



Final professional development package

Deliverable D3.6

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**FaSMEd: Improving progress for lower achievers through Formative Assessment
in Science and Mathematics Education
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Introduction

This deliverable sits within Work Package 3 – Design and production of the toolkit for teaching and assessment. This is the core of the project and involves the design and production of activities for teachers and students, together with guidance on approaches to teaching and assessment and the use of technology. This deliverable builds upon previous work: Deliverable D3.4 Prototype professional development package for teachers¹ and D3.5 Evaluation of professional development package².

The FaSMEd project aims to investigate technology-enhanced Formative Assessment (FA) practices in order to support teachers and raise student achievements in mathematics and science. As a result, the FaSMEd project has developed and finalised a toolkit that is being published as a website (www.fasmed.eu), in which the Professional Development (PD) Package sits. This is most optimally viewed using Google Chrome. The professional development package is meant to be used by anyone organising professional development for teachers of mathematics and science, for example teacher trainers, multipliers, etc., but it can also be used by teachers working either individually or in groups.

1. Structure and description of the final PD package

The FaSMEd project understands professional development to be an on-going process of teacher learning that can take many forms, such as courses; self-study, collaborative teacher groups or taking part in research³. Many of these approaches to PD have been part of the FaSMEd project's work and are presented and explained in the final PD package. Principles for effective PD are presented on the website as a summary of research findings about the efficacy of professional teacher learning to provide a theoretical foundation for successful professional learning. Finally, a number of PD resources are included in the form of modules designed to help teachers use technology enhanced FA more effectively in their classrooms. FaSMEd's final professional development package therefore consists of four main sections: *Principles, Approaches, Modules and FaSMEd videos*.

¹ <https://research.ncl.ac.uk/fasmed/deliverables/>

² <https://research.ncl.ac.uk/fasmed/deliverables/>

³

https://research.ncl.ac.uk/fasmed/positionpapers/TeacherProfessionalLearningPositionPaperRevised_Final_.pdf

1.1 Principles

Even though approaches to PD differ considerably in different countries and education systems, several literature reviews and meta-analyses summarise evidence of the efficiency of various projects and initiatives concerning professional development (Lipowsky 2011, Lipowsky & Rzejak 2012, Timperly et al. 2007, Yoon et al. 2007). A number of principles for designing successful approaches towards continuing professional development (CPD) have emerged from these analyses and have been summarised by the DZLM (Deutsches Zentrum für Lehrerbildung Mathematik/ German Centre for Mathematics Teacher Education, Barzel & Selter 2015). The following six principles should be considered when planning and implementing PD courses or sessions:



Competence-oriented: Successful CPD-units focus on relevant content-related or methodological competencies and make these goals transparent for all participants. Thus, teachers see a connection with their own teaching practice and this increases their motivation.



Participant-oriented: Growth in teacher competence is based on the careful observation and consideration of the participants' individual prerequisites, questions and problems.



Stimulate cooperation: Cooperation among teachers is critical for long-term effects of professional development. In professional learning communities (PLC) teaching is considered a shared matter of interest of a group of teachers, who share and interrogate their practice. Powerful professional learning fundamentally requires teachers to feel safe to experiment and examine the impact of their experiments.



Case-relatedness: Concrete cases such as student products, student interviews or classroom videos serve as a starting point for, and a field of practice, during the CPD. The particular focus on participants' practical experiences is regarded as the core of effective CPD.



Diverse instruction formats: Successful CPD approaches create connections between theoretical knowledge and practical experience, achieved by deploying input, practice and reflection phases. A range of instruction formats should be used to provide opportunities for active participation, experience self-effectiveness and competence transfer.



Foster (self) reflection: The CPD sessions should provide opportunities for participants to reflect not only on their own classroom practice, including the effects of their experiments, but also on what they are learning as part of the CPD.

These principles are not only explained in the PD package but can also be downloaded as a handout for teachers or teacher educators.

1.2 Approaches

This section of the PD package addresses the different ways in which professional development can be organised. These can vary depending on the country context, organisation of school systems or the different practices and expectations of participating teachers.

In FaSMEd all partners used an *‘active involvement of the teachers in the design-based research process’* as an instrument for PD (D3.5 2015, p.1). The teachers were involved throughout the intervention phase of the project (2014/2015) through cluster meetings and school visits. The meetings included dialogues with FaSMEd researchers, sharing of practice with other teachers and participating in the *‘design-do-review-cycles’* of FaSMEd tools. However, this approach to PD was organised in various ways by different partners and often complemented by the use of PD courses or modules. Thus, three main approaches to PD proved essential for FaSMEd and are explained in three sub-sections: *Courses*, *Learning Groups* and *Individual teachers*.

1.2.1 Courses

Courses can vary considerably, but usually one or more experts lead the course, choosing the content to cover and the order in which it is presented. The leaders plan the sessions and prepare materials, such as handouts for teachers. A course has a beginning and an end and consists of a series of meetings, during which the participants cover the course content which is pre-determined by the leader(s) of the course.

The FaSMEd PD package reports on different experiences with professional development courses concerning the topic of technology enhanced FA by different FaSMEd partners. Furthermore, the efficiency of these experiences is evaluated and download links to materials from these courses are provided (Figure 1).

Working with the Digital Assessment Environment (DAE)	FaSMEd partner: Utrecht University		<ul style="list-style-type: none"> • DAE Technical Manual for PD (pdf) • DAE Technical Manual for teachers (pdf) • PD manual (pdf) • Meeting 1 (pptx) • Meeting 1 (pdf) • Meeting 2 (pptx) • Meeting 2 (pdf) • Meeting 3 (pptx) • Meeting 3 (pdf)
Werken met de Digitale Toets Omgeving (DTO)	FaSMEd partner: Utrecht University		<ul style="list-style-type: none"> • DTO Technische Handleiding voor Nascholingsleiders (pdf) • DTO Technische Handleiding voor Docenten (pdf) • Handleiding nascholing (pdf) • Bijeenkomst 1 (pptx) • Bijeenkomst 1 (pdf) • Bijeenkomst 2 (pptx) • Bijeenkomst 2 (pdf) • Bijeenkomst 3 (pptx) • Bijeenkomst 3 (pdf)
FaSMEd PD course	FaSMEd partner: Maynooth University		<ul style="list-style-type: none"> • Introducing formative assessment in science and mathematics education (ppt) • Identifying and responding to conceptual difficulties (ppt) • Improving questioning and increasing student collaboration (ppt) • Students becoming assessors (ppt)
Diagnose und Förderung im mathematischen und naturwissenschaftlichen Unterricht	FaSMEd partner: University of Duisburg-Essen		<ul style="list-style-type: none"> • Diagnose und Förderung Workshop Folien (ppt)

Figure 1: List of PD materials used by different FaSMEd partners in the form of PD courses

1.2.2 Learning Groups

FaSMEd uses the term ‘learning groups’ as an umbrella term which covers groups of teachers working together on their own professional development. Some of these groups might call themselves professional learning communities, while others might be communities of practice but in general the idea is that the members of the group reflect and learn together, usually by examining and inquiring into their own developing practice. Typically, the agenda is set by the group and there is no particular leader although there may be someone or some people who take responsibility for coordinating the group.

This section of the PD package describes some guidelines for thinking about coordinating PD for a group of teachers, such as considering how much time to leave between meetings so that teachers can try out the discussed ideas in their classrooms or sharing leadership with other group members. Furthermore, the PD package describes some experiences of professional development in the form of teacher learning groups within FaSMEd. These are exemplified through two videos showing excerpts from discussions by two teacher learning groups from different FaSMEd schools in England.

1.2.3 Individual teachers

The final approach to professional development described in the PD package focuses on the individual teacher either working alone through self-study or with a teacher educator. Working with individual teachers or small groups of teachers in a school means that a professional development expert can tailor the PD more effectively to the needs of those teachers. For example, if they want to try something new in a particular context, the expert can plan a lesson with them, observe their teaching and talk to them about the lesson afterwards. The discussion helps the teacher to reflect deeply, not only on the way he/she taught the lesson, but also on his/her students' responses. It can also stimulate teachers to think in detail about the design of tasks and lesson plans as a whole. For many teachers this process leads to significant learning. Examples from FaSMEd partners approaching PD with individual teachers can be found in this sub-section of the PD package.

1.3 Modules

This section of the FaSMEd PD package provides a range of PD materials, divided by content into six modules that can be downloaded and used within a range of PD settings. The modules are designed to be used by the person, or people, taking a formal or less formal leadership role in planned PD for teachers of mathematics or science. For each module, guidance together with a supporting PowerPoint presentation is provided for this leader; the guidance suggests how the PD session(s) could be run but it is expected that the leader will tailor the session to his or her own preferences and context. Handouts for participating teachers are also provided. Most modules also include activities using video clips. The videos can be accessed either through the links from the website or the PowerPoint presentations. In addition, a link provides the leader with some practical advice on how to use the modules. These can be used in any order but preferably starting with Module 1. While the first five

modules are adaptations of exciting PD resources⁴, the sixth module has been newly developed for FaSMEd.

1.3.1 Module 1: Introducing formative assessment

Research shows that teaching is more effective when it assesses and uses prior learning so that the teaching may be adapted to the needs of students (Black & Wiliam, 1998). Prior learning may be uncovered through any activity that offers students opportunities to express their understanding and reasoning. For this reason, the first module introduces teachers to FA and considers the different ways FA can be done. The module requires approximately three hours plus teaching time. The activities address the following questions:

- What is formative assessment?
- How can tasks be used to assess students' understanding?
- How can technology be used to assess students' understanding?
- How can this assessment be used to promote learning?
- What kinds of feedback are most helpful for students?
- How can students become engaged in the assessment process?

The activities and teacher handouts that are provided for Module 1 can be found in the following screenshots showing the list of contents on the covers of this module's professional development guide (Figure 2) and teacher handouts (Figure 3).

Activity A: What is formative assessment?	3
Activity B: Teachers' own experiences of formative assessment	4
Activity C: Principles and strategies for formative assessment	5
Activity D: Analyse students' responses to problem-solving tasks	6
Activity E: Observing formative assessment in action	7
Activity F: The effects of feedback on student learning.....	9
Activity G: Exchanging experiences.....	11

Figure 2: Activities for Module 1

⁴Acknowledgement: permissions given by the Bowland Charitable Trust to adapt the PD resources, [Bowland Maths](#), that they had previously funded the University of Nottingham to produce for the UK. This includes some handouts and video extracts. Additional resources were also adapted from Improving Learning in Mathematics, a government funded programme in the UK and from the Mathematics Assessment Project funded by the Bill and Melinda Gates Foundation. © 2010 Centre for Research In Mathematics Education University of Nottingham, adapted for FaSMEd by AIMSSEC and University of Duisburg-Essen.

Handout 1: The importance of formative assessment.....	2
Handout 2: Difficulties with formative assessment	3
Handout 3: Principles and strategies for formative assessment.....	5
Handout 4: Problem-solving in the classroom	7
Handout 5: Counting trees.....	8
Handout 6: Cats and kittens.....	12
Handout 7: Suggestions for questions	16
Handout 8: Formative assessment in action	17
Handout 9: The effects of feedback on student learning	18
Handout 10: A formative assessment lesson plan	20
Handout 11: Exchanging experiences	23

Figure 3: Teacher Handouts for Module 1

1.3.2 Module 2: Using students' mistakes to promote learning

This module is intended to help teachers reflect on the nature and causes of students' mistakes and to consider ways in which they might use them constructively to promote learning. This process, which involves teachers in interpreting students' responses to better understand the cause of students' errors, is fundamental to formative assessment because the decisions teachers make about their teaching are based on their students' current understandings. The module requires approximately two hours and it is suggested that three discussion activities take place:

- Activity A: Assessing student's responses to diagnostic questions;
- Activity B: Diagnosing the cause of errors;
- Activity C: Responding to errors and misconceptions.

This module provides two different sets of handouts; one for teachers of mathematics (Figure 4) and one for teachers of science (Figure 5).

Handout 1(1): Sample student work.....	2
Handout 1(2): Sample student work.....	4
Handout 1(3): Sample student work.....	6
Handout 2(1): Sample follow-up questions	8
Handout 2(2): Sample follow-up questions	9
Handout 2(3): Sample follow-up questions	10
Handout 3: Generalisations commonly made by students	11
Handout 4: Handling students' errors.....	13
Handout 5: Principles to discuss	14

Figure 4: Handouts for mathematics teachers for Module 2

Handout 1(1): Sample student work	2
Handout 1(2): Sample student work	3
Handout 2(1): Sample follow-up questions.....	4
Handout 3: Perceptions on handling students' errors	5
Handout 4: Principles to discuss.....	6

Figure 5: Handouts for science teachers for Module 2

1.3.3 Module 3: Improving questioning

This module requires approximately two hours plus teaching time and contains a selection of professional activities that are designed to help teachers to reflect on:

- characteristics of their questioning that encourage students to reflect, think and reason,
- ways in which teachers might encourage students to provide extended, thoughtful answers, without being afraid of making mistakes,
- the value of showing students what reasoning means by 'thinking aloud'.

The module suggests the following activities (Figure 6) and includes these teacher handouts (Figure 7).

Activity A: Reflecting on the questions we ask	2
Activity B: Types of questions that develop thinking and reasoning	3
Activity C: Observing and analysing a problem-solving lesson	4
Activity D: Solving a problem by 'thinking aloud'	6

Figure 6: Activities for Module 3

Handout 1: Thinking about why we ask questions.....	2
Handout 2: Common mistakes when asking questions	4
Handout 3: What types of questions develop thinking and reasoning?	5
Handout 4: Five principles for effective questioning	6
Handout 5: Observing a lesson	9

Figure 7: Teacher Handouts for Module 3

1.3.4 Module 4: Improving student collaboration

If students are to assess their scientific and mathematical concepts formatively, they will have to elicit evidence of their own and their peers' understanding and to receive feedback on how to move their learning forward. This can be achieved by giving them opportunities to share, discuss and work together. Research has shown that cooperative small group work has positive effects on learning, but that this is dependent on the existence of shared goals for

the group and individual accountability for the attainment of these goals. It has also been seen to have a positive effect on social skills and self-esteem (Askew & Wiliam, 1995). This is why this module (approximately two and a half hours) is designed to help teachers to:

- consider the characteristics of student-student discussion that benefit learning,
- recognise and face their own worries about introducing and using collaborative discussion,
- explore techniques for promoting effective student-student discussion,
- consider their own role in managing student-student discussion,
- plan discussion-based lessons.

The following activities (Figure 8) and handouts (Figure 9) are provided for this module.

Activity A: Experiencing a discussion	1
Activity B: Analysing a discussion	4
Activity C: Recognising the concerns of teachers.....	5
Activity D: Creating and establishing 'ground rules'	6
Activity E: Managing discussion	7
Activity F: Observing and analysing a discussion lesson	8

Figure 8: Activities for Module 4

Handout 1: Experiencing a discussion.....	2
Handout 2: Characteristics of helpful and unhelpful talk	4
Handout 3: Analysing a discussion	6
Handout 4: Common obstacles to classroom discussion	8
Handout 5: Ground rules for students	10
Handout 6: Phases of a discussion lesson	12
Handout 7: The role of the teacher during small group discussions.....	13
Handout 8: Final whole class discussion and the role of the teacher	14
Handout 9: Analysing a discussion lesson	15

Figure 9: Teacher Handouts for Module 4

1.3.5 Module 5: Students becoming assessors

This module is designed to help teachers make effective use of opportunities for students to improve their understanding by encouraging students to take the role of assessors. There are different ways in which students may contribute to FA such as peer assessment, self-assessment or collaborative work. In this module several of the roles that students may take are explored as well as the formative assessment processes involved in the roles. The module makes use of example student tasks which all involve problem-solving. These problems often have no single correct answer and they can all be approached in a variety of ways. The module

requires approximately two hours plus teaching time and includes the following activities (Figure 10) and teacher handouts (Figure 11).

Activity A: Student learning from sample responses	1
Activity B: Involving students as assessors.....	4
Activity C: Planning a lesson in which students are assessors	5
Activity D: Exchanging experiences.....	6

Figure 10: Activities for Module 5

Handout 1: Text messaging	1
Handout 2: Golden Rectangles.....	8
Handout 3: Counting Trees	15
Handout 4: Comments on Emma's and Shane's lessons	20
Handout 5: Track A: Using students' own work	21
Handout 6: Track B: Using sample work provided by the teacher	22
Handout 7: Planning for an assessment lesson	23
Handout 8: Exchanging experiences	24

Figure 11: Teacher Handouts for Module 5

1.3.6 Module 6: Using technology for formative assessment

This module helps teachers to reflect on some ways in which technology can support formative assessment. This is why it introduces teachers to the FaSMEd framework and focuses in on the (digital) technology aspect of the framework. It begins with some general questions about what technology is and what role technology has, or can have, in formative assessment. It then addresses the three key aspects of technology for FA within the FaSMEd framework:

- *Sending and displaying* (e.g., sending work to students to complete before or during a lesson),
- *Processing and analysing* (e.g., using voting software and using software to provide immediate feedback),
- *Providing an interactive environment* (e.g., self-assessment, using GeoGebra).

The module requires approximately two hours and includes the following activities (Figure 12). These activities draw on many examples from FaSMEd tools that use technology to support FA and also include some videos explaining FaSMEd tools and their use. Furthermore, a number of teacher handouts are provided (Figure 13).

Activity A: Technology in the classroom; technology for formative assessment.....	2
Activity B: Sending and displaying.....	4
Activity C: Processing and analysing (using voting software)	5
Activity D: Processing and analysing (feedback)	7
Activity E: Providing an interactive environment (self-assessment).....	9
Activity F: Providing an interactive environment (interpreting on-screen activity).....	10

Figure 12: Activities for Module 6

Handout 1: Technology in the classroom	2
Handout 2: Technology and formative assessment	4
Handout 3: Sending and displaying <i>during</i> a lesson.....	5
Handout 4: Sending and displaying <i>before</i> a lesson.....	6
Handout 5: Processing and analysing	7
Handout 6: An expert's views on using Mathspace	8
Handout 7: Providing an interactive environment (self-assessment).....	9
Handout 8: Providing an interactive environment (examples from GeoGebra)	10

Figure 13: Teacher Handouts for Module 6

1.4 FaSMEd videos

This section of the PD package holds videos produced in the course of the FaSMEd project and used in several PD modules. They are also inserted in the relevant sections of the PD package with supporting materials, but put here as an additional collection for easier access.

2. Implementation of evaluations

In Deliverable D3.5: Evaluate professional development package⁵, the prototype PD package (see deliverable D3.4 for more information⁶) was assessed. The evaluation focused on the different approaches to PD within FaSMEd and their efficacy for professional learning. Conclusions for the development of the final PD package were drawn, that served as a guideline for the design. The following discussion highlights the way in which these conclusions have been implemented in the final PD package.

One of the main concerns of previous evaluations of the PD package is the lack of a clear structure (Technical Review Report, p.4). This issue is solved by the new structure of the PD package, as presented above, and a shift in the addressed audience. While the prototype was

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<https://research.ncl.ac.uk/fasmed/deliverables/Deliverable%20D3%205%20Evaluate%20professional%20development%20package.pdf>

⁶ <https://research.ncl.ac.uk/fasmed/deliverables/D3%204.pdf>

aimed only at teachers, the final PD package includes teacher trainers, multipliers and other people organising professional development for teachers.

Furthermore, it became clear in the FaSMEd Evaluation report that not all approaches to professional learning that took place in the FaSMEd project were part of the PD package (see D3.5). Thus, common approaches to PD were included together with experiences from various FaSMEd partners, also providing supporting materials used by the partners in different PD courses or workshops with teachers. This informs teacher trainers about a possible method of practice and supports teachers in their use of FaSMEd toolkit and PD package materials.

Finally, the evaluation suggested emphasising *‘the value added by this project, particularly in relation to the role of technology’* (D9.1, p.4). This is achieved in the final PD package through the professional development modules. While the first five modules were adapted to stress aspects of FA as well as the agents doing FA, the sixth module was newly written to highlight the role of technology within FA processes. Therefore, all dimensions of the conceptual FaSMEd framework (see D3.3) and their connections with one another have been focused on.

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