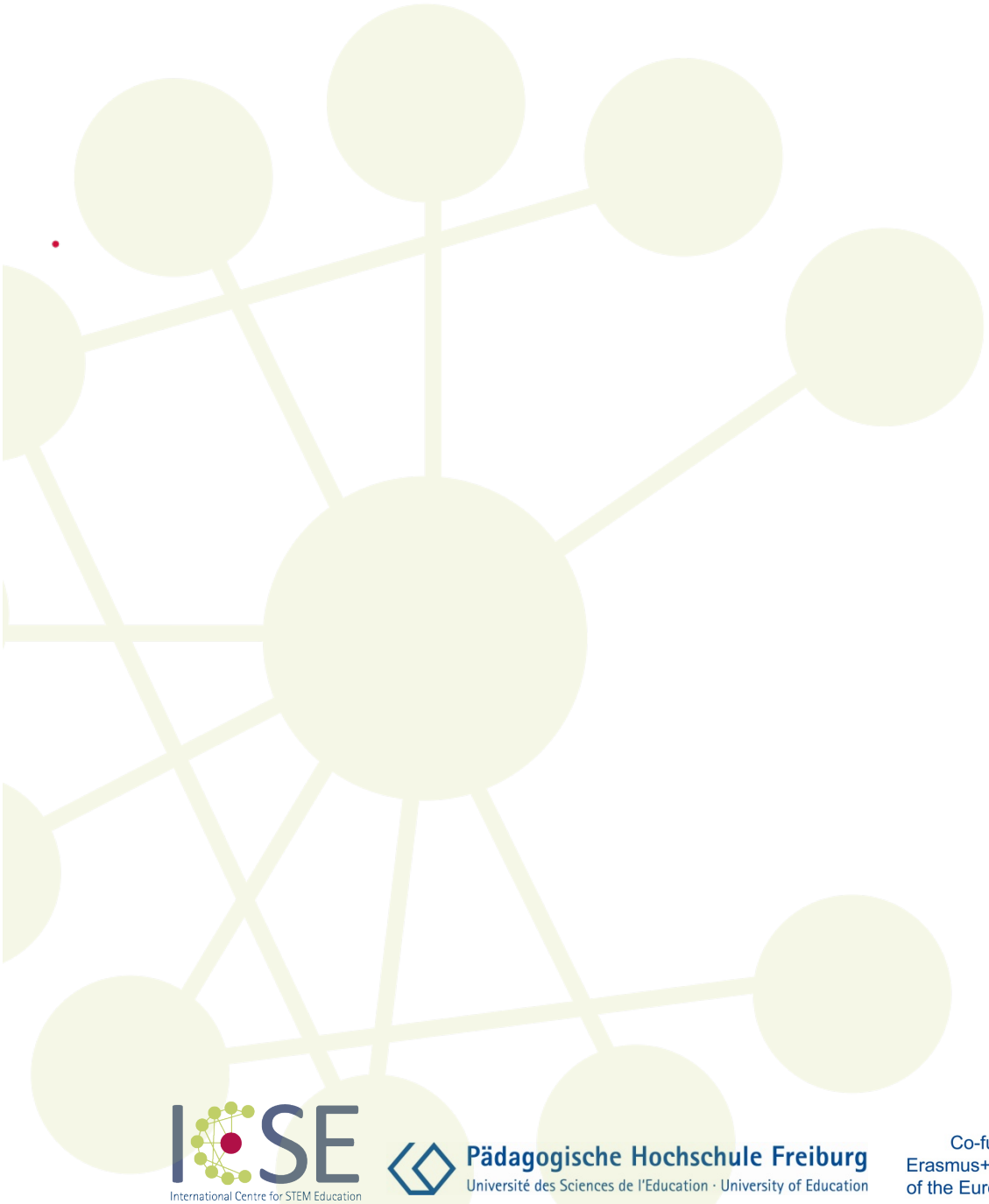
MaSDiV

Supporting Mathmatics and Science Teachers in addressing Diversity and promoting fundamental Values

Report on the Evaluation of the Project *Supporting Mathematics and Science Teachers in addressing Diversity and promoting fundamental Values* (MaSDiV)



ICSE International Centre for STEM Education

Pädagogische Hochschule Freiburg
Université des Sciences de l'Education · University of Education

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Executive Summary

It is the main objective of mathematics and science education to prepare students for a future employment and to become active participants of society. To achieve this goal, teachers need to attend to the diverse backgrounds of their students in order to enable their students to develop to their full potential. The aim of the project *Supporting **Ma**thematics and **S**cience Teachers in addressing **Di**versity and promoting fundamental **V**alues* (MaSDiV) is to deliver professional development courses to mathematics and science teachers to support them to implement inclusive mathematics and science education. Inclusive mathematics and science education includes access for diverse learners in inquiry-based learning (IBL), using contexts to promote fundamental values, and attention to diverse cultural backgrounds.

Within the project, work package 5 (WP5) investigated to which extent the professional development course had an impact on the participating teachers. More specifically, the evaluation focussed on the development of participating teachers' self-efficacy beliefs and learning-related beliefs as key prerequisite for long-lasting change in practice as well as concrete examples of practices. To achieve this goal, WP5 conducted a quantitative pre-post study as well as qualitative case studies in cooperation with all consortium members in the six participating countries. The mixed-method approach allowed to complement perspectives from participating teachers in general and from case study teachers on their concrete experiences.

The results from the evaluation showed on the one hand that teachers already had strong beliefs about the benefits of IBL for achievement-related diversity, the use of contexts, and the attention to diverse cultural backgrounds. On the other hand, prior to the professional development course teachers rarely incorporated investigative practices, contexts and ways to attend to the diverse cultural backgrounds. After completion of the professional development course, teachers reported to use investigative practices, contexts, and ways to attend to the diverse cultural backgrounds significantly more often. Furthermore, teachers also felt significantly better prepared to implement inclusive mathematics and science education in their own classrooms. The results from the quantitative study are supported by the experiences from the case study teachers as several case study teachers referred to the learning experience as an eye-opener. The case study teachers also demonstrated various ways to include the ideas of inclusive science and mathematics education in their lessons. Case study teachers chose contexts that are meaningful and relevant to students' lives and supported their investigation processes through peer- and individualized feedback.

Both studies showed that teachers valued the discussion and shared reflection with other teachers on the use of concrete examples of meaningful contexts. It would therefore be helpful to increase the number of examples and also enable teachers to continuously discuss those examples in an online environment or prolonged professional development program. Policy makers also need to increase the importance of professional development programs since in several countries professional development is not mandatory or incentivised. Additionally, teachers also reported curricular and time constraints as hindering factors for changing their practice. A reduced number of exam-relevant topics and an inclusion of IBL practices and contexts in the exams would therefore raise the likelihood of using those ideas during instruction which in turn could support the development of students from diverse backgrounds.

1. Main report

This report provides an overview of the evaluation from the project *Supporting **Ma**thematics and **S**cience Teachers in addressing **Di**versity and promoting fundamental **V**alues* (MaSDiV). The aim of the project was to support mathematics and science teachers conducting lessons that enable all students to reach their own potential and actively participate in society and democracy. To reach this goal, a professional development program was developed and implemented in six different countries in Europe. WP5 pursued the task to evaluate the impact of the professional development program as well as how and under which conditions teachers implemented the desired type of lessons to support their students. The evaluation utilized a quantitative pre-post study as well as a qualitative case study approach. Both approaches allow a comprehensive overview of the impact from the professional development course as well as of possible supporting and hindering factors for implementing inclusive mathematics and science education.

1.1 Introduction

As the recent PISA 2018 report (OECD, 2019a) points out, a significant 24% of 15-year-old students in mathematics and 22% of the students in science do not attain the basic competence level in these subjects in OECD countries. Those figures are well in line with numbers reported from the EU commission's 2015 Education and Training Monitor showing that 22% of the 15-year-olds are underachievers in mathematics and 17% underachieve in science (ETE 2020). The low performance of those students has been linked to a rather low socio-economic status, which is even more prevalent amongst students with a migrant background (OECD, 2019b). Those students are especially at risk since science and mathematics are seen as key prerequisites for employability and active participation in the society (EC, 2007) and underachieving in those domains will more likely result in school drop-out (EC, 2015). To further prevent the transmission of disadvantages across generations and support the development of the European Union as a whole as well as the development and security of each child (EC, 2013), special attention needs to be directed towards diversity in science and mathematics classrooms.

Teachers are the key stakeholders in the educational system to implement and foster a classroom culture that accounts for students' diversity. However, teachers need additional systemic support to undertake that change in classroom culture in their own classrooms. Teachers echoed that sentiment as they reported a strong need for additional professional development courses addressing multicultural and multilinguistic settings in the TALIS 2013 report (OECD, 2014). One promising approach to account for diverse students' characteristics is inquiry-based learning (IBL) (e.g. Brown, 2017). In IBL lessons students can work actively on scientific problems based on their own capabilities and backgrounds, hence, develop beneficially compared to more commonplace science instruction (Wilson, Taylor, Kowalski, & Carlson, 2010). To go beyond traditional IBL approaches as *doing science*, teachers should also foster students' epistemic agency in order to support students' knowledge construction (Miller, Manz, Russ, Stroupe, & Berland, 2018). To allow students to develop epistemic agency, students should encounter IBL within real-life contexts and should be able to bring intercultural perspectives into their classroom. However, for teachers to plan, conduct and reflect on lessons including IBL, real-life contexts, and intercultural learning, they need specific professional competences (Baumert & Kunter, 2013).

According to the model of teachers' professional competence proposed by Baumert and Kunter (2013) teachers need profound professional knowledge, supporting self-regulation abilities, appropriate learning-related beliefs and sustainable motivational orientations such as self-efficacy beliefs. So, to support teachers in implementing the desired type of instruction, professional development (PD) programs need to target those core aspects of teachers' professional competence. Effective PD is therefore characterized by a change in teachers' knowledge, learning-related beliefs, and self-efficacy

beliefs which in turn lead to a change in teachers' instruction and improved student outcomes (Desimone, 2009). The evaluation of the MaSDiV project therefore focusses on the change in teachers' learning-related beliefs and self-efficacy beliefs as well as the change in their teaching practice. Those changes should manifest themselves on the large scale as well as in single case studies. We therefore utilized both quantitative and qualitative methods to complement both approaches in a mixed-method design (Green, Caracelli, & Graham, 1989) and provide a comprehensive picture of the outcome from the MaSDiV project. The results from the evaluation can inform policy makers and teacher educators alike to help teachers give each student the possibility to develop in an optimal way.

1.2 Pre-post study

1.2.1 Design

To ensure a reliable and valid measurement of the effects from the PD on teachers' professional competence, WP3/WP5 developed an experimentation protocol in accordance with all partner countries. In each country, teachers were asked to provide information about their personal background (e.g. subject, teaching experience) as well as key entry characteristics during the first meeting in the PD course. These entry characteristics served as the baseline for the evaluation of the PD's success. Consortium members were encouraged to implement the post questionnaire during the last session where they expected to have most teachers attending. This instruction ensured to have a sufficient high participation rate and a valid measurement for the PD's impact and not possible side effects from additional teaching experiences.
The PD itself lasted at least 14 hours and consisted of three different modules: 1) IBL and achievement-related diversity; 2) IBL in real-life relevant contexts; 3) IBL as a tool for intercultural learning (see https://icse.eu/wp-content/uploads/2018/SonstigePDFs/PD-COURSE-MANUAL-1.pdf). The local PD leaders were advised to adapt the PD materials to their local context (e.g. use country-specific contexts) and the national PD system. Depending on the national context, the actual duration of the PD varied from 14 hours until 30 hours. The dates were also spread across five days of a summer camp up until weekly meetings for four months. All PDs focussed on strengthening science and mathematics teachers' self-efficacy and learning-related beliefs as well as enriching their knowledge to further change their teaching practices.

1.2.2 Instrument

To evaluate the effectiveness of the PD program, a new instrument was developed. The instrument can be accessed on the project's website (https://icse.eu/wp-content/uploads/2018/SonstigePDFs/WP3_Experimentation-protocol_D3.1_Pre-post-Questionnaire.pdf).
The first section of the questionnaire contains background variables used as independent variables in the evaluation process. These background variables consist of age, gender and teaching experience in order to describe the participation group, as well as their previous knowledge, need for PD courses, and perceived context factors which teachers might experience in their everyday teaching (see for example Skaalvik & Skaalvik, 2010). Motivated by the practical experiences with systematic comparison tests like TALIS (OECD, 2014), a four-point Likert-scale was implemented whenever suitable. The categories were adapted to the questions and reflect agreement (strongly disagree, disagree, agree and strongly agree) or frequencies (Never or hardly ever, some lessons, most lessons and almost every lesson). The questionnaire does not include any open questions to ensure feasibility.
In the second part of the questionnaire, teachers are asked about their perceived effectiveness in aspects of their teaching approaches, as well as their beliefs about using IBL to address diversity, about showing the relevance and implications of science and promoting fundamental values. Items were

newly developed based on existing instruments for self-efficacy (Bandura, 1997) and learning-related beliefs (e.g. Kleickmann et al., 2016). Furthermore, teachers are asked about their current teaching practices in relation to IBL, real-life contexts and multicultural classroom settings. Items assessing teaching practices in relation to IBL stem from a previous project (e.g. Maass & Engeln, 2019) and are complemented by newly developed items focussing on addressing achievement-related diversity, the use of contexts, and accounting for cultural diversity.

Some of the background variables are excluded from the post questionnaire due to stability. The remaining constructs such as self-efficacy beliefs, learning-related beliefs and the reported practices remain in order to ensure evaluation of the PD's effectiveness. Items on the overall PD experience as well as on the perceived effectiveness of the PD complete the evaluation instrument.

Information about the reliability of the instrument can be found in Table 1. Table 1 displays the number of items and Cronbach's Alpha as a measure for internal consistency based on the pre-test results for the targeted constructs of self-efficacy beliefs, learning-related beliefs, and teaching practices differentiated by the type of instruction discussed in the three modules of the PD. All scales show sufficient reliability with values greater than .60.

Table 1. Overview of the instrument including number of items, Cronbach's Alpha, mean, and standard deviation.

Scale	*N*	Cronbach's α
Self-Efficacy IBL for addressing diversity	5	.71
Self-Efficacy using contexts	4	.73
Self-Efficacy addressing cultural diversity	3	.82
Beliefs about IBL for addressing diversity	5	.73
Beliefs about using contexts	4	.74
Beliefs about cultural diversity	3	.64
Authenticity/relevance practices	3	.69
Hands-on practices	3	.66
Student Orientation practices	3	.70
Investigative practices	3	.83
IBL practices accounting for diversity	4	.63
Use of contexts	3	.67
Accounting cultural diversity	3	.78
IBL practices combined	16	.87

Since most of the scales were newly developed, evidence for the construct validity was gathered. Table 2 shows the correlational pattern of the targeted constructs.

Table 2. Correlation matrix for the pre-test results concerning teachers' self-efficacy beliefs, learning-related beliefs, and practices.

	SE_IBL	SE_Con	SE_Cult	Bel_IBL	Bel_Con	Bel_Cult	Prac_IBL	Prac_Con	Prac_Cult
SE_IBL	1								
SE_Con	0,55**	1							
SE_Cult	0,49**	0,50**	1						
Bel_IBL	0,25**	0,17**	0,08	1					
Bel_Con	0,09*	0,28**	0,07	0,51**	1				
Bel_Cult	0,13**	0,21**	0,22**	0,49**	0,58**	1			
Prac_IBL	0,44**	0,38**	0,34**	0,23**	0,18**	0,15**	1		
Prac_Cont	0,24**	0,43**	0,32**	0,05	0,23**	0,18**	0,64**	1	
Prac_Cult	0,24**	0,32**	0,49**	0,08	0,22**	0,31**	0,54**	0,63**	1

Note: $^{**}p < .01$, $^{*}p<.05$. SE – Self-efficacy beliefs, Bel – Learning-related beliefs, Prac – Teaching practices, IBL – Inquiry-based learning, Con – Using Contexts, Cult – Cultural Diversity.

The analysis highlights that the correlations between different topics of the same constructs (see the orange boxes in Table 2; e.g. self-efficacy beliefs about IBL and self-efficacy beliefs about using contexts) show medium correlation indicating convergent validity (mean correlation between the different topics of a construct: self-efficacy beliefs - r = .51, learning related-beliefs – r = .52, teaching practices – r = .60). In addition to that, correlations among the same topics across different constructs (see the yellow boxes in Table 2; e.g. beliefs about IBL and IBL practices) also show significant correlation further indicating a coherent measurement (mean correlations between the constructs addressing the same topic: IBL – r = 0.31, use of contexts – r = .31, cultural diversity – r = .34).
To ensure content validity, we also relied on previously tested items (e.g. Maass & Engeln, 2019) or adapted well-establish items. Further evidence for validity stems from expert reviews, as all items were reviewed by the consortium members in order to ensure that they cover the targeted constructs.

1.2.3 Sample

A total of 515 teachers from six different countries took part in the pre-testing for the evaluation of the MaSDiV PD program. The number of teachers varied by country between 72 (Spain) and 104 (Malta) (see Table 3). About 65% of the teachers in the total sample were female. Gender distribution, however, varied also across countries. While there were only 19% male teachers in Malta, in the Netherlands 55% of the teachers were male (see Table 3). The difference in gender distributions across countries was also detected in the mascil project (Engeln, 2016) as well as in the TALIS 2013 study (OECD, 2014).

Table 3. Distribution of teachers across countries and corresponding gender.

	Cyprus		**Germany**		**Malta**		**Netherlands**		**Spain**		**Turkey**	
N	74		98		104		74		72		93	
Gender (female/male)	71.6%	28.4%	69.4%	30.6%	80.8%	19.2%	45.2%	54.8%	48.6%	51.4%	63.4%	36.6%

Teachers participating in the PD program were on average 37 years old (SD = 11 years) and had 10 years of teaching experience (SD = 9 years). Again, the average age also varied across countries with teachers from Turkey being the youngest with 32 years and teachers from Spain being the oldest with 44 years. The differences in age is also reflected in the differences in the teaching experience varying from 6 years in the Netherlands up to 15 years in Cyprus. There is also a significant correlation between teachers' age and teaching experience (r = .78, p < .001), which is displayed in Figure 1.

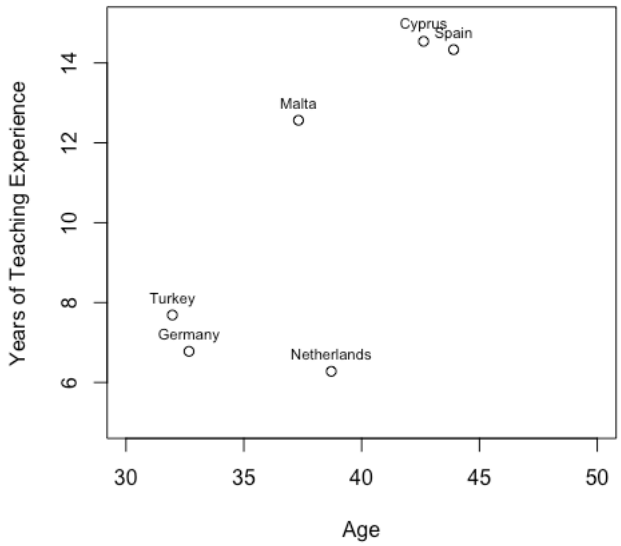

Figure 1. Teachers' age and teaching experience across countries.

It is noteworthy though that teachers from the Netherlands are relatively old compared to their teaching experience, indicating that the teachers in that sample started their teaching career later in their life (e.g. as a second career).

The main target group for the MaSDiV project were science and mathematics teachers from lower-secondary schools. In line with this goal about 78% of the teachers taught at lower-secondary. In countries like Spain and Malta, teachers also had teaching responsibilities for multiple school levels (e.g. primary and lower secondary level). Also, in Germany and Cyprus a significant number of teachers held teaching responsibilities for the primary level only (50% and 37% respectively). In addition to the grade levels taught, teachers were also asked about their subject they want to focus on during the PD. 55% of the teachers focussed on mathematics and 45% of the teachers were grouped together as science teachers. Science subjects comprised of physics, chemistry, biology and general science with most of the science teachers teaching general science or multiple science subjects (44% of the science teachers). The proportion of science and mathematics teachers is also country-specific. The proportion of mathematics teachers ranges from 24% in the Netherlands up to 100% in Germany.

In summary, while there are differences between the participating teachers in the different countries, the sample does represent a broad range from the possible spectrum of lower-secondary science and mathematics teachers in the different countries. The participating teachers, however, are not representative for the different countries, since they volunteered to participate in the PD. It is therefore reasonable to draw conclusion for teachers interested in a PD on inclusive mathematics and science education with varying cultural backgrounds.

From the total sample of *N* = 515 teachers, 376 teachers took part in the post test during the last session of the PD course (73 %). From those teachers, we were able to match *N* = 347 teachers' post-test to their pre-test results allowing for a reliable description of their development. Table 4 provides an overview of the sample with matched pre-post-tests across countries. All countries contributed equally to the final sample with Malta having the highest number of teachers at 81. Comparable to the initial sample 67% of the teachers were female and the mean age was 38 years (*SD* = 11 years). Again, in line with the full sample, the final sample of teachers had on average 10 years of teaching experience and 52% of them focussed on mathematics during the PD. Overall, the final sample does not deviate from the full sample at the beginning of the course. Therefore, there seems to be no general selection bias based on teachers' initial characteristics.

Table 4. Distribution of teachers with matching pre-post-tests across countries.

	Cyprus	Germany	Malta	Netherlands	Spain	Turkey
N	44	63	81	56	53	50

1.2.4 Results

The results of the quantitative pre-post study provide multiple insights into teachers' self-efficacy beliefs, learning-related beliefs and practices covering the different aspects of inclusive mathematics and science education. First, the pre-test results provide a baseline of the beliefs and practices of a substantial sample of European teachers entering a professional development course covering the topics of inclusive mathematics and science education. Second, the design allows to draw conclusions on the effectiveness of the professional development course by investigating changes in teachers' self-efficacy beliefs, learning-related beliefs and practices. Finally, additional questions targeting the subjective effectiveness of the professional development course provide some evidence on possible supporting and hindrance factors of the professional development course.

The results from the baseline assessment in the pre-test is summarized in Table 5. It shows that on average participants rather agree that they feel confident to use IBL in order to address achievement-related diversity and use contexts as well. However, teachers feel less well prepared to address cultural diversity in their classroom. In addition to that, teachers somewhat have weaker beliefs about the benefits of addressing cultural diversity compared to very strong beliefs about the benefits of using IBL

to address achievement-related diversity and the use of contexts. The participating teachers also report that they on average use authentic, hands-on and student-oriented practices as well as IBL practices to account for achievement-related diversity in most of their lessons. Investigative practices, the use of contexts and accounting for cultural diversity only happens in some of the lessons according to the teachers. Overall, it can be concluded that teachers prior to entering a professional development course on diversity and fundamental values already have rather strong beliefs about the benefits of those teaching strategies and feel somewhat prepared to execute this teaching during their lessons. It can also be concluded that actual IBL practices vary in their degree of occurrence with investigative practices being the least often practice. It is well in line with previous studies that teachers value IBL as teaching practice but do not implement those teaching strategies frequently (Maass & Engeln, 2019). It is noteworthy though that pre-test results show that across self-efficacy, learning-related beliefs, and practices, the topic of cultural diversity has the lowest mean scores. Teachers have rather low self-efficacy beliefs addressing cultural diversity, weaker beliefs on the benefits of cultural diversity, and show the respective teaching behaviour more seldom.

Table 5. Overview of the baseline results from the pre-test (*N* = 515).

Scale	Mean	Standard Deviation
Self-Efficacy IBL for addressing diversity	2.92	0.42
Self-Efficacy using contexts	2.84	0.47
Self-Efficacy addressing cultural diversity	2.50	0.58
Beliefs about IBL for addressing diversity	3.38	0.41
Beliefs about using contexts	3.26	0.44
Beliefs about cultural diversity	3.13	0.47
Authenticity/relevance practices	2.78	0.61
Hands-on practices	2.53	0.62
Student-orientated practices	2.66	0.64
Investigative practices	1.93	0.71
IBL practices accounting for diversity	2.75	0.54
Use of contexts	2.22	0.63
Accounting cultural diversity	1.97	0.68
IBL practices combined	2.54	0.47

In addition to their actual beliefs and practices, teachers were also asked to provide information about prior learning opportunities and their own need for PD. Figure 2 provides an overview of teachers' prior learning experiences across all countries. Across all countries, teachers were most familiar with the topic of IBL from their initial teacher training or other professional development courses. In contrast to that, teachers had only a few possibilities to encounter the topic of culturally responsive teaching throughout their career. The topic of fundamental values is addressed in some countries like Cyprus and Turkey, but is rather seldom discussed in the other countries.

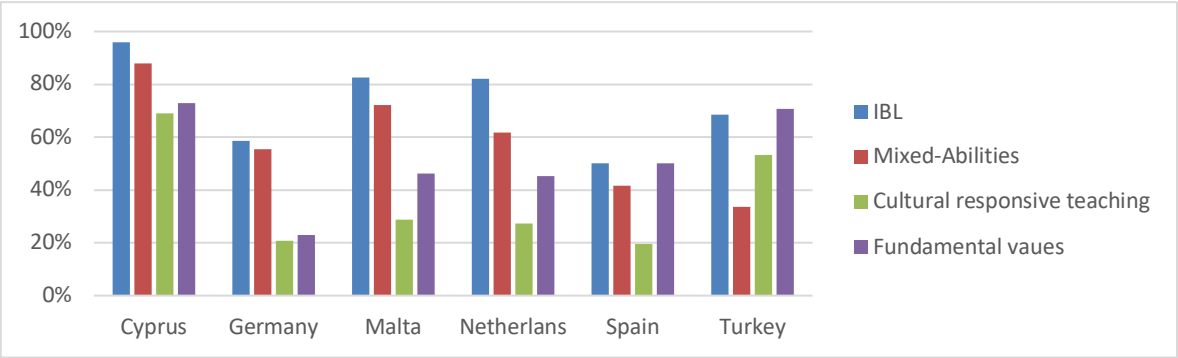

Figure 2. Prior learning experiences across the different countries.

As shown in Table 6, teachers' need for professional development, however, does not necessarily mirror the gaps in teachers' previous learning experiences. Teachers voice a moderate to high need across all topics, with fundamental values, digital resources (as a comparable topic), and multicultural learning and teaching ranking among the lesser important topics. So, despite that teachers already have encountered IBL as a teaching practice, 70% of them still have a moderate to high need to further discuss this topic especially in combination with mixed-ability classrooms. Those results provide a somewhat different picture than the 2013 TALIS report (OECD, 2014) as teachers pronounced their need for professional development on ICT skills for teaching more and had a comparable need for professional development on teaching in multicultural settings as on approaches to individualized learning.

Table 6. Teachers need for PD in different topics.

Topic	Individualized learning	IBL	Multicultural	Mixed-abilities	Fundamental values	Digital resources
Moderate to high need for PD	71%	70%	65%	76%	60%	61%

Following the description of teachers needs and the establishment of a baseline measurement for their self-efficacy beliefs, learning-related beliefs, and practices, the pre-post comparison allows to investigate possible changes after completing the professional development course. Table 7 provides an overview of the results from the pre-post comparison. All pre-post comparisons have been analysed using depended t-tests and Cohen's d to quantify the possible change. The results show that teachers' self-efficacy beliefs regarding the use of IBL to address achievement-related diversity, the use of contexts and addressing cultural diversity all improved significantly with small to medium effect sizes (d = .26, p < .001; d = .39, p < .001; d = .38, p < .001). The results therefore indicate that teachers feel better prepared and more confident to implement inclusive mathematics and science education after the participation in the professional development program. The improvements in their self-efficacy beliefs are especially strong for the implementation of real-world relevant contexts and the considerations of cultural diversity. After the completion of the professional development course, teachers report comparable self-efficacy beliefs about the use of IBL to address achievement-related diversity and the use of context and a somewhat less but still improved self-efficacy about addressing cultural diversity.

Table 7. Results from the pre-post comparison (mean values, standard deviation, paired t-test and Cohen's d).

Scale	Pre	Post	*t*	*d*
Self-Efficacy IBL for addressing diversity	2.92 (0.40)	3.03 (0.37)	4.82***	.26
Self-Efficacy using contexts	2.83 (0.46)	3.01 (0.43)	7.20***	.39
Self-Efficacy addressing cultural diversity	2.47 (0.57)	2.71 (0.58)	6.95***	.38
Beliefs about IBL for addressing diversity	3.37 (0.42)	3.41 (0.42)	2.13*	.12
Beliefs about using contexts	3.26 (0.42)	3.32 (0.45)	2.93**	.16
Beliefs about cultural diversity	3.12 (0.48)	3.17 (0.50)	1.91	.10
Authenticity/relevance practices	2.76 (0.61)	2.88 (0.58)	3.67***	.21
Hands-on practices	2.52 (0.61)	2.60 (0.59)	2.13*	.12
Student-orientated practices	2.67 (0.65)	2.83 (0.60)	4.72***	.27
Investigative practices	1.88 (0.68)	2.13 (0.75)	6.65***	.38
IBL practices accounting for diversity	2.74 (0.54)	2.85 (0.68)	3.10**	.18
Use of contexts	2.19 (0.62)	2.40 (0.66)	6.02***	.34
Accounting cultural diversity	1.92 (0.68)	2.17 (0.73)	6.67***	.38
IBL practices combined	2.53 (0.46)	2.67 (0.47)	5.92***	.33

Note: *** p < .001, ** p < .01, * p < .05.

In addition to changes in teachers' self-efficacy beliefs, teachers also reported significantly stronger beliefs about the benefits of using IBL to address achievement-related diversity and the use of contexts. The changes, however, have only rather small effect sizes (d = .12, p = .03; d = .16, p < .01). Teachers also report a slight increase in their beliefs about the benefits of addressing cultural diversity, which proves to be only marginally significant (d = .10, p = .06). It is noteworthy though that teachers already reported strong beliefs on all three content areas prior to entering the professional development course. It was therefore expected that a strong increase in their beliefs would not be possible. In addition to that, research also points out that beliefs are rather stable constructs and difficult to change (e.g. Gregoire, 2003). It is therefore noteworthy that for two content areas teachers reported small and significant stronger beliefs about aspects that most of them already agreed to.

At the end of the professional development course, teachers already reported that they implement IBL practices more frequently compared to the beginning of the course. The changes in practices were especially prevalent for activities that teachers had done rather seldom at the beginning of the course: investigative practices, use of contexts and accounting for cultural diversity (d = .38, p < .001; d = .34, p < .001; d = .38, p < .001). Teaching practices that were already more present at the beginning of the professional development course were also reported to happen more frequently. Teachers used authentic, hands-on, and student-oriented practices significantly more often after completing the professional development course (d = .21, p < .001; d = .12, p = .03; d = .27, p < .001). All desired teaching practices are reported to happen at least at some lessons after the completion of the professional development course with authentic and student-oriented practices happening at almost most of the lessons right after the professional development course ended. The examination of the new content and possible ways to incorporate new ideas in the own classrooms is a process that will likely continue after the professional development course ended.

Overall, the results from the pre-post comparison highlight that teachers' self-efficacy beliefs, learning-related beliefs and practices changed throughout the course of the professional development program. Similar to the baseline assessment at the beginning of the course, teachers still reported weaker self-efficacy beliefs in dealing with cultural diversity, weaker beliefs about the benefits of addressing cultural diversity and fewer practices accounting for cultural diversity compared to the use of IBL to address achievement-related diversity and the use of contexts. Even though teachers improved in their ideas about dealing with cultural diversity, there is a need to continue the professional development about this topic to better prepare teachers in a way that is comparable to other topics such as achievement-related diversity. While those results heavily rely on self-reports, the combined improvement in self-efficacy beliefs, learning-related beliefs, and practices indicates a raised awareness of the diversity they encounter in their classrooms, possibilities to deal with this diversity and a willingness to actually implement these possibilities in the own classrooms.

The final part of the quantitative evaluation of the MaSDiV project addresses additional quality criteria of successful professional development programs. Additional quality criteria of professional development programs consist of personal satisfaction, subjective gain in knowledge, applicability of the content, utility of the content, and opportunities for collaboration und the use of new materials (e.g. Grohmann & Kauffeld, 2013). The satisfying and active engagement with meaningful (i.e. applicable and useful) content is a key prerequisite for teachers' learning. Table 8 provides an overview of key outcomes from the post-test data (N = 376 teachers). Teachers report a high satisfaction with the professional development course in general (M = 3.16, SD = 0.60) and across all countries. Similarly, teachers also reported a high utility of their experiences for their everyday work (M = 3.12, SD = 0.57) and fruitful and supportive opportunities for collaboration throughout the professional development program (M = 3.19, SD = 0.57). In addition to that, teachers also reported a subjective knowledge gain (M = 3.09, SD = 0.61). This positive evaluation of the professional development program is reflected throughout each country with general high ratings for Cyprus. While still being viewed as positive, the applicability and the materials are reviewed more critical compared to the other factors. More specifically, teachers agreed that they were "provided with teaching materials" throughout the course,

but agreed less that they "applied the teaching materials" in their everyday teaching. A further application of the new content and new materials will likely need additional time after the professional development course ended.

Table 8. Teachers' evaluation of the professional development course across countries (mean and standard deviation) and in each country.

Aspect	Overall	Cyprus	Germany	Malta	Netherlands	Spain	Turkey
Satisfaction	3.16 (0.60)	3.25	3.29	3.00	2.95	3.04	3.23
Applicability	2.77 (0.59)	3.01	2.72	2.88	2.53	2.66	2.83
Knowledge	3.09 (0.61)	3.33	3.09	3.15	2.89	2.96	3.13
Utility	3.12 (0.57)	3.24	3.19	3.10	2.96	3.02	3.22
Collaboration	3.19 (0.57)	3.36	3.02	3.20	2.97	3.33	3.32
Material	2.74 (0.61)	2.99	2.63	2.72	2.68	2.78	2.69

To get a more detailed evaluation of the different aspect of the professional development program, we surveyed the participants to which extent different topics where covered and how they rate the significance of the topics for their everyday teaching. Figure 3 shows the coverage and significance of the topics ranked by coverage. All topics proposed by the MaSDiV professional development program framework were covered at least somewhat (i.e. a rating of 2) or even much (i.e. a rating of 3) throughout the duration of the course. The results therefore indicate that across all courses the professional development leaders followed the proposed plan. A strong emphasis was also given on the introduction of context-based teaching and the discussion of concrete examples throughout the course. The exploration of the cultural roots of science and mathematics, the design of a concrete lesson addressing achievement-related diversity through IBL and discussing achievement-related diversity with sample work from students was covered less intensively. In addition to the coverage, teachers also rated that all topics have a moderate to high significance for their teaching practice. The differences among the significance ratings of the different topics are rather small, but teachers stress the importance of the introduction to teaching method that support IBL and involve all students and the ideas and examples of context-based teaching over the less significant topic of the cultural roots of science and mathematics. Overall, the discussion and design of concrete lesson examples rank among the most important topics that could be explored further if the professional development is expanded as well.

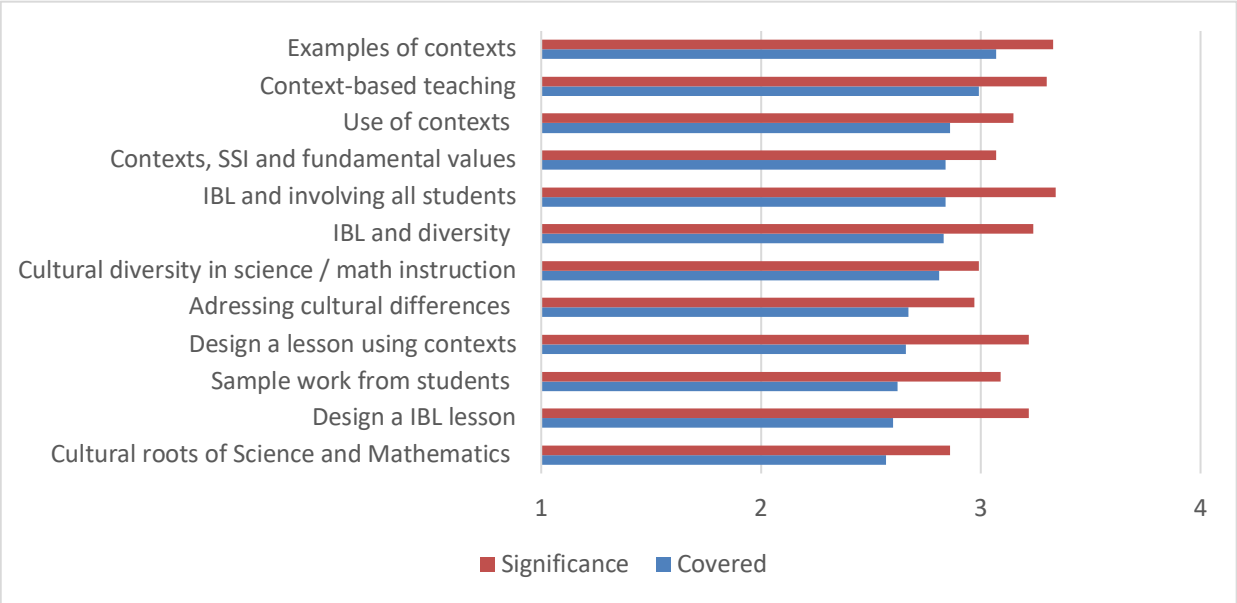

Figure 3. Rating of the coverage and significance of the different topics from the professional development program.

Summarizing the results from the pre-post study, we could observe positive effects on teachers' self-efficacy beliefs, learning-related beliefs, and practices after completing the professional development program. Prior to entering the program, teachers already voiced strong beliefs about the benefits of IBL for dealing with diversity, the use of context, and addressing multicultural diversity. The strongest effects from the program can be found for teachers' self-efficacy beliefs, indicating that teachers feel much more prepared to actually implement the practices discussed in the professional development program. Teachers report a high overall satisfaction and highlight the significance of the different topics covered. More time could be allocated to further discuss and develop example lessons and apply those in the own classroom. This long-term engagement with the topics of inclusive mathematics and science education could support the continuous development of the teachers.

1.3 Case studies

1.3.1 Design

To further substantiate and corroborate the findings from the quantitative study, additional qualitative case studies were implemented. The main aim of the qualitative study is to provide specific examples of the experiences the teachers made with the content and the professional development program to further work out possible hindering and supporting factors for teachers to implement inclusive mathematics and science education. To achieve this goal, teachers should have had the opportunity to experience the professional development program and to work with the new content in their own classrooms. WP3/5 therefore developed an experimentation protocol detailing that in each partner countries at least three participants of the professional development course should be recruited as cases and interviewed and observed after the last session. This procedure allows us to observe how teachers implement IBL to address diversity and use contexts relevant to society as well as to discuss their reasoning for their example lesson and their own experiences throughout the professional development program. The three cases per country were then analyzed individually as well as comparably and finally summarized in a national case study report. This evaluation report uses the national case study reports as case study reports to present similarities and differences between teachers in different European countries.

1.3.2 Instrument

WP 3/5 developed detailed interview guidelines to ensure comparability across interviews and countries (see deliverable D3.2 https://icse.eu/wp-content/uploads/2019/03/WP3_Experimentation-protocol_D3.2_Data-collection-instruments-for-case-study.pdf). The interview guideline reiterated the objectives and the design of the case study and included some general instruction on conducting semi-structured interviews (see for example Patton, 2002). The interview guideline itself consisted of five parts: introduction, teacher's background, discussion of the observed lesson, experience of the professional development program, and some closing remarks. For all five parts, the local interviewers were assisted with concrete prompts (e.g. "What was your intention choosing this context?") as well as additional advice on follow-up questions or connections throughout the interview. All interviews were audio-recorded and transcribed afterwards.
The analysis of the interviews followed a template for writing the national case study reports. The template allowed a more focused analysis of the interviews in contrast to more general narratives. The focused approach allowed a cross-country comparison. The local partners were advised to read the interview transcript as well as notes from the lesson observation multiple times to identify major themes, categories and case examples (e.g. Bowen, 2009). The identified major themes should then be highlighted in a thick description based on quotes and actions from the teacher. The results from the case study analysis were summarized in the national case study report. Each national case study

report contains an overview of the national context (e.g. structure of teacher education, diversity in schools) and a description of the MaSDiV professional development course and its possible adaption to the local context. Furthermore, local partners also had to provide their rationale for choosing the three specific teachers as exemplary cases. After each case study teacher was introduced more specifically, the report focusses on three core questions: What are the key challenges and enabling factors for teachers to use IBL to address achievement-related diversity? What are the key challenges and enabling factors for teachers to use contexts relevant to society? How did the teachers experience the MaSDiV professional development program? These three questions should be answered for each teacher as well as summarized across all teachers. Based on the national case study reports the international comparison was created.
The procedure for creating the international comparison followed similar steps as for the national case study report. Each national case study report was identified as a case and read and re-read multiple times to identify major themes and case examples across multiple countries.

1.3.3 Sample

Participating teachers for the qualitative case studies were recruited during the professional development course from local professional development leaders. In each partner country, at least three teachers took part in the case study. All partner countries were asked to explicitly state their rational for choosing the case study teachers. Across all countries a similar pattern for selection was obvious: case study teachers had to fit the time frame of a school year, needed to make significant contributions during the meetings, and represent information-rich cases with varying backgrounds. Based on these selection criteria three teachers were presented in the national case study report.
Table 9 provides an overview of the case study teachers from each country. Across all six countries, approximately 71% of the case study teachers were female, which is just marginally higher compared to 65% in the quantitative evaluation study. Ten of the 18 teachers focused on mathematics during the professional development course. The proportion of mathematics teachers is a good representation of the overall sample, where a similar proportion of teachers focused on mathematics. The mean years of teaching experiences in the case study group with 11 years aligns with the overall sample's experience of 10 years. The experience of case study teachers also covered a certain range in each country bringing together different perspectives and backgrounds for the national case study reports. Overall, it can be concluded that the case study sample is a good representation of the overall sample in terms of key background variables within the constraints of a qualitative case study.

Table 9. Overview of participating case study teachers.

Country	Teachers	Subject	Years of Teaching Experience
Cyprus	Michelle	Mathematics	10
	Nina	Science	26
	Maria	Science	12
Germany	Tom	Mathematics	10
	Lukas	Mathematics	8
	Bernhard	Mathematics	5
Malta	Jane	Mathematics	2
	Anabel	Science	16
	Deborah	Physics	10
Netherlands	Linda	Mathematics	16
	Astrid	Mathematics	11
	Ronda	Mathematics	9
Spain	John	Mathematics	13
	Antonio	Science	27
	Gisela	Science	20

Turkey[1]	SSi19	Mathematics	1
	BöZ26	Science	4
	CSA16	Science	3

During the interview, case study teachers were asked to talk about prior learning experiences and their school background in more detail. For example, while all case study teachers had no formal prior learning experiences in dealing with achievement-related and cultural diversity, they showed a high motivation to learn more about this topic:

"…I have always been interested in knowing how things work. Therefore, I prepare a project for my classes every year but I need to change it in order not to get bored myself. Even when it works with students, I need to change it every year not to get bored myself. Then I change it in order to maintain interest and to have the opportunity to inquiry and discover new things. I love learning."
(Spain – John)

Additionally, teachers from Turkey, Malta and Cyprus all reported a high diversity in their schools especially in terms of cultural and linguistic backgrounds. Teachers were confronted with students in class speaking different languages and also additional students were added in the classes throughout the school year. Still, teachers from Spain (e.g. John, Gisela), Germany (e.g. Tom, Bernhard), and the Netherlands (e.g. Ronda) point to the fact that they are also confronted with students from different social and cultural backgrounds. So even teachers from countries with smaller percentages of migrant students experience diversity that they have to deal with in their classrooms:

"We have students in the class now in math who are very eager for these problem-solving tasks and can also deal really well with problems and tackle problems and there are students who have massive deficits as far as the, even basic operations are concerned. We are doing this balancing act right now". (Germany - Tom)

Case study teachers in each country are confronted with a range of challenges that they face during their teaching and bring in different types of personal backgrounds as well as support systems (e.g. in a small village school like CSA16 in Turkey or in a school with co-teaching elements like Lukas in Germany). The main aim of this qualitative case study is to highlight how the different case study teachers were able to implement lessons addressing diversity and using contexts based on the professional development course they have experienced.

1.3.4 Results

The qualitative case study was implemented to further substantiate the findings from the quantitative pre-post study with a focus on the actual implementation of inclusive mathematics and science education in teachers' classroom across partner countries. To do so, the national case study reports focused on three key questions: What are the key challenges and enabling factors for teachers to use IBL to address achievement-related diversity? What are the key challenges and enabling factors for teachers to use contexts relevant to society? How did the teachers experience the MaSDiV professional development program? The key themes for each question will be presented accordingly to gather additional information which support systems teachers need in order to change their teaching practices.

[1] The national case study from Turkey used anonymous codes referring to their teachers.

1.3.4.1 Inquiry-based learning

Visiting the teachers at their schools to observe their lessons and conduct the interviews, a wide range of possible applications for IBL to address achievement-related diversity was observed. Most teachers across participating countries planned and enacted lessons that included contextualized problems that students needed to investigate or design a product for. Among the presented problems were for example that students were asked to decide whether the plastic-waste the class produces in one year is enough to cover the whole soccer-field of the school (Germany – Tom) or that students had to figure out why the wax cells in bee combs are hexagons (Spain – John). Other contextualized problems include whether life on Mars is possible (Turkey – BöZ26) or which energy resources can provide a sustainable future (Turkey – CSA16). Other instructional approaches were less centered around conceptual ideas but rather focused on the inquiry process itself. Nina (Cyprus) for example used a crime scene activity for students focusing on hypothesizing, observing, and collecting and organizing data. The combination of conceptual learning, investigations, and social-relevant contexts proved to be challenging for some teachers:

"It was a big step for me. The lessons usually don't include experiments. And I could add fundamental issues they were not there [yet]." (Cyprus – Michelle)

Michelle was rather unfamiliar with the topics of investigations and social relevant context in mathematics instructions and therefore struggled to combine all three aspects simultaneously right away. In the end, she used a physics problem (velocity and acceleration) to motivate the investigation of differentiation. Other teachers also used challenging problems without contextualizing them. Students had to explore different geometry problems they have not encountered before (Malta – Jane) or work on exam problems from higher grades (Netherlands – Astrid). Overall, it can be concluded that the case study teachers showed the complete range of possible IBL lessons. On the one hand, Antonio (Spain) had his students work on producing a slime on their own in an open inquiry. On the other hand, Ronda (Netherlands) had to implement a traditional review lesson on percentages without explicitly incorporating IBL features.

"This is what a normal mathematics class looks like. For all the classes given in this school there is little room for IBL in the curriculum. I do think that is a pity, and I am learning more about IBL. I have been thinking about how to implement IBL practically, but that is still work in progress." (Netherlands – Ronda)

Ronda points out that due to curricular reasons (the lesson observation took place close to the end of the school year), she is not able to use IBL practices as often as she wants to. Teachers therefore need the appropriate amount of time to implement IBL lesson regularly throughout the school year. Teachers, who did implement IBL lessons reported frequently the beneficial activation of all of their students:

"What was good was that students had been working for 80 minutes without filling in blanks on worksheets, which is something that bothers me for a long time now as a teacher and in particular with these students. Here I could see them for 80 minutes being active all the time, without feeling bored or hopeless, being engaged in activities which led to a result, a conclusion. They understood what they did, not passively repeating others" (Cyprus – Nina)

"During the lesson based on MaSDiV ideas all students worked actively even those who in other lessons did not participate or felt bored." (Cyprus – Maria)

Both teachers stress that IBL lessons have the potential to engage all students actively with the content. Cognitive activation is a key aspect of high-quality instruction (e.g. Lipowsky et al., 2009) as it allows students to discover and process the meaning of the concepts. The teachers also point out that this engagement even reaches students who are usually less involved in more teacher-centered instructions. IBL therefore provides a sound foundation to engage students from various backgrounds. Part of this engagement of diverse students is also due to the attention given to diversity during the planning progress:

"With IBL you have to plan and while planning you are somehow «forced» to take into account all different possible issues which in other cases you do not take into account - to consider cultural issues. Here you have to think who are those diverse students in front of you whether cultural - sensitive issues or diverse experiences." (Cyprus – Nina)

Acknowledging the differences among students during the planning process also extends beyond achievement-related differences as it also incorporates cultural issues as Nina has pointed out. These diverse experiences from students then can be productively used to plan lessons that can incorporate multiple ideas from varying backgrounds. To bring together multiple perspectives during the class, all teachers from all countries heavily relied on partner or group work.

"I use small challenges they have to address in teams so they can support each other. I want them to make sense together […] I really like when her mate saw her mistake and how he made her notice. This is what I want, I want them to support each other, to learn together." (Spain – John)

The support from group work also goes beyond peer tutoring since group work also allows the teacher to provide more individualized feedback to their students.

"I mainly supported the students during my work in the group phase. I prepared solution strategies [on the blackboard], but I believe it was a more effective help, when I supported them when they were working. And there I could help individually." (Germany – Tom)

"And what really offers itself with IBL is that student groups, medium to very strong, are actually completely self-sufficient, while low-achieving students can be supported either by their classmates or by myself. Above all, I think it's just good that you then have time to diagnose. Where are the difficulties?" (Germany – Bernhard)

When teachers let students investigate problems in groups, it allowed them to change their own perspective from being the transmitter of knowledge to a supportive facilitator for the students. Teachers have time to analyse the progress of each group and can provide feedback on that progress. These additional resources, however, are only available if appropriate classroom norms can be established:

"I carried out this practice in groups, so high academic level students responded questions, and low academic level students are the more passive situation. The level of understanding and the concerns, are different for all students. For example, someone can achieve it by music or drawing, so it is difficult to get all of them involved. It's hard to learn how all of them understand more easily because the classes are very crowded." (Turkey – SSi19)

"And when you're alone in such a class with thirty children, you've set up group tables, you really want to work intensively with a group and the [students behind you go crazy], then it's going to be

difficult. So, group size may just be a big problem, how do I differentiate with such large groups?" (Germany – Lukas)

Crowded classrooms and a lack of established classroom norms might be a hindering factor to provide the groups with an appropriate feedback. It is therefore important to establish certain rules before implementing the group work and also to group the students together consciously:

"Homogenous groups can cause a problem. Because, if all members of a group have limited abilities, we cannot conclude at the end of activity (…) Heterogeneous groups addressing academic diversity compete in an undesirable competition. For this reason, group pressure on the successful student is increasing." (Turkey – BöZ26)

"You need to plan well. For example, in how to group students so that they can work together and arrive, to make the best of the strengths of all students because otherwise you will have students who do not get there. For example, when I form groups I try to pair up for example Ronald (Maltese student with learning difficulties) with Samuel who is very kind and who would be able to help him. Moreover, Samuel is not bossy so he will give Ronald time to try." (Malta – Anabel)

As the teacher from Turkey points out, homogenous and heterogenous grouping both have their advantages and disadvantages. In homogenous group, it might be possible that students who do not participate often can contribute and come to a solution depending on the difficulty of the problem. In heterogenous groups, high-achieving students sometimes have to carry the majority of the workload, but they can also support other students. As Anabel suggests, grouping needs to be done consciously and should consider the purpose of the activity, the diversity in achievement and personality of the students. Besides the use of group work, redirecting questions to students to keep the epistemic agency at the students is another key strategy for teachers.

"What do you need to do now? […] What are you struggling with?" […] "How do you know that these two equations are the same?" (Malta - Jane, Lesson Observation)

Multiple teachers identified a need to keep the student focused on reasoning activities and also allow them to discuss possible alternatives within their group. There are multiple examples were teachers incorporated similar questions as shown in the lesson observation from Jane. Additional scaffolding activities from case study teachers also involved the re-activation of prior knowledge or pointing out to specific features of the exercise:

"What is a basic triangle, what do you know about it? […] When the task is to 'calculate' a certain number then you cannot 'measure' or calculate with the number you have to calculate. […] What is written below the triangle, what does that mean?" (Netherlands – Astrid, Lesson Observation)

The refocussing of students was especially important for teachers who incorporated more open inquiry activities. Even though open inquiry should allow students to work on their own to resolve a certain problem, some students might get lost in this process and need additional support to achieve their own goal:

"For example, I told them that they could predict rather than dealing with addition-extraction and equations. I told them they could virtually achieve something by drawing. In this way, I guided them." (Turkey – SSi19)

"I have to insist that my intervention was crucial for them not to drop off, to gain self-confidence and to believe in the project, in their project […] due to perseverance and encouragement, finally all the groups reached their goal." (Spain – Antonio)

The scaffolding in inquiry situations is also necessary for students who are not familiar with this way of learning. Several case study teachers identified that students expect to a certain degree that the teacher would provide or at least validate the results in the end.

„And the mathematical result itself, fortunately, we had one, which was good in the sense that afterwards this Aha-experience was there […] independent of the how, if this doesn't come up, this 'Wow, how much is it, and we are responsible for that and we calculated that', if this doesn't come up, then I would have a big problem." (Germany – Tom)

"For some students, it's also important that sometimes they just get told how to solve something, they just cannot figure out how to do it and then give them some help and if that does not work, just let's say, 'kids, listen, so and so can you solve it!'" (Germany – Lukas)

"Because the expectations of the children are always focused on taking a grade or score. I said that my expectation is just related to your participation regardless of any expected correct answer. I mentioned that I wonder what you think about this course and what you have learned, I added. The system leads us to exam-oriented teaching. When students have such an expectation, this makes it difficult for us to make IBL applications." (Turkey – CSA16)

"Now I am more conscious of the fact that different students learn mathematics differently […] Some are not ready to take on a challenge, they rarely try things on their own and tend to give up immediately" (Malta – Jane)

The idea that students need a definite solution in the end of a lesson is related to students' own expectation on the one hand and the type of preferred learning on the other hand. As Jane elaborated, some of her students just appreciate a more teacher-centred way of learning, because it presents the knowledge in a more secured way. Students particularly in an exam-oriented class culture are not used to inquire problems on their own and discuss different ways to solve certain problems. Limited experiences with inquiry instruction could therefore be a barrier to even start using this type of instruction in the classroom. Besides students' inexperience with this type of instruction, case study teachers continuously referred to curricular and time constraints as additional hindrance factors.

"It was an exciting experience. However, it needs time to plan that kind of lesson and this is not always easy in our curricula and school timetable. And sharing our ideas encourages us to do so" (Cyprus – Maria)

"I had hoped that they would finish, but that didn't come through, because, by the time they got to work agreeably, the time was already up." (Netherlands – Linda)

"Time has a significant influence. It may not be possible sometimes that activities can be carried out in 40 minutes. When students are given adequate knowledge, and if the classroom is managed effectively, it becomes useful. However, if there is a quarrel between two students, you have difficulties following the course plan." (Turkey – BöZ26)

"Yes, I think it needs time. And that's a little bit the problem, doing something like that lets me fall behind." (Germany – Tom)

Time constraints are mentioned in a variety of meanings from the case study teachers. First of all, Maria acknowledge that planning IBL lessons already takes up a lot of time, particularly for teachers who are less experienced in planning this type of lesson. As Maria also suggested, collaboration and sharing of ideas could be possible gateways to reduce the costs for planning IBL lessons. A second time constraint mentioned from Linda and BöZ26 is that a thorough investigation of a problem needs a lot of time in class. Students need sufficient time to delve into solving problems, develop possible solution strategies and also have time to explore those different strategies. The effective management of time and classroom can support this process as BöZ26 explained. And finally, a third time constraint is related to curricular requirements: exploring concepts using IBL methods might need more time compared to teacher-centred methods. The additional time needed could be problematic if national curricula specify that a lot of different topics need to be addressed throughout the school year. The problem of time constraints is even more amplified in classes with linguistic diversity:

"When I explain something in English he sometimes asks me to say it in Maltese and I end up saying everything in the two languages. This slows you down." (Malta – Anabel)

The additional use of two or more languages to explain the purpose of activities or the content takes additional learning time away from the students who need this specific support. A more flexible curriculum focussing on a few core concepts would allow teachers to allocate more time to deeply delve into certain aspects of a topic. Additional support through co-teaching or linguistic support would also relief the teachers from some of the time pressure they experience. Finally, more ready-to-use examples and text book materials could also help teachers to incorporate IBL strategies more frequently:

"The main problem is that schoolbooks are rarely represented in this area, they focus on technical exercises and less on the on the development of conceptual knowledge. And there is already the challenge to work out such exercises." (Germany – Tom)

Summarizing the case study teachers' reports on the use of IBL, teachers presented a variety of promising ways to implement IBL after they took part in the MaSDiV professional development program. The investigative nature of IBL allows students to actively work on certain concepts based on their prior understanding. Group work also allowed the teachers and the students to support each other during their working time which highlights the value of IBL for addressing diversity. Teachers can further support students' agency by redirecting questions and scaffold their thought process. Additional support from policy and research could also address some hindrances like time and curricular constraints and missing resources. Despite these hindrances, case study teachers recognized the potential and value of IBL to address different levels of competence.

"That in the end every student has the chance to bring in his prior knowledge, we jointly put that together and I extract the important stuff. Everybody brings input on his own level." (Germany – Tom)

1.3.4.2 Use of Contexts

As indicated above, the use of contexts played a critical role for most of the teachers when implementing IBL in their classrooms. The rationale for choosing certain contexts, however, differed among the case study teachers. Most of the teachers explained that real-life contexts that have a

substantial meaning for the daily-life of their students are the most adequate contexts to be included in their lessons.

"Relevant to society means that students see that somewhere in this world it is meaningful, that they think: 'Yes, that could affect me at some point, in one form or another.' And that they believe it to be important, that they think about it." (Germany – Bernhard)

"It allowed students to solve a particular problem, in this case, the high level of noise at school. We better live and work without noise." (Spain – Gisela's reflective notes)

"Were to help them see neutralisation in every-day life and as a reinforcement of the pH scale, testing with universal indicator paper, but giving it a real-life twist." (Malta - Anabel)

"Contexts must be chosen (…) from the everyday life of students. These must bear the potential to be transferred into mathematics. Where can mathematics be done? Or does a mathematical consideration distort the meaning [of the context]? […] If it is affecting the sustainability of our planet, if it's close to the student's everyday life. Maybe if it is present in the media would be a criterion to offer such contexts." (Germany - Tom)

The case study teachers point out to the fact that contexts need to be relevant in the eyes of the students. This relevance can be achieved by connecting lessons to problems at their school (e.g. noise levels) or everyday life (e.g. neutralisation with pasta sauce). By connecting lessons to concrete experiences of students, it creates a need to know in students and with that a motivation to engage with the content (e.g. Nordine et al., 2019). A more specific way to connect learning with the everyday life of students is to choose contexts presented in the media as Tom indicated and John further elaborates on:

"I decided to focus on bees after seeing the movie 'Much More than Honey'. Then different things happened at the same time: a paper about the disappearance of the blue bee in the area of Axarquía, research on how bees communicate and the use of honeycombs as referents for technology due to high resistance with minimal materials and costs." (Spain - John)

Finally, a different approach to ensure the relevance for students' everyday life is to incorporate their own ideas and perspectives on topics that they want to investigate. Including students in the decision-making process on the purpose of the lessons provides the students with epistemic agency. Students can become the drivers of the investigation process compared to just receivers of a fixed set of knowledge related to a certain topic. However, as outlined in the section on IBL, this free form of IBL needs substantial effort from teachers to further scaffold the learning process.

"One student suggested it when I asked what would you like to learn and I thought why not?" (Spain – Antonio's reflective notes)

Several case study teachers acknowledge that using contexts that are relevant to their students can have positive effects on their interest and motivation during the lesson. The positive influence on motivational characteristics can in turn lead to a deeper involvement during the lesson and improved students' outcomes.

„Students really enjoyed these lessons and you could see how enthusiastic they were. Each time we did something like this lesson […] it motivates me to do more." (Malta - Jane)

"Because as soon as you refer to a situation that students can relate to, you already interest them and I didn't do it before. But I have now taken them up." (Malta - Anabel)

"I am now more oriented to focusing on reality and its connection with the curriculum. They are interested and then it makes sense to them." (Cyprus - Michelle)

The benefits of the use of contexts, however, can even go beyond motivational outcomes, as the discussion of relevant contexts can also support fundamental values such as empathy and tolerance in students. Connecting science and mathematics lessons with fundamental values helps students to become active participants in democracy respecting diverse opinions. In this way, the use of contexts broadens the usual scope of science and mathematics lessons to an important aspect of inclusive mathematics and science education.

"Social relevant contexts are useful for empathy and understanding, and for students to realize that they can be in a society who thinks differently from us. Thinking about this different way of thinking even within the same house and in this sense to consider human values in terms of social values can be useful in the course of processing" (Turkey – CSA16)

"The context itself is closely related to diversity. The fingerprint is a unique characteristic for each of us, so it does not correlate in any way to gender, race, age, height or weight etc. We had twins in the class and it was obvious that fingerprints are unique. It was not the one who spoke Greek who did the job. There were activities in which they worked individually and they had something important to share in their team." (Cyprus - Nina)

To allow this productive discussion in class to happen, contexts need to have the potential to actually bring in different perspectives from students. Each student should be able to contribute from his or her own perspectives to the discussion of the context as Nina mentioned during the interview. By incorporating perspectives from different students and/or cultural backgrounds, it also becomes possible to learn from those different ideas and change the own perspective on ideas such as space travel or evolution. It seems like the ideas about intercultural learning were especially prevalent in countries with greater cultural diversity, as several case study teachers from Turkey and Cyprus talked about this issue.

"I chose this context to have meaning for life and that the students could have a dilemma. Besides, I asked them to pay attention to their benefits and harms when approaching the issues in their lives. In other words, I aimed to make an example of not making a single but multi-dimensional idea." (Turkey – CSA16)

"IBL is the, the way I teach anyway. What was missing was taking into account the culture, the social context is there most of the times there. The fact that I started thinking and taking notes on social issues or on diverse experience from diverse societies. And coming again to, for example, the sessions on space: How humanity works on that, which countries and why they made such a huge progress, differences and similarities. We all have similar question about space that bother people and scientists all around the world. We all observe the sky and the stars, the moon is one for all of us, the sun too. Wherever you live." (Cyprus - Nina)

"I am primarily a supporter of breaking taboos, so someone has a constant knowledge. When we represent him/her the right scientific dimension of knowledge - this idea fits very well to evolution - so I give an example, maybe s/he can change the misconceptions s/he learned. It does not mean to

impose. It is to change this person's current thinking based on the scientific dimension or steps." (Turkey – BöZ26)

In addition to intercultural learning from multiple perspectives, contexts also seem to have the potential to actively support students in a transfer of knowledge. The transfer and use of knowledge in varying contexts are also relevant in exams in some partner countries like the Netherlands. So, due to the change in the type of exams, the use of context as a preparation for those exams becomes more prevalent during instruction.

"I am talking about how we use this knowledge or topic in daily life." (Turkey – Ssi19)

"But every year in the exams there is a practical example for trigonometry, and students regularly struggle with that. Students however did not ask about such problems until after the exam. This made me realize that they were struggling with the fact that it was a practical example. So, I decided to combine the problem with the chapter on trigonometry." (Netherlands – Astrid)

Yet, in countries with high-stakes exams without a focus on solving contextualized problems, the use of contexts in day-to-day teaching is limited. Case study teachers similarly mention time constraints and a strong orientation towards the exams as a core hindrance to use contexts more frequently. Additional flexibility in choosing the topics would allow teachers to choose more challenging contexts for students to engage with.

"It's really great but how much time can I afford? How many lessons have I left before the exams? With some classes, I will probably be unable to do it. There is always the issue of time. For example, the lesson on the greenhouse effect took longer than normal, not much longer but about 15 minutes longer when we discussed recycling. But time is an issue. For example, the lesson on overpopulation, it's not in the syllabus. So, if I'm pressed for time what will be the first to go? This lesson because it's not in the syllabus." (Malta – Deborah)

"We have syllabus constraints and it is always a race against time." (Malta - Anabel)

Also, in line with problems concerning open-inquiry (i.e. not a clear answer), students need to be sensitised to accept other opinions especially when they are in conflict with own personal beliefs. An atmosphere of acceptance and understanding is therefore important to limit possible conflicts among students when they discuss rather controversial contexts. The establishment of acceptance can then further support the development of fundamental values through science and mathematics education.

"When the issue is related to the country's approach, its views, and its values regarding the political dimension, some points of the issue are damaged. Personal perspective is more prominent than providing scientific opinions." (Turkey – BöZ26)

"The students can experience a moment of frustration. Although they cannot have a single correct answer, students who are trying to impose their ideas can create problems. It's hard to tell if there's a single truth. They can look one-sided. They don't listen to the arguments from the other side. Students sometimes cannot accept different opinions among themselves. They cannot benefit from this variety." (Turkey – CSA16)

A third hindrance for teachers was identified in missing resources for ready-to-use contexts. Using contexts in instruction can be challenging since real-life contexts have a rather high complexity compared to idealized problems. Teachers therefore find it challenging to identify interesting contexts

which can be explored by students without being overwhelmed. While some topics such as stochastics are more approachable by contexts, teachers struggle to find contexts for more abstract topics. Addressing fundamental values using contexts is particularly challenging. That is why some teachers would rather address fundamental values without a connection to science or mathematics. More ready-to-use contexts for a variety of topics and the option to discuss ideas related to fundamental values could further support teachers' use of contexts.

"But that's also the problem with information in the text […], when students see two pages of text, then some turn off. That's the way it is and I have to break it down on my class context and then I have to simplify." (Germany – Lukas)

"It is dependent on what you have. With probabilities I can use a thousand and one contexts. And also, in statistics when testing hypotheses, I pretend I will become president of the Netherlands and ask how many people will vote on me?" (Netherlands - Linda)

"Justice and fairness and so on are more relevant to a subject like Personal and Social Development" (Malta – Anabel)

In general, case study teachers used contexts in a variety of ways during their instruction. The most important idea that teachers thought of during the planning process was to identify contexts that are relevant to the lives of their students. By incorporating such contexts, teachers were able to identify several positive outcomes covering students' interest, knowledge transfer and fundamental values such as empathy. With additional support in identifying appropriate contexts for a variety of topics and the inclusion of contextualized problems in exams, teachers could use contexts more frequently during their instruction and allow their students to benefit from discussing relevant problems from multiple perspectives.

1.3.4.3 Experience of the Professional Development Program

The MaSDiV professional development program was a critical first step helping teachers to change their practice towards inclusive mathematics and science education. The case study teachers echo that sentiment and further expanded on their experiences from a more personal view. In general, the teachers all valued the MaSDiV professional development program. However, teachers identified different highlights based on their previous learning experiences and personal needs. Several teachers reiterated that IBL as the fundamental idea behind the MaSDiV professional development program provided a new way to think about their own instruction. Discussing the benefits of hands-on, student-centred instruction for students' learning in connection with concrete examples helped teachers to get a better understanding of how to implement this type of instruction in their own classrooms.

"First I thought IBL would not suit me. However, I found out that such activities aren't just for fun, and that students can actually learn something. That was actually my first objection, the thing of which I was sceptical. […] Now I am convinced that with IBL students can learn something and can get to the right level of understanding." (Netherlands – Linda)

"I felt specially interested in input about collaborative learning as well as inquiry-based learning." (Spain – John)

"The PD program provided me with the shortcomings I thought I knew about the inquiry-based learning approach. It was especially crucial for me to see concrete examples of how to use inquiry-based learning in the course's planning." (Turkey – CSA16)

Several other case study teachers highly valued the ideas of context-based instruction attending to socially relevant topics. Linking lessons to contexts that are relevant to the lives of their students are seen as a new way to motivate and engage students. It is also noteworthy that Anabel as well as John and CSA16 both value IBL as well as contextualized mathematics and science instruction. Both ideas therefore are seen rather as complementary ideas for the design of effective instructions.

"The parts related to IBL and context-based learning because I wasn't that aware of the importance of finding a context that students can relate to. Because as soon as you refer to a situation that students can relate to, you already interest them and I didn't do it before. But I have now taken them up." (Malta – Anabel)

"From the course I most liked the use of context because it provoked a lot of interesting discussion with my colleagues. I love this part because I am really interested in it from very different perspectives. I best remember the part about contexts because it was something I was looking for, it really engages and goes well with projects." (Spain – John)

"When I read the description of the course I focused on the connection with every day social issues and that was what I was looking for […] Now I would start with a video almost every day to connect new knowledge to reality and then come back to implementing new knowledge." (Cyprus – Michelle)

"I would think that there might be differences in terms of cultures related to school meals, but I never thought there would be so much diversity in the same classroom setting. And in this way, I would not consider contexts relevant to society. In this sense, it ensured that I interpret the contexts more carefully." (Turkey – CSA16)

CSA16 also refers to the possibility to use contexts to address social and cultural diversity. The discussion of possible examples such as school meals helped to sensitise teachers for the diversity they could encounter and also possible ways to address this diversity in their classrooms. For some of the case study teachers accounting for cultural diversity was a completely new way of thinking about science and mathematics instruction that changed their perception completely. The teachers frequently talked about eye-opening moments which also indicates that cultural diversity is rarely addressed in initial teacher education or other professional development programs.

"When our CPD leader showed us the diagram of the iceberg of culture I thought: 'my goodness that is so true!' And you never think about it." (Malta – Deborah)

"So, above all, [the module] about cultural diversity, I found it incredibly helpful, because it's just stuff that makes perfect sense as soon as you hear it, but I just did not think about it in my hectic everyday teaching. And it is also interesting for the students to see which social value mathematics has in other countries and can therefore compare it. Also, for the historical context, this is actually interesting for students." (Germany - Bernhard)

"What was most impacting from the course was to realize that science education was no longer a field for the most smart or capable. The first thing I got from the course is, as you demonstrated repeatedly with examples, that it is absolutely possible to teach STEM in a diverse classroom, achieving very good objectives for all." (Spain - Antonio)

Based on the positive experiences in the different modules of the MaSDiV professional development program, teachers reported to change their approach to plan and conduct lessons. Teachers across all

countries appreciated the new methods and ideas presented throughout the professional development program and declared their intention to use these new ideas as inspiration to change their own practice. These changes are characterized by a stronger connection to students' thinking and possibilities to investigate problems on their own. However, the declared intention to incorporate new ideas also indicates that teachers need additional time to actually use and explore these new ideas in their own classrooms.

"Rather than giving students a worksheet to work through, I now try to think of how I can integrate IBL and relate the activity with real-life, where possible." (Malta – Jane)

"I won't let it go to waste. I will start preparing lessons and I will see how I can integrate what I have learnt into the new lessons." (Malta – Deborah)

"There have been a lot of inspirations […] these mini posters, how to focus more on validation. It is good to get different impulses to things you already do in class." (Germany – Tom)

"I am very happy with the course because I got so many strategies and resources that I can implement in my classes. For example, that thing we saw about getting students to help each other, I had not thought of that before. It seems obvious, but you do not think of that. But all these new strategies you gave us, well, maybe they are not that new, but I they are so helpful." (Spain – Gisela)

"It [students as scientists] got my attention very much, and I thought about it in terms of space. I could develop an activity problem related to how to clean up space trash. PD course provided me with different ideas and showed the likelihood of their practicability." (Turkey – BöZ26)

The teachers who were already able to apply new ideas learnt reported positive feedback from their students. This feedback, in turn, encouraged the teachers to continue their efforts of attending to the diverse needs of their students and create a learning environment where everyone can participate. Repeatedly involving students in the investigation process then would increase students' preparedness which was initially seen as a possible hindrance for implementing IBL. A cycle of try-outs and positive feedback can strengthen teachers' beliefs about the benefits of inclusive mathematics and science education and change their classroom culture accordingly.

"Enthusiastic each time we presented lessons similar to this one." (Malta – Jane)

"The implementation of the task in the classroom has been an inflection point in the story of my classroom, a demarking point between before and after. It has changed the way the group communicates and interacts and my relationship with them, enhancing empathy and complicity. Students felt valued and I could see their self-esteem increased. The experience made them find their space in the school." (Spain – Antonio)

Some teachers still reported some kind of scepticism about the benefits and practicability of inclusive mathematics and science education. Those teachers discuss the need to further explore and try out new instructional ideas they discussed during the professional development program. It is noteworthy though that even these teachers are committed to further use the ideas presented during the professional development program. An additional need for try-outs also points to the fact that teachers need continuous support and that the change in classroom practice takes some time.

"Well, the course showed me that you can use contexts more broadly, bigger. So, I will have to think about that again. About how I will use that. That that is also possible." (Netherlands – Linda)

"I think that leaving the task open and thinking of your own answers in a diverse way does not fit every student, because they do not have the same attention span. So, it is really going to be trial and error. (…) But I'm going to try it in all groups and find out which method works best for which group." (Netherlands – Ronda)

The importance of enactive self-mastery and role-models (Bandura, 1997) is also reflected in teachers' appreciation of personal experiences and collaboration during the time of the workshop. Teachers valued the fruitful discussion and reflection among their peers during the workshops. The discussion of different experiences and ideas helped them not only to see the practicability of inclusive mathematics and science education but also provided them with new ideas to implement. Collaboratively, teachers developed a sense that they can do IBL in their own classroom.

"Helped the group to collaboratively learn about IBL and aspects within MaSDiV" (Malta – Jane)

"What opened my eyes a little bit was that we did the tasks [...] Doing the task ourselves, pondering for ourselves, developing solutions and then comparing with the solution of the other teachers and letting them explain their solutions and considering how they made that now, can I use that for my lessons?" (Germany – Lukas)

"It was very encouraging that the PD course and in particular activities and the session that gave the opportunity to listening to other colleagues' experiences and to collective reflection." (Cyprus – Michelle)

Due to the importance of collaborative discussion and reflection, several teachers wished to have the opportunity to continue this exchange. A possible way to allow a continuous exchange could be through the use of a digital platform. Such a platform could allow the upload of newly created materials by the teachers and possible discussions and feedback from other teachers from around Europe. Setting up such a platform could also encourage teachers to use IBL and contexts in topics or domains where they have less experience to do so.

"A website where teachers can share lesson plans. If every teacher shares one lesson plan there will be a large number available, all related to our syllabi. Because a lot of work has been done and it would all be forgotten if it is not made available." (Malta – Anabel)

To further improve the professional development program itself, more time could also be devoted for discussions of additional practical examples. For teachers with a rich knowledge background, the theoretical introduction to IBL did not provide many new insights. It is therefore crucial to tailor the MaSDiV professional development program to the needs of the participants with a strong focus on presenting and discussing practical examples.

"The second and the third meeting were very good. The first meeting, diversity and inclusive education, we already knew that. This was too theoretical. In the second and the third meeting it became more concrete. Simply these exemplary exercises, to think about them, how they work. There was this pool of exercises you provided, an unbelievable benefit for us." (Germany – Tom)

"For me IBL was not new. I needed more to see how it correlates with issues of diversity. I did not want that to come at the end separately. I was anxious for the module 3 session to learn how to deal with my refugee students." (Cyprus - Nina)

"By increasing the number of applications and examples, it would be more practical during the program. If we had more chances to practice in classrooms and the possibility for researchers to give feedback, we could see how accurate it is. A meeting could only be made with feedback on our class practices." (Turkey – CSA16)

To enrichen possible additional examples, they should be presented as part of a full lesson or even unit, which would allow teachers to get a better understanding of how to integrate examples into their own unit. The discussion of authentic classroom videos could also provide the teachers with a more concrete idea of how to facilitate a discussion of a social relevant context, for example. These two methods could support teachers in relating their own instructional approach to the ideas presented in the MaSDiV professional development program.

"I would suggest perhaps some more videos showing this happening in class, so that we can get more ideas. Local or whatever. For example, when she showed us the video of the lesson with bottles, you see a lot of relevance, the way he worked. Because otherwise it is limited to what we are doing." (Malta – Deborah)

"I liked the teaching styles and the ways teachers teach the topic and involve students in the activity during the videos […] The course might contain classroom practices used from Turkey. We always examine international examples. If we study national practices, they are both related to our curriculum and our culture. We might comprehend better the practices. We can say that if they do it, we can do it." (Turkey – SSi19)

"Then I would think about how to recycle such tasks in terms of the spiral curriculum, maybe there are already some ideas. Because this is partly such a recognition value for students." (Germany – Bernhard)

In conclusion, case study teachers did value the learning experience during the MaSDiV professional development program very much. While teachers differed in which part of the program had the most impact depending on their personal background and needs, conjointly all modules led to a change in the planning approach and the commitment to further explore the ideas presented for the own classroom. For the teachers, it was critical to witness the effects of a new instructional approach on their own students as it validates the efforts to implement these ideas. The importance of feedback and discussions among teachers is a possible pathway to further improve the professional development program. The continuous discussion of lesson plans or authentic classroom videos could show teachers ways to implement inclusive mathematics and science instruction.
The case study showed that teachers already had developed several possible ideas to use IBL accounting for diversity in contextualized instructions. The powerful stories and examples from teachers across all countries highlights that the MaSDiV professional development program had a significant impact on the way teachers approach their instruction. Case study teachers reported that peer-feedback and individualized support as well as an orientation towards meaningful contexts evoked positive reactions from their students. Additionally, teachers also identified possible shortcomings that could be addressed to further support them incorporating new ideas in their own instruction. Among those shortcomings are curricular constraints that limit the time that can be devoted to discussing a single topic. A more flexible curriculum and exams would allow teachers and students to investigate problems in more depth. More practical examples or a digital exchange platform as well as more time to discuss examples during the professional development program could further support teachers' professional growth. In general, the MaSDiV professional development program was a first eye-opening experience for several teachers that it is necessary and possible to attend to the diverse needs of their students in mathematics and science instruction.

2. Conclusions & Recommendations

In an ever-evolving society, teachers face the challenge to provide learning opportunities and instructional as well as emotional support for their diversified students. To allow all students to become active and productive members of society, teachers need to develop teaching strategies that bring together different social and cultural perspectives and allow approaches based on these perspectives and prior knowledge of their students. Implementing teaching strategies aiming at an inclusive mathematics and science education requires high professional competences from the teachers. The purpose of the MaSDiV project was to develop, implement, and evaluate a professional development program aimed at supporting the development of teachers' professional competence in order to change their teaching practice. The quantitative pre-post study and the qualitative case studies showed that teachers indeed develop more adequate self-efficacy beliefs, beneficial learning-related beliefs and changed their teaching practice after attending the professional development program. The case studies additionally highlighted the newly-found and various ways teachers across all six partner countries implement IBL and used relevant-contexts in their lessons to address the diverse needs of their students.

Before attending the professional development program, teachers indicated in the pre-test that they rarely use investigative practices, use contexts, and account for cultural diversity. Despite the limited use of these teaching practices, teachers already had strong beliefs about the possible benefits of IBL for addressing diversity, the use of contexts and attending to cultural diversity. Among these three aspects of inclusive mathematics and science education, teachers felt less prepared to address cultural diversity in their classrooms. After completing the professional development program, we could observe that teachers felt significantly more prepared to use IBL for addressing diversity, use contexts, and address cultural diversity. While the already strong learning-related beliefs only improved marginally after the course, teachers did report to use investigative practices, use contexts, and account for cultural diversity significantly more often during their lessons. The significant changes in teachers' self-efficacy beliefs, learning-related beliefs and practices indicate that the MaSDiV professional development program successfully supported the professional growth of the attending teachers.

The positive effects for the attending teachers was also evident during the lesson observation and subsequent interview from the case study teachers. The case study teachers showed a range of possibilities to include IBL and relevant contexts in their own instruction. For example, one teacher discussed whether the plastic garbage produced from the class was enough to cover the school's soccer field. Other teachers guided students to make their own slime or discussed the neutralization of pasta sauce. During the interviews, multiple teachers indicated that they pay more attention to contexts that are relevant to students' every-day life and provided opportunities for them to work collaboratively on those problems. The collaborative work allowed students to help each other and teachers to provide individualized feedback. The change in the instructional approach was largely attributed from the teachers to the input they got from the professional development program and the positive effects they observed trying out these new ideas in their own classroom. Interestingly, teachers reported similar experiences throughout all participating countries with less experienced teachers focusing more on IBL in general and more experienced teachers from countries with higher diversity focusing on cultural diversity.

Both in the post-test and the interviews, teachers stressed the importance to discuss specific examples of contexts that can be included in classrooms. While the post-test results also show that, on average, examples for fruitful contexts were discussed throughout the professional development program, case study teachers explained that more time to discuss more examples would have been helpful. Some case study teachers proposed that a web-based platform could be helpful to collect and discuss lesson plans including relevant contexts. We therefore recommend that additional powerful examples are necessary to cover topics that are more difficult for teachers to address in contextualized lessons.

Those additional examples should also contain information about how the lesson is situated in a whole unit. In line with the development of more examples, we also recommend to extent the time of the professional development program so that teachers have more time to practice new ideas in their own classroom and discuss those experience with their fellow teachers. However, in some countries in the EU prolonged and extensive professional development is difficult to implement since professional development courses are not mandatory and/or not incentivized. As a result, we recommend policy makers to prioritize professional development courses more throughout the whole teaching career and provide the time and support needed to develop new knowledge and skills in professional development programs like MaSDiV.

Other hindrances for implementing inclusive mathematics and science instruction identified in the case studies are curricular and time constraints as well as high-stakes exams. Due to the investigative and student-centered nature of IBL, it takes more time to get deeply engaged with phenomena. Case study teachers reported that they are not able to allow their students to investigate phenomena frequently since they have to cover a broad range of topics due to curricular constraints and an appropriate preparation for exams. Exams also barely include investigative practices or contexts which limits the necessity for teachers to discuss them during instruction. Research should therefore investigate possible ways to use investigative practices during formative and summative assessments as well. We also recommend policy makers to focus the curriculum on selective and relevant topics that can be explored in greater detail.

Finally, the cooperation between teacher educators, policy makers, and teachers as exemplified in the MaSDiV project can conjointly address the hindrances identified in the project and provide teachers with the necessary support for professional growth. The ideas of inclusive mathematics and science education discussed during the professional development program already showed a significant impact for the participating teachers. We therefore recommend the dissemination and continuous use of the professional development program as well as an adaptation of the professional development program to the needs of the local participant group. With a systematic approach for supporting teachers, a change in practice could follow that allows each student to develop according to his/her own potential and secure an active participation in society based on shared fundamental values.

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