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A report of the cross-country analysis and the conclusions drawn

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	CO=Confidential, only for members of the consortium (including the EC)

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1. EXECUTIVE SUMMARY

This report presents the findings of a comprehensive study focused on the effectiveness, accessibility, and transferability of professional development (PD) activities for STEM teachers across Europe. The research was conducted as part of a collaborative initiative involving thirteen partner countries as part of the ICSE Academy project. The project aimed to improve the quality of STEM teaching by providing continuous professional development (CPD) opportunities for both pre-service and in-service teachers. The key strategies employed included cross-border job shadowing, peer-learning activities for Initial Teacher Education (ITE) and CPD providers, and regionally tailored PD initiatives. This executive summary outlines the main conclusions, implications, and recommendations derived from the study.

The study sought to explore the following key questions:

1. To what extent are the individual regional PD activities effective and accessible?

2. To what extent are the regional PD activities transferable to different contexts?

3. What are the characteristics of effective PD activities and technologies, and in which settings do they work best?

To address these questions, the study employed a multi-case study approach to evaluate PD activities in various regional and cultural contexts. Data were collected through semi-structured interviews, observations and reflections provided by the participating ITE/CPD providers and in-service teachers and pre-service teachers.

The main findings

Effectiveness of professional development activities

PD activities were effective when they addressed the specific needs of the teachers. This was especially true when activities were hands-on, practical, and directly linked to teachers' everyday classroom practice.

Teachers experienced growth in their pedagogical content knowledge, content knowledge, and teaching competences. This aligns with existing literature that emphasizes the importance of CPD in improving both instructional skills and teacher motivation.

Motivation and engagement were significantly enhanced when PD activities involved collaborative methods, inquiry-based learning, and opportunities for peer learning. Teachers expressed a high level of satisfaction when they could see immediate applications to their own teaching practices.

Accessibility of professional development

Accessibility was largely influenced by the design of the PD sessions, including the use of digital tools and flexible scheduling. Digital tools facilitated participation, but there was also an identified need for targeted training on these tools.

The study highlighted that PD activities were more accessible when they were adapted to local educational contexts, considering cultural sensitivities and policy differences. Teachers appreciated the flexibility in the design of PD activities, which allowed them to participate based on their individual needs and circumstances.

Some pedagogical approaches used were also found to make the activities more accessible. Group work and a blend of theory and practical activities were found to make the sessions more accessible. On the other hand, some online formats did not engage all participants equally. The use of digital tools was both a facilitator and a barrier, depending on the context, emphasising the need for careful consideration in their implementation.

Transferability across contexts

Cross-country analysis indicated that PD activities were highly transferable when the content focused on universal aspects of pedagogy, such as promoting inquiry-based learning, argumentation, and collaboration.

The successful transfer of PD activities relied on adapting content to align with local policies, cultural expectations, and institutional practices. Factors like local adaptation, cultural sensitivity, and collaboration and exchange between original and transferring institutions were crucial for successful transferability. Conversely when the content was highly specialised, assumed prior knowledge or unfamiliar, transferability was hindered. Unavailability of resources, class size and other institutional and logistical barriers may also hinder transferability.

Implications for Policy Makers

Support for cross-border collaboration

Support for transnational mobility and for collaboration among teachers and ITE/CPD providers, which proved effective in fostering professional growth, is crucial. Funding and resources should be allocated for cross-border job shadowing, since exposing educators to diverse educational environments was reported to result in professional growth and can in the long term improve teaching. The educators from the Higher

Education Institutions (HEIs) participating in job shadowing reported improvement in their practices as a result of the job shadowing experiences.

Context-sensitive professional development

PD programs should be designed to meet the specific needs of teachers based on their teaching experience, career stage, and local context. Policy makers should encourage uptake of professional development by teachers and ensure that teachers find the content relevant and applicable to their unique settings.

Investments in Digital Tools

Investments in digital tools and training are necessary to ensure that teachers can effectively engage in virtual and blended PD opportunities. Training programs on the use of digital tools should be included as an integral part of PD initiatives.

Teacher Motivation and Engagement

Fostering teacher motivation is crucial for ensuring successful PD outcomes. Activities that are practical, contextually relevant, and involve hands-on learning are more likely to engage teachers. Support for the development of PD programs that provide real-world classroom applications and opportunities for collaboration, which enhance teacher motivation is needed.

Conclusion

The findings of this study underline the importance of providing high-quality, flexible, and collaborative professional development opportunities for STEM teachers across Europe by focusing on teacher needs, supporting cultural adaptability, and investing in digital tools. The professional learning of ITE/CPD providers through job shadowing and cross-border collaboration is also important. These results hold significant implications for leaders and policy makers who are developing initiatives aimed at building a high-quality STEM teacher workforce capable of addressing the challenges of contemporary education in Europe.

The study results contribute to a broader understanding of effective professional development in STEM education, emphasizing the value of flexibility, collaboration, and contextual relevance in creating impactful learning experiences for educators.

2. INTRODUCTION

The ICSE Academy project attempted to address the European Union's goal of tackling the underperformance in STEM (Science, Technology, Engineering, and Mathematics) education. Through innovative approaches to teacher professional development (PD) and transnational collaboration, the ICSE Academy has sought to enhance the quality of the STEM teaching workforce across Europe.

One of the primary challenges identified at the outset of the project was that over 20% of 15-year-olds in Europe were unable to perform basic tasks in science and mathematics (COM 2020a). Studies such as the Trends in International Mathematics and Science Study (TIMSS) confirmed that a large proportion of European students ranked at the lowest levels in these subjects, with fewer than 10% reaching top performance levels (Mullis et al. 2019).

In response, the ICSE Academy focused on improving STEM education by investing in the continuous professional development of both pre-service and in-service STEM teachers. This initiative emphasized mobility and collaboration across Europe, providing opportunities for teachers at all career stages to develop the competencies required for high-demand educational systems. By fostering cross-border collaboration, the ICSE Academy has helped to prepare STEM teachers to address contemporary challenges such as digital learning, climate neutrality, and the promotion of gender equality in education (ET2020 2015).

The ICSE Academy recognized that many EU Member States were facing, or would soon face, a shortage of highly qualified STEM teachers (COM/EACEA/Eurydice 2018). Additionally, many teachers lacked the specific skills needed to teach effectively in the context of modern educational demands. Given that up to 75% of student achievement can be attributed to teacher effectiveness (Rivkin, Hanushek & Kain 2005), addressing these gaps was essential. The ICSE Academy responded by offering high-quality professional development opportunities, aimed at improvements in teacher competence, commitment, and job satisfaction (ET2020).

The project focused on teachers at all stages of their professional journey—from pre-service education to ongoing professional development with special emphasis on transnational exchange and collaboration among teachers and teacher education providers. This has enabled the sharing of best practices, and the development of innovative teaching strategies tailored to the diverse needs of European classrooms.

One of the main activities of the project focused on peer learning through job shadowing. A significant portion of the professional development for pre- and in-service STEM teachers depends on the quality of ITE (Initial Teacher Education) and CPD

(Continuous Professional Development) educators and teaching staff. However, there is limited formalized education for this professional group responsible for preparing teachers, and the academic discourse on how best to prepare them is still in its early stages (Rösken-Winter, Schüler, Stahnke & Blömeke 2015, Maass 2018). Therefore, PD for STEM ITE and CPD providers was an essential aspect of this project.

This was achieved through peer learning among STEM ITE and CPD teaching staff from all partner countries through job shadowing. In the first phase, these educators participated in each other's ITE and CPD courses through a job shadowing programme, which facilitated peer learning and exchange. These courses were part of the regular ITE and CPD programmes of the project partners, offering "real" STEM ITE and CPD scenarios from various European Member States.

Mobility was an integral aspect of the format, with participants able to attend sessions either online or physically. The sessions were in many cases bilingual, conducted in both the national language of the host country and in English. The job shadowing experiences focused on best-practice examples, including methods that actively engage teachers using collaborative approaches, the application of innovative teaching strategies like inquiry-based learning, and the incorporation of European priorities and multi-country, multi-disciplinary perspectives.

One unique aspect of this approach was the peer learning cycle, where after attending a session, participants provided feedback on the format, allowing session hosts to make necessary optimizations. This feedback loop fostered continuous improvement and refinement of the PD sessions.

The peer learning through job shadowing took place across 13 partner countries. Each activity involved a relatively small number of participants, depending on the specific activity. Apart from serving as job shadowing experiences, these professional learning activities also served as an opportunity to assess the effectiveness and accessibility of the individual regional activities from the perspective of the participants. The extent to which these activities could be transferred to different educational contexts was also evaluated. Each country prepared a case study focusing on a specific professional learning activity.

Following the completion of these regional activities, a cross-country analysis was conducted to provide a broader European perspective on the professional learning activities undertaken. This analysis evaluated how effective, accessible, and transferable these activities were, building on the framework outlined by Crowe, Cresswell, Robertson, et al. (2011).

This report provides an overview of the PD sessions offered as part of this peer learning job shadowing experience, outlining the feedback from participants about the overall effectiveness of the sessions. It also provides a cross-country analysis that aimed to explore the effectiveness, accessibility, and transferability of professional learning activities across diverse contexts. The case studies were guided by three main research questions.

At a regional level the research questions behind country-based case studies were:

To what extent are the individual regional activities effective and accessible?

To what extent are the regional activities transferable to different contexts?

The research question for the cross-country analysis was:

What are the characteristics of professional development activities and technologies, and in which particular settings do they work best?

3. BACKGROUND

3.1. Introduction

Continuous professional development (CPD) is a cornerstone of quality education, especially in the field of science, technology, engineering, and mathematics (STEM). It aims to foster growth in various areas crucial for effective teaching, such as content knowledge, pedagogical content knowledge (PCK), pedagogical knowledge, and teacher competences, all of which are important aspects of teacher knowledge (Shulman, 1986). Effective CPD is essential to help teachers adapt to ongoing educational changes and to support learners effectively (Baumert & Kunter, 2013). This section explores key characteristics of effective, accessible, and transferable CPD, drawing from relevant literature to provide a background for the case studies and cross-country analysis in the ICSE Academy project.

3.2. Effectiveness in CPD

Effectiveness in teacher professional development can be defined in multiple ways, but it generally refers to growth in teachers' knowledge, pedagogical beliefs (Baumert & Kunter, 2013) and classroom practice (Clarke & Hollingsworth, 2002). Effective CPD has been extensively studied, and the consensus is that impactful PD should:

Target Teachers' Needs and Classroom Context

Effective CPD should align closely with teachers' needs and the realities of their classroom practice (Guskey, 2002; Maass, 2011). When PD is directly relevant to what teachers face daily, it is more likely to lead to sustained changes in their teaching behaviour.

Link Theory with Practice

CPD activities should combine phases of theoretical learning in seminars or workshops with practical, school-based components (Lipowsky & Rzejak, 2012). Clarke and Hollingsworth (2002) emphasize the importance of cyclic interaction between reflection and application to solidify new learning and integrate it into classroom practice.

Encourage Teacher Collaboration and Reflection

According to McLaughlin and Talbert (2006), PD that involves collaboration among teachers is more likely to lead to positive changes in practice and teacher growth. Similarly, Tirosh and Graeber (2003) argue that encouraging teachers to reflect on their beliefs and practices in CPD enhances both self-awareness and instructional skills. The cooperative elements and opportunities for reflection are seen as key factors that foster a deep understanding of content and pedagogy.

Include Long-term and Sustained Learning Opportunities

Sustained CPD over an extended period has been found to be more effective compared to short, one-off workshops (Desimone, 2009). Continuous engagement enables teachers to implement and evaluate new strategies, gain feedback, and refine their practice over time. Lipowsky and Rzejak (2012) suggest that the length and recurrence of sessions are critical for ensuring that new knowledge is well integrated into classroom practice.

Motivation

Desimone (2009) highlights that effective professional development includes elements that increase teacher motivation by being relevant and providing practical value. CPD that respects and integrates teachers' perspectives, addresses their everyday teaching challenges, and involves collaborative activities contributes to enhanced motivation and a positive attitude towards learning. Similarly, Baumert and Kunter (2013) argue that professional development fosters teacher motivation by promoting competence and self-efficacy. When teachers see the relevance of CPD content to their classroom practice and feel supported in applying new strategies, their motivation to continue learning and improving their practice grows. Clarke and Hollingsworth (2002) note that CPD designed as a continuous process involving collaboration and reflection leads to greater teacher agency, which is directly related to intrinsic motivation. As teachers participate in reflective activities that enhance their understanding of the impact they have on their students, they feel more empowered and motivated to improve their

teaching practices. Teacher motivation is thus both a product and a contributing factor to the effectiveness of CPD.

The ICSE Academy project has adopted these criteria for designing and evaluating effectiveness of CPD activities, considering effectiveness to result in growth in teachers' knowledge, beliefs, and classroom practice and in the development of motivation and competence in self-reflection.

3.3. Accessibility in CPD

Another aspect evaluated by the case studies is accessibility. Accessibility in teacher professional development refers to the extent to which CPD meets teachers' needs concerning content, pedagogical approaches, scheduling, and resources required. For CPD to be accessible, it must consider a number of factors.

Relevance and Flexibility

CPD must be relevant to the diverse contexts of teachers, considering differences in curricula, instructional challenges, and student demographics (Desimone, 2009). Flexible scheduling is also essential to ensure that teachers can balance participation with their existing responsibilities.

Digital Accessibility

Digital tools play an increasingly significant role in enhancing accessibility, especially in contexts where physical mobility is limited, and offer new opportunities for personalised learning and collaboration (Schleicher, 2012). Digital formats such as online workshops and resources facilitate wider participation, ensuring that teachers from diverse geographical regions can access learning opportunities.

Cultural and Contextual Sensitivity

Accessibility also requires sensitivity to the cultural contexts in which teachers operate (Banks, Cochran-Smith, Moll et al., 2007). CPD activities must consider teachers' cultural norms and values to effectively engage participants and provide applicable knowledge.

The case studies within the ICSE Academy project assessed the accessibility of its CPD activities by examining teachers' needs in terms of content, pedagogical approaches, schedules, and digital requirements, ensuring that the activities were contextually and culturally suitable.

3.4. Transferability of Professional Development Activities

Transferability in professional development refers to the extent to which CPD activities can be adapted to different contexts, including various countries, regions, and school types. Transferability is an important concept for promoting widespread educational improvement across different educational systems. Key factors influencing transferability include:

Relevance to Multiple Contexts

Transferability requires that professional development content is relevant across multiple contexts and adaptable to different educational systems. Activities that focus on universal aspects of pedagogy, such as promoting inquiry-based learning, are generally easier to transfer (Maass & Engeln, 2018, 2019).

Local Adaptation and Flexibility

The ability to adapt activities to align with local policies, cultural expectations, and institutional practices is crucial for successful transferability (Banks, Banks, Cortes et al., 2007). Maass (2011) emphasizes the need for CPD facilitators to understand both the context from which an intervention is derived and the context to which it is transferred. Effective transfer relies on careful alignment between these contexts, ensuring that the essence of the activity is preserved while accommodating local variations.

Expertise and Collaboration

Successful transfer also depends on the involvement of experts familiar with educational policy in both the source and target regions (Desimone, 2009). Collaborative planning between sending and receiving institutions ensures that the transferred activities align with local priorities and needs.

In the ICSE Academy project, the transferability of CPD activities was evaluated by involving STEM teacher education experts who assessed the feasibility and adaptability of activities across different educational systems in partner countries.

3.5. Conclusion

This background to the case-studies has defined the key aspects of effectiveness, accessibility, and transferability in teacher professional development as used in this study. These key concepts were discussed and agreed upon by the ICSE Academy consortium and the definitions were used in the evaluations carried out.

4. METHODOLOGY

4.1. Introduction

The aim of this study was to explore the effectiveness, accessibility, and transferability of professional learning activities across diverse contexts. The methodological choices made to ensure the collection of rich, context-specific insights, which are crucial for understanding the complex phenomena underlying professional development (PD) across different countries are described and justified in this section.

4.2. Research Approach and Design

A case study approach was adopted for this investigation. Case studies are recognized as a robust approach for systematically investigating real-life phenomena in their context (Yin, 2014), utilizing various data sources to deepen understanding (Rashid, Rashid, Warraich, Sabir, & Waseem, 2019). By employing a case study design, this project aimed to provide an in-depth, nuanced understanding of how specific regional PD activities operate in different educational settings and their potential for transferability. This approach allows for an exploration of context-bound experiences, thus revealing significant details that cannot be generalized but are valuable for understanding professional development in specific situations (Flick, 2012). The case-studies were exploratory in nature, allowing the researchers to understand the complexity and diversity of these professional learning activities across different contexts.

According to Stake (1995), exploratory case studies are often utilized to identify patterns, themes, or issues that arise from examining real-life events within their context, and this is precisely what this project aimed to achieve with respect to STEM teacher development activities.

The research approach adopted was a multiple-case design (Yin, 2014). In multiple-case designs, each case represents a unique example, and they are analysed both individually and collectively to gain a more comprehensive understanding of the phenomenon. The focus of the study was on professional development sessions implemented in the 13 partner countries, where each country is treated as an individual case.

Yin (2014) suggests that in a multiple-case design, each case (in this case, professional learning activities in each partner country) serves as an individual study, and the overall study is strengthened by examining similarities and differences across these cases. The purpose of this project was to assess the effectiveness, accessibility, and transferability of professional development activities across multiple European countries, and the use

of multiple cases allows the researchers to make cross-case comparisons and validate findings across diverse contexts.

Stake (1995) argues that a multiple-case design is useful when researchers are interested in understanding a phenomenon from different perspectives and in different contexts. This project uses a cross-country analysis to identify patterns and variations across partner countries, contributing to a more holistic understanding of the professional development practices being studied.

A cross-country analysis was used to explore what professional learning activities work best in various contexts and to provide a broader European picture identifying common patterns and themes across different contexts.

4.3. Guiding Research Questions

The case studies were guided by three primary research questions. At a regional level the research questions behind country-based case studies were:

To what extent are the individual regional activities effective and accessible?

To what extent are the regional activities transferable to different contexts?

The regional case studies were then used for a cross-country analysis. In this case the research question was:

What are the characteristics of professional development activities and technologies, and in which particular settings do they work best?

4.4. Case Study Procedure

According to Yin (2014), Stake (1995), Creswell (2007), and Cohen, Manion, & Morrison (2018), there are several key steps that are generally followed in case study research. In the following sub-sections, the steps carried out and aspects considered as part of the case study methodology are described and justified. These are based on the typical steps taken in case study research according to the literature.

4.4.1. Identifying the Case

The first step is to identify the specific case that is to be studied. The case can be an individual, an organization, an event, or an activity. It is crucial to clearly define the boundaries of the case so that the scope of the study is well-understood (Yin, 2014). In this project, the case consisted of one professional learning activity in each of the

partner countries. Each Higher Education Institution (HEI) offered several learning activities to project partners for job shadowing. The sessions were part of the regular courses offered by the HEI as part of ITE courses or CPD. Project partners selected activities from other HEI that they wished to observe, and the learning activities were implemented. Each HEI identified one learning activity that would make up their case. Multiple data sources were used to comprehensively capture each case, as a case is influenced by various factors that need to be considered (Cresswell, 2007; Cohen, Manion, & Morrison, 2018).

4.4.2. Data Collection within the Case Studies

Data were collected through semi-structured interviews, observations, and session documentation. Semi-structured interviews were conducted with pre-service and in-service teachers participating in the professional development activities. The interviews provided an opportunity to gather diverse perspectives while maintaining a degree of flexibility, which allowed the interviewer to explore topics in depth (Cohen, Manion, & Morrison, 2018). Team members who were not directly involved in delivering the sessions conducted the interviews and wrote the case study reports.

Written observations and reflections were also collected from two Initial Teacher Education (ITE) or Continuous Professional Development (CPD) providers who attended the sessions as observers, as well as from the ITE/CPD provider leading the session. This combination of data sources enabled triangulation, providing multiple perspectives on the sessions, which strengthens the validity of findings (Patton, 2002).

The same data collection methods were applied across all case studies to ensure comparability. Templates with the questions for the interviews and the points for reflection were provided for uniformity.

4.4.2.1. The main concepts within the Evaluation

One of the first tasks carried out involved identifying the main concepts that would be evaluated. The main concepts for evaluation through the country case studies were effectiveness, accessibility and transferability. These were described in Section 2 of this report.

For the purposes of this evaluation, growth in at least one of the areas listed below was considered as contributing to and showing effectiveness:

Growth in

- Teachers' content knowledge
- Teachers' pedagogical knowledge

Teachers' pedagogical content knowledge (Shulman, 1986)

Developing teachers' classroom practice (Clarke & Hollingsworth, 2002)

Developing teachers'

Beliefs

Motivation

Competence in self-reflection (Baumert & Kunter, 2013)

Accessibility was evaluated by looking at how the session meets teachers' needs with respect to:

Content

Pedagogical approaches used

Schedule, duration

Digital tools needed

The third main concept evaluated was transferability. A session was considered to be transferable if experts from the area of STEM teacher education and with knowledge of educational policy contexts consider the professional learning activity to be applicable to other countries, contexts, regions and types of school.

4.4.2.2. The data collection instruments

Instruments for semi-structured interviews, observation sheets, and analysis templates were developed and used consistently in the various case studies. These consisted of an interview guide for teachers, an interview guide for pre-service teachers, an observation sheet for observers of a session and a reflection sheet for the session provider. The interview guides were based on the *Data Collection Instruments for Case Study* developed for the MaSDiV (*Supporting Mathematics and Science teachers in addressing Diversity and promoting fundamental Values - https://icse.eu/international-projects/masdiv/*) project. These were adapted for the needs of this project. The instruments were prepared by the work package leader and peer reviewed by the members of the consortium.

A copy of the data collection package consisting of interview schedules, observation sheets, reflection sheets, permission letters, information letters, consent forms, and analysis guide are given in Appendix I.

4.4.3. Data Evaluation

Each partner HEI responsible for a professional development activity analysed the interview data from teachers and incorporated data from peer observers' reflections and the reflections of the provider. To minimize bias, team members who were not directly involved in delivering the sessions conducted the interviews and wrote the case study reports. This approach also aimed to reduce the potential pressure on respondents to provide answers they believed were expected by the activity leaders, enhancing the reliability of the data (Bowling, 2002).

In this project, thematic analysis was employed as the primary method for analysing qualitative data, following the approach proposed by Braun and Clarke (2006). Thematic analysis is a widely used method in qualitative research due to its flexibility and adaptability across various research contexts. It is particularly effective for identifying, analysing, and interpreting patterns or themes within a dataset, which allows for a deep exploration of the experiences and perspectives of participants.

The analysis procedure was discussed in a workshop for the consortium in which the main steps and procedures were agreed.

The analysis process for individual case studies began with familiarization with the data, which involved immersing in the data by reading and re-reading transcripts of interviews, observation notes, and other textual materials such as reflections written after the session was transferred. This step allowed the researcher to become thoroughly acquainted with the data and begin identifying initial patterns. During this phase, preliminary notes were taken to capture initial impressions and points of interest, laying the groundwork for more detailed analysis.

The next step involved generating initial codes. This was a systematic process in which each researcher worked through the data, assigning labels or codes to segments of the data that appeared significant in relation to the research questions. The consortium was provided with an analysis framework with possible codes related to the research questions. Thus, the coding process was driven by both theoretical expectations and patterns emerging from the data, which helped ensure that the analysis was comprehensive. The codes (such as *need*, *improved confidence*) represented basic units of meaning and were later grouped into more complex themes (such as *effectiveness*).

Once the data had been coded, the researchers working on the country case studies reviewed the codes and identified broader patterns or themes that connected various codes. Themes are central organizing concepts that capture something important about the data in relation to the research questions. During this phase, the researcher

texorganized the codes into potential themes and sub-themes, ensuring that these themes provided a coherent structure that accurately reflected the data.

The themes were reviewed to ensure that they accurately reflected the coded data. Some themes were combined or broken down into smaller sub-themes. This step was essential in ensuring that the thematic structure was both consistent and meaningful. The themes were given concise, informative names that encapsulated their essence and made them easily understandable.

The final step in this thematic analysis was producing the case study reports. The reports not only presented the themes but also demonstrated their relevance to the research questions, supported by direct quotations and excerpts from the data. This allowed the analysis to be grounded in the participants' own words and experiences, providing rich, detailed insights into the research topic.

Braun and Clarke's (2006) thematic analysis offers a structured yet flexible approach that suited the needs of this project. Its flexibility allowed for both inductive and deductive approaches to coding, enabling a balance between theory-driven insights and emergent themes from the data. Thematic analysis was considered particularly effective for exploring participants' experiences and perspectives in depth.

This methodological choice aligns with the project's goals of examining professional development activities and their effectiveness, accessibility, and transferability across multiple contexts. The flexibility of thematic analysis allowed for an in-depth exploration of various themes related to participants' experiences, while the systematic coding and reviewing process ensured the rigour and credibility of the findings.

Analysis within cases was carried out using an analysis guide, and reports were written based on a pre-established template. This enhanced uniformity across the case studies.

4.4.4. Selection of Cases and Transfer

After the individual cases were completed, each partner country selected a professional learning activity to adapt to their own context. Upon completion, country representatives wrote a reflective analysis that incorporated their experiences and participant feedback, which further informed the transferability analysis. Figure 1 gives an overview of the case study sessions observed (O) by each consortium partner and the learning activities transferred (T) to another HEI.

	AU	CY	CZ	DE	ES	GR	LT	MT	NL	NO	SK	SW	TR
Host													
AU				O									
CY						T				O			
CZ											T		
DE		T											O
ES	T	O							O				
GR										O	T		
LT		O						T					
MT	O				T					T			
NL		O		T		O				O			
NO							O					O	T
SK			O										
SW									O				
TR					T			T					

Key: O=Observed, T=Transferred

Figure 1: Overview of the case study sessions observed and transferred in the respective countries

4.4.5. Cross-Country Analysis

Following the transfer and reflective analysis, a cross-country analysis was conducted to provide a European perspective on the effectiveness, accessibility, and transferability of

the professional learning activities carried out (Crowe, Creswell, Robertson, et al., 2011). Once the research objectives were defined as a consortium and the project partners chose cases that were relevant to the study and wrote case studies it was possible to carry out the cross-case analysis. An analytical framework was established based on the research questions for cross-case comparison. Common themes, trends and divergences were identified across the cases. Results were then validated collectively by all partners, providing a comprehensive overview of the professional development activities across the partner countries and the impact of the job shadowing activities.

4.5. Justification for Methodological Choices

The adoption of a case study approach and a qualitative research methodology is supported by the nature of the research questions and objectives. Case studies provide a rich, context-sensitive understanding of professional development experiences (Yin, 2014; Stake, 1995). Semi-structured interviews allowed the researchers to delve deeply into participants' experiences while retaining the flexibility to explore new themes (Cohen, Manion, & Morrison, 2018).

Moreover, participant observation enabled the researchers to capture the dynamics of the sessions, which was crucial for understanding the complexities of PD activities. The approach of involving both observers and providers in reflective analysis helped ensure that multiple perspectives were considered, enriching the quality of the data and providing a more holistic view (Flick, 2012).

4.6. Ethical considerations

When conducting the case study research, ethical considerations were carefully made to ensure the integrity of the research process and the protection of participants. In this section these ethical considerations are outlined.

4.6.1. Informed Consent

This entails ensuring voluntary participation of well-informed participants. To ensure voluntary participation interviewees were provided with detailed information about what their involvement entailed, ensuring that their participation was voluntary and without coercion. Participants were informed about the research purpose, procedures, potential risks, and benefits. Interviewees were also informed about how the data were going to be used. This ensured transparency. This information was provided in an information letter and then again given during the data collection. Participants were also informed that they were free to withdraw from the study without any consequences. The information letter was created by the work package leader and shared with the consortium as part of the pack of data collection materials. In each country it was ensured that the information was presented in an accessible format, by translating to the national language involved.

4.6.2. Confidentiality and Anonymity

Protection of identity was maintained by anonymizing participant information. Names and other identifiable details were altered and audio-recordings, signed consent forms and other data were securely stored.

4.6.3. Power Dynamics and Relationships

Researchers reflected on possible power imbalances that may exist between researchers and participants to prevent coercion or exploitation. This was particularly important in this project since some of the participants were students at the HEI. To reduce this issue the persons providing the learning activities were not involved in the data collection, the data analysis or the writing of the case study.

At the end of the interviews, participants were offered the possibility to read the report with the findings when available.

4.6.4. Cultural Sensitivity

These case studies were carried out in different countries with different cultural contexts. All the materials used in the data collection were peer reviewed by the consortium, not only for their feedback on research-related aspects but also as a way of ensuring that different cultural contexts are respected.

Cultural awareness and sensitivity were also important at the analysis stage. The cross-country analysis was reviewed by partners as part of the validation process.

4.6.5. Harm Minimization

A risk assessment was carried out to assess any possible risk of harm to the participants.

4.6.6. Ethical Approval

Ethical approval from the institutional review boards or ethics committees of the various HEI involved was obtained before beginning the research. Permissions were sought from the gatekeepers at these HEI.

4.6.7. Language and Communication Barriers

Appropriate language was used throughout to ensure clear communication. Partners from the respective countries were responsible for translations of information letters,

consent forms, interviews guides, and other materials ensuring they were accurate to avoid misunderstandings or misrepresentation of participant views.

4.6.8. Reporting and Reflexivity

Where possible, findings were validated with participants to ensure that their views have been accurately interpreted and represented. Partners also took part in a validation exercise after the analysis.

These ethical considerations were considered essential for maintaining the credibility of the research and safeguarding the rights and well-being of participants.

5. RESULTS

The results of this qualitative study include both contextual information and a thematic cross-case analysis. In Sections 4.1 to 4.3 contextual information from each case is presented. Understanding these contexts is critical for interpreting patterns and themes across cases. Contextual information includes the background of each case, the key actors and relevant situational factors. In Sections 4.4 to 4.10 the results from the thematic analysis are presented. These themes reveal shared or divergent experiences and interpretations. When reporting, richness and significance are considered over numbers, since while counting might be interesting, some aspects may be important even if mentioned by only a few participants. The interest is thus more in the why than the how many. Quotes from participants are used to bring depth and to contextualise findings. Where possible findings from the different sources of data were used to ensure robustness.

5.1. Who are the participants (pre- or in-service teachers) interviewed

In this section the participants who were interviewed in the different countries are presented. This includes insights into their professional background, their goals as educators, personal stories, preferred teaching styles, motivations for joining the course, and their prior experience with Continuing Professional Development (CPD).

5.1.1. The interviewees

The participants (teachers and pre-service teachers) interviewed come from a diverse range of educational backgrounds and professional experiences, spanning from pre-service teachers to educators with decades of experience. Many are enrolled in various teacher education programmes or advanced degrees. The participants' professional backgrounds range widely, with years of teaching experience varying from none for pre-service teachers to over 30 years for some educators.

Thirty-seven participants consisting of 18 in-service teachers and 19 pre-service teachers were interviewed. These were coming from the 13 participating countries:

- **Austria**: 2 participants ITE
- **Cyprus**: 4 participants CPD
- **Czechia**: 3 participants ITE
- **Germany**: 3 participants CPD
- **Greece**: 3 participants CPD
- **Lithuania**: 3 participants CPD
- **Malta**: 2 participants ITE
- **Spain**: 4 participants ITE
- **Sweden**: 2 participants ITE
- **Netherlands**: 3 participants CPD
- **Turkey**: 3 participants CPD
- **Slovakia**: 3 participants ITE
- **Norway**: 3 participants ITE

Across different countries, several common goals and reasons for following the course emerged among the interviewed participants. These included: enhancing critical thinking and problem-solving skills in their students (Austria and Cyprus); improving student engagement and motivation (Austria, Greece, Norway and Turkey); incorporating new teaching methods and technologies such as new educational technologies and innovative teaching methods to improve student learning outcomes (Germany, Greece and Lithuania), developing strong foundational teaching skills and methodologies (pre-service teachers from Malta and Slovakia); project-based and experiential learning (Lithuanian teachers). Several interviewees expressed their desire to motivate students to learn, be interested in science and to inspire them to opt for STEM careers (Malta, Lithuania).

While individual preferences varied, several common teaching styles were noted. Interviewees from Germany, Greece, and Cyprus leaned towards student-centred, interactive, and inquiry-based teaching methods, emphasizing active student participation and self-discovery. Educators from Austria, the Netherlands, and Turkey preferred practical, hands-on approaches that make learning tangible, engaging and relevant for students. Pre-service teachers from Malta, Sweden, and Slovakia were still in the process of experimenting and developing their preferred teaching styles, with an interest in interactive and student-centred learning.

Participants across various countries shared several motivations for joining the courses. For some participants the session was a mandatory part of their education programmes (such Austria, Malta and Spain). For many of the in-service teachers this was an opportunity for professional development citing improving teaching methods and learning new strategies for engaging students as their main reason for joining the course. Teachers from Lithuania, for example, were motivated to address challenges related to integrating technology into their teaching practices. Other in-service teachers attended for further certification (e.g. Cyprus) and to enhance their professional qualifications.

Participants' stories reflect personal and professional journeys that have led them to seek continuous improvement and adaptation to new educational challenges. For example, a number of teachers transitioned from other careers for example from mathematician or nuclear physicist or from pharmaceutics to teaching as they were passionate both about the subject and about teaching (Slovakia, Netherlands). Other teachers with an extensive teaching experience wished to improve their teaching when faced with challenges due to low student motivation and a diverse school environment (Turkey).

5.1.2. Prior experiences with Continuous Professional Development (CPD)

The participants' prior experiences with CPD vary widely. For the pre-service teachers who were still in their initial training, there was little or no CPD experience. Some in-service teachers had attended international workshops or summer schools while others were seeking formal pedagogical training through programmes such as post-graduate degrees. Some educators, with extensive teaching experience, have been involved in multiple professional development programmes and collaborative projects. These were related to new curricula, modern pedagogical approaches and adapting to new teaching environments.

Despite their varied backgrounds, common goals, teaching styles, and motivations highlight the shared dedication among the participants to continually improve their teaching methods and better support student learning and engagement.

5.2. Educational Contexts

5.2.1. Programmes involved

The case studies were based in different educational contexts. They consist of a number of Continuing Professional Development workshops and programmes designed to update and enhance the skills of practising teachers and initial teacher education (ITE) programmes providing the foundations for pre-service teachers. The following is an overview of the educational context of the case studies.

The ITE programmes involved were:

Austria: The course is part of the ITE programme at the University of Klagenfurt, provided by the Institute for Didactics of Mathematics. This programme includes job shadowing sessions that are mandatory for the students.

Czechia: The ITE for secondary education includes a five-year programme, combining a level 6 and a level 7 degree. The session observed focused on combinatorics and graph theory, which is compulsory for mathematics and informatics teachers.

Malta: The ITE course at the University of Malta is a Master in Teaching and Learning (MTL) with a specialization in science. This programme is offered as a two-year full-time or three-year part-time course, typically for students with a first degree in a STEM-related field.

Norway: The Norwegian University of Science and Technology hosted an ITE session focusing on inquiry-based teaching and learning approaches focusing on questioning and exploratory talk. The session was part of an optional course within a two-year Master programme in science education.

Slovakia: The ITE for secondary education is a five-year Master programme, including compulsory courses in combinatorics, algebra, analysis, and geometry. These are essential transition courses for mathematics teachers.

Spain: The observed lesson was part of an ITE course in chemistry and physics education. The session was framed within a one-year Master degree compulsory for working as a secondary education teacher in Spain.

Sweden: The ITE includes comprehensive courses in educational science and various theoretical subjects such as natural science, mathematics, social science, English, Swedish, special pedagogy, and field-based teacher training (VFU). The course that was observed is part of a final mathematics course aimed at teachers who will teach children aged 6-9 years and 10-12 years. The mathematics course is based on the principles of variation theory.

The CPD courses or sessions involved were:

Cyprus: The University of Nicosia offers CPD through online MA courses and a PhD programme. These CPD courses are delivered via Moodle and include weekly materials, collaborative activities, live online sessions, final exams, and assignments. The programme duration is three semesters.

Germany: The educational context revolves around CPD for teachers, specifically in 3D printing, hosted by the International Centre for STEM Education (ICSE) at the University of Education Freiburg. This CPD course is a three-hour workshop.

Greece: The National and Kapodistrian University of Athens participated in an Erasmus+ programme, focusing on Lesson Study to improve mathematics achievement. This

programme ran for three years and was a CPD initiative. The session involved in the case study was part of this programme.

Lithuania: The observed CPD workshop, part of a programme titled "Inquiry-based STEM education," was provided by the STEM centre of Šiauliai Academy of Vilnius University. It is a 40-hour qualification improvement programme for in-service teachers.

Netherlands: Utrecht University (UU) organizes an annual two-day conference for mathematics teachers, which includes various CPD workshops such as the one involved in the case study on ChatGPT which was attended by about 25 teachers.

Turkey: CPD workshops have been provided for in-service teachers, some of whom are postgraduate students. The workshop focused on the process of argument construction and argumentation in science.

5.2.2. Number of students/participants in the observed sessions

The number of students or teachers participating in the observed sessions varied from small numbers to larger groups of participants. Table 1 summarises the number of participants in each case study session.

Table 1: Number of participants (students or teachers) in the observed sessions

Country	Number of participants
Austria	8
Cyprus	24
Czechia	19
Germany	16
Greece	4
Lithuania	6
Malta	4
Netherlands	25
Norway	11
Slovakia	22
Spain	11
Sweden	80
Turkey	26

5.2.3. Lecturers' background and teaching experience

The lecturers and session providers have varied experience levels in CPD and ITE, ranging from two years to over 20 years. The majority have been involved in education for over a decade, contributing to both the development of future educators and the professional growth of in-service teachers. A summary of the number of years each lecturer or session provider has been involved in CPD or ITE is given below:

Austria: Two lecturers were involved, one with **four years' experience** as a university lecturer while the second lecturer has been **i**nvolved in teacher training for approximately eight years.

Cyprus: **The lecturer has been** involved in ITE and CPD for 15 years.

Czechia: **The lecturer has been involved** in education for around 19 years.

Germany: **The session provider has substantial** experience in STEM education, with several years in ITE and CPD.

Greece: **The lecturer has been involved** in the LESSAM programme for two years and in teaching at the university level for a significant period.

Lithuania: The session leader has spent over 12 years working with students, with more than 2 years actively involved in STEM education.

Malta: **The lecturer has been teaching at the university for** 21 years, with 34 years of total teaching experience.

Netherlands: **The lecturer has** a combined experience in secondary education and as a teacher educator at the university.

Norway: The session leader has been involved in teacher education since 2004 (20 years of experience).

Slovakia: The session provider has been teaching undergraduate courses since 2004, involved in CPD since 2011 (approximately 12 years in CPD and 19 years in ITE).

Spain: The lecturer has over 16 years of experience in pre-service and in-service teacher professional development.

Sweden: The session provider has several years of experience as an assistant professor and course manager in ITE. She is also an active researcher in science education.

Turkey: The session provider has 12 years of experience in academia, including roles as a research assistant, assistant professor, and associate professor. The session provider teaches undergraduate, graduate and doctoral courses and his doctoral research area is related to argumentation.

5.2.4. Lecturers' beliefs, goals and philosophies

The teaching philosophies of the lecturers providing the observed sessions share common themes of constructivism, student-centred learning, and connecting theory with practice. Many lecturers emphasize the importance of inquiry-based and practical approaches, in science and mathematics education. There is also a strong focus on integrating technology into teaching, fostering critical thinking, and providing professional development to empower educators. Overall, these philosophies reflect a commitment to creating engaging, relevant, and effective learning experiences that prepare students for the challenges of the modern world.

The main teaching philosophies of the lecturers and session providers across the different countries mentioned in the interviews are summarised below.

Constructivist Approach

Czechia & Slovakia: Lecturers in these countries hold a constructivist philosophy, emphasizing the importance of building deep, conceptual understanding. They focus on helping students actively construct their own knowledge rather than passively receiving information. This approach often involves problem-solving frameworks, like Polya's four-step method, and emphasizes the development of critical thinking and problem-solving skills.

Connecting Theory with Practice

Austria & Sweden: The lecturers aim to bridge the gap between theoretical knowledge and practical application. They believe in the importance of reflection, regular feedback and in making theoretical concepts relevant and applicable to real-world situations, particularly in the context of mathematics education.

Student-Centred

Malta: The philosophy here is centred on the belief that teaching should focus on the student rather than just the subject matter. The lecturer emphasizes the importance of developing personal relationships with students, addressing their individual learning needs, and helping them reach their full potential.

Inquiry-Based and Practical Teaching Approaches

Norway & Netherlands: The lecturers advocate for motivating teachers to incorporate inquiry-based and practical activities into their teaching. This philosophy emphasizes engaging students in hands-on learning experiences that connect with their everyday lives, moving beyond traditional textbook-based instruction.

Broader Science Education Focus

Cyprus & Lithuania: Lecturers in these countries focus on creating positive attitudes towards science and promoting scientific practices. They aim to make science relevant by introducing socioscientific issues and simplifying complex natural processes to foster understanding and critical thinking.

Innovation and Technology Integration

Germany: The lecturer in Germany is committed to integrating innovative technologies, like 3D printing, into educational practices. This philosophy is rooted in an interest in enhancing teaching methods and preparing students for a technologically advanced world.

Professional Development and Teacher Empowerment

Greece: The lecturer's goal is centred on professional development, particularly through the Lesson Study (LS) approach. This philosophy involves supporting the development of communities of practice among teachers, enhancing their professional roles, and improving the quality of education in mathematics.

Inspiring and Transformative Education

Spain & Turkey: The teaching philosophy here is about inspiring and motivating educators to reflect and acquire key strategies and resources. The aim is to provide transformative learning experiences that improve STEM education based on students' active participation and high-quality interaction.

5.2.5. Challenges experienced

Some of the lecturers mentioned challenges that they and their students experienced. The lecturers from Malta and Cyprus indicated that there is a significant recruitment challenge. In Malta there is a significant challenge in recruiting students for the Master in Teaching and Learning (MTL) course. Teaching, especially in science, is not an attractive career option in Malta, leading to low enrolment numbers (4-10 students per year specialising in Science). In Cyprus there is a similar difficulty with recruitment particularly for the online MA courses, which are CPD-focused.

Two other challenges were mentioned by the Maltese lecturer. One was the workload of part-time students. These students, who work full-time and attend lectures after

work, struggle to manage their workload due to time constraints and striking a balance between their professional and academic responsibilities. The second challenge mentioned were students' views of science and science teaching. Pre-service teachers often view science as a body of knowledge to be conveyed, leading them to favour traditional teaching methods. The challenge for the course is to encourage these students to adopt student-centred pedagogies and to reflect on alternative perspectives of science teaching.

An Austrian lecturer described a challenge resulting from the diversity within the student cohort:

> *"The group of students is made up of a mixed audience. There are students who are already teaching at school as well as students who have little teaching experience and are not yet working in the school system. This means that the students' previous experience, expectations, and needs are very different. It is therefore very challenging to cover this broadly in the few dates (blocked events 4 dates with teaching units of 45 minutes each)"* (L1).

5.3. The sessions offered

In this section the session involved in the case study in each country is briefly presented. The topic, the learning goals and the structure of each session are described. These are followed by an evaluation of the effectiveness, transferability and points for improvement as reported in the country case study. The full case study report for each learning activity is given in Appendix III of this report.

5.3.1. Austria

1. Topic of the Session

The session focused on integrating 21st-century skills into mathematics education, specifically emphasizing collaboration, communication, creativity, and critical thinking. The session also linked mathematical content (e.g., percentages, statistics, equations) with socially critical contexts, addressing broader issues such as economic, social, and political matters. It was led by two lecturers.

2. Learning Goals or Planned Learning Outcomes

The session aimed to achieve the following learning outcomes:

- Understanding the Role of Mathematics in Social Contexts: Participants were expected to reflect on how mathematics can be linked to broader societal issues, consistent with interdisciplinary teaching approaches.

- Development of Key Competencies: The course aimed to develop participants' abilities to plan, structure, implement, assess, and reflect on pedagogical situations independently, using a theory-based approach.

- Professional Skills for Mathematics Teachers: The session focused on equipping participants with the skills necessary to teach mathematics, including the appropriate use of mathematical and everyday language in the classroom.

- Creation of Differentiated Educational Materials: Participants were encouraged to create or adapt materials suitable for differentiated and language-conscious mathematics lessons.

3. Structure of the Session and Activities Involved

The session was structured into four teaching units, each lasting 45 minutes. The activities included:

Lecturer Presentations: Provided key inputs on the session topics.

Group Discussions: Encouraged self-reflection and exchange of ideas among students, focusing on key questions related to the topics.

Work Assignments: Students engaged in group or partner work, reflecting on assignments from previous sessions and preparing for future ones.

Interactive Problem-Solving: The session included exercises where students worked on solutions, discussed potential problems pupils might face, and examined possible learning opportunities.

Integration of Theory and Practice: The session was co-taught by lecturers from different professional contexts, combining practical knowledge with theoretical insights. This approach emphasized the interconnectedness of theory and practice in teaching.

4. Philosophy Reflected

The session reflects several educational philosophies.

Constructivism: The emphasis on reflection, discussion, and problem-solving aligns with constructivist principles, where learners actively construct their understanding through experience and interaction.

Student-Centred Learning: The session was designed to be interactive, encouraging students to engage deeply with the content and reflect on their learning process. The inclusion of practical exercises aimed to put students in the role of their future pupils.

Interdisciplinary and Contextual Learning: By linking mathematics to social issues and broader educational contexts, the session reflects a philosophy that values interdisciplinary teaching and making learning relevant to real-world situations.

5. Effectiveness of the session

Content

Participants mentioned three aspects related to effectiveness of the content. Firstly, they appreciated the opportunity to influence the course content at the beginning, which led to a more personalized and relevant learning experience. One student noted that this approach ensured that "the content was right" for their interests.

The main topic, “Critical Mathematics Education”, was seen as important and exciting. Students valued the integration of mathematics with broader social issues like the climate crisis and sustainability, which helped them see the practical applications of mathematical concepts in everyday life. This relevance motivated them and provided a context for using mathematics as a tool for discussion on various topics: *“…because it is easier to demonstrate why you need differential calculus or integral calculus. There are then easier links to everyday life. If you introduce social issues such as the climate crisis, sustainability, etc., you motivate the students”* (I1 P8).

Students also found that the chosen topics and teaching examples allowed for broader reflection on mathematics and its applications. One student observed that the tasks encouraged them to think about how they could use similar approaches in their own teaching.

Students found the session to be well-structured and appreciated the logical flow of the content. They also valued the practical relevance of the topics, which were integrated.

The content was designed to connect mathematical concepts with real-world issues, which the lecturer felt was successful in engaging students and encouraging them to think about how these concepts could be applied in their teaching. The lecturer considered the session successful because it actively involved students and led to stimulating discussions. The goal of showing how overarching topics could be integrated into mathematics lessons was achieved, according to the lecturer: *“You could see that there are many approaches and possible solutions - which is the aim of such tasks. I think that most people really enjoyed it. Many of them have perhaps realized that they can use it in their own lessons”* (I2 P24)

The observers too had positive feedback on the effectiveness, however, they also noted that students faced difficulties with certain tasks, such as creating a poster on wealth distribution. This challenge was evident in the graphic representations produced by the students, indicating some struggles with the mathematical content.

Effectiveness of Pedagogical Methods

Students appreciated the teaching dynamic created by the two lecturers, who complemented each other well. The students appreciated the way the lecturers alternated roles, with each bringing their own professional insights—one from a didactic perspective and the other from teaching experience.

One of the lecturers stated that the session was well-structured and carefully planned, which contributed to its success in engaging students and fostering discussions.

While the overall pedagogical approach was effective, the observers noted that some practical tasks, like the poster exercise, revealed students' difficulties in grasping the mathematical concepts, which could suggest that the tasks were challenging or that more scaffolding was needed.

The session successfully contributed to the growth of teachers' pedagogical content knowledge, their ability to integrate social issues into mathematics teaching, and their overall engagement with the material.

6. Suggested improvements

The need for more time to reflect and process the material was identified as a factor in improving effectiveness and transferability. Participants felt there was too much content for the allotted time, leading to feelings of being overwhelmed. The provider noted that: “After the session, we had the impression that there was quite a lot of content for the time and some students seemed a bit overwhelmed towards the end” (L1 P68). One participant suggested a longer break: “The break was a bit too short - or several breaks would have been great” (I P26).

7. Transferability

The observers noted the potential usefulness of the learning content in their own teaching contexts, particularly regarding examples, exercises, and the issue of political messaging. One observer noted the need for self-reflection and consideration of political elements within their explanations to ensure clarity for students: *“Some of the examples, exercises and ideas could be useful for my own mathematics lessons. Practically, I should also think more about possible political messages in my presentations as they can maybe not be as clear as expected when a part of the explanation is missing.” (O2 P27)*

5.3.2. Cyprus

1. Topic of the Session

The session focused on introducing teachers to the concepts of argumentation in science education and SSI. The session aimed to provide practical examples of how to incorporate these concepts into teaching.

2. Learning Goals or Planned Learning Outcomes

The learning goals of the session included:

Understanding Argumentation in Science: Teachers were introduced to the importance of argumentation in science education and the challenges associated with it.

Practical Application: The session aimed to equip teachers with practical examples and tools to introduce and implement argumentation in their science classes.

Incorporating SSI in Teaching: Teachers were provided with examples of how to explain SSI in the classroom, linking these to the structure of a good argument.

Familiarization with EU Projects referring to SSI and argumentation: The session introduced teachers to relevant EU-funded projects, and provided examples of how these can be used to teach SSI.

3. Structure of the Session and Activities Involved

The session was conducted online and was structured primarily as a lecture, with the following activities:

Presentation of Core Concepts: The lecturer presented on the importance of argumentation in science, common difficulties faced by teachers and students, and the role of SSI in education.

Practical Examples: The session included examples of simple activities that teachers can use to introduce argumentation in science education.

Discussion of Teacher Experiences: There was a discussion segment where the experiences of teachers with argumentation in their classes were discussed.

Use of Technological Tools: Examples were provided on how to use technological tools to facilitate argumentation and SSI in science education.

Introduction to EU Projects: The session introduced and provided examples of SSI from previous EU-funded projects.

4. Philosophy Reflected

The session reflects a constructivist educational philosophy, where the focus is on helping teachers build their understanding and application of argumentation and SSI in science education through practical examples and discussions. The session also emphasizes the importance of integrating contemporary issues (e.g. SSI) into science education, reflecting a philosophy that values relevance and real-world application in teaching.

5. Effectiveness of the session

Content

Participants generally found the session effective in introducing the main concepts of argumentation and SSI. They appreciated the practical examples provided, which they felt could be useful in their teaching. The session was effective in introducing important concepts related to argumentation and SSI, and the content was well-received by participants. However, some participants noted the challenge of implementing these activities within the school curriculum due to time constraints. One participant mentioned that while the activities were useful and could be applied in afternoon classes, they were difficult to fit into the standard curriculum.

The observer, an experienced educator, acknowledged the value of the examples and theoretical content presented: "*The combination of theoretical ideas and teaching practices, as well the interesting examples used was the most successful aspect and I am satisfied that I had the chance to follow this and reflect on the educator's rationale.*"

However, the observer also highlighted the limitations of the online format, which restricted collaboration and deeper engagement. The observer pointed out that the session's design, which could not facilitate face-to-face interaction, limited the potential for collaborative learning. Despite this, the observer found the examples and theoretical ideas presented to be strong and well-chosen.

The educator who offered the session believed it was successful in terms of content delivery and introducing key concepts. However, the provider agreed that the session would have been more effective in a face-to-face format, which would have allowed for more interactive elements like group discussions and role-playing to better promote argumentation. The educator believed that the content was successfully delivered, but shared concerns about the online format's limitations.

Pedagogical Methods

The observer noted the limitations of the online pedagogical methods, particularly the lack of collaboration opportunities. Despite these limitations, the observer appreciated the combination of theoretical ideas and practical examples, finding them effective in stimulating meaningful questions and reflections among participants.

The educator expressed a preference for more interactive pedagogical methods, such as face-to-face group work and role-play, which were not possible in the online format. The educator believed these methods would have enhanced the effectiveness of the session by promoting more active participation and deeper engagement with the material.

The session was effective in introducing important concepts related to argumentation and SSI, and the content was well-received by participants. However, both the observer

and the educator noted significant limitations due to the online format, particularly in terms of fostering collaboration and deeper engagement.

6. Suggestions for improvement

The suggestions included points related to the content (such as, including the structure of a good argument and using Toulmin's argumentation structure) and the activities involved. In fact, more collaboration and discussion between teachers were recommended, potentially achievable through face-to-face interactions rather than online sessions. The observer suggested integrating additional activities, such as specific scenarios for debate.

7. Transferability

Both the observer and the educator believed the session could be easily transferred to other contexts. The focus on scientific practices, competences like argumentation, and making science relevant to everyday life makes adaptable for different schools and age groups.

The session provider reflected that "*other colleagues can transfer the session in their teaching as the main emphasis is on a competence that is high in the agenda of the upcoming PISA evaluation, that of argumentation*." This was confirmed by the observer who noted that the: "*session is based on international current research trends in science education and on material produced during European projects. I can adapt and transfer in the Master courses I teach*."

5.3.3. Czechia

1. Topic of the Session

The session focused on mathematical concepts related to set theory, specifically on understanding and proving the equivalence of different sets. The session also emphasized problem-solving, inquiry in mathematics, and the role of collaboration in learning.

2. Learning Goals or Planned Learning Outcomes

The learning goals for the session were:

a. Proving Set Equivalence: Students should be able to prove that different sets are equivalent.
b. Understanding Bijections: Students should be able to find a bijection between two sets.

c. Mathematical Inquiry: Students should understand what it means to "work as a mathematician" and be able to explain the steps of inquiry in mathematics.
d. Group Work Dynamics: Students should be able to explain the rules for working effectively in groups.
e. Collaboration in Problem-Solving: Students should understand the role of collaboration in solving mathematical problems.
f. Appreciation of Diverse Representations: Students should recognize that different students may prefer various representations of mathematical concepts.

3. Structure of the Session

The session was structured as a single learning activity spanning 135 minutes (3 sessions of 45 minutes each). The activities included:

Problem Solving: Students began by solving several problems that had the same solutions but used various combinatorial models (selection, distribution, and partition) and different mathematical models.

Equivalence Groups: Students were presented with various situations/sets that were equivalent and were asked to group these situations based on their equivalence and prove why the sets were equivalent.

Class Discussion: The session concluded with a whole-class discussion where students shared their bijections, and the equivalence of all the sets was revealed.

Reflection: The session also included a reflection on the various approaches used to solve the problems, the experience of working in groups, and the teachers' roles during the lesson.

4. Philosophy Reflected

The session reflects a constructivist educational philosophy, emphasizing active learning, where students build their understanding through problem-solving and inquiry. The focus on collaboration and group work indicates a social constructivist approach, which values learning as a social process where students learn from each other's perspectives and approaches. Additionally, the session's emphasis on reflection aligns with reflective teaching practices, encouraging students to think critically about their learning processes and the strategies they used.

5. Effectiveness of the Session

Content and Format

One participant reflected positively on their personal learning experience, noting that given enough time and collaboration with peers, they were able to tackle more difficult tasks than they initially expected indicating growth in their problem-solving abilities and

confidence. This suggests that the session's content challenged them in a positive way, pushing them to explore more complex problem-solving techniques.

By allowing different groups to tackle the problem using varied approaches, the lecturer ensured that the session accommodated diverse learning styles and problem-solving strategies.

The provider pointed out the emphasis made on different approaches. The lecturer highlighted the different approaches taken by the groups (visual vs. algebraic) during the final discussion. By encouraging the students to explain their thinking, he fostered a deeper understanding among the participants and facilitated a reflection on the diverse methods used to solve the problems, contributing to the participants' development in both content knowledge and problem-solving strategies.

Pedagogical Methods

The collaborative nature of the session was a key factor in their learning since the possibility to discuss and develop solutions in a group setting helped them overcome challenges and enhanced their problem-solving skills. As one of the participants reflected, "*On a personal level, I've definitely learned that given enough time (and smart colleagues), I can come up with more difficult tasks than I might have expected".* (C)

The provider noted that encouraging explanation and reflection on the differences in problem-solving methods and allowing students to explain their thought processes encourages active learning, critical thinking, and peer learning, all of which are essential for deepening students' understanding of mathematical concepts.

6. Suggestions for Improvement

Following the original session, the selection of materials and problems used during the session was changed, as some content needed adjustment and as a result some materials were replaced.

7. Transferability

The observer adapted the timing of the activity to suit their teaching approach. Parts of the original session were transferred. The original session permitted flexibility in transferring the course content and in the approach.

5.3.4. Germany

1. Topic of the Session

The session focused on introducing and training teachers in the use of 3D printing technology, specifically within the context of mathematics education. The workshop aimed to help educators understand the basics of 3D printing, learn to use CAD software

like Tinkercad, and explore ways to integrate 3D printing into their teaching practices to enhance student engagement and learning.

2. Learning Goals or Planned Learning Outcomes

The learning goals for the session included:

a. Understanding 3D Printing Technology: Teachers were expected to learn the basics of 3D printing, including how it works and the different types of 3D printing processes.
b. Using Tinkercad for 3D Design: Participants were to gain proficiency in using Tinkercad, a CAD software, to design and manipulate 3D models.
c. Practical Application in Education: The session aimed to help teachers integrate 3D printing into their mathematics teaching, using the technology to create interactive and engaging learning experiences.
d. Hands-On Experience: Teachers were to design and print their own 3D models, gaining practical experience from the design phase to the finished product.
e. Sustainability in 3D Printing: Participants were encouraged to use 3D printing technology in an environmentally conscious manner.
f. Innovative Teaching Methods: The session aimed to inspire teachers to innovate and experiment with new teaching methods using 3D printing technology.

3. Structure of the Session and Activities Involved

The workshop was structured as a three-hour session, divided into several phases:

Lecture (45 minutes): The session began with a lecture covering the basics of 3D printing technology, the functionality of 3D printers, and their applications in education, particularly in mathematics.

Practical Activity (90 minutes): Participants engaged in hands-on activities using Tinkercad to design their own 3D models. They then printed these designs using 3D printers provided at the workshop. A specific activity involved creating a “loaded cube”, where participants learned to design and print a cube with a cavity to insert a weight, thereby understanding the principles of 3D design and printing.

Discussion and Reflection (45 minutes): The workshop concluded with a discussion session where participants reflected on their experiences, shared potential challenges, and brainstormed ways to integrate 3D printing into their teaching practices. There was also a discussion on the sustainability of using 3D printing in education.

4. Philosophy Reflected

The workshop reflects several educational philosophies:

Constructivism: The hands-on, experiential learning approach aligns with constructivist principles, where learners actively construct knowledge through doing and reflection.

Innovation in Education: The session encouraged participants to experiment with new teaching methods, reflecting a philosophy that values innovation and the integration of technology into education.

Sustainability and Practical Application: The emphasis on using 3D printing sustainably and in practical, real-world applications underscores a philosophy of responsible and relevant teaching practices.

5. *Effectiveness of the Session*

Content and Format

Participants found the content and format of the session effective, particularly in how the practical activities were integrated with the theoretical content. However, the technical details could be overwhelming, suggesting a need for a more streamlined approach to this aspect of the content. Both interviewees appreciated the practical aspects of the workshop, particularly the hands-on experience with 3D printing. One of the participants highlighted the value of “getting active” and physically creating a small 3D print, which she found engaging. Another participant, on the other hand, found working with Tinkercad particularly beneficial and valued the opportunity to experience the learning process from a student’s perspective: "Especially with the Tinkercad and how you can then, well for me it was also interesting to try it out from the student role, because I only ever fight as a teacher."

This indicates that the session effectively contributed to the participants' content knowledge and practical skills in 3D printing.

The observer concurred with the participants that the content was appropriate and effective and that there was a good balance between theory and practice. However, the observer also noted that simplifying the technical information could enhance the overall learning experience. One of the teachers in fact mentioned that the session sometimes included overly technical details, which she found overwhelming. This suggests that while the session was effective in many areas, the complexity of the technical content may have hindered some participants' understanding or engagement.

"I think what I liked was that we actually got active ourselves and made a small 3D print ourselves…. And before that, it was particularly the case that it sometimes drifted into overly technical details for me personally. What kind of pressure there is, how exactly it works, that’s just not my world." (Participant A)

The provider agreed with this point and concluded that the session was successful in its goals but recognized that simplifying the technical aspects would make the content more accessible and engaging for all participants.

The observer also pointed out the need for more introductory guidance on using Tinkercad, which would help participants transition more smoothly into the practical tasks.

Pedagogical Methods

The two teachers who were interviewed highlighted the effectiveness of the hands-on approach. One teacher's experience with Tinkercad from a student's perspective emphasized the importance of teachers understanding the learning process from their students' point of view, which can inform and improve their pedagogical approaches.

The observer agreed that the pedagogical methods used were appropriate, particularly the combination of theory and practice. However, like the participants, the observer noted the need for more introductory guidance to support the practical application of Tinkercad.

The provider reflected positively on the use of interactive and practical methods but recognized the need to balance these with more accessible explanations of technical content.

The session was effective in engaging participants and enhancing their content knowledge and practical skills, particularly in the context of 3D printing and its applications in teaching. The hands-on approach and practical engagement were highly valued by participants, though some found the technical details challenging. Both the observer and the provider recognized the appropriateness of the pedagogical methods used but also noted areas for improvement, particularly in simplifying technical content and providing more introductory guidance.

6. Suggestions for Improvement

Simplification of the technical details presented in the workshop was a key recommendation, as some participants found the content too complex. A more guided introduction to the software (Tinkercad) was suggested to ensure participants were comfortable with the tools: "*I would have found it personally helpful if there had been a little introduction or demonstration, a tutorial on this Tinkercad*". Observers recommended more interactive elements during lectures and a better balance between technical content and practical application.

7. Transferability

Both the provider and observers found the hands-on approach to 3D printing workshops adaptable across various educational settings as "*3D printing is an easy tool to use and can be adapted in different contexts and lessons*." The emphasis on digital literacy, sustainability, and interdisciplinary learning makes the workshop relevant to different countries and educational systems as expressed by one of the observers: "*This was a really good example of an integrated STEM approach*."

Another observer noted that the objectives of the session themselves were also transferable to their context "*The original objectives were transferable to the needs of my class, and I only adapted the topic to fit with the needs of my class*".

5.3.5. Greece

1. Topic of the Session

The session focused on enhancing teachers' knowledge and skills in developing students' mathematical reasoning through a Lesson Study approach. Specifically, it aimed at guiding teachers in planning, implementing, and reflecting on research lessons in Geometry.

2. Learning Goals or Planned Learning Outcomes

The learning goals of the session were:

Enhancing Mathematical Reasoning: Teachers were expected to learn how their lesson planning and classroom actions can improve students' mathematical reasoning skills.

Understanding the Lesson Study Project: Teachers were to gain knowledge on how to collaborate with colleagues to enhance students' mathematical reasoning through the Lesson Study approach.

Planning a Research Lesson: Teachers were guided to organize and plan a Research Lesson Study focused on Geometry.

Defining and Assessing Goals: The session aimed to help teachers define a clear research goal, identify case students, and assess and reflect on the outcomes of the implemented research lesson.

3. Structure of the Session and Activities Involved

The session was structured into three main parts:

a. Online Design Meeting: This initial meeting focused on planning the lesson. The objectives were to help teachers set the lesson goal, translate this goal into specific learning activities, and ensure that the lesson focused on student

reasoning. The meeting encouraged discussion and pedagogical argumentation among the participants.

b. Classroom Implementation: Teachers attended the implementation of the designed lesson in a classroom setting. This allowed them to observe the lesson in action and gather data on how students engaged in mathematical reasoning.
c. Online Reflection Meeting: The final session was a reflection meeting where teachers identified key episodes from the lesson to reflect upon. They discussed critical classroom incidents, the suitability of the learning activities, and how well the teacher's actions supported student reasoning. Teachers then drew conclusions about the lesson's success, interpreted evidence, considered implications beyond the lesson, and shared their findings with the group.

4. Philosophy Reflected

The session reflects a constructivist educational philosophy, emphasizing active learning through reflection, collaboration, and practical application. It also aligns with social constructivist principles, as it encourages collaborative work among teachers and focuses on improving teaching practices through peer interaction and shared experiences. The use of a Lesson Study approach suggests a philosophy that values continuous improvement in teaching through iterative cycles of planning, observing, and reflecting.

5. Effectiveness of the Session

Content and Format

The content of the session was seen by teachers as relevant and practical, particularly in terms of its applicability to classroom settings. Teachers appreciated the focus on developing new classroom practices and supporting mathematical reasoning, which are directly relevant to their everyday teaching. Teacher C noted that they learned to provide more time for students to complete tasks, which allowed all students, including those who were typically slower to engage, to participate fully.

"I've learned about new ways of mathematical thinking; ideas about using different type of teaching materials e.g., tablets and manipulatives; ideas on how to provide more time to my students [...] Usually in my classroom I ask my students in 15 minutes to complete the given task. So the five high achievers are raising their hands and start talking. The other ten will be left behind. On the other side, teacher B provided them more time to work on a task. I have noticed (Teacher C was an observer in Teacher A's class) that all the children were inspired and had time and students who were usually lazier at the beginning slowly took it up and participated and I saw a very nice work of the children, all the children. This is rare. Thus, tomorrow in my class I'll provide students more time to collaborate and to inquire. (Interview with Teacher C).

This suggests that the session was effective in promoting more inclusive teaching practices that cater to different learning paces.

Teacher A highlighted that the session contributed to their understanding of mathematical reasoning, particularly inductive and deductive reasoning. This indicates a growth in the teacher's content knowledge and epistemological beliefs about how mathematical reasoning develops in students. Teachers also developed ideas about how to support mathematical reasoning in the classroom. Teacher A mentioned that digital tools and group organization could be beneficial strategies, suggesting that the session was effective in expanding teachers' pedagogical content knowledge. Teachers also reported improved ability to notice and understand students' behaviors during tasks. For example, Teacher A became more aware of why a particular student was consistently behind others, indicating an enhancement in their observational skills and reflective practices.

According to the observer the format of the session, which included structured discussions, reflections, and feedback, was seen as inclusive and conducive to learning. The opportunity for teachers to share and reflect on their experiences with colleagues was particularly valued.

The provider reflected positively on the content delivery, noting that the session's objectives were met and that the discussions were both lively and constructive. This suggests that the content and format were well-suited to the needs of the participants.

Pedagogical Methods

Teachers like Teacher A and Teacher C appreciated the pedagogical strategies discussed in the session, such as providing more time for students and using digital tools to support learning. These methods were seen as effective in fostering student engagement and developing mathematical reasoning.

The session encouraged teachers to reflect on their own teaching practices and those of others, which was appreciated by the participants. The structured reflection activities, such as discussing student responses in notebooks, were particularly valued.

Observers were impressed by the way the educator facilitated the session, particularly in how they encouraged discussion and provided timely and constructive feedback. The pedagogical approach of promoting open discussion and reflection was seen as effective and something the observers wanted to incorporate into their own CPD sessions. The provider agreed that the facilitation methods were successful, particularly in fostering discussion and debate.

Observers also valued the opportunities for reflection and the chance to discuss teaching practices with colleagues from different backgrounds, which they found particularly beneficial for in-service teachers. They appreciated how the educator facilitated reflection by sharing a student's notebook and encouraging participants to consider how they might have approached the situation differently.

The session was effective in developing teachers' classroom practices, enhancing their understanding of mathematical reasoning, and promoting reflective practice. Participants valued the practical strategies and the opportunity to engage in reflective discussions. Observers appreciated the inspiring facilitation and the structured reflection activities, which they found particularly beneficial for in-service teachers. The educator reflected positively on the session's outcomes, noting that the primary objectives of discussion and idea exchange were successfully achieved. Overall, the session contributed to the growth of teachers' pedagogical content knowledge, their ability to notice and reflect on student learning, and their confidence in implementing new classroom practices.

6. Suggestions for Improvement

Suggestions were made to give more attention to the role of representational tools in teaching and learning (e.g., Geogebra). The use of intentionally incorrectly solved problems was proposed to stimulate argumentation and reasoning during lessons: "*We would include intentionally wrong solved problems in the trial*" (Provider).

7. Transferability

The session was highly transferable in terms of content and pedagogy employed. The session focused on mathematical reasoning, which can be applied in various countries and educational settings, given its generality: "*As mathematical reasoning can be included in any mathematical activity, it was very easy to transfer it to another country*." (Provider) An observer pointed out that they: "… did not realize the affordances of MathCityMap for this, before and consider argumentation and reasoning as a crucial skill for a citizen in a democratic country."

The potential need for adaptation for different pedagogical content knowledge was noted. In addition, transferring the 'lesson study' approach may be challenging when working with teachers unfamiliar with lesson study methods.

5.3.6. Lithuania

1. Topic of the Session

The session focused on the study of enzymatic reactions, particularly the pectinase enzyme, and its practical applications in biological research and the food industry. The session explored the impact of environmental factors on enzyme activity and aimed to refine participants' practical skills in designing and conducting laboratory experiments.

2. Learning Goals or Planned Learning Outcomes

The learning outcomes for the session were:

Understanding Enzymatic Reactions: Participants were expected to understand how enzymatic reactions work and how they are affected by environmental factors.

Experimentation and Analysis: Teachers were to conduct experiments to optimize juice extraction using the pectinase enzyme and apply statistical methods commonly used in biological research.

Application of Knowledge: The session aimed to help participants discover practical applications of the pectinase enzyme, particularly in the food industry.

Skill Development: The main objective was to enhance teachers' theoretical understanding and practical skills in designing and executing laboratory work.

3. Structure of the Session and Activities Involved

The workshop was structured into six phases with specific activities:

a. Introduction and Safety Briefing (5 minutes): Participants were briefed on safety protocols and familiarized with the working environment and necessary equipment.
b. Setting Goals and Hypothesis (5 minutes): Participants defined the goal and hypothesis for the experiment.
c. Designing the Experiment (15 minutes): Participants used the provided tools to design a test procedure to compare the effect of the pectinase enzyme on apple cell walls, documenting their progress.
d. Determining Optimum Temperature (60 minutes): Participants conducted experiments to determine the optimum temperature for pectinase activity, using three different temperatures and recording the results.
e. Optimizing Enzyme Use (60 minutes): Participants calculated the minimum amount of enzyme required to achieve the highest juice yield, supporting their findings with mathematical calculations.
f. Final Exercises and Discussion (15 minutes): The session concluded with a discussion, answering questions, and sharing results to make a collective decision on the best approach.

4. Philosophy Reflected

The session reflects a constructivist educational philosophy, emphasizing hands-on, experiential learning where participants actively engage in the process of scientific inquiry. The focus on experimentation, collaboration, and problem-solving aligns with inquiry-based learning principles, where learners construct knowledge through exploration and application of concepts in real-world contexts. The collaborative group work and shared decision-making give students opportunities to learn from each other's perspectives and experiences.

5. Effectiveness of the Session

Content and Format

Participants described the session as structured and comprehensive. The focus on both theoretical knowledge and practical application was particularly appreciated. TF3 felt inspired by the workshop's structure: *" … which focused on hands-on activities and collaboration, showed me how to effectively engage students and motivate them to learn. It really inspired me to use different learning methods and create a conducive learning environment." (TF3).* The session covered not only the principles of laboratory work but also provided insights into the functioning of enzymes, statistical data processing, and the economic aspects of enzyme use.

After the workshop, TF2 expressed increased confidence in using new technologies and addressing diverse issues in the STEM classroom. This suggests that the session was successful in equipping participants with the skills and knowledge needed to apply what they learned in their own teaching contexts. Participants also felt more confident and competent in addressing sustainability issues and applying green skills. TF2 also noted an increased awareness of diversity issues in STEM classrooms, indicating that the session was effective in enhancing teachers' awareness and capability to address these topics in their teaching.

Observer EO2 saw the content as adaptable to their own teaching needs, indicating that the session's format and content were not only effective in the immediate context but also had potential applications in other settings.

Participants found that the content of the seminar was well-aligned with their expectations as biology teachers.

Pedagogical Methods

Participants found the teaching style and methods to be very effective and engaging. The use of varied presentation styles and balanced content allowed them to learn from different perspectives, which is consistent with STEM principles. Participant TF2 noted that group work allowed teachers to share ideas, experiences, and learning, fostering

cooperation and creativity. This indicates that the session's pedagogical methods were effective in promoting collaboration and active learning.

Participants recognized the importance of collaboration in the session. EO2 specifically mentioned that collaboration was not only important for the task at hand but also for teaching students how to work together, which is vital for the specific task. This reflects the session's emphasis on cooperative learning as a core pedagogical strategy.

"Collaboration was the key to the activity not only because it is important for students to learn to collaborate with others but because it was vital for the specific task. They had to figure out the ideal technique and everyone to follow it." (EO2)

Observer EO2 too appreciated the cooperative learning format used in the session and noted its potential adaptability for their own teaching context. However, EO2 also mentioned class size as a potential restriction, which suggests that while the methods were effective, their implementation might require adjustments depending on the teaching environment.

The session was highly effective in expanding teachers' content knowledge, particularly in the areas of biology, enzyme function, and statistical data processing. The hands-on, practical approach was particularly valued, as it allowed participants to actively engage with the material and apply their learning. The pedagogical methods, including group work and collaboration, were well-received and seen as conducive to cooperative learning. Both participants and observers recognized the value of the session's content and format, with many expressing confidence in their ability to apply the new knowledge and skills in their teaching practice. The session was also seen as adaptable to different teaching contexts, though some adjustments might be necessary based on class size or other logistical factors. Overall, the session contributed to the development of teachers' practical skills, confidence, and pedagogical content knowledge.

6. Suggestions for Improvement

Teachers suggested including time for individual work and exchanging experiences, allowing participants to apply what they had learned in their own context.

When transferring the session, some adaptations were needed to align with local conditions, such as laboratory access and student backgrounds.

7. Transferability

The workshop was considered highly transferable across different educational contexts, particularly due to its emphasis on hands-on activities. Observer EO1 reflected that "The topic is universal, so it can be transferred to many different contexts."

However, access to lab facilities can be a limiting factor in some institutions. Observer EO2: "*The main difficulty experienced was the unavailability of a lab, so it was not possible to transfer the whole session*."

5.3.7. Malta

1. Topic of the Session

The session focused on designing a scheme of work for the topic of flotation in physics. The purpose was to guide pre-service teachers (PSTs) in creating a lesson plan using given resources, without relying on prior experiences. The session also incorporated discussions on pedagogical knowledge (PK) and pedagogical content knowledge (PCK), emphasizing the application of these concepts in lesson planning.

2. Learning Goals or Planned Learning Outcomes

The learning outcomes for the session were for students to be able to:

Design a Logical and Sequenced Scheme of Work: Students were expected to create a scheme of work that is logical, well-structured, and includes a clear sequence of lessons.

Ensure that the Scheme of Work is comprehensive: The scheme of work should include an overview of course content, teaching methods, expected learning outcomes, assessments, and resources.

Adapt to Learners' Needs: Students should be able to design a scheme of work that is appropriate for the learners' age, abilities, and the school context.

Justify Pedagogical Decisions: Students should justify their decisions and choices in lesson planning by applying relevant educational theories, particularly those related to continuity, progression, cognitive development, and learning theories.

3. Structure of the Session and Activities Involved

The session was structured as follows:

a. Introduction: The session began with an introduction to the topic of flotation within the context of curriculum objectives, learning experiences, and evaluation.
b. Task for Students: Students were tasked with sequencing a series of sub-topics or activities related to flotation and justifying their choices.

c. Criteria for Sequencing: Students shared their sequences and discussed the reasons behind their choices. The discussion also explored the link between the sequencing, the Nature of Science, and personal teaching philosophies.
d. Discussion on Continuity: Planning for continuity in the lesson sequence was discussed.
e. Discussion on Progression: The session included a discussion on planning for progression in learning.
f. Reflection: Students were encouraged to reflect on their sequence and consider any changes based on the discussions.
g. Introduction to the Scheme of Work Document: The process of preparing a detailed scheme of work document was introduced.
h. Final Task for Students: Students were asked to return to their scheme of work and fill in the first row for the first lesson, incorporating what they had learned.

4. Philosophy Reflected

The session reflects a constructivist educational philosophy, where students (PSTs) actively engage in creating their own understanding and solutions through hands-on activities and reflective discussions. The focus on sequencing lessons and justifying decisions using educational theory aligns with a reflective practice approach, emphasizing the importance of thoughtful and evidence-based teaching methods. The integration of pedagogical knowledge (PK) and pedagogical content knowledge (PCK) into the session highlights the value placed on informed, research-based teaching practices.

5. Effectiveness of the Session

Content and Format

PSTs found the content of the session highly relevant and applicable to their future teaching careers. The focus on lesson sequencing, understanding different teaching strategies, and the importance of a scheme of work were all seen as essential components of their training.

The session's format, which included both theoretical discussions and practical exercises, was effective in helping PSTs understand and apply the concepts being taught. Pre-service teacher, P2, for example, mentioned that the session's focus on structuring lessons would be directly applicable when she begins teaching as it helped P2 in seeing *"how I'm going to divide that topic in a certain way, not I just write for example the different chapters to be covered. There should be a certain order and how to do it."* Such an approach *"might make teaching easier or more efficient… it might help the students understand the concepts more because it's like you're breaking them down. I think it will help them grasp the concepts more, especially in science there's quite a lot of concepts to understand." (P2)*

Observers appreciated the comprehensive nature of the session, which covered both content knowledge and pedagogical strategies. Observer, O1, specifically noted how the session met her expectations and expanded her understanding of teaching-learning sequences and the importance of continuity and progression in lesson planning. Similarly, observer, O2, said

"The sequencing activity is highly relevant in science education since there are lots of different teaching activities in the sciences (e.g. experiments, lab, field work, demonstrations), in addition to the more traditional lectures, textbook tasks etc. Thus, it is very important for science teachers to be aware of how they structure their sessions." (O2)

The session was particularly effective in helping PSTs develop their PCK, especially in lesson sequencing. PSTs recognized the importance of organizing content logically and pedagogically to facilitate student understanding. For instance, P2 mentioned learning how to divide topics effectively, making teaching easier and helping students grasp concepts more thoroughly. This indicates a growth in their understanding of how to sequence and structure lessons.

The session also played a role in exposing and challenging the PSTs' beliefs about teaching and learning. P1, for example, was surprised to learn that the same topic could be delivered using different sequences, which challenged her previously held belief that there was only one "correct" way to structure a topic. This reflection on different teaching approaches contributed to a deeper understanding of pedagogical flexibility. The session enhanced the PSTs' awareness of different teaching strategies. P1 and P2 highlighted how the session helped them see the value in various approaches, such as whether to start with theory or with practical experiments, and how these choices reflect underlying beliefs about teaching and learning and about their beliefs of the Nature of Science.

Both PSTs appreciated learning about the importance of a scheme of work, which they had not previously understood. Pre-service teacher, P2, emphasized the necessity of a scheme of work for effectively planning lessons throughout the academic year, indicating that this session provided essential practical knowledge for their future roles as teachers.

Observers found the session beneficial for their own professional development, particularly in learning about sequencing activities in lessons. O2 noted that she became more aware of the criteria for sequencing and how it is applied in science education, which was not typically covered in her previous training. This suggests that the session was effective in broadening the observers' pedagogical knowledge as well.

Observers appreciated the session's focus on practical and theoretical integration. O1 mentioned learning about the importance of connecting students' contexts with the topic, using key questions to stimulate reflection, and building a dialogue between the teacher and students. This indicates that the session was effective in showcasing effective teaching strategies.

Pedagogical Methods

The session was appreciated for its ability to expose PSTs to different teaching approaches, such as varying the sequence of theory and practice. P1 and P2 both reflected on how this exposure broadened their understanding of how to structure lessons and adapt teaching methods to different contexts.

The hands-on nature of the on-line session, which involved exercises like sequencing activities, was particularly effective in helping PSTs internalize the concepts being taught. This practical engagement was important for developing their PCK and understanding of effective lesson planning.

Observers found the session's pedagogical methods to be insightful. Observers O1 and O2 both noted that the session provided them with new perspectives on teaching strategies, particularly in the context of sequencing and lesson planning which could be easily transferred. Observer O1 specifically mentioned the value of watching the lecturer connect content with student contexts and using reflection to deepen understanding.

The session provider (L) reflected positively on the session, noting that the main objectives—such as developing PSTs' PCK through lesson sequencing and challenging their beliefs about teaching—were successfully met. This indicates that the session's pedagogical methods were well-aligned with its goals.

"The idea behind the session was to improve STEM learning by making sure that the future teachers do not simply look at the syllabus as a list of topics that they need to somehow cover. It was intended to show them how sequencing can depend on complexity of ideas, can target motivation, can encourage inquiry and reasoning by doing experiments first and then the theory. It also intended to improve STEM learning by reflecting on continuation and progression, students' needs and interests. It was also meant to start introducing (more will be done in other study units) them to the need to involve pupils in reasoning and thinking and to develop these skills." (L)

The session was effective in developing PSTs' PCK, particularly in lesson sequencing and challenging their preconceived beliefs about teaching and learning. The practical exercises and discussions were well-received, providing valuable insights into different teaching strategies and the importance of structuring lessons effectively. Observers also

benefited from the session, gaining new perspectives on lesson sequencing and teaching strategies. The content and format of the session were well-suited to the participants' needs, effectively bridging theoretical knowledge with practical application. Overall, the session contributed to the professional growth of both the PSTs and the observers, equipping them with the tools and knowledge needed for effective teaching.

6. Suggestions for Improvement

The lecturer (provider) suggested using group work or pair work to encourage collaboration and knowledge exchange among students: "I would use group work so that students have the opportunity to discuss and learn collaboratively" (L). The students, however, did not identify any major issues, expressing overall satisfaction with the session: "I don't really see anything that was wrong or anything" (P2).

7. Transferability

Both the provider and observers agreed that the session on developing a scheme of work could be transferred across different countries: "*The structure and most of the content is applicable to other countries and other contexts*" (Lecturer). The observers agreed: "*I chose to observe this session since I think the topic addressed is highly transferable and useful for my students*." (O1)

They recognized the universal principles of preparing a scheme of work but emphasized the need to adapt certain pedagogical approaches and scientific content to fit specific educational contexts.

5.3.8. Netherlands

1. Topic of the Session

The session focused on understanding and exploring the role of ChatGPT, in mathematics education. The session was divided into three main areas: the mathematics behind ChatGPT, assessing ChatGPT's ability to solve mathematical problems, and exploring the potential uses of ChatGPT in a math classroom setting.

2. Learning Goals or Planned Learning Outcomes

The learning goals for the session included:

Understanding the Mathematics Behind ChatGPT: Participants were expected to gain insight into the mathematical principles and processes underlying ChatGPT, including how it was developed and how it generates responses.

Evaluating ChatGPT's Mathematical Capabilities: Participants were to assess how effectively ChatGPT can solve mathematical problems, including identifying its limitations and errors.

Exploring Educational Applications: The session aimed to help participants explore ways to integrate ChatGPT into math teaching, including using it to generate problems and engaging students in correcting the chatbot's solutions.

3. Structure of the Session and Activities Involved

The session was structured into three main parts:

a. Introduction to ChatGPT and its Mathematical Foundations:

The session began with an introductory question about the meaning of the abbreviation "GPT".

Participants were presented with ChatGPT's explanation of how it works, which was then broken down and illustrated with visual aids to explain machine learning concepts like input, output, layers, and weights.

b. Evaluating ChatGPT's Mathematical Performance:

The second part featured a short video showing a humorous interaction between ChatGPT and a speaker, where the chatbot struggled with a math problem.

Participants were then given examples of mathematics problems generated and solved by ChatGPT. They worked in small groups to evaluate whether the problems made sense and whether the solutions provided by ChatGPT were correct.

c. Discussion on Using ChatGPT in Math Education:

The session concluded with a discussion about the potential uses of ChatGPT in teaching math.

4. Philosophy Reflected

The session reflects a constructivist and inquiry-based learning philosophy, where participants actively engage with the content through exploration, discussion, and critical analysis. The interactive format of the session, especially the group work and discussion elements, encouraged participants to construct their own understanding of ChatGPT's capabilities and limitations in the context of mathematics education. Additionally, the focus on critical thinking—evaluating and correcting ChatGPT's outputs—aligns with critical pedagogy, which emphasizes teaching students to question and analyze information critically.

5. Effectiveness of the Session

Content and Format

The observer found the content of the session highly relevant to current educational needs. The focus on understanding ChatGPT's capabilities, and more importantly, its limitations, is crucial as it prepares educators to deal with the potential influx of AI-generated student work. This session was not just about the technical aspects of ChatGPT, but also about its pedagogical implications.

The observer found it particularly insightful that the mistakes made by ChatGPT in solving mathematics problems closely resembled the errors typically made by students. This observation suggests another practical implication of using AI tools like ChatGPT in education.

The observer strongly emphasized the relevance of the session's topic to modern teaching practices: *"I believe the topic is highly relevant to teaching. Even if teachers do not intend to use ChatGPT in their work they need to know about it because for sure some students will use it."*

Pedagogical Methods

The observer was inspired by the engagement with relevant educational tools. The session was designed to engage participants with the practical realities of AI tools in education. By drawing direct connections between AI-generated mistakes and typical student errors, the session highlighted the relevance of AI to the teaching profession. This method of teaching is closely tied to real-world applications, making it effective for engaging educators with new technological tools.

6. Suggestions for improvement

The provider commented that the hands-on part of the workshop is "tricky since ChatGPT is not always running/available". They thought that it would be nice to show that you can get different answers when making the same query. The provider admitted that it would take more time and that it is best to have something at hand as an alternative just in case.

The teachers suggested fewer, but longer time slots for collaborative work during the session. They also asked for a follow-up session building on their experiences with ChatGPT.

7. Transferability

The observer felt that it was easy to transfer this workshop perhaps extending it with experiences of teachers who already use ChatGPT in class or a video of students working with ChatGPT in mathematics.

5.3.9. Norway

1. Topic of the Session

The session focused on enhancing pre-service teachers' questioning techniques and improving classroom dialogue to support inquiry-based learning. It emphasized the development of pedagogical knowledge (PK) and pedagogical content knowledge (PCK) related to effective questioning strategies and conversation patterns in the classroom.

2. Learning Goals or Planned Learning Outcomes

The learning outcomes for the session were:

Improve Classroom Dialogue: Participants were expected to improve their ability to facilitate effective dialogue in the classroom, particularly by using well-prepared and varied questioning techniques.

Improve Inquiry-Based Approaches: The session aimed to increase the degree of inquiry-based approaches in schools by helping pre-service teachers create environments where students can explore scientific concepts through dialogue and questioning.

Build Confidence in Facilitating Exploratory Talk: The session sought to enhance participants' confidence in leading exploratory conversations, where students engage deeply with the material through inquiry and discussion.

3. Structure of the Session and Activities Involved

The session was structured around several activities:

Introduction to Questioning: The session began with an introduction to the principles of effective questioning, including why questions are important, what types of questions promote exploratory work, and common mistakes teachers make when asking questions.

Exploratory Activity ("The Box"): One activity involved students trying to determine the contents of a box through exploratory questioning, fostering an inquiry-based approach.

Role Plays and Conversation Patterns: Participants engaged in role plays to practice different conversation patterns (e.g., IRE—Initiate-Response-Evaluate, IRPRP—Initiate-

Response-Prompt-Response-Prompt). They also reflected on various types of talk, including cumulative, disputational, and exploratory talk.

Cooperative Learning: Participants worked in small groups of 3-4 to practice and reflect on the questioning techniques and conversation patterns introduced during the session. This cooperative learning approach allowed them to apply the concepts in a collaborative setting.

4. Philosophy Reflected

The session reflects a constructivist educational philosophy, emphasizing active learning through role plays, group work, and reflection. The focus on exploratory talk and inquiry-based learning aligns with social constructivist principles, where learning is seen as a social process that occurs through dialogue and interaction. Additionally, the session's emphasis on practicing and refining questioning techniques in a collaborative environment highlights the importance of reflective practice in teaching, where teachers continuously improve their skills through active engagement and feedback.

5. Effectiveness of the Session

Content and Format

The content exceeded observers' expectations by including more than anticipated, particularly in the areas of discourse patterns and communication approaches within inquiry-based science education:

I had no prior knowledge that the course content would include discourse patterns and communication approaches within the context of inquiry-based science education. I expected to learn how another country approaches inquiry-based learning at the undergraduate level and how they impart this understanding to teacher candidates. The course exceeded my expectations because, in addition to inquiry-based science education, it also covered content related to discourse patterns, communication approaches, and types of talk. (Observer 1)

The session provided a comprehensive learning experience, offering valuable insights into both content and pedagogy. The content was highly relevant to the participants' future roles as teachers. The focus on questioning techniques, discourse patterns, and communication approaches was directly applicable to their daily work. Participants recognized the importance of these skills in enhancing the quality of inquiry-based learning and adapting teaching methods to better support student learning, gaining an "*insight into how to make the learning material interesting. In my job as a teacher, I want to plan the lessons as done on this course*".

The students felt more aware of the importance of dialogues and questioning by the end of the session, indicating growth in their didactical knowledge. This self-awareness

reflects the session's effectiveness in enhancing their understanding of how questioning and dialogue can be used as tools in teaching. Participants realized the critical role that asking the right kind of questions plays in teaching. This realization indicates the session's success in imparting practical skills. One of the observers emphasised the relevance of the topic pointing out that "*the ability to ask questions and to use questions as a mediating tool is central to a teacher's teaching skills. This art is something that teachers need to continuously practice regardless of the subject …*"

The course content was deemed suitable for developing students' PCK. The growth in PCK indicates that students were able to connect theoretical knowledge with practical application, enhancing their overall teaching competence.

Pedagogical Methods

The session's use of group activities, role-playing, and whole-class discussions was highly effective in enhancing learning and reflection. According to the session provider, these methods encouraged participants to actively engage with the material, reflect on their learning, and apply it in practical scenarios. The interactive nature of these activities helped solidify the participants' understanding of discourse patterns and questioning techniques.

The pedagogical approach that combined short plenary lectures with active group work was well-received. This method allowed students to learn more effectively through participation and collaboration, rather than passive listening. The positive feedback on the role plays and group discussions highlights the importance of interactive learning experiences.

One of the observers reflected that the variation in teaching methods was crucial for including all students in the learning process. By presenting the content from multiple perspectives and varying the instructional methods, the session effectively reached a diverse group of students. This approach ensured that all students could engage with the material, regardless of their preferred learning styles.

According to one of the observers, the lesson was well-planned and organized, with clear instructions and a well-paced structure. The explicit communication of the lesson plan helped build students' confidence and facilitated a smooth learning experience, despite the high number of activities. This structured approach was crucial in maintaining student engagement and ensuring the effectiveness of the session.

6. Suggestions for Improvement

Participants requested more time for exercises, role-playing, and plenary reflections. The provider stated: “I feel that we should have given this topic more time. I would have liked to give the pre-service teachers even more exercises” (L).

There was a suggestion to include tasks that are less open-ended. Another suggestion was to provide examples of other types of interactions for comparison during role-play activities: “Maybe try different tasks for the role plays” (L).

7. Transferability

The general nature of the course content made it easily transferable across contexts. The teaching strategies and styles, which emphasized inquiry-based learning, discourse patterns, and communication approaches, were also seen as adaptable to other settings.

One of the observers concluded that: “*Everything from this session could be adapted and transferred as it’s not context-based knowledge but universal practice*.”

5.3.10. Slovakia

1. Topic of the Session

The session focused on mathematical proofs, specifically three different proofs of formulas for Catalan numbers. It aimed to deepen students' understanding of these proofs, their relationships, and how to apply the concepts to other mathematical situations. Additionally, the session introduced the concept of a "thinking classroom" and emphasized collaborative problem-solving in mathematics.

2. Learning Goals or Planned Learning Outcomes

The learning goals for the session included:

a. Performing and Understanding Proofs: Students should be able to perform three different proofs of formulas for Catalan numbers and explain the relationships between these proofs.
b. Applying Proof Techniques: Students should apply the idea of proof to other isomorphic situations, demonstrating the equivalence of different formulas.
c. Mathematical Inquiry: Students should understand what it means to “work as a mathematician” and explain the steps of mathematical inquiry.
d. Thinking Classrooms: Students should be familiar with the concept of a "thinking classroom" and understand the rules that govern it.

e. Collaboration in Problem-Solving: Students should appreciate the role of collaboration in solving mathematical problems, recognizing its importance in the learning process.

3. Structure of the Session and Activities Involved

The session was structured over two weekly meetings

First Session:

Group Work: Students were divided into groups of 2-3 members, with a total of 9 groups. Each group was assigned one of the three proofs of Catalan numbers, along with three hints to guide their approach to the proof.

Thinking Classroom Setup: The session utilized a "thinking classroom" approach, where students worked on whiteboards, and the groups were organized visibly and randomly.

Collaboration and Summary: After the first session, students had a week to summarize their work and share their findings with other groups that were working on the same proof.

Second Session:

Presentations: Each group presented their findings to the class. During these presentations, other groups could ask questions to gain a detailed understanding of the proofs.

Lecturer's Role: The lecturer provided additional information, posed further questions to both the presenters and the audience, and guided the discussion.

Application of Proofs: After the presentations, students were asked to apply their proof techniques to other isomorphic situations. The lecturer presented two possible applications.

Assessment: Each group was required to submit their proof as an assessed piece of work for the course.

4. Philosophy Reflected

The session reflects a constructivist educational philosophy, where students actively construct knowledge through collaboration, problem-solving, and hands-on activities. The use of a "thinking classroom" aligns with the social constructivist approach, emphasizing the importance of social interaction and collaboration in learning. The session also reflects the philosophy of inquiry-based learning, encouraging students to engage deeply with mathematical concepts, explore different methods of proof, and apply their understanding to new situations.

5. Effectiveness of the session

Content and Format

The content of the session was well-aligned with the needs of the participants and covered all necessary aspects of the topic, as one participant noted “The session was excellently structured, and the content covered all the necessary aspects. Teacher was knowledgeable and supportive, ensuring that all participants received ample opportunities to grasp the concepts. Overall, it was a well-rounded experience that exceeded my expectations”.

The balance between direct instruction and collaborative activities was particularly effective in maintaining engagement and ensuring that all participants had the opportunity to contribute and learn.

Participants appreciated the well-rounded nature of the session, noting that it was both structured and flexible enough to allow for personalized learning. The teacher’s knowledge and supportive approach were key factors in the session’s success. The opportunity to engage in collaborative exercises, observe different approaches, and receive constructive feedback was particularly valued by the participants.

The session was described as effective in contributing to both teachers’ content and pedagogical knowledge. The structured approach, starting with an illustrative problem followed by the review of definitions and proofs, allowed participants to deeply engage with the material. This method not only clarified the mathematical concepts but also enhanced the teachers' understanding of how to present complex topics effectively. The opportunity to work with hints while the lecturer was engaged with other groups ensured that all participants were continually involved in the learning process.

The session emphasized the importance of reasoning and provided personalized feedback. The ability to listen to students' reasoning and tailor feedback accordingly is a key skill for teachers, and this session provided a practical example of how to develop this skill. The participants were able to see firsthand how to manage classroom discussions and support individual learning, which would directly benefit their classroom practice.

The session's structure, which encouraged collaboration among students, the use of thinking classrooms, where students share with other groups and support each other, enhanced student engagement and learning. This approach not only fosters a

collaborative learning environment but also allows teachers to focus on providing targeted feedback, thus improving the overall classroom dynamic.

The method used by the lecturer, which involves starting with a problem and then reviewing definitions and proofs, challenges traditional teaching methods and encourages a more inquiry-based approach. The participants' feedback suggests that they found the session motivating, as it provided them with practical strategies that they could implement in their own teaching.

The collaborative exercises and the opportunity to observe and provide feedback on each other's approaches contributed to the development of self-reflection skills among the participants. Being able to critique and refine their own teaching methods based on peer feedback is a valuable outcome of the session.

Pedagogical Methods

The pedagogical methods used in this session were well-received by both the participants and the observers. The structured approach, which began with an illustrative problem and included the use of hints and group work, was seen as effective in engaging students and deepening their understanding. The ability of the lecturer to provide personalized feedback was particularly valued, as it allowed for a more tailored learning experience.

The use of collaborative exercises was highlighted as a key strength of the session. This approach not only allowed participants to engage with the material more deeply but also provided opportunities for peer learning. The ability to share and discuss different approaches within the group helped to reinforce the concepts being taught and encouraged a deeper level of understanding. One of the students said "*We learned more than if only one student or the teacher would calculate on the board in a seminar. I think it was also better that we counted on the board and not on paper, I was better able to concentrate on the example*".

The lecturer's teaching style, which involved guiding students through their reflections and encouraging a collaborative approach to problem-solving, was also viewed positively, "*During the session we actively engaged in collaborative exercises, observed each other's approaches, and provided constructive feedback*".

The session was effective in meeting its learning objectives and in contributing to the professional development of the participants. The combination of well-structured content, effective pedagogical methods, and a supportive learning environment ensured that participants left the session with a deeper understanding of the subject matter and practical strategies that they could apply in their own teaching. The positive

feedback from both participants and observers indicates that the session was successful in promoting growth in teachers' content knowledge, pedagogical knowledge, and classroom practice.

6. Suggestions for Improvement

The hints provided during the session were reformulated for clarity, as participants struggled with their understanding. One participant stated that: “despite the hints, I felt like we were getting more lost, but at least together as a group” (Participant).

7. Transferability

While the observer noted certain logistical challenges (such as larger class sizes, lack of resources and room setups), the collaborative group-work format used in the session was seen as adaptable to other contexts.

5.3.11.Spain

1. Topic of the Session

The session focused on the role of STEM (Science, Technology, Engineering, and Mathematics) education in promoting environmental citizenship. It aimed to explore how effective teaching strategies and transformative educational interventions can help create well-informed and committed citizens who are prepared to address current environmental challenges.

2. Learning Goals or Planned Learning Outcomes

The learning goals for the session included:

Reflection on STEM Education: Participants were encouraged to reflect on the critical role of STEM education in developing citizens who can address environmental challenges.

Personal Reflection on Teaching and Learning: The session aimed to prompt participants to reflect on their own ideas about effective teaching and learning.

Identifying Features of Transformative Interventions: Participants were expected to identify key features of educational interventions that promote environmental citizenship.

Experiencing Different Teaching Strategies: The session provided an opportunity to experience various teaching strategies and ways of exploring, sharing, and co-creating knowledge.

Learning from Inspiring Initiatives: Participants were introduced to inspiring experiences and initiatives that address environmental issues.

Acquiring Knowledge and Tools: The session aimed to equip participants with key knowledge and tools to promote environmental citizenship through STEM education.

3. Structure of the Session and Activities Involved

The session was structured as follows:

a. Introduction with Climate Crisis News: The session began with the presentation of a recent news item about the climate crisis to raise interest and engage the audience.
b. Presentation of Inspiring Initiatives: Participants were introduced to initiatives like The European Network for Environmental Citizenship, which served as examples of efforts to address environmental issues.
c. Posing Challenges: Current challenges related to the topic were posed to the audience to stimulate critical thinking.
d. Shared Discussion and Reflection: The session included a collaborative discussion where participants reflected on the issues presented.
e. Review of Specialized Literature: Participants examined what could be learned from the specialized literature on the topic, providing a research-based foundation for the discussion.
f. Drawing Design Principles: The session involved identifying design principles for effective educational interventions based on research.
g. Presentation of an Educational Intervention: An example of an educational intervention that reflected the key design principles was presented to demonstrate how these principles can be applied in practice.

4. Philosophy Reflected

The session reflects a constructivist educational philosophy, where learning is seen as an active, reflective process. The focus on discussion, reflection, and the co-creation of knowledge aligns with social constructivist principles, emphasizing the importance of collaborative learning and the shared construction of understanding. The session also incorporates elements of transformative learning, aiming to change participants' perspectives on STEM education and its role in promoting environmental citizenship. By engaging participants in discussions about real-world challenges and drawing on research-based principles, the session also reflects an evidence-based approach to education incorporating “strategies to teach effectively and motivationally, and how to organize teaching” according to one of the participants.

5. Effectiveness of the Session

Content and Format

The content and format of the session were deemed highly suitable and effective by both participants and observers. The integration of climate change education with STEM and the use of varied pedagogical strategies ensured that the session was both informative and practically applicable. The focus on environmental citizenship and green competences aligned well with contemporary educational goals, making the session particularly relevant.

The session was described as thoroughly prepared and able to contextualize knowledge within broader scientific and social contexts. This approach not only made the content more engaging but also ensured that it was directly applicable to the teachers' professional practices. The structured format, which included a mix of content delivery and reflective discussion, was particularly praised for its effectiveness.

The session was highly effective in enhancing teachers' content knowledge, particularly concerning climate change and its broader environmental implications. Participant 1 (P1) highlighted that the session covered "*some content knowledge related to climate change and its implications on the generation of extreme meteorological phenomena, the loss of biodiversity, the alteration of ecosystems and the resilience of different populations towards change and crisis*." (P1)

The session also significantly contributed to teachers' pedagogical knowledge. It explored various teaching strategies, including Problem-Based Learning, Inquiry-Based Learning, Open Schooling, and Socio-Scientific Inquiry-Based Learning. These strategies are essential for educators aiming to integrate STEM education with environmental and sustainability education effectively. By discussing these methods, the session equipped teachers with practical tools to apply these approaches in their classrooms.

Teachers' pedagogical content knowledge was also developed, particularly in understanding how to effectively deliver STEM and sustainability education. One of the participants, P1, mentioned that the session explicitly discussed the challenges of achieving learning outcomes related to STEM and sustainability. This indicates that the session not only provided content knowledge but also offered insights into how this knowledge could be effectively taught, addressing specific challenges in these areas.

The session encouraged self-reflection among participants by addressing how to promote green competences and education for environmental citizenship:

"Yes, we discussed specific challenges related to the achievement of the learning outcomes related to STEM and sustainability education and how they should be addressed according to the specialised research" (P1).

Pedagogical Methods

The session was well-received by the participants, with P1 noting the exploration of various pedagogical strategies as a key takeaway. The discussion of challenges in achieving STEM and sustainability learning outcomes reflects an engagement with real-world teaching issues, which is crucial for effective pedagogy. The hands-on and/or minds-on approach to discussing specific strategies made the session practical and relevant to their teaching practice.

Observer 3 (O3) found the session to be *"very well-prepared, informative, and application-oriented. The lecturer gave a profound overview of integral perspectives of goals and challenges in Environmental Citizenship. Connections to STEM and actual topics were outlined well (e.g. COVID). The presented knowledge contextualized with "insights from science" was very nice"*.

This suggests that the pedagogical methods used were effective in delivering the content in a way that was both engaging and practically applicable. The connection of the session content to current issues like COVID-19 and its contextualization with scientific insights further enhanced its relevance and effectiveness.

The provider reflected that the session had successfully integrated various pedagogical strategies and content areas, making the session comprehensive and relevant.

The session was effective across multiple dimensions, including the development of teachers' content knowledge, pedagogical knowledge, and pedagogical content knowledge. The participants, observers, and the provider all viewed the session as successful in promoting self-reflection, addressing real-world teaching challenges, and equipping teachers with practical strategies for integrating STEM and sustainability education. The positive feedback on both the content and format suggests that the session was well-designed and met its intended educational objectives.

6. Suggestions for Improvement

Some participants expressed a desire for more time to work on topics, while others suggested offering the session in their national language instead of English (which was used to accommodate the observers).

An observer recommended changing the sequence of the session to begin with concrete examples and then discuss theoretical points: “He suggested presenting the example in the beginning and ending up by discussing how the example meets the designed criteria” (P1).

7. Transferability

The environmental education topic, which is inherently transdisciplinary and aligned with global priorities, made the session highly transferable to various educational systems. The observers noted that it could easily be integrated into their teaching practices with minor adjustments. One of the observers felt that the session: “*showed an open and understandable approach to Environmental Citizenship and in this sense is easy to be transferred*.”

Moreover, the provider pointed out that “it is based on international knowledge and a wide experience acquired through international collaborations, so it is very likely that it might be easily used in different countries.”

5.3.12.Sweden

1. Topic of the Session

The session, part of a five-week advanced-level course, focused on mathematics didactics for early childhood and primary education, specifically targeting preschool through grades 1-3 and 4-6. The course aimed to deepen students' understanding of mathematics teaching and learning through the lens of variation theory and other educational theories.

2. Learning Goals or Planned Learning Outcomes

The learning goals for the session were divided into three categories:

Knowledge and Understanding:

Explain mathematics didactic research relevant to early childhood education.

Describe and exemplify the principles of variation theory and how they can be applied in teaching and research.

Skills and Abilities:

Analyse and interpret students' understanding of specific mathematical content, identifying critical aspects.

Reflect on and design lessons that facilitate mathematics learning for all students.

Evaluation Ability and Approach:

Critically review and discuss mathematics teaching and learning from various theoretical and didactic perspectives.

Discuss and evaluate an intervention study using a variation theory perspective.

3. Structure of the Session and Activities Involved

The course was structured over five weeks and included the following activities:

Introduction by Lecturers: The course began with an introduction to variation theory by researchers, providing a theoretical foundation for the students.

Group-Based Lesson Planning and Implementation: Students worked in groups of 4-5 and planned to conduct two lessons with a pre-test and post-test. The students prepared for pupils in grades 106 depending on their specialization. The process involved:

Assessing the pupils' prior knowledge.

Planning and teaching a lesson based on the identified mathematical content.

Administering a post-test to observe what the pupils learned.

Revising the lesson based on the test results and teaching it again.

Conducting a final test to evaluate the revised lesson's effectiveness.

Poster Presentation: Students created posters to present the results of their study, which included data on student learning outcomes and insights from the revised lessons.

Job Shadowing: This occurred during two key phases—during the revision of the lesson plan and during the poster presentation—providing students with additional observational learning opportunities.

4. Philosophy Reflected

The session reflects a constructivist educational philosophy, particularly through the application of variation theory, which emphasizes the importance of variation in teaching to help students discern and understand critical aspects of mathematical concepts. The collaborative learning approach, with group work and peer presentations,

further supports social constructivist principles, where knowledge is co-constructed through interaction with others.

5. Effectiveness of the session

Content and Format

The provider views the five-week format as suitable for achieving the course objectives. The structure, which includes guidance and a focus on both theory and practice, is designed to ensure that students gain a thorough understanding of the content.

According to the provider, students were expected to engage with research and apply it within their planning in a subject area in mathematics hence integrating theory with practice. Students received guidance from teachers and researchers throughout the course.

The focus on variation theory and its application both in theory and practice suggests that students are likely to find the session relevant and useful in developing their classroom practice. This dual approach allows students to both understand and apply the theory in real-world contexts.

Pedagogical Methods

The involvement of experienced teachers and researchers implies a pedagogical approach that values collaboration and expert guidance.

6. Suggestions for Improvement

It was suggested that the course should be conducted over a longer period to allow deeper exploration of the topics.

7. Transferability

The observer expressed an intention to adopt aspects of the session such as using a form making "the theoretical underpinning of design decisions explicit" and using "*the poster gallery and poster presentations as a final event of the course. This could be an alternative for the currently required written account of their lesson study process*".

5.3.13.Turkey

1. Topic of the Session

The session focused on developing participants' understanding of argumentation, particularly through Stephan Toulmin's model of argument structure, and applying these concepts within the context of sustainability. The session aimed to enhance participants' skills in constructing persuasive arguments and recognizing the dynamics of persuasion in various situations.

2. Learning Goals or Planned Learning Outcomes

The learning outcomes for the session were:

Understanding Argument Structure: Participants were expected to learn about the components of argument structure as defined by Stephan Toulmin, including the importance of evidence in constructing a persuasive argument.

Recognizing Argument Components: Participants would practice identifying simple argument components through examples from scientific knowledge.

Awareness of Persuasion Dynamics: The session aimed to make participants aware of potential challenges and situations that might occur in the persuasion process.

Argument Production: Participants were to produce their own arguments through group work, specifically focusing on sustainability themes.

3. Structure of the Session and Activities Involved

The session was structured as follows:

a. Ice-Breaking Activity ("Which is More Persuasive?"): The session began with an interactive ice-breaking activity where participants compared different arguments to determine which was more persuasive. This activity set the stage for understanding the components of effective argumentation.
b. Introduction to Toulmin's Model: The session continued with a discussion on how arguments are structured according to Stephan Toulmin’s model.
c. Importance of Evidence: A segment of the session was dedicated to emphasizing the critical role of evidence in making arguments persuasive, supported by examples from scientific contexts.
d. Recognizing Argument Components: Participants were given examples from scientific knowledge to help them identify and understand the basic components of arguments, reinforcing their theoretical understanding.

e. Dynamics of Persuasion: The session included a discussion on the possible challenges and situations that might arise during the persuasion process, helping participants anticipate and navigate these in real-world applications.
f. Group Work on Sustainability: Participants engaged in group work where they collaboratively produced arguments under the theme of sustainability, applying what they had learned about Toulmin's argument structure and the importance of evidence.
g. Whole group discussion: The arguments produced in small groups were discussed with the whole group and criticised their structure in terms of argument components.

4. Philosophy Reflected

The session reflects a constructivist educational philosophy, with a strong emphasis on active learning and critical thinking. The ice-breaking activity, group work, and focus on real-world application (through sustainability) involved participants learning by doing and reflecting on their experiences. The integration of Toulmin's model emphasizes a structured approach to reasoning, encouraging participants to think critically about how arguments are constructed and evaluated in both academic and practical contexts.

5. Effectiveness of the session

Content and format

The content of the session is described by Teacher 1 as satisfying and impressive, indicating that the material covered was appropriate and engaging. Teacher 3 found that the examples and summarizing techniques used were effective, further supporting the view that the content was well-suited to the session's objectives. Teacher 3 specifically mentions that the session content was good as a first-time training, implying that the format was appropriate for beginners.

Observer 2 notes that the session helped teachers and students become aware of key elements involved in argumentation, such as the relationship between claims, evidence, hence contributing to an enhanced participants' understanding of argumentation, a critical aspect of both content and pedagogical content knowledge.

Teacher 1 reflects that the session was effective in helping them learn "*how to discuss an issue with students, how to approach it from a different point of view…" and* improve their professional approach to discussions. This indicates a positive impact on their pedagogical content knowledge and classroom practices.

Teacher 3 found the session useful, particularly in learning about rebuttals, data, backing, and justification in argumentation. They felt that this knowledge is also crucial

for writing academic reports and projects, suggesting that the session contributed to their content knowledge and professional skills.

Observer 1 finds the content adaptable and transferable, suggesting that it was well-structured and relevant to broader educational contexts. Observer 1 also notes that the session supported diversity and group work, highlighting the inclusive nature of the content and pedagogy. This suggests that the session format was effective in catering to a diverse group of participants.

Pedagogical Methods

Teacher 2 appreciated the training involving Web 2 tools which they found efficient.

On the other hand, Teacher 3 highlights the usefulness of examples provided during the session and expresses a desire for more participation from peers, suggesting that while the pedagogy was effective, greater engagement could have enhanced the learning experience. This feedback reflects on the effectiveness of interactive pedagogical methods used in the session.

Teacher 1 appreciated the concise and summarized content, suggesting that the session's pedagogy was clear and well-structured, contributing to their understanding without overwhelming them with information.

Observer 2 comments on the pedagogical approach, noting that it effectively guided students' reasoning and discussions, which is essential for teaching argumentation. The pedagogical methods used in the session were aligned with active learning strategies. In fact, Observer 2 appreciated the interactive nature of the session, including cooperative learning methods and continuous interaction between the Educator and participants. They note that these pedagogical approaches can be adapted for use in their own sessions, indicating a positive evaluation of the methods employed.

6. Suggestions for Improvement

One recommendation was to extend the duration of the session: “I can say that it would have been more useful to have a longer duration to learn better” (Teacher 1). Allowing participants to introduce themselves to increase engagement was another suggestion: “Maybe the teachers could introduce themselves in a few sentences” (Teacher 3). The group was a heterogeneous group including participants with a PhD in Physics and others who were pre-school teachers. One of the participants suggested grouping based on the participants’ teaching levels.

Technological problems with Microsoft Teams were mentioned, suggesting the use of a more familiar platform.

7. Transferability

The session, which focused on argumentation and critical thinking, was deemed highly transferable to other teaching contexts. The use of online tools, such as Padlet for collaborative work, was highlighted as an easily transferable methodology.

Teacher 3 said that: “From now on, when I plan my lessons, I will always plan them according to what is here.”

The session was also described as transferable to other Higher Education Institutions and observer 1 explained: “I like the content of the session which went into more detail into argumentation than I usually do.”

5.4. Cross-country analysis: Effectiveness

Following a description of what each respective country team did, the following sections will present a cross-country analysis and will try to answer the research question: to what extent was what we did effective, accessible and transferable? This section aims to present an analysis of the perspectives of the various persons involved about the *effectiveness* of the session. Teachers’ experience and views, the observers’ comments and the self-reflection of the provider were combined in the analysis as an evaluation of the achieved learning outcomes and overall impact. Effectiveness may refer to the topic, content, the format, the pedagogy, and the learning outcomes among other things. For the purposes of this project, *effectiveness* was regarded as a contribution to one or more of the following: growth in teachers’ content knowledge, teachers’ pedagogical knowledge, teachers’ pedagogical content knowledge, development of their classroom practice, developing teachers’ beliefs, motivation, competence in self-reflection.

5.4.1. Characteristics of Effective Professional Development Activities

1. Content Relevance and Practical Application

Effective professional development activities provide content that is directly relevant to teachers' classroom practices. For example, in Austria, the students appreciated the connection between mathematical concepts and real-world issues, such as the climate crisis, which made the content more engaging and applicable: "It is easier to demonstrate why you need differential calculus or integral calculus. There are then

easier links to everyday life" (Austria). This approach helps teachers see the practical value of the content, enhancing their motivation to integrate these concepts into their teaching. The effectiveness of activities with content that is relevant to teachers' classroom practice was emphasised in a number of case studies including those from Greece, the Netherlands, Spain and Sweden. In the Netherlands for example, the session on ChatGPT and mathematics education was found to be effective due to its relevance whether teachers intend to use ChatGPT in their work or not. Activities can be made more relevant by customization according to the participants' needs (Austria).

2. Interactive and Collaborative Learning

Sessions that promote interaction and collaboration among participants are highly effective. In Norway, the use of role plays, and group work significantly enhanced the learning experience by encouraging thoughtful reflection and active participation: "The role plays and collaboration in groups led to thoughtful reflections in plenary" (Norway). This interactive approach is effective in promoting deep learning and understanding of pedagogical content. Interactive and collaborative learning among pre-service and in-service teachers can take other forms such as lesson study as reported by Greece, or in class problem-solving activities (e.g. Czechia and Lithuania).

3. Incorporation of Technology

Integrating technology into professional development can enhance its effectiveness, particularly when it aligns with the content being taught. In Turkey, the use of Web 2 tools and technology integration in experiments were highlighted as efficient and beneficial: "It is a planned training due to the presence of Web 2 tools, so I found it efficient" (Turkey). Teachers (including those from Lithuania, the Netherlands and Germany) found the incorporation of technology into professional development useful for improving their teaching practices, especially in scientific subjects.

4. Focus on Pedagogical Content Knowledge (PCK)

Activities that enhance teachers' PCK are particularly effective. In Malta, the session focused on lesson sequencing, which is an important component of PCK. Participants learned how to sequence concepts and structure lessons effectively, which is crucial for improving student understanding: "This session helped them to think about how to break down the content into teaching and learning activities" (Malta). This focus on PCK ensures that teachers are better equipped to deliver content in a way that maximizes student learning.

5. Structured and Well-Planned Sessions

A clear and well-organized structure is essential for effective professional development. In Slovakia, the planning and clarity of the session were acknowledged, with participants noting that the structured approach reduced stress and facilitated learning: "The planning and clear instructions and pace of students' work worked very smoothly and didn't stress students despite a high number of activities" (Slovakia). This demonstrates the importance of thoughtful session design in achieving educational goals.

6. Balance between theory and practice

When professional development activities strike a balance between theory and practice, they tend to be more effective in contributing to the growth in content knowledge, pedagogical knowledge, and pedagogical content knowledge, which are crucial for teachers' professional development. In several instances, participants explicitly valued sessions that effectively integrated theoretical knowledge with practical application. This balance helped in reinforcing the concepts taught, making them more accessible, and directly relevant to the participants' teaching practices. For example, in Lithuania, the combination of theoretical knowledge with practical experimentation was seen as particularly effective in deepening understanding. In Germany the hands-on nature of the workshop balanced the theoretical aspects discussed.

7. Opportunities for self-reflection

Opportunities for self-reflection are critical for teachers' growth and development as they allow educators to critically assess their own practices, beliefs, and learning. This self-assessment can lead to deeper understanding, more meaningful changes in classroom practices, and improved pedagogical content knowledge. In the case studies, there were several instances where self-reflection was highlighted as a valuable component of professional development sessions. In Greece, for example, teachers reflected on their actions and the learning outcomes, which helped them develop their classroom practices and pedagogical strategies. In Turkey, the session included elements that prompted participants to reflect on their understanding of argumentation practices and their application, contributing to a deeper grasp of the content. In Norway, the use of exit notes for students' self-evaluation showed how reflection was integrated into the session to enhance the learning process. In the Spanish case study, the reflection on students' own ideas about effective teaching and learning helped to establish the starting point for their learning process.

These examples illustrate that self-reflection not only helps in the consolidation of new knowledge but also empowers teachers to adapt and improve their teaching practices based on their reflections.

5.4.2. Evidence of teacher motivation

The case studies provided evidence that teachers were motivated by the learning activities offered during the professional development sessions. The evidence suggests that teachers found the sessions engaging and relevant to their professional practice, and they were driven by a desire to apply the knowledge and strategies they learned to their own teaching contexts. In this section are aspects of motivation identified, supported by examples.

1. Relevance of content to professional practice

One of the strongest motivators for teachers was the direct relevance of the PD content to their teaching practice. When teachers saw clear applications of the content in their classrooms, their engagement and motivation increased.

Pre-service teachers from Malta, were motivated by the content's applicability in helping them design a scheme of work. Similarly, teachers in Cyprus appreciated the content related to scientific argumentation and its connection to real-world issues.

2. Hands-on and practical activities

Teachers were particularly motivated by hands-on, practical learning activities, where they could engage directly with the content and see immediate applicability.

The practical aspects of the 3D printing workshop were highlighted as engaging by participants in Germany. One participant, commented, "I think what I liked was that we actually got active ourselves and made a small 3D print ourselves." This hands-on component motivated teachers by allowing them to experience the learning process from a student's perspective. The opportunity to actively participate and use the technology themselves provided a sense of accomplishment and increased their engagement in the session.

3. Personalized Learning Opportunities

Teachers were motivated by opportunities to personalize and individualize the learning experiences during the sessions. This was particularly evident when teachers could adapt tasks and content to suit their own needs and teaching contexts.

In Greece, the flexibility of the learning activity to allow teachers to adapt the content to their own contexts was a significant motivator. The ability to adapt learning to the specific context motivated educators to engage more deeply with the material, as it felt relevant and applicable.

4. Collaborative Learning and Group Work

Collaborative activities, which allowed teachers to engage with one another, discuss ideas, and share experiences, acted as a key motivator for many participants. Group work and shared reflections on tasks fostered a sense of community and professional growth.

In Norway, teachers were motivated by collaborative learning strategies used in the sessions. An educator noted that the collaborative nature of the activities encouraged participants to engage more deeply: “Cooperative ways of learning... It could be adapted and transferred if only the student group is enough in number to have great quality discussions.”

The collaborative environment allowed teachers to learn from one another, which increased their motivation by creating opportunities for mutual support and professional growth.

5. Desire for Continuous Improvement

Many participants expressed a desire to improve their teaching practice, which was a significant source of motivation. The feedback they received, the opportunity to learn new teaching strategies, and the possibility of integrating new tools into their lessons kept them engaged. A participant in Czechia commented on how the assignments helped her improve her teaching: “The results from the assignments also helped me in determining my grade, and I corrected some of them, but that helped me learn even more.” This participant’s motivation stemmed from her desire to refine her skills and gain a deeper understanding of the subject matter. The process of improving through feedback and reflection on assignments kept teachers motivated to continue learning and applying new strategies.

6. Positive Learning Environment

The overall structure and style of the sessions, which included a balance of practical and theoretical content, contributed to teacher motivation. A positive learning environment with opportunities for reflection and active participation was an important factor in keeping participants engaged. In Spain, participants were motivated by the interactive and structured nature of the sessions. One participant mentioned, “The session leader held a short introduction. I liked that the introduction was quite short in time, that the session was set in context with the rest of the course, and that the teacher talked slowly and explained everything very thoroughly.” This structured approach motivated teachers by making the content clear and manageable.

The evidence across the different PD sessions shows that teachers were motivated by various factors, including the relevance of the content to their teaching contexts, the practical and hands-on nature of the activities, the opportunity for collaborative learning, and a structured, supportive learning environment. These elements helped teachers feel that the sessions were valuable, relevant, and directly applicable to their professional growth, fostering engagement and active participation in the professional development process.

5.4.3. Settings where particular activities work best

1. Small Group Settings

Professional development activities that involve discussion, collaboration, and interactive learning are particularly effective in small group settings in environments that facilitate interaction. For instance, in Cyprus, the observer noted that the online format limited collaboration, which could have been more effective in a face-to-face setting: "The observer commented that the online nature of the course was limiting" (Cyprus). This suggests that activities designed for collaboration work best in environments where participants can interact closely.

2. Face-to-Face Learning Environments

While online sessions can be effective, certain activities, especially those involving group work and hands-on experiences, are more successful in face-to-face settings. The educator in Cyprus expressed a preference for face-to-face sessions to better engage participants in discussions and practical exercises: "The session would have been more useful and beneficial if it was in a face-to-face mode" (Cyprus).

3. Flexible and Adaptable Content

The ability to adapt content and pedagogy to different educational contexts is crucial for the effectiveness of professional development. In Turkey, the content and pedagogy were noted for their adaptability, which is vital for transferring the learned skills to various teaching environments: "The content and pedagogy applied can easily be adapted and transferred" (Turkey).

5.4.4. Less effective aspects and why

1. Lack of Active Participation

A significant drawback in some sessions was the lack of active participation from teachers. In Turkey, despite the overall effectiveness of the session, a teacher noted the challenge of engaging participants actively in the first part of the workshop: "You ask a question and they don't answer. I wish they had said different things" (Turkey). This may be due to the participants' unfamiliarity with the concepts of argument and argumentation which were discussed in the workshop. This highlights the importance of fostering a more engaging and participatory environment to enhance the effectiveness of professional development when participants do not feel confident or are not familiar with the topic being addressed.

2. Complexity of tasks and overly technical content

When content becomes too technical without adequate support, it can overwhelm participants. In Germany, one participant noted that the technical details of 3D printing were overwhelming: "It sometimes drifted into overly technical details for me personally" (Germany). This suggests that while technical content is important, it should be delivered in a way that is accessible to all participants, with sufficient guidance and support. Similarly, tasks used may be too complex requiring more scaffolding (Austria).

3. Limitations of online formats

While online formats offer flexibility, they can also limit the effectiveness of certain pedagogical approaches, particularly those requiring interaction and collaboration. In Cyprus, both the observer and the session provider noted that the online format restricted collaboration: "The online nature of the course was limiting" (Cyprus). This indicates that for activities relying heavily on group interaction, face-to-face settings may be more effective. This may also depend on the type of online platform used and on how it was used.

5.4.5. Conclusion

Effective professional development activities are relevant to teachers' classroom practices, promote interactive and collaborative learning, incorporate technology appropriately, focus on enhancing PCK, and are well-structured. These activities are most effective in settings that allow for close interaction, such as small group settings and face-to-face environments. However, the effectiveness can be reduced by a lack of active participation, overly technical content, and the limitations of online formats. Adapting the format and content to the specific needs of the participants and the teaching context is crucial for maximizing the impact of professional development.

5.5. Cross-country analysis: Accessibility

Participants were asked to provide feedback about the accessibility of the sessions for them, focusing on content, pedagogical approaches, schedule, duration, and digital tools. Some aspects of the courses that made them accessible according to the participants are presented in this section.

5.5.1. Content Accessibility: tailored and relevant content

The content of the sessions was generally designed to meet the specific needs of the participants. For instance, in Cyprus, the course was redesigned to fit the teachers' needs, incorporating materials from past EU projects, making the content highly relevant and accessible. The availability of most content online through Moodle further enhanced accessibility: "The session was easily accessible to the participants, and most of the content was already available to them online through the materials in the weekly sessions on Moodle" (Cyprus). This fitting of content to needs can be especially enhanced if the participants are asked to suggest what the sessions should focus on as was the case in Austria. In Czechia a student appreciated the opportunity to learn from their mistakes and to test their acquired knowledge at the Gymnasium where they teach showing that timely feedback is a way of making content more tailored to the students' needs.

In Spain, the content was aligned with the participants' learning goals, making it accessible and relevant: "I had the idea of learning resources, learning methodologies and how to treat and teach younger students... Yes, these objectives are being met." This suggests that the content effectively addressed the participants' professional needs.

Interactivity and hands-on experiences were other characteristics of professional development that made it accessible to the participants. In Germany, the hands-on

nature of the workshop contributed to content accessibility by engaging participants actively. One of the participants appreciated this approach: "I think what I liked was that we actually got active ourselves and made a small 3D print ourselves." This hands-on experience made the content more accessible by providing practical, real-world applications of theoretical concepts.

5.5.2. Pedagogical Approaches

The use of interactive pedagogical methods was a key factor in making the sessions accessible. In Germany, the blend of lectures and practical activities, such as using *Tinkercad* (a web app for 3D design, electronics and coding), helped facilitate understanding: “The content and format of the session were considered suitable and effective by participants and observers alike.” However, the need for more introductory guidance was noted to ensure that all participants could easily follow the technical aspects.

In Czechia, the group-work approach was highlighted as creating an active environment that promoted sharing and trust among participants: "The group-work with signalising provides an activating environment and enables teachers to develop the atmosphere of sharing and trust, which was also reported by students."

However, in some cases, the pedagogical approaches were less effective. One reason mentioned was due to the online format. In Greece, the session did not engage all participants equally, highlighting a potential area for improvement: “The session was not successful in the engagement of all the participants in equal terms.”

5.5.3. Schedule and Duration

The scheduling of sessions was generally well-received. In Turkey, participants appreciated the evening scheduling and the online format, which made the sessions more accessible: "I think it was good that it was in the evening. Also, online sessions are inevitable now. You can't gather people in one place."

There were instances where participants felt that the duration of the sessions could be extended to cover the material more comprehensively. A teacher in Turkey commented, "I can say that it would have been more useful to have a longer duration to learn better," indicating that while the sessions were accessible, the time allocated was not always sufficient for deeper learning. The short time frames and lack of time were often mentioned in the case studies.

5.5.4. Digital Tools

The integration of digital tools, such as Web 2.0 tools, was a significant factor in enhancing accessibility. In Turkey, the use of these tools increased productivity and was well-received by participants: "I think the training was very productive. Because of that Padlet, using web tools effectively. I think they are very useful."

5.5.5. Challenges with Language and Participation

The sessions were attended by observers from other countries. This caused some language-related challenges for the observers when either the whole session was carried out in a language other than English or when small group discussions were taking place between participants in their native language. In Norway, for example, the observers reported language barriers during group work. Participants conducting discussions in their native languages made it difficult for non-native observers to fully engage: "It is not possible to follow group works in native languages." Some of the language barriers experienced by observers were reduced by occasional code-switching to English to explain what was going on (e.g. Lithuania) or by providing recorded online sessions with English sub-titles (e.g. Turkey). In some countries students are used to the English language and the session was held entirely in English (e.g. Malta). Language can be a challenge for job shadowing in a different country. It is also an important consideration when organising professional development sessions, like workshops or seminars for an international audience. In Spain, the session was held in English for the benefit of the observers, but the participants were not all comfortable speaking in English rather than their own language.

5.5.6. Overall Accessibility and Inclusiveness

In Slovakia, the session catered to diverse learning needs, accommodating students with ADHD who appreciated the way the session accommodated their specific needs: "Despite my ADHD, I did not have problems with sustaining attention for the full 90 minutes." This indicates a high level of accessibility and inclusiveness in the session design.

The case studies show that the sessions were generally accessible to participants in terms of content, pedagogical approaches, schedule, duration, and digital tools. The content was well-tailored to meet the needs of the participants, and the pedagogical approaches were interactive and practical, enhancing accessibility. However, some challenges were noted, such as the need for extended session durations and the potential barriers posed by language during digital participation. The use of digital tools was both a facilitator and a barrier, depending on the context, emphasizing the need for careful consideration in their implementation. Overall, the sessions were effective in meeting the diverse needs of participants, making them accessible and relevant in various educational contexts.

5.5.7. Meeting Diverse Needs of observers involved in job shadowing

The needs of the observers were often different from those of the pre-service teachers or in-service participants. When course objectives are similar in different countries, the sessions are found to meet the needs of the observers too. In Malta, the session met the needs of both local and international participants by aligning with course objectives and using similar pedagogical approaches. This was particularly appreciated by observers who wanted to learn about teaching approaches in different countries: "I wanted to learn about teaching approaches used in Malta, and I wanted to learn more myself about sequencing of sessions."

5.6. Cross-country analysis: Transferability of learning activities across different contexts and countries

The learning activities were generally perceived as highly transferable across the various educational settings and countries, particularly due to their focus on universal skills such as inquiry-based learning, critical thinking, and argumentation. The sessions' adaptability is facilitated by their alignment with global educational priorities like sustainability, digital literacy, and interdisciplinary learning. The reflections from both the providers and observers suggest that while certain content may need adaptation to fit local contexts, the core pedagogical strategies and approaches are widely applicable across different countries and educational institutions. The main characteristics that facilitated the transferability of the sessions are presented in this section.

5.6.1. Universal and Relevant Content

Content that aligns with global educational trends, such as sustainability, digital literacy, or scientific competencies, is easier to transfer. In Cyprus, the provider mentioned that the session could be transferred because it dealt with scientific practices and argumentation, which are high priorities in science education worldwide, and are included in assessments like PISA. This relevance makes the content applicable to various contexts. In Germany, the 3D printing workshop focused on sustainability and the use of recycled materials, which are important global educational priorities. This made the session relevant to a wide range of educational settings, including other countries and types of schools.

Sessions focusing on topics that are universally recognized as important, such as environmental citizenship, mathematics reasoning, or STEM, are more easily

transferred. For example, in Spain, the topic of environmental education was seen as transdisciplinary and socially significant, making it highly adaptable to different educational settings. The provider noted that the session was based on "international knowledge and a wide experience acquired through international collaborations", enhancing its transferability.

Sessions that integrate multiple subjects or skills (e.g. combining STEM with sustainability or digital literacy) tend to be more easily transferable. In Germany, the interdisciplinary nature of the 3D printing workshop (which combined mathematics, science, and technology) was highlighted as a good example of an integrated STEM approach that could be transferred to other educational contexts that prioritize interdisciplinary learning.

5.6.2. Teaching approaches

The pedagogical approaches employed were deemed highly transferable. For example, sessions that employ hands-on, practical learning are generally more adaptable because they can be easily understood and implemented by educators across various contexts. In Germany, the provider and observers highlighted the practical, hands-on nature of the 3D printing workshop, which made it easier to adapt to different educational environments. The provider noted that 3D printing is an easy tool to use and can be adapted to different contexts and lessons.

Observer T1 in the Spanish case study could not transfer the content of the observed session but found that the didactic approach was transferable and reported that "*I don't teach STEM topics in my lecture. But I had a closer look in the Job Shadowing about my colleagues' didactic approach to reach the students in a personal way: So that the students can find themselves in the discussed topics and use scientific approaches and knowledge for their self and world understanding*" (T1).

Activities that promote collaboration and group work were highlighted as transferable because they can be applied in diverse educational settings. For example, in Norway, the use of collaborative learning approaches was emphasized as easily adaptable. The session's role-playing, group discussions, and inquiry-based learning strategies were highlighted as effective and easily transferable teaching methods.

In the Maltese case study, observer O1 reflected that: "*It was really enriching to watch some strategies the lecturer used to connect students' contexts with the topic addressed, to make them reflect through key questions and to link the contents addressed with those approached in previous and future sessions … I considered the teaching style*

applied in the observing session as highly appropriate for the topic addressed so I tried to adopt the same approach for my session".

5.6.3. Flexible and adaptable structure

Sessions that are designed in a structured way with several activities, allowing educators to pick and choose elements for adaptation, were seen as more easily transferable. In Malta, the session focused on sequencing learning tasks in a way that could be applied to different subjects (like biology or chemistry), allowing for flexibility in adapting the content to various contexts. Both observers noted that while they changed the specific science concepts from physics to biology, they kept the overall structure of the session, which included a short introduction, task-solving, and reflection among other things. In Sweden the observer identified aspects that could be transferred such as "*the poster gallery and poster presentations as a final event of the course. This could be an alternative for the currently required written account of their lesson study process*."

Sessions that provide adaptable pedagogical frameworks, such as inquiry-based learning, were considered more transferable. In Lithuania, an observer noted that hands-on activities promoted a student-centred approach, which could be easily adapted to other contexts despite challenges like the unavailability of laboratory resources. Similarly in the Spanish case study, the group reflection worked out well and that aspect was selected and transferred. This was possible due to the structure of the session.

5.6.4. Alignment with Educational Frameworks and Competencies

Sessions that emphasize the development of competencies, such as critical thinking, argumentation, or reasoning, are more easily adapted to different contexts. In Greece, an educator pointed out that mathematical reasoning is topic-independent and can be transferred to different educational settings without significant alterations. Similarly, in Turkey, the focus on argumentation and critical thinking was seen as universally applicable to various teaching contexts.

In Norway, the focus on inquiry-based learning and the teaching of questioning techniques made the session applicable across different contexts. The observer mentioned that the pedagogical methods could be transferred across diverse subjects and educational levels because they were based on universal principles of discourse and interaction.

5.6.5. Adaptability to different levels and types of education

Content that can be adapted to different educational levels or types of institutions is easier to transfer. In Cyprus, the observer noted that the session's focus on argumentation could be applied to different types of schools and age groups, as the core competence remained the same, but examples could be modified. Similarly, in Norway, the observer noted that the teaching strategies and content could be applied to diverse groups at various educational levels.

In Malta, the session on sequencing learning tasks could be applied across different scientific disciplines. The flexibility to change the scientific context (from physics to biology) while maintaining the core pedagogical principles made the session highly transferable to other institutions.

5.6.6. Digital and online learning adaptations

Sessions that incorporate widely available digital tools make content more adaptable to other contexts. In Turkey, the use of Web 2.0 tools like Padlet was seen as an enhancement to productivity and made the session easier to replicate in other settings. The observer in this session mentioned that the online format of the session, combined with digital collaboration tools, made it easily transferable to other institutions that offer online or hybrid learning.

5.6.7. Hindrance to transferability

Across the different contexts, several factors emerged that can make learning activities harder to adapt to new educational settings.

1. Content and specialized knowledge

Some content is highly specialized and deeply tied to a specific subject, making it harder to adapt to other subjects or educational contexts. For example, in the Greek session, the educator noted that pedagogical content knowledge might need significant adaptation when transferring mathematical reasoning to other contexts.

Content that assumes prior knowledge may not be easily transferable to participants with different backgrounds or levels of expertise. When transferring the Maltese session, one of the observers highlighted that the session on sequencing tasks had to be adapted because the physics content was too advanced for their students. They created a new task based on a biology context, demonstrating that transferring content tied to

specific topics can be challenging when the audience does not have the required level of subject knowledge.

When technology is too advanced or unfamiliar, it makes the session harder to replicate. In Germany, the practical aspects of a 3D printing workshop were highly valued by the observers, but the need for introductory guidance and familiarity with Tinkercad when transferring the session was highlighted, ensuring that all participants could effectively use the digital tools, regardless of their prior experience.

2. Availability of Resources

Some activities, especially those involving hands-on or laboratory work, are harder to transfer due to resource limitations. For instance, when transferring the laboratory session originally held in Lithuania, one observer noted the lack of laboratory facilities, which prevented the full transfer of the biology lab-based session. This kind of content requires specific equipment, making it difficult to implement in under-resourced settings.

In the German case study, one observer mentioned that the logistics of running a 3D printing session could pose challenges, particularly where schools or institutions may not have the necessary equipment.

3. Cultural and Pedagogical Norms

Pedagogical approaches that are deeply rooted in a particular teaching culture or system may not transfer smoothly. In the Greece case study, it was noted that lesson study methods may not be as easily understood or accepted in certain educational cultures, where teachers are unfamiliar with these practices. Methods that require a significant cultural shift in teaching styles can be harder to transfer.

Variations in curricula and educational standards can make content adaptation difficult. For example, in Malta, an observer mentioned that due to differences in curricula between countries, adaptation was necessary even though the principles remain universal.

4. Class Size and Group Dynamics

Some sessions are designed for small groups and adapting them for larger groups can dilute the effectiveness of interactive or hands-on learning. In the Slovak case study, an observer mentioned that while group work was possible, managing a larger class without sufficient room space and resources made it challenging. Sessions that rely heavily on collaborative, small-group formats can be harder to adapt to settings with larger class sizes or fewer resources.

5. Language and Localization Issues

In some cases, content may be in a language that is not familiar to all participants. For example, in Norway, an observer noted that some participants conducted group discussions in their native languages, which made it harder to evaluate the transferability of these sessions for non-native speakers.

Sessions that use localized examples, such as culturally specific case studies or local issues, may need significant adaptation to make them relevant to other regions. When commenting on the session held in Austria, for instance, an observer reflected on messages within the mathematics content, realizing that these messages may not always be clear or relevant in other contexts.

6. Institutional and Logistical Barriers

In Turkey, the preference for holding online sessions (due to logistical challenges in gathering people in one place) illustrates how institutional constraints can affect the transferability of certain types of content.

In Spain, the observers noted that time limitations restricted the ability to fully explore certain aspects of the session: "*I will give the practical…experiences and the group reflections more space in my next lecture. Probably I will skip some theoretical parts…*" (T1).

This suggests that content requiring extended time periods or deeper engagement may not be easily transferable to more constrained schedules.

5.6.8. Conclusion

While many educational sessions can be adapted and transferred across different contexts, several factors can complicate the process. When these factors are considered, educators can better anticipate the necessary adjustments to ensure the effectiveness of the transferred content.

5.7. Suggestions for improvement

The points for improvement suggested by the various participants, providers, and observers across different countries focus on several key themes: timing and structure, technology, content complexity, and participant engagement.

5.7.1. Timing

Participants often suggested that sessions needed more time for reflection, discussion, and hands-on activities.

5.7.2. Content Complexity

Some participants found the material too complex, particularly technical content, and recommended simplifying it.

5.7.3. Collaboration

Providers and participants valued opportunities for collaboration and recommended more group work, discussions, and collaborative learning approaches.

5.7.4. Technology

Providing better guidance on using digital tools and addressing technological challenges was often requested.

5.7.5. Adaptability

Another recommendation was ensuring that the content can be adapted to fit the specific needs of different participants based on their context (e.g., laboratory access, subject background).

These recommendations suggest a need for more flexibility in content delivery, structured guidance, and opportunities for participant interaction to enhance the effectiveness and adaptability of learning activities.

5.8. Benefits of job shadowing in Higher Education Institutions as experienced by observers

This project involved a not so common practice of job shadowing for educators in Higher Education Institutions. The observers highlighted several benefits.

5.8.1. Cross-cultural learning and transferability

Observers appreciated the opportunity to witness different teaching methodologies, pedagogical approaches, and practices across various Higher Education institutions in different countries. This cross-cultural exposure provided insights into how similar pedagogical objectives are addressed differently. For example, in Cyprus, one observer highlighted how the session was "based on international current research trends in science education" and could be adapted to their own Master's courses. They also noted that the session's organization and conceptual sequence were meaningful and aligned with their scientific agenda. In Malta, observers commented on the potential transferability of pedagogical approaches, such as the design of a teaching-learning sequence. This approach was found to be adaptable to different countries with minor adjustments in the content area.

5.8.2. Reflecting on pedagogical approaches and methods

Observers in several contexts reported gaining a deeper understanding of different pedagogical methods and practices that they could apply in their own teaching. For example, in Germany, the observers noted that the interdisciplinary STEM approach was a valuable takeaway that could be adapted and implemented in other contexts.

In Malta, observers mentioned how they could transfer the teaching style used in the observed session to their own contexts, adapting it based on specific content needs.

5.8.3. Exposure to innovative and emerging technologies

Observers were able to witness the use of technologies such as 3D printing in education. This not only enhanced their understanding of the integration of digital literacy and sustainability in teaching practices but also showed how these tools could make abstract concepts tangible in various subjects. For example, in Germany, the observers noted the 3D printing workshop's alignment with current global priorities such as sustainability, which made it adaptable for different educational systems. Similarly in the Netherlands the session on ChatGPT and mathematics education was found to be inspiring.

5.8.4. Development of teaching and professional competencies

Observers often reflected on how job shadowing helped them improve their own teaching competencies by learning from how others facilitate discussions, manage classrooms, or incorporate different tools. For example, in Norway an observer reflected

on how the teaching styles, particularly the collaborative learning approaches, were adaptable to other contexts and could be integrated into their own courses.

5.8.5. Facilitating reflection and self-evaluation

Job shadowing allowed observers to reflect critically on their own teaching methods by comparing them with the practices they witnessed. This often led to identifying areas for improvement or adaptation in their own courses. For example, in Lithuania observers gained ideas on how change the way they introduce practical work and digital tools into their teaching to enhance student engagement and learning outcomes.

5.9. Challenges of job shadowing in higher education institutions

5.9.1. Language Barriers

As may be expected, one of the most reported challenges was the language used during sessions. In some cases, observers struggled to follow the content when it was presented in a language that they were not familiar with. On the other hand, in Spain the student participants expressed difficulty engaging with the content when it was presented in English rather than their national language. Some felt this hindered their full participation.

5.9.2. Adapting to local contexts

Not all aspects of the sessions observed could be easily transferred to the observers' institutions or local contexts due to differences in educational systems, curricula, or student needs. When transferring the session observed in Lithuania some challenges arose from the need to have a laboratory setting to replicate the practical work observed. If universities do not have access to the necessary resources, it would be difficult to implement the same methods.

5.9.3. Time constraints

A recurring challenge was the limited time for deeper engagement with the materials and discussions. Observers sometimes felt that sessions were too short to fully explore topics.

5.9.4. Observer's role and limitations

Observers sometimes found it difficult to engage fully with the session or provide meaningful feedback due to their observational role. In some cases, there was limited

opportunity for interaction with students or teachers, which reduced the level of engagement. In Turkey one observer noted that they were unable to observe group discussions in breakout rooms during an online session, which limited their ability to evaluate the full collaborative experience.

5.9.5. Conclusion

Job shadowing in Higher Education provides valuable cross-cultural learning opportunities and contributes to the transfer of pedagogical practices. However, challenges such as language barriers, time constraints, and adapting content to different contexts highlight areas for further research and refinement of the process.

5.10. What works in which situations?

Different professional development approaches seem to be more effective when adapted to specific contexts, including teaching experience, culture, and the professional goals of the participants. In this section some aspects of the PD content and style that were found to work in different situations are described.

5.10.1. Content that Works in Different Contexts

a) Technology Integration (e.g., 3D Printing, Digital Tools)

Teachers who are already familiar with technology or STEM education benefit most from sessions that integrate advanced technological tools like 3D printing and CAD software (e.g., Tinkercad). In the German case study, the 3D printing workshop was well-received, but some participants expressed a need for more structured guidance. Teachers who had previous experience with technology were more comfortable with the advanced tools, while others needed introductory support. For instance, a participant mentioned, "I would have found it personally helpful if there had been a little introduction or demonstration, a tutorial on this Tinkercad."

This type of PD content works best for teachers who have a foundational understanding of technology. It may not be as effective for teachers from contexts where access to technology or digital literacy is limited, such as those in less technologically advanced institutions.

b) Interdisciplinary and Cross-Curricular Content

Interdisciplinary and cross-curricular content works where there is teaching in interdisciplinary contexts, especially where there is a focus on STEM, sustainability, or global issues. Observers in the German case study noted the effectiveness of the STEM workshop and its transferability across different educational settings. The interdisciplinary nature of integrating subjects like mathematics, science, and technology, alongside broader global issues such as sustainability, resonated with teachers working in contexts that prioritized interdisciplinary teaching.

This content works particularly well in cultures and schools where STEM education is a priority or where there is flexibility to integrate subjects. In cultures with strict separation between disciplines, it might need adaptation.

c) Argumentation and Inquiry-Based Learning

These were found to be highly adaptable across different educational systems and are particularly useful in contexts where student-centred learning and critical thinking are emphasized. For example, the case study based in Cyprus highlights how a focus on scientific argumentation, which aligns with broader international trends like the PISA evaluation, was found relevant across different types of schools and teaching levels. The flexibility of this content allowed teachers to adapt it to different school settings.

This type of PD works well in both early-career and experienced teaching contexts, where the educational culture values such learning. However, in more traditional, teacher-centred educational systems, there may be challenges in adopting such practices without cultural adaptation.

d) Research-Based STEM Education

Works in teacher development in contexts that emphasize research-based teaching and the STEM/STEAM framework (Science, Technology, Engineering, Arts, and Mathematics). The Lithuanian session, focused on STEAM education, demonstrated that hands-on, laboratory-based activities were effective for teachers in environments with access to such facilities. However, observers noted that the session's reliance on laboratory access posed challenges in contexts without such infrastructure.

Hands-on PD sessions work well in institutions with access to labs and technological resources, particularly for teachers with experience in science teaching. In environments lacking these facilities, the content needs adaptation to more theoretical methods or methods that are not resource-intensive.

5.10.2. Professional development style that works in different situations

a) Hands-on, practical Learning

This works with teachers at different experience levels, especially in contexts where the focus is on applying new skills directly into practice.

Across several sessions, including those in Germany, Netherlands and Malta, hands-on activities were highlighted as effective. The practical elements, such as designing 3D models or working on teaching-learning sequences, were engaging and useful for participants. However, some participants in Germany requested more structured guidance during hands-on activities to feel comfortable applying the tools and methods presented.

Hands-on, practical learning styles are effective in PD sessions designed for teachers of all experience levels. However, novice teachers or teachers with limited exposure to certain tools (e.g., technology) may benefit from a step-by-step approach or initial demonstrations to reduce feelings of being overwhelmed.

b) Collaborative and Group Work

This is most effective in cultures where collaboration and community learning are valued. More experienced teachers or those in contexts where peer learning is encouraged can benefit from group work. For example, in the Norwegian and Cypriot contexts, group work was emphasized as essential for promoting discussion and knowledge sharing. Participants in Norway noted the importance of exercises that involved collaborative dialogue and reflection, which helped teachers practice their skills.

This style seems to work best in contexts where teachers are accustomed to working in collaborative environments.

c) Lecture-based, content-heavy sessions

More experienced teachers or those with a strong theoretical foundation in their subject matter may benefit from lecture-based, content-heavy sessions.

In some case studies such as that of Austria, Germany and Turkey content-heavy or theoretical aspects were overwhelming for some participants who felt there was too much material for the time allocated. Other participants in the same sessions felt that the content was fine. In Austria, one lecturer mentioned, “There was quite a lot of content for the time, and some students seemed a bit overwhelmed towards the end.”

Lecture-based PD may work best for teachers with a high level of expertise or experience who are comfortable with theoretical content. For novice teachers or those with less

experience, this style may need to be complemented with more interactive elements to maintain engagement and avoid cognitive overload.

d) Blended Learning and Online Formats

These are effective in contexts where participants have access to reliable digital tools and infrastructure. The Turkish case study showed that online sessions can be useful but also come with challenges, especially when participants are not familiar with the platform being used (e.g., Microsoft Teams). The flexibility of online formats was appreciated, but participants expressed that technical issues need to be addressed for smoother interaction. The pedagogy employed may need to be re-thought and re-designed for online formats (Cyprus).

Blended learning works well in institutions with strong digital infrastructure and where participants are familiar with the necessary tools. In regions with limited digital literacy or access to technology, more in-person support or simpler platforms might be needed.

5.10.3. Situational Variables Affecting Effectiveness

a) Teacher Experience

Experienced teachers generally respond well to research-based sessions, especially when there is room for discussion and application of concepts to practice. Sessions such as those in Cyprus, which included reflection on their practice, were well-suited to experienced teachers who could adapt complex theoretical ideas into practice.

Novice teachers often benefit more from hands-on, guided sessions. In contexts like Germany, where technical details of 3D printing were presented, more support was needed for teachers to engage fully. Practical sessions with clear demonstrations and gradual complexity are more effective for early-career teachers or teachers who are new to a particular concept or technology.

b) Cultural Expectations

In contexts like Norway, collaboration and discussion were highly valued and effective in fostering engagement. In contrast, in more individualistic cultures, PD may need to gradually introduce collaborative elements.

As observed in Spain, some participants expressed difficulty engaging fully in sessions conducted in English rather than their native language. Adapting PD to local languages or providing additional support in non-native language contexts can increase effectiveness.

6. CONCLUSION

The research through case studies carried out as part of the ICSE Academy project was guided by three primary research questions. At a regional level the research questions behind country-based case studies were:

To what extent are the individual regional activities effective and accessible?

To what extent are the regional activities transferable to different contexts?

The regional case studies were then used for a cross-country analysis. In this case the research question was:

What are the characteristics of professional development activities and technologies, and in which particular settings do they work best?

Based on the rich data obtained through the case studies, a number of conclusions and implications concerning the effectiveness, accessibility, and transferability of regional professional development activities, as well as the characteristics that contribute to the success of such activities across different contexts can be drawn.

6.1. At a regional level

6.1.1. Effectiveness and accessibility of regional activities

The professional development activities were generally effective in enhancing teachers' content knowledge, pedagogical content knowledge, and classroom practices. The peer learning activities and opportunities for reflection contributed significantly to improving teachers' instructional strategies. The integration of practical activities with theoretical knowledge was found to be a major contributor to effectiveness, as highlighted by the feedback from participants across multiple countries.

Teacher motivation was strongly impacted by the nature of activities. Participants expressed high levels of motivation when activities were hands-on and relevant to their teaching practice, aligning with the principle that teachers are more likely to engage in professional development that directly addresses their daily challenges (Baumert & Kunter, 2013).

Sessions were found to be accessible when they met the practical needs of participants regarding duration, format (online vs. in-person), and use of digital tools. Flexibility in scheduling and digital access played a crucial role, with several participants mentioning the ease of participation in virtual formats. Challenges with accessibility, however, included the need for greater introductory content for specific tools and software, which limited some participants' engagement, particularly those with less prior exposure to technology.

6.1.2. Transferability of Regional Activities to Different Contexts

Transferability of activities depended largely on their adaptability to local contexts. Activities that incorporated inquiry-based learning, collaborative approaches, and universal teaching principles (such as argumentation or reflection) were found to be more transferable across different educational systems. Flexibility in adapting these activities to different cultural and institutional contexts ensured their relevance. On the other hand when the content was highly specialised, assumed prior knowledge or unfamiliar, transferability was hindered. Unavailability of resources, class size and other institutional and logistical barriers may also hinder transferability.

Differences in regional educational policies, curriculum standards, and teacher preparedness were noted as challenges in transferring certain activities without significant adaptations. The feedback highlighted that successful transferability required sensitivity to local norms and the active involvement and collaboration of educators familiar with both the source and target educational contexts.

6.2. Cross-country analysis conclusions

6.2.1. Characteristics of effective professional development activities

Activities that promoted active engagement through collaborative methods, hands-on practice, and reflective discussions were particularly effective. Participants appreciated the interactive nature of these sessions, which enhanced their ability to immediately apply new knowledge in their own classrooms.

The alignment of activities with teachers' needs and challenges—such as adapting content to different grade levels, aligning with local educational policies, and incorporating culturally relevant materials—was crucial for effectiveness. This conclusion supports findings from previous literature that CPD activities are more effective when they directly respond to participants' professional needs (Desimone, 2009).

Digital tools played an important role in enhancing accessibility. Tools that supported collaboration, such as online breakout rooms and platforms like Padlet, contributed to successful peer learning experiences. However, familiarity with these tools was a prerequisite for effective participation, emphasizing the need for preliminary training sessions since some teachers experienced some difficulties when using unfamiliar tools.

Effectiveness can be reduced by a lack of active participation, overly technical content, and the limitations of online formats. Adapting the format and content to the specific needs of the participants and the teaching context is crucial for maximizing the impact of professional development.

6.2.2. Contexts where professional development activities work best

Activities were more effective when they were culturally sensitive and aligned with participants' experiences, needs and expectations (Banks, Banks, Cortes et al., 2007). This was related to the content of the activities (e.g. integration of technology or argumentation) and the professional development style and pedagogies employed (e.g. hands-on practical work or collaborative group work). There are also situational variables such as teachers' experience and cultural expectations and needs. Transferability across countries was facilitated when activities were designed with an understanding of both the origin and target cultures, curricula and needs allowing for nuanced adaptations.

The job shadowing component was successful in fostering cross-country learning and peer collaboration, particularly among ITE and CPD providers. Observers expressed that the opportunity to see "real" teaching scenarios from different countries helped broaden their perspectives and improve their teaching methods. However, challenges such as language barriers, time constraints, and adapting content to different contexts highlight areas for further research and refinement of the process.

6.3. Implications for policy and practice

6.3.1. Supporting cross-border teacher mobility and peer learning

The peer learning by job shadowing experience of the ITE and CPD providers involved in this project proved highly effective. The educators involved found the experience enriching and inspiring, enhancing their professional growth. Exposure to different educational contexts allowed participants to learn from diverse practices, which contributed to improving their teaching skills and broadening their perspectives. In turn, they were able to expose teachers to new ideas because of the experience. Policy makers should continue to support, fund and prioritize cross-border mobility and peer learning opportunities, as these are instrumental in exposing teachers to varied teaching

practices and in promoting the exchange of best practices in STEM education across different regions, ultimately improving the quality of STEM education. These efforts also align with the European Education Area goals of fostering collaboration and mobility among educational institutions. Funding opportunities for transnational mobility, virtual or physical, are essential for encouraging teachers to learn from best practices across Europe as is the continued professional development of ITE and CPD providers.

6.3.2. Customized professional development

The professional development activities were most effective when they were designed to meet the specific needs of teachers, considering their level of teaching experience, educational contexts, and cultural background. Activities were most impactful when they included practical, inquiry-based, and hands-on methods that were applicable to participants' own classrooms. CPD programs should be designed with flexibility to adapt to different cultural, institutional, and regional contexts and to enhance the accessibility and effectiveness of these programs. This approach requires allocating resources to develop programs that can be adapted based on the specific needs of teachers (e.g. career stage, subject expertise, and cultural context) including locally relevant content and pedagogical practices.

6.3.3. Focus on motivation

Maintaining teacher motivation through meaningful and contextually relevant CPD is crucial. Teachers participating in the study reported that activities that combine practical, collaborative, and reflective elements were particularly motivating them to improve their classroom practices and participate actively in professional learning. Teachers expressed a high level of motivation and satisfaction when they could see the direct impact of the CPD on their daily teaching practice. Designing CPD activities that focus on motivating teachers by dealing with real-world classroom challenges, supported by hands-on strategies, can increase teacher engagement and lead to greater retention in the teaching workforce. This can also play a role in tackling issues related to teacher burnout and dissatisfaction.

6.3.4. Promoting non-traditional pedagogical strategies

Many teachers participated in the professional learning activities specifically because they were interested in non-traditional strategies such as inquiry-based learning or argumentation or to learn about ways of engaging students in STEM. Such professional development opportunities continue to be necessary to help improve STEM education. Activities focusing on inquiry-based learning, argumentation, and other universal pedagogical strategies were found to be highly transferable and effective. Emphasizing these strategies in professional development could lead to broader applicability and higher impact across diverse contexts.

6.3.5. *Pre-training in digital tools*

As digital tools are increasingly used for virtual professional development, policy makers and training providers need to ensure that participants receive adequate training in the use of digital tools before participation. This will improve accessibility and help participants engage more effectively in CPD activities.

6.4. Funding for further research

The results of the case studies have provided answers to the questions that the project sought to investigate. However, some new questions arise as a result of these case studies. Support and funding are required for further research. Some of the topics that may be researched in the future are given below.

6.4.1. *The impact of job shadowing on practice*

The job shadowing experience has shown a great potential for learning for ITE and CPD providers. The educators involved in job shadowing often shared common beliefs and philosophies. It would be interesting to investigate how peer learning influences educator beliefs and instructional strategies over time, especially when the educators have more traditional philosophies. This job shadowing exercise could also be extended to lesson study between educators from different HEI. Moreover, providing teachers with job shadowing opportunities will give teachers the opportunity for peer learning too. Further research could investigate the long-term impact of job shadowing on teaching practice and student outcomes.

6.4.2. *Barriers to transferability*

This study has provided very useful insights related to transferability including possible challenges to transferability. Additional studies are needed to understand the barriers to transferring professional development activities across countries, particularly focusing on regional policy differences and cultural factors.

6.4.3. *Role of Digital Tools*

Future research could examine the role of digital tools in professional learning environments, specifically evaluating their effectiveness in different types of professional development settings (e.g., synchronous vs. asynchronous learning).

6.5. Concluding comment

The case studies have provided valuable insights for policy makers, teacher educators, and researchers, highlighting the importance of contextually sensitive, flexible, and engaging professional development activities that foster cross-border collaboration and adaptability.

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8. APPENDIX I. DATA COLLECTION PACKAGE

ICSE Academy WP4: Data collection instruments for the case studies

Interview with teachers participating in the CPD session

(Interview guide based on the *Data Collection Instruments for Case Study* developed for the MaSDiV project).

One of the aims of the ICSE Academy is developing and testing effective, accessible and transferable models for professional learning of pre- and in-service STEM teachers. This interview contributes to the case study for the evaluation. The guiding **research question** for this interview is:

To what extent are the individual regional activities effective and accessible?

Part A Introduction

I would like to thank you for taking the time to participate in this interview.

My name is _____. I am _____ (give a short introduction of the interviewer and role in the project).

I would like to talk to you about the session about *TOPIC* that you attended. The interview is part of the evaluation of the ICSE Academy project which involves 13 countries.

The main aim of this interview is to obtain an insight into how teachers perceive the session and how to improve it. The interview will take about 45 minutes. With your permission, I will record the session because I do not want to miss any of your comments. Later the interview will be transcribed and I will send you the transcript for your approval.

All responses will be kept confidential. We will ensure that any information included in our report will not identify you as the respondent.

You are free not to answer any question that you do not wish to answer and you may end the interview at any time. Do you have any questions? Are you willing to participate in the interview?

On the basis of the written information I provided earlier, please provide your signed consent.

Starting time _____

Start recording the interview

Part B The teacher and his/her school context

Guiding question	Prompts	Comment
For how many years have you been teaching?		The first few questions will give an insight into teachers' professional background. It will also put the teachers at ease. It is important to show interest in the person. You do not have to stick to the written questions. Try to create a good atmosphere for the interview
How long have you been teaching in the current school?		
Why did you decide to become a teacher?	What are your most important goals as a teacher?	This question will give insight about the teacher, his/her story and possibly an insight into the values of the teacher.
How would you describe your school?	How many teachers and students? What are the main challenges in your school? What kind of diversity is there at your school (e.g. achievement, cultural, socio-economic)?	The prompts may help to get an insight into the contextual factors that might influence the teacher's perception of the effectiveness of the session. Listen carefully all the time as you may need to refer to the school context later.
How would you describe a typical lesson that you teach?		

Part C Questions about the CPD

What motivated you to join the CPD?	How did you learn about it? What did you hope to acquire/learn through the course? What were your expectations?	This will give an insight on the needs, expectations of the teacher. Ask why?

	What kind of CPD have you experienced in the past? What kind of CPD do you like best?	
What do you think about the course in general?	So far, did it fulfil what you were after? Explain what you liked and what was missing.	Ask why?
What are your views about the session about **TOPIC**? Or What are your views about today's session?	What do you think about the schedule, time, length of the session? What do you think about the content of the session? What do you think about the style/method adopted? Why/which ones? Do you feel that you have learnt anything related to science/mathematics content? Do you feel that you have learnt anything related to how to teach the subject or how students learn? Do you feel more confident and competent in any of the following: • using technology, addressing sustainability • addressing diversity in STEM classrooms • green skills • climate change or intercultural STEM approaches? Was there anything in particular that made you think and reflect about your students or your teaching?	These questions need to be adapted according to the topic of the session. If the interview does not take place immediately after the session the questions may be: In which way did the session change your practice? How did you implement the activities/ideas from the session into practice? Are there any benefits for your students derived from the session? Some aspects may be addressed in a previous question, in that case you may repeat what was said before or refer to it.

	Do you think that there is anything that you will apply to your teaching? What are you planning to try out? Do you think there is anything in the session that is likely to improve STEM learning?	
To what extent do you feel that the session targeted your needs?	Did the session reflect or in any way address your needs? What challenges do you envisage in putting the ideas/activities into practice?	What challenges do you encounter when putting CPD ideas into practice?
What are your views about the collaborative aspect implemented during the session?	What kind of collaboration was possible: for example working with others; observing others; providing feedback to others? What do you think about the collaboration between practitioners and student-teachers? What do you think about the collaboration across disciplines? What do you think about the collaboration between teachers?	These questions need to be adapted according to the session and its participants. Some of the questions may not be relevant and may be left out.
How would you change the session?		

Conclusion:
Is there anything else that you would like to add?

Next steps
I will be transcribing your interview and will send you the transcript to ask for your approval in approximately one month. We will be analysing the information that you and other participants gave us. We will write a national report in June 2024. Furthermore we will submit an international report to the European Commission with

recommendations about CPD. I will be happy to send both reports to you, if you are interested.

Thank you for your support.
Ending time: _____

ICSE Academy WP4: Data collection instruments for the case studies

Interview with a pre-service teacher participating in the CPD session

(Interview guide based on the *Data Collection Instruments for Case Study* developed for the MaSDiV project).

One of the aims of the ICSE Academy is developing and testing effective, accessible and transferable models for professional learning of pre- and in-service STEM teachers. This interview contributes to the case study for the evaluation. The guiding **research question** for this interview is:

To what extent are the individual regional activities effective and accessible?

Part A Introduction

I would like to thank you for taking the time to participate in this interview.
My name is _____. I am _____ (give a short introduction of the interviewer and role in the project).
I would like to talk to you about the session about *TOPIC* that you attended. The interview is part of the evaluation of the ICSE Academy project which involves 13 countries.

The main aim of this interview is to obtain an insight into how participants perceive the session and how to improve it. The interview will take about 45 minutes. With your permission, I will record the session because I do not want to miss any of your comments. Later the interview will be transcribed and I will send you the transcript for your approval.

All responses will be kept confidential. We will ensure that any information included in our report will not identify you as the respondent.

You are free not to answer any question that you do not wish to answer and you may end the interview at any time. Do you have any questions? Are you willing to participate in the interview?

On the basis of the written information I provided earlier, please provide your signed consent.

Starting time _____

Start recording the interview

Part B The pre-service teacher and his/her background and teaching experience

Guiding question	Prompts	Comment
What initial teacher education course are you following?		The first few questions will give an insight into

How long is the course? In which year are you?		student-teachers' professional background. It will also put the participants at ease. It is important to show interest in the person. You do not have to stick to the written questions. Try to create a good atmosphere for the interview
Do you have any teaching experience?	For how long were you teaching?	
Why did you decide to become a teacher?	What are your most important goals as a future teacher?	This question will give insight about the student-teacher, his/her story and possibly an insight into the values of the student-teacher.
How would you describe your ITE course?	How many students? What are the main challenges? Do you have work or observations in schools as part of your course? What is your school like? How would you describe a typical lesson that you observed?	The prompts may help to get an insight into the contextual factors that might influence the student-teacher's perception of the effectiveness of the session. Listen carefully all the time as you may need to refer to the school context later.
How would you describe a typical lesson that you have prepared so far?		This is only applicable to student-teachers who have had some teaching experience.

Part C Questions about the CPD

What motivated you to join the CPD?	Is it part of your ITE course? *If the answer is no*: How did you learn about it? What did you hope to acquire/learn through the course?	This will give an insight on the needs, expectations of the teacher. Ask why?

	What were your expectations? What kind of lectures have you experienced in the past? What kind of lectures/sessions do you like best?	
What do you think about the CPD course in general?	So far, did it fulfil what you were after? Explain what you liked and what was missing.	Ask why?
What are your views about the session about **TOPIC**? Or What are your views about today's session?	What do you think about the schedule, time, length of the session? What do you think about the content of the session? What do you think about the style/method adopted? Why/which ones? Do you feel that you have learnt anything related to science/mathematics content? Do you feel that you have learnt anything related to how to teach the subject or how students learn? Do you feel more confident and competent in any of the following: using technology addressing sustainability diversity in STEM classrooms green skills climate change intercultural STEM approaches?	These questions need to be adapted according to the topic of the session. If the interview does not take place immediately after the session the questions may be: In which way did the session change your practice? How did you implement the activities/ideas from the session into practice? Are there any benefits for your students derived from the session? Some aspects may be addressed in a previous question, in that case you may repeat what was said before or refer to it.

	Was there anything in particular that made you reflect about students or teaching? Do you think that there is anything that you will apply to your teaching? What are you planning to try out? Do you think there is anything in the session that is likely to improve STEM learning?	
To what extent do you feel that the session targeted your needs?	Did the session reflect or in any way address your needs? What challenges do you envisage in putting the ideas/activities into practice?	What challenges do you encounter when putting teaching ideas into practice?
What are your views about the collaborative aspect implemented during the session?	What kind of collaboration did you experience in the session, for example working with others, observing others, providing feedback to others etc.? What do you think about the collaboration between practitioners and student-teachers? What do you think about the collaboration across disciplines? What do you think about the collaboration between teachers?	These questions need to be adapted according to the session and its participants. Some of the questions may not be relevant and may be left out.
How would you change the session?		

Conclusion:
Is there anything else that you would like to add?

Next steps
I will be transcribing your interview and will send you the transcript to ask for your approval in approximately one month. We will be analysing the information that you and other participants gave us. We will write a national report in June 2024. Furthermore we will submit an international report to the European Commission with recommendations about CPD. I will be happy to send both reports to you, if you are interested.

Thank you for your support.
Ending time: _____

ICSE Academy WP4: Data collection instruments for the case studies

Reflection sheet for the Educator providing the CPD session

One of the aims of the ICSE Academy is developing and testing effective, accessible and transferable models for professional learning of pre- and in-service STEM teachers. This reflection contributes to the case study for the evaluation. The guiding **research question** for this reflection is:

To what extent are the individual regional activities effective, accessible and transferable?

Introduction

The main aim of this reflection is to obtain an insight into the planning, the desired learning outcomes and into how the CPD provider evaluates the session and how to improve it.

All responses will be kept confidential. We will ensure that any information included in our report will not identify you as the respondent.

Part A The Educator and the context

1. **Please introduce yourself briefly.**

(How long have you been teaching? How long have you been involved in ITE and/or CPD of teachers? What are your most important goals as an Educator?)

2. **How would you describe your ITE/CPD course?**

(How many students/participants? What are the main characteristics? What are the main challenges? How would you describe a typical lecture/session that you provide? Please give any other contextual factors that are relevant and that might influence choices made.)

Part B Questions about the CPD

3. **What were the objectives/learning outcomes for this session?**

4. **What did you try to cover through the session?**
(Did the session target anything related to science/mathematics content? What was the science/mathematics content of the session?
Did the session target anything related to pedagogical knowledge? Explain.
Did the session target anything related to pedagogical content knowledge? Explain.)

5. **Did you target any of the European priorities? How did you integrate it/them in the session?**
(Example: sustainability; climate change; green skills; digital skills; gender-sensitive STEM; diversity in STEM classrooms; intercultural STEM approaches; promoting shared values such as equality, gender equality, non-discrimination, diversity, social inclusion).

6. **What format did you adopt? Why did you adopt this format?**
(Example: *School-based learning; Digital learning format; cooperative ways of learning; lesson study; action research).*

7. **What teaching styles/approaches did you adopt? Why?**

8. **Was there anything in the session that was intended to improve STEM learning?**

9. **How did you try to include the collaborative aspect during the session? What are your thoughts about the collaborations that took place in your session?**
   (Example collaboration between practitioners and student-teachers in your session; collaboration across disciplines; collaboration between primary and secondary level teachers; between teachers; collaboration by working together, collaboration by observing other teachers; collaborating by providing feedback.)

10. **What is your evaluation of the session? Were the objectives/learning outcomes achieved in your opinion? Why?**
    (What was in your opinion successful/less successful during the session? How do you feel about the session?)

11. **To what extent do you consider this learning activity to be applicable to other countries or contexts?**

12. **Was there anything in particular that made you reflect about the session?**

13. **If you were to do this session again, how would you change it?**

14. **Is there anything else that you would like to add?**

ICSE Academy WP4: Data collection instruments for the case studies

Reflection sheet for the Educator observing the CPD session

One of the aims of the ICSE Academy is developing and testing effective, accessible and transferable models for professional learning of pre- and in-service STEM teachers. This reflection contributes to the case study for the evaluation of peer learning through job shadowing. The guiding **research question** for this reflection is:

To what extent are the regional activities transferable to different contexts?

Introduction

The main aim of this reflection is to obtain an insight on the transferability of the regional activities to different contexts.

All responses will be kept confidential. We will ensure that any information included in our report will not identify you as the respondent.

Part A The Educator and the context

1. **Please introduce yourself briefly.**

(How long have you been teaching? How long have you been involved in ITE and/or CPD of teachers? What are your most important goals as an Educator?)

2. **How would you describe the ITE/CPD course offered by your institution?**

(This will help provide details about the educational context. How many students/participants? What are the main characteristics? What are the main challenges? How would you describe a typical lecture/session that you provide? Please give any other contextual factors that are relevant and that might influence choices made.)

Part B Reflections about the CPD observed

3. **Why did you choose to observe this course or session? What did you expect to learn? Did it meet your expectations?**

4. **What were the objectives/learning outcomes for the observed session? Which of these are applicable to your institution/teachers' needs?**

5. **To what extent can you adapt and transfer:**
   science/mathematics content
   pedagogical knowledge
   pedagogical content knowledge
   that participants were learning during this session (if any)? Explain.

6. **Did the session target any of the European priorities? To what extent can you adapt and transfer these to your context? Why?**

(Example: sustainability; climate change; green skills; digital skills; gender-sensitive STEM; diversity in STEM classrooms; intercultural STEM approaches; promoting shared values such as equality, gender equality, non-discrimination, diversity, social inclusion).

7. **What format was adopted in the session? To what extent can you adapt and transfer the format? Why?**
   (Example: *School-based learning; Digital learning format; cooperative ways of learning; lesson study; action research).*

8. **What teaching styles/approaches were adopted? To what extent can you adapt and transfer the teaching styles? Why?**

9. **What are your thoughts about the collaborations that took place in the session? To what extent can they be adapted and transferred to your context? Why?**
   (Example collaboration between practitioners and student-teachers in your session; collaboration across disciplines; collaboration between primary and secondary level teachers; between teachers; collaboration by working together, collaboration by observing other teachers; collaborating by providing feedback.)

10. **What did you learn from the job shadowing that you might transfer to your teaching and why do you plan to transfer it?**

11. **Was there anything in particular that made you reflect about the session?**

12. **If you were to do this session at your institution, how would you adapt it?**

13. **Is there anything else that you would like to add?**

ICSE Academy WP4: Data collection instruments for the case studies

Reflection sheet for the Educator observing the CPD session AFTER adapting and transferring the CPD session

One of the aims of the ICSE Academy is developing and testing effective, accessible and transferable models for professional learning of pre- and in-service STEM teachers. This reflection contributes to the case study for the evaluation. The guiding **research question** for this reflection is:

To what extent are the regional activities transferable to different contexts?

Introduction

The main aim of this reflection is to obtain an insight on the transferability of the regional activities to different contexts.

All responses will be kept confidential. We will ensure that any information included in our report will not identify you as the respondent.

Part A The Educator and the context

1. **Please introduce yourself briefly.**

(How long have you been teaching? How long have you been involved in ITE and/or CPD of teachers? What are your most important goals as an Educator?)

2. **How would you describe the ITE/CPD course offered by your institution?**

(This will help provide details about the educational context. How many students/participants? What are the main characteristics? What are the main challenges? How would you describe a typical lecture/session that you provide? Please give any other contextual factors that are relevant and that might influence choices made.)

Part B Reflections about the CPD session transferred and implemented following adaptation

3. **What were the objectives/learning outcomes for the session? To what extent were the original objectives/learning outcomes applicable to your institution/teachers' needs?**

4. **To what extent were you able to transfer:**
   science/mathematics content
   pedagogical knowledge
   pedagogical content knowledge
   that participants were learning during this session (if any)? Explain.

5. **Did the session target any of the European priorities? To what extent were you able to adapt and transfer these to your context? Why?**
   (Example: sustainability; climate change; green skills; digital skills; gender-sensitive STEM; diversity in STEM classrooms; intercultural STEM approaches; promoting shared values such as equality, gender equality, non-discrimination, diversity, social inclusion).

6. **What format was adopted in your session? To what extent was it possible to adapt and transfer the format of the original session? Why?**
   (Example: *School-based learning; Digital learning format; cooperative ways of learning; lesson study; action research).*

7. **What teaching styles/approaches did you adopt? To what extent was it possible to adapt and transfer the teaching styles? Why?**

8. **What collaborations took place in your session? To what extent can collaborations used in the original context be adapted and transferred to your context? Why?**
   (Example collaboration between practitioners and student-teachers in your session; collaboration across disciplines; collaboration between primary and secondary level teachers; between teachers; collaboration by working together, collaboration by observing other teachers; collaborating by providing feedback.)

9. **What difficulties and challenges did you experience when attempting to adapt and transfer the session?**

10. **Was there anything in particular that made you reflect about the session?**

11. **If you were to do this session again, how would you improve it?**

12. **Is there anything else that you would like to add?**

ICSE Academy WP4: Permission letters, information letters and consent forms

Permission letter to conduct research at the University

[Addressee name]
[Address]

[Date]

Request for permission to conduct research at the University

Dear [title and name of recipient],

We are [insert names], lecturers at the University of XXX, presently participating in a research project titled ICSE-Academy. One of the objectives of the project is developing and testing effective, accessible and transferable models for professional learning of pre- and in-service STEM teachers. Among other things the project involves peer-learning by job shadowing, in which lecturers from one institution observe professional learning sessions such as lectures, organised by another institution.

We are hereby seeking your permission to invite a lecturer from another institution to observe a lecture delivered by one of us. This will take place in person/via zoom. The focus of the observation will be the lecturer. Following the lecture we wish to carry out interviews with three of the participants. The interview will be about 45 minutes long and will be audio-recorded.

Participation will be entirely voluntary and participants will be free to withdraw at any point, without any repercussions. Data collected will be pseudonymised. The data collected will be treated confidentially. Pseudonyms will be used when reporting the case study. All raw data will be securely stored in an anonymised form and the data obtained will be solely used for the compilation of this research. Data will be stored in a password-protected personal computer. We are the only persons who will have access to it.

Should you require further information, please do not hesitate to contact us; our contact details are provided below.

Thank you for your kind consideration of this request.

Sincerely,

[Researcher's name] [Researcher's name]
[Researcher's email address] [Researcher's email address]

ICSE Academy WP4: Permission letters, information letters and consent forms

Information letter and consent form for participants of the course

[Date]

Information about the study

We are [insert names], two lecturers at the University of [insert name]. We are presently taking part in a research project titled ICSE-Academy. One of the objectives of the project is developing and testing effective, accessible and transferable models for professional learning of pre- and in-service STEM teachers. Among other things the project involves peer-learning by job shadowing, in which lecturers from one institution observe professional learning sessions such as lectures, organised by another institution.

Your Participation

We would like to inform you that a lecturer from another University will be observing one session from your course delivered by one of us. The focus of the observation will be the lecturer.

Any data collected from this research will be used solely for purposes of this study.

In order to evaluate the session, we would like to obtain feedback from students/teachers who participate in the professional learning session. Should you choose to participate, you will be asked to participate in one interview which will be about 45 minutes long and will take place at a time and place that is convenient for you. The interview will be audio-recorded.

Participation in this study is voluntary; in other words, you are free to accept or refuse to participate, without needing to give a reason.

You are also free to withdraw from the study at any time, without needing to provide any explanation and without any negative repercussions for you. Should you choose to withdraw, any data collected from you will be erased as long as this is technically possible (for example, before it is anonymised or published), unless erasure of data would render impossible or seriously impair achievement of the research objectives, in which case it shall be retained in an anonymised form.

If you choose to participate, please note that there are no direct benefits to you.

Your participation does not entail any known or anticipated risks.

Data Management

The data collected will be treated confidentially. Pseudonyms will be used when reporting the case study. All raw data will be securely stored in an anonymised form and the data obtained will be solely used for the compilation of this research. Data will

be stored in a password-protected personal computer. We are the only persons who will have access to it.

Please note also that, as a participant, you have the right under the General Data Protection Regulation (GDPR) and national legislation to access, rectify and where applicable ask for the data concerning you to be erased.

All data collected will be erased within two years of completion of the study.

Participant's consent

☐ I hereby declare to have read the information about the nature of the study, my involvement and data management.
☐ I have had the opportunity to ask questions about the study and my questions have been satisfactorily answered.
☐ I declare that I am 18 years or older.
☐ I understand that should I have any further queries, I can contact [insert researcher's name and contact details].
☐ I agree to participate in this research study.

_____ _____
Participant's name (in block) Researcher's name (in block)

_____ _____
Participant' signature Researcher's signature

_____
Date

ICSE Academy WP4: Analysis guide for the case study

Procedure for analysis based on Braun & Clarke (2006)

The procedure will involve thematic analysis reporting experiences, meaning and reality of the participants.

The procedure involves the following steps:

1. Transcription of interviews
   This involves the preparation of a word for word written transcript of the audio recordings. It helps if you plan how you will work on the transcripts during the analysis process. For example you may use a table with one column for the dialogue and another column for your codes, analytical notes and comments.

2. Familiarisation with the interview/reflection/observation notes
   This involves reading the transcripts, reflections and observation notes.

3. Coding
   While reading the transcript line by line, a code or label is assigned. Based on the needs of the project some of the codes are given below. However it is important to note other things that may be important but that are not captured by these codes. Sections that have the same code can be grouped together.

4. Developing themes
   Codes are then grouped into themes. Themes are broader and developing them requires interpretation of the codes and the data. “A theme captures something important about the data in relation to the research question” (Braun & Clarke, 2006, p. 82). Based on the needs of the project and on the research questions we will be looking for some specific themes. This does not exclude the development of other themes.

5. Reviewing themes
   Themes are reviewed and refined. There should be a distinction between themes but coherence within a theme.

6. Description of the themes. Each theme identified should be named and described.

7. Reporting based on the analysis. Extracts/quotations are included.

Possible themes and codes

Theme	Code/Interview Teacher (T) or Student-teacher (ST)	Code/Observation
Context	T/ST – years teaching T/ST – years in current school T/ST- goals as a teacher T/ST preferred teaching style School – size School – challenges School - diversity	
CPD course as a whole	T/ST – needs T/ST – expectations T/ST – positive comments T/ST – negative comments T/ST - suggestions	
Effectivity of observed CPD session	T/ST - needs T/ST - positive comment T/ST - negative comment T/ST - improved confidence or competence T/ST - reflection T/ST – change in practice/application T/ST – suggested improvements to the session T/ST - collaboration	Teacher engagement Collaborative methods Innovative methods Teacher motivation Relevance to practice Evidence of link to learning on the job Evidence of teacher reflection Transferability
Accessibility of observed CPD session	Duration Time Schedule/format/structure	

Reference:
Braun, V & Clarke, V. (2006) Using thematic analysis in psychology. Qualitative Research in Psychology, 3:77-101.

9. APPENDIX II. LIST OF TABLES AND FIGURES

Table 1. Number of participants (students or teachers) in the observed sessions

Figure 1. Overview of the case study sessions observed and transferred in the respective countries

10. APPENDIX III. THE INDIVIDUAL CASE STUDIES