Deliverable D5.1: Methodology: A proposal for a common methodological approach for the analysis

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Introduction and background

The FaSMEd project comprises of nine teams from eight different countries. It aims "to research the use of technology in formative assessment classroom practices in ways that allow teachers to respond to the emerging needs of low achieving learners in mathematics and science so that they are better motivated in their learning of these important subjects" (Project Description of Work). More precisely, consortium partners will "adapt and develop existing research-informed pedagogical interventions (developed by the partners)" (ibid) for working with learners/students and helping to transform teaching. Moreover, the project will report on the varying assessment tools, and the pedagogic/didactical practices associated with these tools, seek to "reveal the educational opportunities that are open to these students" (ibid). This, it is suggested, is likely to "expand our knowledge of technologically enhanced teaching and assessment methods", also addressing low achievement in mathematics and science. Ultimately, the objective is that a greater number of students will have more positive experiences and formative assessment support, and hence develop more positive dispositions towards further study of these subjects (and perhaps develop the desire to be employed in related fields).

The purpose of WP5 is "to elaborate a systematic comparative analysis of the results and findings emerging from the assessment of existing experiences and the newly developed interventions". When doing that, we will use the "products" (e.g. results and findings) of WP2, WP3 and WP4. Hence, the main anchors for the analyses are the consortium members' case studies. This analysis will disclose maximum potential leverage and impact for the measures to be taken, and the optimal use of existing structures and materials to make this impact effective.

In D5.1 "Methodology" (this report) we propose a common methodological approach for the cross-comparative analysis drawing upon the findings of the groups. In previous meetings (e.g. in Turino), the consortium partners have commented on this approach, and we will present our first findings from the cross-comparative case analyses at our next consortium meeting in South Africa (February 2016).

Research questions

The research questions form the basis for our research design (case study, see Yin 2004) and data collection strategies. Research questions to be addressed as a theme across the project and answered in a summary in WP6 are:

1. How can research-informed approaches help to understand and address key challenges in enhancing participation, engagement and achievement in science/ mathematics [in particular to address differences linked to socio-economic status, gender, and ethnicity which appear to be linked to low achievement]?
2. What specific new interventions, or changes in policy or practice, offer the greatest potential to improve engagement and learning in science / mathematics and how could their potential effectiveness and feasibility be assessed more fully?

Case studies from WP4 and analysed in WP5 will report on:

- How do teachers process formative assessment data from students using a range of technologies?
- How do teachers inform their future teaching using such data?
- How is formative assessment data used by students to inform their learning trajectories?
- When technology is positioned as a learning tool rather than a data logger for the teacher, what issues does this pose for the teacher in terms of their being able become more informed about student understanding?

In the following we explain our theoretical and analytical frameworks.

Theoretical framing of the analyses

In order to structure our analysis, we used several theoretical approaches to structure our analyses. Firstly, we base our analysis on Chevallard's Anthropological Theory of Didactics (ATD- see Chevellard 2005), which provides tools for a description of mathematical or science activity in terms of praxeologies, as a way to describe mathematical or scientific organisations at different levels. In principle, considering the work of Chevallard (2005), a learner encounters a given mathematics/science knowledge in an institution (e.g. school) and in a particular context (e.g. region/country). The institution/school (and learning environments) frames this knowledge, and this framing entails several components. This led us to a presentation using Chevallard's nine levels of determination in order to help us understand formative assessment processes mediated/supported by technology tools. Since the five lower levels (subject, theme, sector, domain, and discipline) are mostly visible when one makes detailed observations of classroom practices, they comprise one of our levels. Moreover, the two highest levels (civilisation and society) have been regrouped into one, reflecting the fact that the differences between these two levels did not seem very relevant for our purpose. Thus, the nine levels were regrouped into four levels, but previously separated levels were still separated into different aspects. This led us to the following framework, which organised our cases:

- country and national frames (e.g. national curricula; etc.)

- school environment (e.g. school organization; level of schooling; etc.)
- formative assessment/pedagogic practices
- discipline (e.g. mathematics; science).

Secondly, we have a specific interest in the links between the activities and the resources/tools intervening in the students' mathematic/science works. In previous works (e.g. Gueudet, Pepin & Trouche 2012) we have shown that the use of resources – we considered here curriculum resources, like textbooks, or digital resources (e.g. websites, for example) - contributes to shaping mathematics instruction and learning. In this analysis we not only consider text and digital text resources (e.g. curriculum materials), but also technology resources, such as computer aids, applets, etc., in particular for the use of formative assessment. This led us to consider the instrumental/documentational approach (see Pepin 2014; Trouche 2004; Guin, Ruthven, & Trouche 2002; Gueudet & Trouche 2009 in mathematics education) to didactics as a suitable framework. In principle, the documentational and the instrumental approach to didactics are based on the fundamental idea of teacher/pupil interactions with a resource or tool. In that process the teacher/pupil is influenced by the affordances and constraints of the tool/resource, whilst at the same time the tool/resource is "influenced" and shaped by the teacher/pupil. The documentational and instrumental approach have certain epistemological points of view and concepts in common:

- based on Vygotski's work (1978), the epistemological stance incorporates the ideas that each human activity builds on a world of artefacts, which are culturally, socially, and historically situated; and that one has to distinguish between the artefact, appropriated by a subject along his/her activity, and the result of this appropriation, that is each *appropriation* process is an *adaptation* process;

- there are two facets of this adaptation process: *instrumentation* describes the ways in which a subject adapts herself in order to integrate this new artefact; *instrumentalisation* process describes the ways in which a subject adapts this artefact to fit her needs, dispositions and habits.

Hence, based on the research questions and the analytical frame, we decided on the data collection strategies, which are described in the subsequent section.

Data collection strategies

As previously mentioned, the overall research design is that of case study (Yin 2004). The unit of analysis is the teacher with his/her mathematics/science class, each forming one case. Each case study is anchored in the following data, which link to the relevant research questions.

Information on **context** and environment:

- contextual information of (at least two) schools;
- teacher demographic information;
- student demographic information.

Mathematics/science **content**: at least one lesson on "graphs/functions" (travel graph activity)

<table>
<tr><th>Research question</th><th>Data collection strategies</th></tr>
<tr><td>How do teachers process formative assessment data from students using a range of technologies?</td><td>Description of tool/s & observation in use/s:
- description & development of tool;
- adjustment to context/class
- intended implementation

Teacher report/logs on a series of lessons
Including the following:
- length of lessons, date & time
- year group & class size
- objectives & lesson theme
- significant events
- resources used
- reflections on lesson/s

Observation/s of series of lessons/teacher (including video):
- observations of lesson development/preparation
- lesson observations
- if possible, re-design observation

Interview/s with participant teachers (from two different schools)
-> interview schedule (see WP1)</td></tr>
<tr><td>How do teachers inform their future teaching using such data?</td><td>Interview/s
Observation/s
Teacher log/s</td></tr>
<tr><td>How is formative assessment data used by students to inform their learning trajectories?</td><td>Interviews of participant students -> (focus group) interviews based on q-sorting
on their perception of:
- mathematics/science and its learning;
- how the FA and technology helped them in their learning of mathematics/science
- on particular FaSMEd lessons</td></tr>
</table>

	Local attainment data (teacher assessment) from the two teachers/classes (e.g. tests)
When technology is positioned as a learning tool rather than a data logger for the teacher, what issues does this pose for the teacher in terms of their being able become more informed about student understanding?	**Interview/s** **Observation/s**

Analyses

Our analyses can broadly be divided into two levels:

(1) within-case analysis; and

(2) cross-case analysis (Cohen, Manion, & Morrison, 2000).

In terms of (1), we will analyse the teacher (and their class) cases individually, and each consortium has written up at least two cases (based on the questions/grid provided, to have comparable data for analysis). These cases are then analysed in terms of cross-case analysis (2). Here both the instrumental/documentional analytical approach (e.g. for the interactions in the classroom), as well as the anthropological approach (e.g. for the 'larger picture' in terms of teachers' educational practices in different regions/countries) are clearly helpful. These processes of comparing similarities and differences within and across cases are conducted within each country, before turning to the cross-case comparative international analysis.

In developing a 2x2-layered analytic framework (within- and across- case analysis, with two different lenses) used in the study, we pursue an iterative approach that combines results from the literature/theoretical frames with our investigation of (1) teachers' use of formative assessment/technology tools; and (2) pupils' use (and perceptions) of formative assessment strategies/tools for their learning. Hence, and in line with the main aims of the study, namely "to research the use of technology in formative assessment classroom practices in ways that allow teachers to respond to the emerging needs of low achieving learners in mathematics and science so that they are better motivated in their learning of these important subjects", the research design had two strands, and connected analyses. Formative assessment tools (in particular technology tools and resources) were examined with respect to their use by (a) teachers and (b) pupils, and the links between these. Each of these strands will then be analysed cross-nationally/regionally, and considering their respective environments.

In short, the analyses involve initial category generation, followed by saturation based on constant comparison as advocated by Glaser and Strauss (1967). Categories are checked and re-checked against further data, compared with other material (e.g. previous findings), strengthened and refined, similar to a procedure described by Woods (1996). Moreover, at one level, and in order to maintain the coherence of each theme, the results are analysed in the light of the researchers' knowledge of formative assessment with technology in mathematics/science education; at another level, analyses are conducted across each country's cases, testing the hypotheses offered by the literature (and previous studies), and building explanations and theorizations grounded in the data.

However, due to the additional cross-cultural dimension, it is important to address the potential difficulties with cross-national research, in particular issues related to conceptual equivalence (e.g. meaning/intentions of the actions) and linguistic equivalence (e.g. translation of words/expressions) (Warwick and Osherson 1973). Particularly important are the validity checks with respect to particular notions that are identifiable in some but not all cases, and related curricular or (mathematics/science) didactical 'practices'. Selected time needs to be spent (amongst the consortiums' researchers) to ensure 'equivalent' meanings and constructs. Hence, and to counter threats to validity, it is important to locate and understand mathematics/science curricular practices (of teachers and pupils) in context, in terms of their 'local' meanings (that is, how they are perceived in each country's environment). In this respect it is useful to draw on expertise and knowledge gained from earlier research, which highlights the complex nature of cross-cultural dimensions, in particular in the light of complex influences such as educational policy developments and traditions in each country (e.g. Pepin 2009).

By examining each of these cases (within-case analysis), and by contrasting them (cross-case analysis), in addition to the cross-national analysis, we anticipate being able to identify how technology may help teachers to develop better understandings of student learning and how to support them in their learning. We also expect the individual cases to provide fertile grounds for the identification and examination of phenomena related to teachers' formative assessment practice. To emphasize, we will not try to compare teachers internationally, but rather to develop deeper insights into the phenomena under study, i.e. formative assessment strategies (in particular technology based) can help teachers and students to develop better learning trajectories.

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