Overall concept for professional learning (final version)

Deliverable D3.1 WP3

Information about the report

D3.1 / WP3 Publication date: 28.02.2025
Report/WP title: Overall concept for professional learning (final version) WP7 Professional Learning

Project Information

Contact Information

How to cite this report:

HISTORY OF CHANGES		
VERSION	**PUBLICATION DATE**	**CHANGE**
1.0	6-12-2024	First version for internal usage
2.0	10-1-2025	Consortium-approved structure, main results, and summary
3.0	19-2-2025	Following minor changes/updates from internal review and close reading by specified partners
4.0	27-2-2025	Final version with reflections on applied practices

DISSEMINATION LEVEL	
	PU=Public
	PP=Restricted to other program participants (including the EC)
	RE=Restricted to a group specified by the consortium (including the EC)
	CO=Confidential, only for members of the consortium (including the EC)

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

During the period 2022-2025 the ICSE consortium created a teacher academy for pre- and in-service STEM teachers and teacher educators. The aim of the ICSE Academy was to develop and test three innovative formats supporting professional development for STEM education in Europe:

1. Collaborative summer schools (all)
2. Peer learning through job-shadowing (educators)
3. European workshop series (teachers)

These formats for professional learning intended to respond to European needs for STEM education and addressed the following key priorities: environmental challenges, digital competencies, diversity and inclusion, and interdisciplinary and inquiry-based STEM education. **We designed and piloted implementations of these learning formats**. Based on experiences, observations and feedback we outline and suggest ways to implement professional learning formats that have the potential to enhance STEM education by addressing European priorities on an international and multicultural level.

Each partner offered **job shadowing**-activities for professional development of teacher educators. These activities focused mainly on observing sessions with (student)teachers with the purpose of adapting and trying out the session in the local context of the observer and reflecting on transferability. Most of the 25 job shadowing activities were performed online and, in some cases, face-to-face. Findings are that JS is do-able, appreciated and can be informative and inspiring. Live visits are much richer than online-observations. Language is an issue, especially when the target audience is not familiar with English.

The **summer schools** had two iterations, first a one-week event in Utrecht (2023 with 49 participants) and next a two-week summer school in Prague (2024 with 41 participants). The aim of the summer schools was to provide a vivid and inspiring environment for international colleagues to work and learn together. The participants highly valued the variety of topics, the interactive workshops, the international interactions, cultures and contexts, the transferability of activities to their local contexts, and the summer school locations. Challenges that participants mentioned were scheduling the summer school in varied national academic years, sustaining collaboration with colleagues, and the financial arrangements for travel and accommodation.

We organized two iterations for the **workshop series**: Fall 2023 with 50-60 synchronous participants and Spring 2024 with 30-40 synchronous participants. These iterations comprised the implementation of 14 two-hour sessions, each organized as a course during one semester, in a Moodle environment and Webex for video-conferencing & breakout rooms, with tools for interaction. Resources, including the program and guidelines for the workshop series, are published online and on eTwinning. Our key findings are that interactivity in such an international environment is challenging but possible. Some partner countries organized the course asynchronously to give extra language support. EU key priorities can be addressed, and online workshops can engage (student)teachers. The course was offered in form of a Microcredentials format.

Participants got ECs after participating successfully. The experiences have resulted in resources that can be adapted and used flexibly for synchronous and asynchronous professional development of (student)teachers.

2. INTRODUCTION

In the ICSE Teacher Academy Work Package 3 (WP3) specifically contributed to our mission to develop and test effective, accessible, and transferable models for professional learning of pre- and in-service STEM teachers in Europe. The specific objectives of WP3 are:

1. Develop and pilot innovative professional learning formats for joint learning with a strong European dimension.
2. Address the key priorities of the EU, such as learning in the digital world, sustainability, equity, and inclusion, by offering teacher courses on these topics.
3. Develop and test jointly different models of mobility (virtual, physical and blended) in initial teacher education and as part of teachers' professional development.

The consortium members developed and studied three formats for professional learning of pre-service teachers and teacher educators: job shadowing, summer schools, and a workshop series (see Figure 1). We first organized national meetings in all participating countries for an analysis of needs. This analysis is used to connect the targets group's needs with the European priorities and the European dimension in STEM teacher education. The analysis aimed at guidelines for how to motivate teachers for mobility, how to overcome related obstacles, and identifying collaborative practices (e.g. Maass & Engeln 2018, 2019).

The next step was a workshop with all partners to elaborate on our overall concept. By matching the analysis of needs with the available expertise we identified four themes for our teacher academy (sustainability, diversity, digitalization, and assessment). Partners in the project signed up for themes, worked closely together in the following months, and collected and designed resources for the academy. In a second workshop with all partners, we discussed content, templates and working formats for the online workshop series.

We developed a first version of the concept for professional learning. During 2023-2024, the formats were piloted. At intermediate reflective workshops during consortium meetings with all higher education institution partners we reflected on the experiences and optimised resources and ways of working. This thorough development of the overall strategy and the exchange of experiences and analysis of piloted activities resulted in an optimized version of our formats for professional learning. This document describes successively the analysis of needs in section 3, the piloting of the three concepts in section 4, and the final formats in section 5.

3. ANALYSIS OF NEEDS FOR PROFESSINAL LEARNING

The analysis of needs was performed at the start of the project (month 3) and based on reports from the consortium members. Each country was briefed in advance for a national workshop. All partners were provided with example questions to collect data and a presentation to introduce the project and the needs analysis. This analysis focused on the preferences of in-service teachers and pre-service teachers regarding the content and working formats of (1) the European workshop/lecture series and (2) the collaborative summer schools to be developed and studied as part of this project.

Most partner countries organised a workshop to collect the data. Some countries used an online questionnaire to reach out to their partner schools or used both methods to collect data. Most countries involved pre- and in-service teachers in the data collection. Some countries only involved teachers from their model schools.

3.1. CONTENT AND LEVEL OF LEARNING ACTIVITIES

Most teachers preferred interdisciplinary topics focusing on STEM, teaching for sustainability, using authentic contexts and making connections with the world of work. On the other hand, teachers also mentioned strong connections with their (often subject-oriented) curricula. Some teachers also   mentioned a focus on digital competences, which could be highlighted by the recent pandemic and online learning. This focus on digital tools also opened opportunities for topics like robotics and computational thinking.

Most teachers have seem to prefer to have PD sessions with other STEM colleagues rather than have mono-disciplinary sessions. Some pointed out that both kinds of sessions have advantages and can be positive learning experiences.

Reasons for content choices

NL: School subject like mathematics also have social responsibility and for that reason I like to learn more about its possible link with themes like sustainability, inclusion and responsible citizenship.

AT: Practical contexts/advice are essential and needed for STEM and for sustainability education.

TR: These topics are preferred for reasons such as students' curiosity, the abstract nature of the topics, and environmental needs.

DE: The link between school content and everyday life has the greatest added value for students.

ES: Because of the new Spanish curriculum mainly, which is demanding these new approaches and topics.

MA: The new curriculum uses a Learning Outcomes Framework, which requires new (continuous) assessment skills.

CZ: Curricular changes in lower secondary emphasize Science or STEM education instead traditionally separated approach (Phy, Che, Bio).

The diversity of working environments of our partners and their model schools creates some challenges with respect to school systems and grade levels.

In general, it seemed that focusing on the middle grades for students aged 10-14 years old was most popular.

Reasons for level choices

NL: We like to have the level a bit higher than your teaching practice (to be able to look beyond).

NO: Grades 8-10 need most attention for implementing interdisciplinary STEM education (lower-secondary).

CZ: We need a whole school approach focusing on learning trajectories from second level of elementary school (grades 6 – 9) towards high school.

CY: Best option for trying out innovative ideas is in grades 1-9 (primary and lower-secondary), because in upper-secondary teachers prepare for test.

3.2. CONTENT AND LEVEL OF LEARNING ACTIVITIES

In general, it seemed that teachers favour workshops, possibly with a hands-on aspect, followed by implementation of what is discussed in class and follow-up discussions. Online sessions also appeared to be popular. Most teachers indicated formats that include sessions with teachers with one or two weeks in between to give them time to try out something in class. Some of the teachers preferred to work within their schools only while others felt that meeting teachers from other schools would be beneficial. Some teachers also indicated their preference for a mix of international and local seminars.

The main reason given for collaborating with teachers or student-teachers from other countries through professional development activities was often to learn from each other and obtain new ideas. This can include learning about different strategies and approaches to teaching and assessment. They also suggested the possibility of observing lessons delivered by other teachers from other countries. Another reason given was to understand how different cultures result in differences and similarities in approaches and in teaching.

Reasons for format choices

AT: It should be made as practical as possible. Peer teaching observation and subsequent evaluation is a theme of school development plans.

LT, SK, TR, CZ: lack of teachers, limited time (families, leisure activities), not able to travel during the school year

For the timing of the workshops, we need flexibility. Teachers are very busy (so do not use the evenings and the weekends). In most countries, most teachers liked collaboration with STEM colleagues (sometimes alternated with disciplinary work).

Additional remarks by teachers

DE: It is important to make appointments early in order to be able to block out times.

CZ: Take care of a connection with professional development of teachers (accredited courses by ministry).

CY&SK: teacher prefer in-school training

CY: teacher are not allowed to use their teaching time for PD during the school days. They have teacher week (last week before Christmas for secondary, 1 week of September for primary)

LT: changes in school year are planned.

3.3.   EUROPEAN DIMENSION AND MOBILITY

We first needed to acknowledge that the partner schools were already interested in a European collaboration. Most teachers addressed the wish to observe each other's classrooms, sharing and comparing curricula, syllabi, lesson plans, and assessment practices. Moreover, they would like to exchange visions on societal changes, environmental challenges in the various countries, and the role of schools and school subjects to address them.

Reasons for collaborating with (student)teachers from other countries in professional learning activities that were mentioned are:

1. Broaden the horizon
2. Explore possibilities for comparison and adaptation
3. To learn from each other and obtain new ideas and professional cooperation
4. Become less dependent of own textbooks/habits
5. Traveling with professional interest
6. Benefit from the educational cultures of different countries
7. Achieve universality in education

Teachers were willing to travel to a European Summer school, but also raised concerns about budget, time needed, family commitments, and selection criteria. They considered a European Summer School to be a good opportunity for networking, professional development, learning about methods, materials, and activities used by other teachers, and learning about curricula in other countries.

4. PILOTS OF A EUROPEAN CONCEPT FOR PROFESSIONAL LEARNING

4.1. JOB SHADOWING

4.1.1. Introduction

The analysis of needs showed that teachers wish to observe each other's classrooms, sharing and comparing curricula, syllabi, lesson plans, and assessment practices. In this project one of the professional learning formats, we designed and piloted is peer-learning through job shadowing. We have chosen the format of job shadowing to have STEM ITE and CPD teaching staff from all partner countries to attend each other's ITE or CPD courses to engage in peer learning. These courses are part of project partners' regular ITE/CPD programs, thus the sessions are "real" in the sense of demonstrating "real STEM ITE and CPD scenarios in many Member States". This form of job shadowing also embeds mobility as a core element. We have chosen to use mainly digital mobility, using an online environment such as Teams or Zoom. However, in a few cases face-to-face-job shadowing (physical) took place.

The job shadowing consisted of 2 phases. In phase I the actual Job shadowing plus feedback, reflection and discussion on the adaptability between the partners involved takes place. In phase II the visiting partner adapted the session (based on outcomes of phase 1 and the local context) to enhance the quality and tested it in the local context to investigate if it can be effectively transferred to regular programs and courses.

4.1.2. Way of working

A guideline was written by WP3 leader of case studies (Malta) to inform partners about the way the job shadowing was organized, including the tasks for the partners and a brief reporting template. Each partner was asked to offer a few job shadowing opportunities and to shadow at least two activities offered by others. We followed the planning below.

All partners selected best practices from their regular national ITE/CPD programs.

These were listed as job-shadowing opportunities in a table providing additional information, namely: Country; ITE or CPD; subject & main topic; target group; number of participants; format; data and time; language; remarks.

All partners indicated in this table which of the activities they could shadow.

Further communication was by email between the partner offering the opportunity and the partner attending/shadowing it.

We performed these activities in the spring semester March to July 2023 and the fall semester September 2023 to January 2024. A few job shadowing activities fell outside these periods. Each partner shadowed at least two activities at one of the other partner countries. WP3 also provided a report template to fill in after the job shadowing, with the following topics:

1. Brief description and goal(s) of the activity
2. Participants and starting situation
3. Aim/learning questions of the shadowing partner(s)
4. Summary of observation
5. Lessons learnt educator/activity
6. Lessons learnt job shadowing

Later a more extensive lesson observation reporting template was used.

4.1.3. Experiences and reflections

Planning was sometimes an issue: it was not always easy to fit the schedules of attendees to the job shadowing options partners were providing. Of course, this was much easier to solve, than if job shadowing had been done physically. All partners managed to shadow at least two activities. From the reports we summarize the most prominent experiences and illustrate them with relevant quotations from the reports.

A drawback of shadowing a live activity online, was the **limited viewing window**. Especially when group work was involved, much took place unseen for the shadower. Even during a lecture, it was often not possible to see the live audience (class), since the camera was aimed at the teacher and/or the presentation.

> *I did not have the possibility to watch participants' collaborative work, but just the whole group discussion [...]. However, I can conclude that the methodology followed is perfectly transferable to my context (offering break out rooms for small group discussions and inserting conclusions in a padlet per groups).*

> *It is loud enough, but more difficult to catch what the participants say, nevertheless. Not much to do about it though... the woman speaking now is easier to interpret*

Language could form an obstacle. For some target groups (students, teachers) it was not possible to listen or speak in English. On the one hand, this limited the number of activities fit for job shadowing. On the other hand, it hindered attendees when they attended an activity in an unfamiliar language. Sometimes this was overcome by giving a 'whispered translation' by one of the local partners.

> *Although it wasn't possible for me to follow the group work and parts of the discussion afterwards (due to technical reasons), I got some fresh perspectives on diversity and inclusion in science education.*

Job shadowing offered partners opportunities to **transfer** the experience to their own practices. They could for example shadow an activity that had them experience a new way of working (like lesson study) or learn about a new topic (like a teaching approach for SSI or environmental issues in math class), which they then could use in another setting. This happened especially if job shadowing was done face-to-face.

> *One of the learning contexts provided (the raise in CO_2 in the Earth atmosphere) can be linked to climate change and therefore, it is somehow connected to one of the European priorities and could be used also for teaching about it.*

I wanted to learn more about how to familiarize postgraduate students with specific functionalities of digital tools and their role in the teaching and learning process. The course met my expectations.

During a consortium meeting we collected feedback from partners in an online document and reflected on our job shadowing experiences. Findings are categorized below.

1. Participation
   Participants observe and learn in real-time.
2. Transferability
   Transfer of shadowed activities is possible when general topics were offered, and topics that easily could be converted/adjusted to own courses in other subjects/topics. Participants had the opportunity to reflect on their own practices and identify areas for improvement. Feedback provided the opportunity to both enrich and revise the education content in line with the priorities of the European Union. Job shadowing resulted in high-level reflection on the own teaching practices (in particular, considering the process of transferring the observed session of one's own practice). Transferring a job-shadowing activity makes Europe a bit "smaller" and provides a possibility for a more equal STEM teacher education in Europe.
3. Learning from colleagues
   Participants valued the ability to reflect and discuss with a colleague. It allowed for gaining practical knowledge. The Job shadowing inspired to learn from other teacher educators in other countries and even effectively changed in some cases participants' research direction.
4. Online or face-to-face
   Advantages of online shadowing are the flexibility, no travel money needed, and less time needed for the observing person. In person visits have the advantage of a deeper comprehension of the activity and the local context.

Also, suggestions for improvement were given:

1. Participation: Time and opportunities
   More time to observe is needed. Otherwise, it is superficial.
   More offers - in different topics - so that it is easier to find something that is relevant to transfer to own courses in other countries.
   It was difficult to find times and topics that fitted in everyone's schedule.
2. Feedback, reflection, and transferability
   Include a reflection session immediately after the session - for all involved parties - to get insights on adaptability and transferability.
   A prior session is suggested to establish the teaching objectives of the session, and a subsequent session to reflect on them.
3. Online or face-to-face
   In person job shadowing has been proved to be more effective.
   Online job shadowing events can be organized using artificial intelligence with the possibility of instant translation.

It would be nice not only to write about reflection and feedback, but also to directly meet and talk to colleagues.

Even though conducting the shadowing digitally was positive, visiting each other and being present on-site would have provided more insights.

As long as there are lessons learned, they can be applied beyond the context or content since many of them have to do with the way of organizing the session, engaging and questioning the students or the way of intervening and answering their questions...more related to key (science) teaching practices.

4. Language

Local language of the target group remains an issue.

If the observing person is aware of the content in advance, the language in the class is not so hard. Knowing the key term in unknown language and the intended way how the lesson should proceed allows the observer to gain insights to the lesson.

4.2. SUMMER SCHOOLS

During ICSE Academy we organized two STEM Summer schools:

2023 - Utrecht, Utrecht University, The Netherlands - August 21 to 25 (5 days)
2024 - Prague, Charles University, Czech Republic - June, 28 to July 5 (8 days)

The focus of these STEM Education summer schools was bringing participants up to date in research and teaching practices in the field of the STEM subjects (Science, Technology, Engineering and Mathematics), and refreshing and deepening knowledge of meaningful and relevant educational practices. Topics included inquiry-based learning and interdisciplinarity, cultural diversity and inclusion, connections to sustainable development goals (SDGs), and the use and impact of technology on STEM education. At the end of each summer school participants working in groups had to produce a poster and portfolio of work which explained how they could integrate what they learnt at the summer school in their own lessons.

The intended outcomes are an increased awareness of STEM teachers with regards to diversity in STEM education and to values such as sustainability and inclusivity in STEM classrooms, an increase of teaching quality through updated and relevant thematic knowledge and practical skills, and first-hand intercultural experience in education among STEM teachers.

4.2.1. Experiences from Utrecht Summer School

The summer school in Utrecht offered a blend of lectures, seminars and workshops on educational research and development in the fields of primary, secondary and teacher education. The program was tailored towards the diverse interests of student-teachers, doctoral students, teachers, teacher educators and researchers. Credits (1,5 ECTS) were provided by Utrecht University. The program of the summer school in Utrecht was:

Day	Topics
Monday	Introduction to the summer school and the diverse educational systems in the world Cultural diversity in STEM education Coming to know each other through STEM estimation activities
Tuesday	Socio-scientific issues, transformative skills, sustainability in STEM education Group work: create multinational groups and choose an issue to work on
Wednesday	Technology-enhanced STEM education and computational thinking Group work: digest new input and integrate in your issue
Thursday	Inquiry-based learning and its relevance for (inter)disciplinary teaching, diversity and inclusion Group work: digest new input and integrate in your issue
Friday	Group work and finalizing posters Poster gallery and closure of the summer school

The Utrecht summer school started with beautiful weather and an introductory outdoor activity. A group picture shows the 49 participants (Figure 2).

Participants were asked to fill out a form before attending the summer school such that we had a good overview of their backgrounds in terms of career, school level and discipline (Figure 3).

4.2.2. Experiences from Prague Summer School

The summer school in Prague had as overarching theme: Socio-scientific Issues in Mathematics and Science Teachers Education. Lectures and workshops were:

Fermi tasks in STEM Education by Stefan Zehetmeier (University of Klagenfurt, Austria), Living in Climateville and Climate map by Jakub Opršal and Kateřina Borovinová (NGO SEVER Horní Maršov, Czechia), Powerful pictures: virtual tours as learning contexts to enhance STEAM education by Maria Martín Peciña (University of Jaen, Spain), Sustainability – wicked problems by Ellen Andersson (NTNU Trondheim, Norway), Design Thinking by Gultekin Cakmakci (Hacettepe University, Ankara, Türkiye), Diversity and inclusion in STEM education by Kyriakos Demetriou (University of Nicosia, Cyprus), From circuitry to creativity: an interdisciplinary STEAM journey with BBC micro:bit by Martin Cápay and Magdalena Bellayová (Constantine Philosopher University in Nitra, Slovakia), and Decision-making based on confronting scientific positions on the example of food provision for the world by Martin Bílek, Charles University, Prague, Czechia).

The program also included additional science & society related study and cultural events as Prague and Alchemy, Ancient elements in the chemistry/science lab, Beyond the (dis)comforts of academia: Researching science education for social justice and Mathematics Outdoors. An overview of the program:

Day	Topics
Friday	Opening, Cultural diversity in STEM education – country presentations Fermi task
Saturday	Decision-making based on confronting scientific positions
Sunday	Socio-scientific issues in the city – Prague as city of Science&Society
Monday	Sustainability – wicked problems
Tuesday	Diversity and Inclusion in STEM Education
Wednesday	Design Thinking
Thursday	From Circuitry to Creativity: An Interdisciplinary STEAM Journey with BBC micro:bit
Friday	Colloquium with portfolios presentations Closure of the summer school

In the program participated 41 teachers and future teachers (university students) from 11 countries: Czech Republic (11), Slovakia (6), Türkiye (6), Norway (3), Malta (3), Spain (2), Cyprus (2), Greece (2), Austria (2), The Netherlands (2) and Lithuania (2) (see Figure 4).

The Faculty of Education at Charles University issued a certificate for each participant, and for university students also Erasmus free mover certificate describing the scope of the summer school program, and the learning outcomes attained by measuring the learning outcomes (defending of the portfolio) with awarding of 3 ECTS credits.

4.2.3. Experiences and reflections

Both summer schools fitted into a longer tradition within the two organizing universities, so the organisation within ICSE Academy does not stand on its own. Participants and also lecturers from all consortium members evaluated the summer schools very positively by interesting content, positive climate and working atmosphere. Transnational collaboration between the lecturing partners was very high with great support from participants of the summer school as well as students from hosting institutions.

From a post-survey we can see the appreciation by participants for the learning activities:

To some extent (n=12)

"I already knew about some findings and/or tools."

"our educational system is not ready for this kind of transformation"

"as a teacher time is a limited resource, and it is difficult to have "spare time" to get to use the things we learn about."

To a large extent (n=29)

"The workshops focused both on general didactical approaches and also offered a variety of activities that could be incorporated in the classroom."

"I will be able to manipulate this new information to fit the needs of my future students"

"Working and learning with learners from all of over the world increased my intercultural competence."

The central strength of the two STEM summer schools organized was the opportunity to discuss different topics with student/teachers from all over the world. Key issues were:

Have a good balance between reflection (listening) and creating something (group work).
Put learning goals for the different activities in the guidelines.
Have a good STEM balance. Not only the previous mentioned balance 'STE + M', but also extra attention to Engineering.
Too specific topics in one subject are not so suitable for STEM courses.
Active-learning methods (e.g. math trails) are easier to be transferred.
Share modules and experiences from previous EU projects (Ensite, Primas, MasDiv, etc.).

4.3. EUROPEAN WORKSHOP SERIES

The European priorities and our needs analysis (see section 3) gave rise to a workshop series on four main topics (clusters), each consisting of three sessions. Participants were expected to at least follow all sessions related to a cluster. Student-teachers were invited to attend the whole course. The four clusters are:

1. Tools and approaches to deal with sustainability issues in STEM education
2. Diversity and inclusion in STEM
3. STEM in a digital era
4. Assessment in Europe

The sessions were provided online and had very interactive characters with various working formats. Most sessions consisted of a general introduction followed by group work, either in country groups or in mixed groups. Local teams had the opportunity to join and follow the course from one room. In between sessions of a cluster the participants were requested to do homework, and if possible, to try-out ideas with students in their classrooms. The course was implemented in Moodle in combination

with Webex for online communication. Video streams of sessions were saved and made accessible in the Moodle environment. We experienced variation in the joining by participants, which made it not always easy to organize group work and to monitor all participants.

The experiences with the first series (fall 2023) showed the potential of an international online workshop series and that the content was appealing to most participants (50-60 joined synchronously). However, the first try-out also gave rise to some challenges and guidelines for improvement:

All countries had to find their way to reach out to and involve teachers for participating in the workshop series (various barriers, time, language, on-line).

Country representatives need to be better informed when participants get the information (e.g. with cc-s in the correspondence emails).

Most sessions were prepared by one country. This resulted in well-organized sessions, but coherency within and between clusters can be improved.

The big number of participants is demanding for workshop leaders, difficult to manage interactivity in break-out rooms. Possible solutions: use bigger rooms / more people involved in management of break-out rooms / assign the leader in the group.

We need very clear instructions about how to behave in a breakout room: open camera, introduce yourself, decide who makes notes, …

Guidelines for homework and summarizing take-home messages can be improved.

Workshop leaders are encouraged to use a tool like Task card or Padlet for documenting and sharing what happens during group work.

Several times participants were silent or shy to talk as a result of language barriers.

In some countries, participants joined collectively in one room, which resulted in too much noise during the group work in online breakout rooms (next time, teachers will join from home).

The workshop series in the Moodle environment was improved based on these experiences. In respond to challenges related to this environment, new for some partners, while preparing the workshops and managing interactivity during the sessions, we were very thankful to the support from colleagues at the University of Cyprus.

We developed a course guide for participants and workshop leaders, and all workshop leaders were briefed on the experiences of the first run. For the second run (spring 2024) we organized a peer review quality control system to evaluate each other's clusters with observation guidelines. Moreover, we improved the formulation of more coherent learning goals and more flexible guidelines for a local start of the series. We also clustered homework assignments (collaboration, upload, feedback, …), and supported continuous (international) collaborative work in groups (within clusters). Finally, we

organized recognition of joining the workshop series with Microcredentials offered by the University of Klagenfurt, Austria (see figure 5). The second run with 30-40 synchronous participants was evaluated with peer review information. At the start 58 teachers registered for the Micro-credentials course. We handed out certificates to 36 teachers (those teachers visited all clusters/sessions and provided all homework). The evaluation resulted in reflections on each of the clusters.

4.3.1. Reflections on Cluster 1: Tools and approaches to deal with sustainability issues in STEM education

Cluster 1 addressed ways to deal with sustainability in STEM education. The first session highlighted the importance of sustainability and its educational value, especially through socio-scientific contexts (Evagorou & Puig, 2017; Sadler et al., 2016). The second session covered inquiry-based approaches, guiding participants in re-designing closed tasks. The final session emphasized argumentation and decision-making activities (Gunbatar & Sardag, 2022). The sessions were connected by the theme sustainable Socio Scientific Issues (SSIs) and how to address them in STEM education (e.g., Wan & Bi, 2020). Session 2 explicitly connected to session 1 by giving a brief summary and showing the overview of the cluster and referring to the homework: an open task on animal footprint. In session 3 the overview was shown but no explicit reference to the 2nd session was made.

For this cluster, overall homework assignment was given to be handed in one week after session 3. This assignment was mentioned in each of the 3 sessions.

Sessions were also connected by having fixed breakout rooms for the group-work in the same small mixed country groups in each session. This was only partly successful. Also due to changes in the participants. Not everyone attended each session. The number of participants decreased from 50+ to 40 to 30.

The second session had a good balance between plenary and group-work. It started with a brief look back on session 1 and the homework, which was very useful. Theory and different models on IBL were presented in a plenary for about 20 minutes. It was followed by group-work for 20 minutes on a classroom example (a selected SSI) using task-cards/padlets. The same mixed country groups were used as in session 1. A brief sharing referred to what was written on the task card.

The third session addressed argumentation skills and decision-making in design-based STEM education.

It is very important in the sessions (with new groups) to explicitly give the groups time (and a small task) to get to know each other. An effort was made to make participants remember their group by giving each group the name of a famous scientist. This was helpful, but some participants remembered the group number instead of the name.

Not every participant was in each session, but the presenters flexibly assigned new participants to the groups.

The cluster leaders took part in group work as session leaders to facilitate cooperation and help with reporting in plenary (see figure 6).

4.3.2. Reflections on Cluster 2: Diversity and Inclusion in STEM Education

The Diversity and Inclusion cluster starts with an introduction to raising awareness about diversity in STEM education, presenting teaching strategies from critical postmodern science pedagogy (Demetriou, 2022). The second session focuses on redesigning tasks for inclusion, with participants preparing an activity and lesson plan (Sorge et al., 2023; Maass et al., 2019). In the final session, participants reflect on their lessons using research-based tools for inclusive practices (e.g., Braaten & Sheth, 2017; Harper, 2017; Prediger, Clarkson & Bose, 2015).

Lecturers used interactive tools to attract participants. Padlet, google doc as well to share ideas in the groups. This was welcomed by the students and helped to solve language issue between teachers.

The mixed country groups were the same during all sessions. This makes it easier to manage participants and to collaborate in the groups. The lectures were very structured and explained to participants what to do in each task clearly. The choice to use the same mix country groups in the sessions group work was successful. Some groups worked very well. In online group work helps to have the coordinators from the lecturer side (maybe assistant or student etc.) in each group. This can help to manage group work, to involve every participant to work, and reach more active involved groups.

Although the lecturers paid a lot of attention to recommending how the group could work together, helping to highlight the group leader, but the participation of the participants was lower than could be expected from such a large number (over 60 participants). One group did not present their homework lesson plan. Making participants do their homework in groups was an issue as there were mixed country groups.

The ice-breaking tasks at the beginning of the session were very nice and successfully applied in groups.

New choices for supporting group work were very helpful for the participants: in addition to padlet, you now let international groups work in the same breakout room over the sessions, organized online folders to allow for joint work in a group document during the cluster, made group members responsible for intermediate reports. This resulted in 4/5 active groups. Using Google Docs (or other sharing documents) allows groups to have collaboration areas as well. An example activity designed by an international group was the *Sustainable Cultural Park Design Challenge.* They outlined the activity and argued:

By incorporating elements from various cultures into the park design, students connect mathematical concepts to cultural diversity. This not only makes the lesson more engaging but also highlights the relevance of mathematics in understanding and appreciating different cultures.

4.3.3. Reflections on Cluster 3: STEM in a digital era

This cluster begins with an overview of educational competences, focusing on digital skills, particularly 3D printing and AI in STEM (Xu & Ouyang, 2022; Hsieh & Chen, 2019). The second session introduces escape games in STE(A)M, offering resources and methods for building digital competencies through student-created escape games (e.g., Veldkamp et al., 2021). The final session covers computational thinking research and classroom activities to enhance these skills in STEM education (Bocconi et al., 2022).

Session 1 included mixed country group work. In the group work participants were able to reflect upon and apply what was introduced in the plenary part. During the first break out session they worked in mixed country groups on secure passwords in order to identify what competencies (knowledge, attitudes, skills) could be developed through this task. During the second break out session they practiced using GPT to solve a STEM-related problem, analysed the creativity and accuracy of the AI solution and discussed the possibility of using AI as a teaching tool. There was a good balance between lectures and group work.

Session 2 focused on Escape games. There was a good balance between lecture and group work, where the main part of the session was group work. The participants had one short work task (a few minutes) with the whole group, one longer break-out session (40 minutes) where they had plenty of time to try to test an escape game and one shorter break out session at the end (15 minutes) where they got to use the tool provided (GeoGebra). As homework they were challenged to design an escape room themselves (see Figure 7).

The first part of session 3 was a 20-minute lecture followed by a 50-minute small group work. During the lecture the interaction was limited, and the tools employed (tossing a coin) elementary. In the second part, the lecture was 45 minutes where some participants were able to log in micro bit. There was a 5-minute review summary at the end.

All in all, a well-organized cluster addressing a rich variety of topics on using technology in STEM education.

4.3.4. Reflections on Cluster 4: Assessment/STEM in Europe

Cluster 4 explores innovative assessment methods in STEM education. The first session examines how assessment aligns with educational practices across educational contexts and presents tools to enhance student thinking, reasoning, collaboration, and problem-solving (Black & Harrison, 2004). The second session introduces frameworks for assessing creative reasoning and STEM competencies, while the final session addresses equity in assessment (Heritage & Wylie, 2018; Montenegro & Jankowski, 2020).

The first session participants discussed the dominant assessment approach in their own countries and how this supports or hinders achievement in the classroom, both in group work and in whole-group discussions. They did all of this by choosing one or more competence issues to work on. One of the homework assignments entailed the design

of an inclusive assessment activity. A participant designed a combination of a group presentation and individual reflection report for an assessment task on sustainable urban transport. She argued:

To accommodate students with different cultural backgrounds, I consider incorporating examples and applications relevant to diverse cultures. In this task, students discuss how sustainable transport initiative are implemented or valued in their own city (or country). The main goal of this task is to encourage students to share perspectives on sustainable transport practices from their cultural backgrounds.

The three sessions were conducted mainly through plenary lecturing, small-group work and whole-group discussion. Almost 50 percent of each session was designed for group work. The remaining time was allocated for plenary lecturing and whole group discussion. Approximately 20% of the total time of each session was allocated for whole group discussion. With this perspective, it is seen that group works and discussions are supported in each session.

To support the interaction in the sessions, participants were encouraged to express themselves verbally as well as to share their thoughts in the chat area. Especially in Session 3, the chat tool was used extensively. In the homework for Session 1, the participants could be asked to prepare the assessment tools. In this way, the participants will also gain experience in preparing tools. In Session 3, on-the-fly formative assessment, it was also discussed how it can be used both for increasing classroom interaction. The understanding of assessment in classroom interaction should be integrated into the assessment perspective of the three sessions.

4.3.5. General reflection

The teacher educators met several challenges in these online series. For instance, dealing with varying numbers of participants, their different cultural backgrounds, and their limited proficiency in English. Nevertheless, the educators also experienced several benefits of their involvement in these online workshop series. They experienced how participants valued the opportunity to share their teaching experiences with colleagues from other countries on specific topics such as implementing STEM activities or inclusive practices or summative assessment. Moreover, these workshops provided the ultimate chance to teach in a multicultural context and to develop ways to overcome challenges that every teacher meets in multicultural contexts.

5. KEY FEATURES OF THREE EUROPEAN PROFESSIONAL LEARNING FORMATS

5.1. JOB SHADOWING

Based upon our experiences, we conclude that job shadowing is do-able, appreciated and can be informative and inspiring. Live visits are much richer than online-observations. Language is an issue, especially the language of the target audience that is been shadowed by someone who doesn't master this language. Some of the shadowed activities are transferable/adjustable, but it still appears to be a time consuming follow-up effort to adapt experiences to your own practice. Job shadowing may also be interesting both for pre-service and in-service teachers. Teachers from partner schools showed interest in this working format, but their participation was not foreseen within ICSE Academy.

5.2. SUMMER SCHOOL

The piloting of the summer schools resulted in several key features for successful organizations of international summer schools on European priorities in STEM education.

To get to know each other and to profit from the multicultural and international setting it is helpful to change the group compositions throughout the summer school. Create mixed country groups with varied disciplinary backgrounds, but acknowledge grade level and shared topic of interest.

Take care of an inclusive environment! Participants with English language difficulties should be distributed over the groups. It helps when teacher guides these groups a bit extra to ensure they include everyone as much as possible. Inclusion is important.

Participants often have different disciplinary backgrounds. In a STEM summer school this needs to be addressed. In particular since mathematics is not always deeply addressed in STEM education. Workshop leaders need to be aware of this. The topics we recommend, that were highly appreciated, are relevant and need professionalization, are diversity and inclusion in STEM education, addressing socio-scientific issues and inquiry-based learning, and computational thinking and gamification. In addition, depending on the expertise available, we advise attention for more general topics like giftedness, scaffolding, and language-sensitive teaching, and for specific topics like fostering inquiry in mathematical contexts and early childhood learning.

Let participants work during the week towards final products that they can present, which can be used for certifying their contributions. Participants appreciate to work on a product that facilitates implementation of what is learnt in their own teaching practice.

This can be a portfolio or a poster of a learning activity together with links to topics from the summer school (see Figure 10). Such a poster can be presented on the last day to summarize and digest what has been learnt and to evaluate their progress. A poster gallery is a nice event to share experiences.

Acknowledge the different demands to certificates in various countries (e.g. some require an explicit list of all topics covered). The certificate ceremony can be enriched in various ways, e.g. by having participants hand-out certificates to each other and inviting them to tell something about the person. Make it a joyful celebration!

5.3. EUROPEAN WORKSHOP SERIES

The experiences with the two try-outs gave rise to a workshop series for bringing participants up to date in research and teaching in the STEM subjects (Science, Technology, Engineering and Mathematics) in connection with European priorities such as fostering sustainability, digital skills and intercultural learning. The workshop series aimed at refreshing and deepening the knowledge of meaningful and relevant educational practices. Topics include inquiry-based learning and interdisciplinarity, cultural diversity and inclusion, curriculum development and assessment, and the use and impact of technology on STEM education.

A program for such a workshop series can offer a blend of seminars and workshops in the fields of primary and secondary education tailored to the diverse interests of (student)teachers. The workshops that we piloted were organized by the ICSE Academy (International Centre for STEM Education) with a program for a weekly series of twelve international sessions and two local sessions of two hours:

Session	Topic
Cluster 1: Tools and approaches to deal with sustainability issues in STEM education	
Session 1	Local introduction to the workshop series
Session 2	1. Sustainability and socio-scientific issues in STEM education
Session 3	2. Inquiry-based STEM learning
Session 4	3. Argumentation and decision making in STEM education
Cluster 2: Diversity and inclusion in STEM	
Session 5	1. Introduction to diversity and inclusion in STEM education
Session 6	2. Analysing and designing STEM tasks for diversity and inclusion

Session 7	3. Analysing inclusive classroom practices (based upon try-outs)
Cluster 3: STEM in a digital era	
Session 8	1. Digital Competencies, Skills and Technology in STEM Fields
Session 9	2. Escape Games in STEM Education and VR
Session 10	3. Computational Thinking
Cluster 4: Innovative Assessment in STEM education disciplines	
Session 11	1. Innovative assessment in STEM disciplines
Session 12	2. Preparing innovative assessment practices
Session 13	3. Innovative assessment practices and equity
Session 14	Local session for finalizing the workshop series

The tested and improved resources for each of the clusters in the workshop series can be found at: https://icse.eu/materials/teacher-professional-development/ (see Figure 11).

5.4.   SHARING RESULTS ON ETWINNING

We reflected on how eTwinning and the European School Education Platform can keep the ICSE Academy Lighthouse for STEM teacher education and training in Europe shining for teachers and teacher educators. To this end, we have created the ICSE Academy TwinSpace where teachers and teacher educators can find inspiration and engage in professional development activities. We named it A Lighthouse for STEM teacher education and training in Europe (see Figure 12). Here you can collaborate with other STEM colleagues on international professional development projects. For eTwinning registration and validation process for teachers and teachers educators; see information at ICSE Academy website www.icse.eu/icse-academy/.

6. BIBLIOGRAPHY AND REFERENCES

Black, P. and Harrison, C. (2004). *Science Inside the Black Box - Assessment for Learning in the Science Classroom*. London: GL Assessment.

Bocconi, S., Chioccariello, A., Kampylis, P., Dagienė, V., Wastiau, P., Engelhardt, K., ... & Stupurienė, G. (2022). *Reviewing computational thinking in compulsory education: State of play and practices from computing education*. https://doi.org/10.2760/126955

Braaten, M., & Sheth, M. (2017). Tensions teaching science for equity: Lessons learned from the case of Ms. Dawson. *Science Education, 101*(1), 134-164.

Evagorou, M., & Puig, B. (2017). Engaging elementary school pre-service teachers in modeling a socioscientific issue as a way to help them appreciate the social aspects of science. *International Journal of Education in Mathematics, Science and Technology, 5*(2), 113-123.

Demetriou, K. (2022). Special Educational Needs Categorisation Systems: To Be Labelled or Not?. *International Journal of Disability, Development and Education, 69*(5), 1772-1794.

Gunbatar, S. A., & Sardag, M. (2022). Discourse Analysis of In-Service Teachers' Interdisciplinary Collaboration for Decision-Making through Design-Based Integrated STEM Activities. *Education and Science, 47*(212), 17-54.

Harper, G.S. (2017). Engaging Karen refugee students in science learning through a cross-cultural learning community. *International Journal of Science Education, 39*(3), 358-376. https://doi.org/10.1080/09500693.2017.1283547

Heritage, M., & Wylie, C. (2018). Reaping the benefits of assessment for learning: Achievement, identity, and equity. *ZDM Mathematics Education, 50*(4), 729-741.

Hsieh, M. C., & Chen, S. H. (2019). Intelligence augmented reality tutoring system for mathematics teaching and learning. *Journal of Internet Technology, 20*(5), 1673-1681.

Maass, K., Doorman, L. M., Jonker, V. H., & Wijers, M. M. (2019). Promoting active citizenship in mathematics teaching. *ZDM - Mathematics Education, 51*(6), 991–1003. https://doi.org/10.1007/s11858-019-01048-6

Maass, K. & Engeln, K. (2018). Effects of scaled-up professional development courses about inquiry-based learning on teachers. *Journal of Education and Training Studies, 6*(4). 1- 16. https://doi.org/10.11114/jets.v6i4.3083

Maass, K. & Engeln, K. (2019) Professional development on connections to the world of work in mathematics and science education. *ZDM Mathematics Education, 51*(6). https://doi.org/10.1007/s11858-019-01047-7

Montenegro, E., & Jankowski, N. A. (2020). *A new decade for assessment: Embedding equity into assessment praxis* (Occasional Paper No. 42). Urbana, IL: University of Illinois and Indiana University, National Institute for Learning Outcomes Assessment.

Prediger, S., Clarkson, P., & Bose, A. (2015). *Building theory and teaching strategies for bilingual learners based on an integration of three traditions.* Mathematics education and language diversity: The 21st ICMI Study. Dordrecht: Springer.

Sadler, T. D., Romine, W. L., & Topçu, M. S. (2016). Learning science content through socio-scientific issues-based instruction: A multi-level assessment study. *International Journal of Science Education, 38*(10), 1622-1635.

Sorge, S., Doorman, M., Maass, K., Straser, O., Hesse, A., Jonker, V., & Wijers, M. (2023). Supporting mathematics and science teachers in implementing intercultural learning. *ZDM - Mathematics Education, 55*(5), 981–993. https://doi.org/10.1007/s11858-023-01478-3

Veldkamp, A., Knippels, M. C. P., & van Joolingen, W. R. (2021). Beyond the early adopters: Escape rooms in science education. *Frontiers in Education* (Vol. 6, p. 622860). Frontiers Media SA. https://doi.org/10.3389/feduc.2021.622860

Wan, Y. & Bi, H. (2020). What major "socio-scientific topics" should the science curriculum focus on? A Delphi study of the expert community in China. *International Journal of Science and Mathematics, 18*, 61-77

Xu, W., & Ouyang, F. (2022). The application of AI technologies in STEM education: a systematic review from 2011 to 2021. *International Journal of STEM Education, 9*(1), 59. https://doi.org/10.1186/s40594-022-00377-5

7. LIST OF TABLES AND FIGURES