definition of socio-scientific issues A1b. Characteristics of a dilemma, examples of socio-scientific dilemmas A2a. Goals and definition of scientific conversation A2b. Techniques for effective scientific conversation: organise tasks, create groups, prepare a conversation, support conversation, decide. B. Skills: B1a. Develop ability to select / design a dilemma which is relevant and engaging for teaching a particular socio-scientific issue to a specific group of students B1b. Enhance ability to select / create supporting materials for students to solve the dilemma B1c. Develop techniques to guide, assist and scaffold students in solving the dilemma B2a. Develop ability to choose / design the conversation scheme most suited for teaching a particular socio-scientific issue to a particular group of students B2b. Develop skills to help all students engage in the conversation B3a. Develop student observation skills so to collect data to improve teaching practice B3b. Enhance reflection skills and come up with ideas to improve practice C. Dispositions and attitudes: C1a. Develop an attitude that science is not only performed by scientists but that all citizens should participate in scientific discussion C1b. Consider the role that ethics and moral judgement play in science C2a. Conceive the teacher as a facilitator between students and knowledge/skills/attitudes

Education is the key to success in life, and teachers make a lasting impact in the lives of their students

Solomon Ortiz·

	C2b. Accept that the teacher might not know the results of a dilemma or how the class will evolve C3a. Think of students as active seekers of knowledge, not receivers C3b. Develop a positive attitude towards students talking in class
Scenario Title	**Self-directed learning for educators.**
Country	The Netherlands
Type	General teaching / learning thematic
Rationale	This module is designed in cooperation with representatives of a teaching institute (Iselinge Hogeschool) because of the relevance of teaching self-directed and self-regulated learning skills to teachers
Training objectives	This module aims at enhancing teachers': • Knowledge of the concept and insights in the way of self-directed learning and self-regulated learning • Affinity with instruments for evaluating SDL and SRL skills in teachers • Openness and flexibility to new approaches and ideas • Critical attitudes to one's own teaching (examining, discussing, questioning practices) • Disposition to team-working, collaboration and networking • Reflective and metacognitive skills
Learning outcomes	Having completed the course, participants will have a deep understanding of the concepts of SDL and SRL and the way they play a role in teacher professional learning. Participants have answered their specific learning questions and demonstrated their own skill development as self-directed learners.
Scenario Title	**Seamless Learning: connecting contexts for (STEM) education, scenario 1**
Country	The Netherlands
Type	STEM related issues
Rationale	The focus of this module is on the concept of seamless learning and the pre-requisites of integrating seamless learning (projects) into formal school curricula and in STEM education, in particular. Learners (teachers, eg. teachers in STEM disciplines) will be introduced to the concept and will be invited to brainstorm and reflect on the added value, opportunities and challenges or barriers to linking classroom learning to learning in the real world. Connecting classroom learning to outside world learning and working together with a variety of partners on realizing seamless learning reflects the societal needs of a new generation equipped with 21st century skills and competences. However, integrating real life experiences in classroom learning can be challenging and demand other skills and competences from the teachers that they may lack. Collaboration with specialists from a variety of disciplines is necessary and instructional design skills may be needed. Foremost, teachers need to have an idea of what seamless learning entails and what opportunities it offers. Furthermore, they need to understand the possible challenges and be aware that effort might be neessary in tackling them.
Training objectives	This module aims at enhancing teachers': • understanding of the concept of seamless learning • ability to critically reflect on the current classroom learning • collaboration and negotiation skills (optional) • openness and flexibility to new approaches and ideas

	• disposition to team-working, collaboration and networking
Learning outcomes	Having completed the course participants will • Demonstrate understanding of and insights in the concept of seamless learning by discussing the possibilities of and the barriers to organizing such projects in practice. • Demonstrate their ability to elaborate on new ideas and approaches to learning including the concept of seamless learning • Be able to proceed to the Designing Seamless Learning Experiences course which will be offered as a follow-up scenario
Scenario Title	***Open air lessons – myth or not…***
Country	Bulgaria
Type	STEM related issues
Rationale	When teaching science, there is a necessity of building a common *picture* of the nature. It is natural that this *picture* to be created in the nature. Interdisciplinary learning is integrated in most science subject curricula, but there is a lack of rich experiences in working in teams of teachers and design such education. In addition, applying the IBL model requires more specific teacher competences. It is still difficult to organize outdoor lessons in Bulgaria – there is quite a hard procedure and new set of normative documents, that need to be prepared. To implement outdoor learning processes, STEM teachers need to develop competences to prepare such documents in accurate and efficient way. Open-air lessons by themselves are challenging for students and for teachers. The scenario is designed to support teachers to face these challenges.
Training objectives	This module aims at: • Becoming familiar with normative documents related to organizing and delivery of open-air lessons. • Building skills to prepare documentation related to outdoor education. • Motivating STEM teachers to organize and deliver outdoor lessons • Improving teachers' skills to plan, organise and assess students' activities during open-air IBL education. • Developing competences to design non-traditional lessons • Forming and developing key teachers' competences for open-air (in natural environment) lessons delivery. • Development of team working competences
Learning outcomes	After the training, the participating teachers will be able to: • Prepare all documents necessary to be authorised for open-air learning; • Design open-air IBL interdisciplinary lessons on given topic; • Work in a team with other STEM teachers in the school; and will experience what their students would like to reach.
Scenario Title	**Supporting gender-neutral approaches to STEM at home**
Country	All project countries
Type	General teaching / learning thematic

When you study great teachers… you will learn much more from their caring and hard work than from their style

William Glasser.

Rationale	Gender bias in STEM is a well-known and well-researched topic. It can be conscious, based on beliefs and traditions, but unconscious gender bias also exists. Research also clearly shows that a supportive family environment is inevitable for good learning outcomes, so the parents and family should be the primary ally for any teacher. The training scenario is aiming at mapping the level and depth of gender bias by parents and developing an action plan addressing the issue.
Training objectives	**Enhanced knowledge and understanding on contextual aspects of learning and teaching** - understanding the (un)supportive home environment - understanding the general attitude towards STEM subjects - identifying entry points to influence attitudes and discourse **Enhanced professional skills- relating to teachers' role as part of educational communities** - enhance communication skills with special focus on non-professional adult audiences - holistic, not subject-segregated approach to STEM engaging parents in STEM teaching
Learning outcomes	**Demonstration of knowledge on educational sciences foundations** (sociological knowledge) - gain a deeper understanding of the roots, causes and effects of early and ongoing gender bias in STEM - strengthen the holistic approach to STEM, having a higher level of teachers' awareness of subjects they do not teach - strengthen the holistic approach to education by gaining a deeper understanding of early childhood education and home education on school-related learning outcomes and attitudes **Demonstration of collaboration skills** (with colleagues, parents and social services) - deeper understanding of different forms of parental engagement and having toolsets for different groups of parents - practical tools to provide opportunities for parental engagement in the school and outside - practical tools for collaborating with colleagues within the school for offering holistic, STEM related programmes **Demonstration of ability to adapt to educational contexts** development of home-school collaboration tools, based on the local context, in order to increase the level of understanding on the importance of STEM by parents and help them avoid gender bias or balance an existing one
Scenario Title	**Overcoming personal bad experiences of parents for STEM success of their children**
Country	All project countries
Type	General teaching / learning thematic
Rationale	Traditionally, STEM subjects are considered difficult and in public discourse it is considered natural that a student struggles with STEM subject, while arts subjects are considered differently. This is based on anecdotal, experiential parental approaches, mostly based on their own schooling experiences. The use of innovative teaching

	methodology and technology can help counterbalance this on two preliminary conditions: teachers' awareness of this phenomenon and tools to change parental mindsets and attitudes.
Training objectives	**Enhanced knowledge and understanding on contextual aspects of learning and teaching** - understanding the (un)supportive home environment - understanding the general attitude towards STEM subjects - identifying entry points to influence attitudes and discourse **Enhanced professional skills- relating to teachers' role as part of educational communities** - enhance communication skills with special focus on non-professional adult audiences - holistic, not subject-segregated approach to STEM engaging parents in STEM teaching
Learning outcomes	**Demonstration of knowledge on educational sciences foundations** (sociological knowledge) - gain a deeper understanding of STEM's position in different societal groups' understanding - strengthen the holistic approach to STEM, having a higher level of teachers' awareness of subjects they do not teach **Demonstration of collaboration skills** (with colleagues, parents and social services) - deeper understanding of different forms of parental engagement and having toolsets for different groups of parents - practical tools to provide opportunities for parental engagement in the school and outside - practical tools for collaborating with colleagues within the school for offering holistic, STEM related programmes **Demonstration of ability to adapt to educational contexts** development of home-school collaboration tools, based on the local context, in order to increase the level of understanding on the importance of STEM by parents and change their attitudes towards these subjects