



# FAMT&L
# FORMATIVE ASSESSMENT IN MATHEMATICS FOR TEACHING AND LEARNING

Work Package 2 - *Educational/learning needs analysis of teachers: teachers and students beliefs about formative assessment*

# Deliverable D2.2– Educational/learning needs analysis of teachers: teachers and students beliefs about formative assessment

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| This is going to be an Analysis Report for the beliefs and conceptions of teachers and students about formative assessment in mathematics. This report will include information collected from the literature, projects, studies, conference proceedings. Its content will be based also on the outcomes of the analyses of qualitative and quantitative data that will be collected from mathematics teachers and students in the country of each project partner. Based on the empirical results emerged from the survey and the results of the literature review directions for the pilot training courses (WP4) aiming to improve teachers' conceptions and beliefs about formative assessment in mathematics will be drawn. | | | |

**Executive summary**

This document is an Analysis Report including the methodology and the results of the survey for the beliefs and conceptions of teachers and students about formative assessment in mathematics and directions for the pilot training courses aiming to improve beliefs emerged in survey.

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## 1. About the document

This document is an Analysis Report including the methodology and the results of the survey for the beliefs and conceptions of teachers and students about formative assessment in mathematics and directions for the pilot training courses aiming to improve beliefs emerged in survey. This report includes information collected from the literature, projects, studies, conference proceedings. Its content is be based also on the outcomes of the analyses of quantitative data collected from mathematics teachers and students in the country of each project partner. Based on the empirical results emerged from the survey and the results of the literature review directions for the pilot training courses (WP4) aiming to improve teachers' conceptions and beliefs about formative assessment in mathematics are be drawn.

Regarding the data collection there were some difficulties and limitations. In particular, details are provided about the partners from the Netherlands. The University of Applied Sciences Inholland acts as a partner in the research project FAMT&L. During the first months of the project there was an internal reorganization. This had a big effect on the participating employees. Although it was clear there would be a reshuffle, it took quite some time before it was clear who would be participating in the project. As a result the start up of the project was delayed.

Furthermore, it took longer than previously anticipated to find teachers at schools willing and able to participate as research-partner in the project. As the school year 2014 – 2015 had already started most of the teachers were given their tasks and assignments. This meant that it was hard to find teachers who had any time left in their schedule to give their contribution. Other contributing factors in the difficulties of finding partners in schools are that the government has made mandatory changes in the examination of mathematics what resulted in the introduction of a new school subject (basic calculations) and a new program for the nationwide exams in mathematics. A lot of time and energy of colleagues at the schools in Holland is used for the preparation and implementation of these changes. This will take up to five years. As a consequence not many schools and teachers are eager to take on more work in research as this would be another amount of work resting on the shoulders of the same teachers implementing the nationwide changes. Schools give priority to these because this has a direct effect on the education of the students and their examination. All these factors contributed to the fact that the results from the questionnaires could be analyzed at a much later date than planned. Another consequence is that especially the response from teachers was very low. For this reason, no report about the teachers' results is included, but only the results of the implicative analysis, just for presenting some indications about the teachers' thoughts in this country.

# 2. INFORMATION COLLECTED FROM THE LITERATURE, PROJECTS, STUDIES, AND CONFERENCE PROCEEDINGS.

## 2.1. PART A: formative assessment in the teaching and learning of mathematics

### 2.1.1. Purpose of formative assessment

The National Council of Teachers of Mathematics Assessment Standard (NCTM, 1995) define assessment as "the process of gathering evidence about a student's knowledge of, ability to use, and disposition towards mathematics and of making inferences from that evidence for a variety of purposes" (p.3). In accordance to this, Harlen (2000) points out that "children have a role in assessment for this purpose since it is, after all, the children who do the learning" (p.112). That is why many researchers stress that assessment must be formed "for" learning and not "of" learning, as it is generally acknowledged that increased use of formative assessment (or assessment for learning) leads to higher quality learning (Wiliam, Lee, Harrison & Black, 2004).

In this sense, Nicol and Macfarlane-Dick (2004) argued that formative assessment should be an integral part of teaching and learning in higher education. We agree with this opinion, because of the fact that formative assessment is useful in the learning process; it explains how well the process progresses and it guides students what they wish to learn. In addition, we agree with the aforementioned opinion, emphasizing that the use of formative assessment in teaching can have many benefits on one hand on improving the students' mathematical learning but also the development of positive beliefs towards the learning of mathematics, and on the other hand in helping the teachers in doing proper adjustments according to their students' needs. Formative assessment develops fully autonomous learners, who can self-assess their work, make meaningful inferences from it and plan the next steps for further progress (Black and Wiliam, 1998). Formative assessment also provides information to teachers about students' difficulties and where to focus their teaching efforts. Our opinion is also in line with other researchers' definitions (e.g. Black and Wiliam, 1998) that stress the effects of formative assessment in modifying learning in relation to the students' needs. Van De Walle, Karp and Bay-Williams (2013) define formative assessment as "an along the way evaluation that monitors who is learning and who is not and helps teachers to form the next lesson". Wiliam (2007) claims also that "to be formative, assessment must include a recipe for future action" (p.41). Formative assessment then is a strategic process which

uses evidence regarding the extent of student knowledge (declarative knowledge) and skill (procedural knowledge) to support further learning (Clark, 2011a) and as such increases student motivation, engagement and achievement (Cauley & McMillan, 2010). In accordance to this, Chappuis and Stiggins (2002) argue that formative assessment is designed to monitor student progress during the learning process (i.e., assessment for learning).

Additionally to the aforementioned focus points about the monitoring of teaching and learning, the role of feedback is also emphasized in many other definitions about formative assessment. According to such definitions, formative assessment refers to assessment that is specifically intended to provide feedback on performance for improving and accelerating learning (Sadler, 1998). Cauley and McMillan (2010) add to this by defining formative assessment as a process through which assessment elicited evidence of students' learning is gathered and instruction is modified in response to feedback. In the same sense, for Nicol and Macfarlane-Dick (2004) formative assessment, besides providing a framework for sharing educational objectives with students and for charting their progress, it can also generate feedback that can be used by students to enhance learning and achievement and by teachers for adjusting their teaching practices in order to correspond to their students' needs. Furthermore, Popham (2008) defines formative assessment as 'a process used by teachers and students during instruction that provides feedback to adjust ongoing teaching and learning to improve students' achievement of intended instructional outcomes'. It is thus obvious that formative assessment can have a powerful influence on achievement by providing meaningful feedback to students as to what they know and where they make errors or have misconceptions (Hattie, 2009). Moreover, formative assessment can be helpful for teachers too, while the formative assessment results suggest teachers how to 'modify' and 'adapt' their instructional plans according to their students' needs (Young and Kim, 2010). [P9]

Regarding to the statement saying that 'Formative Assessment is subjective while summative assessment is objective', it refers to a myth about formative assessment. Formative assessment is considered subjective while summative assessment is considered objective. According to Black and Wiliam (2009) 'formative assessment occurs during the learning process while summative happens at the end, but formative assessment is equally objective. The difference lies in how evaluative instruments are used. For example, a rubric that lists criteria for evaluating writing can be used formatively to help students understand what is expected and summatively to assign a grade. High-quality formative assessment avoids being subjective by focusing on the learning task.' Another myth related to the purpose of formative assessment argues that the purpose of formative assessment is to improve teaching. In reality, the results from formative assessment help teachers in decision making, because of the fact that it gives information

about students' difficulties, what they have understand and it leads teachers to change classroom practices in order to reach instructional goals (NCTE, 2010).

High-quality formative assessment always puts student learning at the center. For this reason, formative assessment is using testing / outcomes to direct future learning of groups and/or individuals. Providing feedback to individuals on specific skill areas enhance students' learning (Century Island School, February, 1999 in Lee & Wiliam, 2005).

Summarizing, a definition combining all the points stressed previously is the one provided by Popham (2008, p.5), who characterizes formative assessment as "a process used by teachers and students during instruction that provides feedback to adjust ongoing teaching and learning to improve students' achievement of intended instructional outcomes". This definition is accepted by the Formative Assessment for Teachers and Students (FAST) group as the most accessible to educators (Clark, 2011b; Melmer, Burmaster, & James, 2008).

### 2.1.2. Techniques of formative assessment

The second focus point for our examination is the teachers' beliefs about the use of particular techniques and practices for implementing formative assessment and about factors that influence their choice of particular techniques and practices. In fact, assessment practices and their outcomes on the students' learning, but also their affective domain have drawn the interest of different researchers in the last 30 years (i.e Crooks, 1988; Black & Wiliam, 1998). The actual methodology, data analysis, and use of the results are what distinguish the difference between formative or summative assessment and not the form that may be designed and named as formative or summative. Previous works suggest different formative assessment techniques, most of which appear to have common points. For example, Cauley and McMillan (2010) try to highlight some formative assessment techniques by comparing formative with summative assessment. They actually say that the results of summative assessment provide evidence only about the current achievement of the students, at the time the assessment is done. On the contrary, despite the fact that a summative technique can be used in formative assessment, such as a test, the results of formative assessment can provide teachers information about students' misunderstandings and use these information during their teaching in order to provide feedback to students and help them correct their errors. Cauley and McMillan (2010) provide particular techniques that should be used in teaching for the effective integration of formative assessment in instruction. Specifically, informal observations and oral questions posed to students while content is being taught or reviewed is a practice that allows ongoing formative assessment. And if the information from the observations and questions to students is accurate, the teacher

identifies instructional adjustments that can help improve the students' learning. According to Bliem and Davinroy (1997) the fairness of formative assessment includes standardized tasks administered to individuals rather than groups of students. Moreover, in 2011, Clark emphasizes to teachers' comprehension and recognition about the social construction of knowledge in order to improve their students' learning. This practice leads to the professional development of classroom assessment.

From our experiences, observations and oral questions are included in the teachers' repertoire of formative assessment techniques and are very commonly used in teaching. Despite the frequency of their use, we are not sure that these techniques can be included among the most effective ones for formative assessment. However, research indicates that teachers' opinions and preferences are not totally in line with our opinion. In fact, Kyriakides and Campbell (1999) examined primary teachers' opinions about the appropriateness of particular techniques of assessment in mathematics. Performance test and structured observation were considered to be the most appropriate methods. On the other hand, unstructured observation and oral question-and-answer were seen to be the least appropriate techniques. Teachers were also asked to express the degree of difficulty of these techniques. The results indicated that unstructured observation was considered to be the easiest technique and oral question-and-answer as the next most easy. In an effort to shed some light to this contradiction, statements examining the teachers' beliefs about the appropriateness of the use of the aforementioned assessment practices were included in our questionnaire (Table 2).

Furthermore, Cauley and McMillan (2010) recognize that formative assessment does not always mean giving students a grade, while the comments on students' work can be important for students' improvement, however the absence of grade does not constitute high-quality formative assessment. Black and Wiliam (2009) claim that high-quality formative assessment takes many forms (quality, advice and guidance, not comparison and feedback), but they focus on some of them which are used in table 2 (T18). Furthermore, significant quality formative assessment can take different forms, but it always has some standards. For example, a high-quality formative assessment emphasizes the quality rather than the quantity of student work. Moreover, it targets in giving advice and guidance over giving grades, it avoids comparing students in favor of enabling individual students to assess their own learning, fosters dialogues that explore understandings rather than lectures that present information. Moreover, formative assessment encourages multiple iterations of an assessment cycle, each focused on a few issues and provides feedback that engenders motivation and leads to improvement. Nevertheless, whatever the form the formative assessment takes, it should aim acquiring the knowledge of the task rather than the student. In more detail, instead of saying "You are a great writer," a teacher who uses high-quality formative assessment will say "You used transitions very effectively in this middle section. See if you can do

the same thing in the last section of the paper" (Kluger & DeNisi, 1996). The emphasis and detail provided in this type of assessment aims to give students a clear idea of what, why, and how to proceed, as they continue to work on a mission or an assignment. On the other hand, this method should be offered into manageable pieces of work so that students are not overwhelmed such processing. Formative assessment, for example, is much more efficient since focuses only on some specific features, such as the organization and transitions rather than identifying any possible review a student can do. However, students should be given more immediate formative assessment for unknown and more difficult tasks so that they don't become too overwhelmed or frustrated. When they are requested to read a new classification or a particularly hard text, for instance, answering (either orally or in writing) teachers' questions about the text can provide a clear indication of students' understanding. As a result, this will enable teachers to illuminate misunderstandings or misinterpretation and help students determine what they still need to learn (Clariana, 1990).

In addition, Cauley and McMillan (2010) stress also the power of using the practice of providing clear learning targets to the students. They explain that formative assessment is more effective when students have a clear idea about their teachers' expectations of them, because providing clear expectations enables students to set realistic and attainable goals. Thus, teachers can improve the clarity of student learning targets by providing examples of both weak and stellar work. Furthermore, such knowledge is powerful because students have a good understanding of what they are doing and why the teacher provides them feedback and these help them understand what they are learning, to set goals, and to self-assess. Although this technique was suggested by Cauley and McMillan (2010) for formative assessment in general, we consider that this practice is also important for the formative assessment in mathematics also, as the students' knowledge of their teachers' criteria allows them have a clear idea about the mathematical content they learning or the mathematical processes, the strategies they need to develop and the way they are expected to be involved in the teaching and learning process.

The aforementioned techniques discussed by Cauley and McMillan (2010) and Kyriakides and Campbell (1999) are also found in the "Teaching Quality Papers" published by the General Teaching Council for England (2011). In fact, the General Teaching Council for England (GTCE) considers the effective use of questioning techniques, the use of marking and feedback strategies, the sharing of learning goals to students and peer and self-assessment by pupils to be key characteristics of formative assessment. As a result, such policies generate a classroom climate of low-control and high-autonomy, which in turn catalyzes greater congenial motivation, stronger desire to learn, and desire for challenge (Deci, Nezleck and Sheinman, 1981).

The GTCE provide also a number of techniques, which embody these key characteristics. Some of these techniques include sharing learning goals with pupils (Turner, Warzon and Christensen, 2010, p.5), helping pupils know and recognize the standards to aim for, providing feedback that helps pupils to identify how to improve and pupils learning self-assessment techniques to discover areas they need to improve. Black and Wiliam (2009) highlight that self-assessment by pupils, far from being a luxury, is in fact an essential component of formative assessment. When anyone is trying to learn, feedback about the effort has three elements: redefinition of the desired goal, evidence about present position, and some understanding of a way to close the gap between the two. All three must be understood to some degree by anyone before he or she can take action to improve learning.

It should be comprehensible that formative assessment lessons are necessarily less dogmatic and as a consequence the students are energetic and active participants in the co-construction of the learning procedure. Students may be motivated to capture with an activity by writing the issue on the board as a question and then using cooperative learning groups to consider and debate how the answer may be found (AAG/APMG, 2002-2008). More specifically, Clark (2011) provides a richer list of sixteen formative assessment-teaching techniques, suggesting that these techniques engage students in reflective thinking and problem solving. Among these sixteen techniques, higher order questioning techniques, feedback for students as comments and not grades, oral feedback to students, sharing assessment criteria with students, peer-assessment and collaborative goal setting with and by students are included. Thus, the strategies used in formative assessment aid creative social behavior because the learning situation is one of mutually helpful interaction and positive interdependence among students (Johnson & Johnson, 1996). It is obvious that the techniques suggested by Clark (2011) are also found in the previous suggestions that were discussed. Therefore, we can see that there is a general agreement between the different researchers in the techniques they consider as important for the effective implementation of formative assessment in the mathematics classroom.

Another one issue, which impacts teachers' techniques in formative assessment, is related to teachers' prediction of students' outcomes. According to Muijs and Reynolds (2001), there exist some factors that may form teachers' expectations about their students' future assessment. These factors are described in table 2 (T19).

Nevertheless, Black and Wiliam (2009) list some factors that promote formative assessment in the classroom. More specifically, they refer to understanding and articulating in advance of teaching the achievement targets that their students are to hit, informing their students about those learning goals, in term that students understand, from the very beginning of the teaching and learning process, becoming assessment literate and thus able to transform their expectations into assessment exercises and

scoring procedures that accurately reflect student achievement, using classroom assessment to build students' confidence in themselves as learners and help them take responsibility for their own learning, so as to lay a foundation for lifelong learning, translating classroom assessment results into frequent descriptive feedback (versus judgmental feedback) for students, providing them with specific insights as to how to improve, continuously adjusting instruction based on the results of classroom assessments, engaging students in regular self-assessment, with standards held constant so that students can watch themselves grow time and thus feel in charge of their own success, and actively involving students in communicating with their teacher and their families about their achievement status and improvement. In short, the effect of assessment for learning, as it plays out in the classroom, is that students keep learning and remain confident that they can continue to learn at productive levels if they keep trying to learn. In other words, students don't give up in frustration or hopelessness.

Last but not least, Brown (2004) claims that any assessment strategy that aims to be *inclusive* should establish a range of techniques for assessment (for example written assignments, presentations, reflective accounts and so on), so that the same students are not always impoverished. All participants need to be provided with *the same opportunities* to show their abilities and potentials. This indicates that the assessment criteria need to be clear, explicit, framed in language that is worthwhile to staff and students and available well in advance of the beginning of activities that will eventually be assessed.

### 2.1.3. THE EFFECTIVE USE OF FORMATIVE ASSESSMENT RESULTS

#### 1.1. The use of feedback

Feedback is an important dimension of formative assessment, either as provided by teachers to students through questions, comments etc., by students to the teacher, or by students between them or, in relation to self-assessment and peer-assessment practices. Thus, the use of feedback as a result of formative assessment is included in our third research question about the teachers' beliefs about the way the results of formative assessment can be used effectively.

It is noteworthy that feedback is not always formative, but there are some factors which determine when the feedback becomes formative. More specifically, feedback becomes formative when students a) are engaged in a process which focuses on meta-cognitive strategies, b) are supported in their efforts to think about their own thinking, c) understand the relationship between their prior performance, their current

understanding, and clearly defined success criteria, and d) are activated as owners of their own learning (Clark, 2011a).

Assessment considered as a way for sharing educational objectives with students and for charting their progress. It generates feedback information that can be used by students to enhance learning and achievement. This feedback information is also helpful to teachers in order to re-align their teaching according to their students' needs. When assessment serves these purposes it is called 'formative assessment'. It is argued that formative assessment should be an integral part of teaching and learning process (Nicol and Macfarlane-Dick, 2004).

The power of feedback becomes evident in different definitions of formative assessment that highlight the importance of integrating feedback in instruction. For example, Sadler (1998) refers to formative assessment as specifically intending to provide feedback on students' performance for improving and accelerating their learning. In line with this opinion, Cauley and McMillan (2010) explain that by showing the students specific misunderstandings or errors that frequently occur in a content area or a skill set, and showing them how they can adjust their approach to the task, students can see what they need to do to maximize their performance. As a result, feedback to students that focuses on developing skills, understanding, and mastery, and treats mistakes as opportunities to learn is particularly effective for their progress in learning and gives students hope and positive expectations for themselves. Besides the focus on the positive effects of providing feedback to students, researchers emphasize also on gaining feedback from students about their learning and understanding. Actually, Hattie (2009) adds that a powerful influence of formative assessment on achievement is the meaningful feedback from students as to what they know and where they make errors or have misconceptions. Therefore, formative feedback is benefit both to students and to teachers. Feedback on performance, in class or on assignments, enables students to restructure their understanding /skills and enhance their ideas and capabilities (Nicol and Macfarlane-Dick, 2004). For this reason, formative feedback is crucial. It is very important formative feedback to be detailed, comprehensive, meaningful to the individual, fair, challenging and supportive (Brown et al., 1994).

However, not only the teacher can provide feedback information, but peers often provide feedback. For example, in group-work contexts, students generate their own feedback while engaging in and producing academic work (Nicol and Macfarlane-Dick, 2004).

Despite the fact that providing feedback to students occurred as one of the formative assessment techniques in the previous session, in this section we focus on feedback in the sense of incorporating the information and results of feedback for improving the students' teaching and learning. Therefore in this section we discuss about how feedback should be provided, referring to how and when it should be

provided and what the results of providing effective feedback to students are. Nicol and Macfarlane-Dick (2004), suggest that the good feedback practice facilitates the development of self-assessment (reflection) in learning, encourages teacher and peer dialogue around learning, helps clarify what good performance is (goals, criteria, expected standards), provides opportunities to close the gap between current and desired performance, delivers high quality information to students about their learning, encourages positive motivational beliefs and self-esteem and provides information to teachers that can be used to help shape the teaching. In order to be able to benefit in the aforementioned ways, these researchers provide also suggestions drawn from research about particular strategies that increase the quality of feedback, in relation to the way and the time feedback should be provided. Specifically, these strategies include making sure that feedback is provided in relation to pre-defined criteria (paying attention to the number of criteria) providing feedback soon after a submission, providing corrective advice not just information on strengths/weaknesses, limiting the amount of feedback so that it is used, prioritizing areas for improvement and focusing on students with greatest difficulties. Furthermore, Nicol and Macfarlane-Dick (2004) suggest some good examples of feedback dialogue in class which include (1) providing feedback using one-minute papers (Cross and Angelo, 1990), (2) reviewing feedback in tutorials where students are asked to read the feedback comments they have been given and discuss these with peers, (3) asking students to find one or two examples of feedback comments that they found useful and to explain how they helped. Other ways of using feedback dialogue in a planned way, for assignments, might involve (1) having students give each other descriptive feedback on their work in relation to published criteria before submission and (2) group projects.

Sadler (1998) raises an important issued regarding the use of feedback, turning the focus on the way the students can reclaim and benefit from feedback. He identifies three conditions necessary for students to benefit from feedback. In particular, the student must possess a goal or standard level for the concept acquisition, compare the actual level of performance with that goal or standard and engage in appropriate action, which leads to some closure of the gap. He also notes that for feedback to act, the teacher has to provide a verbal statement about the quality of the students' work (the reasons for the judgment and ways in which some of the shortcomings could be remedied). Therefore, students should also be trained in how to interpret feedback, how to make connections between the feedback and the characteristics of the work they produce, and how they can improve their work in the future. Sadler (1998) successfully claims that we cannot simply assume that when students are given feedback they will know what to do with it. This is indeed an important factor to take into account when providing feedback to students, in order not only to provide comments about their performance or errors, but also to include particular suggestions and solution about ways

that can help the students overcome their weaknesses and improve themselves. Further, Ames (1992) recommends that feedback should be private, must be linked to opportunities for improvement, and should encourage the view that mistakes are a part of learning. Nevertheless, it would be significant to help students to understand not only where they have gone wrong, but also what they need to do to improve. The positive feedback when they have done well is essential in order to help them understand what is good about their work and how they can build on it and develop further.

### 1.2. The use of students' errors

The use of students' errors is an important dimension of formative assessment, as it helps the teachers modify their practices for helping the students correcting them, but also the students in identifying their weaknesses and try overcoming them. We strongly agree with this, thus in this section the important of using and interpreting the students' errors is going to be discussed emphasizing on the role of the teachers' beliefs about errors, which is a part of our objectives for our project when examining the teachers' beliefs for formative assessment. Wragg (2001) supports that "if students are to learn from their assessment, then correction of errors and discussion of what they have done is essential" (p.74). This strengtheners our opinion about the significance of studying teachers' beliefs regarding the origination of the students' errors, as these beliefs can affect the way the teachers will decide to discuss about errors and work with them for helping the students overcoming them.

In fact, the identification of mistakes helps teachers decide how to identify and meet pupils' learning needs and how to use their teaching time and their resources (Kyriakides, 1999). The reason on which the teachers attribute the errors will affect their decisions for their future intervention teaching practices. Therefore, the students' errors can have a formative use, as the teachers can exploit this information for modifying their future actions (Gagatsis & Kyriakides, 2000). Thus, decisions about the next learning steps follow from the formative identification of pupils' errors (Desforges, 1989). And this is particularly important, because a teaching plan which is organized in such a way, might help teachers to plan class and individual programs of work according to the different performance levels of the pupils (Gagatsis & Kyriakides, 2000).

Therefore, in order to be able to provide suggestions through our project towards the effective formative use of students' errors we have to get an insight to the teachers' beliefs about the source of these errors. By encouraging the analysis of pupils' errors in the training model we plan to develop, we can enable teachers to seek specific information about individual pupils' thinking and understanding and then adjust the level of content to match individual pupils' performance levels. A number of studies (Milhaud, 1980; Charnay, 1989; Economou, 1995) revealed that teachers attributed errors mainly to

the pupils' lack of interest or lack of preparation. Gagatsis and Christou (1997) examined also the extent to which the didactical and epistemological approaches to the concept of error influence teachers' attitudes investigated. They actually examined the interpretations that primary school teachers give about their pupils' errors. The results of their study showed that the majority of teachers hold similar beliefs. For example, 90% of primary school teachers attributed errors to the psychological situation of the pupil, 80% of the teachers attributed errors to the limited capabilities of the pupil, and 85% considered the lack of knowledge as a reason for errors. Gagatsis and Kyriakides (2000), examined not only whether teachers agreed with aspects of the didactical and epistemological approach to the concept of error but also whether they could identify errors of their pupils associated with the concepts of obstacle and didactic contract. In their study, teachers' responses revealed that items concerned with reasons for errors can be classified into four broad categories. These are pupils' characteristics, teachers' role, the mathematical knowledge, and the rules which pupils are supposed to follow in a typical mathematics classroom. The first factor is related to items which imply that errors are a negative behaviour. Errors are seen as the result of "confusion" (Economou, 1995) and thereby pupils' lack of interest and/or preparation are the main reasons for errors. The second factor is concerned with the role that the teacher has to play in order to enable pupils to avoid mistakes, and is very significant educationally. A significant contribution of this study to educational theory on reasons associated with mathematical errors has to do with the other two factors which emerged. More specifically, the items associated with the third factor partly derive from the epistemological approach to the concept of error and especially with the concept of obstacle. Finally, the fourth factor is highly correlated with items concerned with the concept of didactic contract.

The survey, also, showed that teachers supported that errors in mathematics are often associated with the characteristics of the pupils. This seems to be in line with the findings of a number of studies (i.e Charnay, 1989; Economou, 1995; Milhaud, 1980) which revealed that teachers attributed errors mainly to the pupils' lack of interest or lack of preparation. Finally, the teachers considered error analysis as a significant way of improving their teaching practice.

### 2.1.4. FORMAL AND INFORMAL FORMATIVE ASSESSMENT

Formative assessment can be distinguished in two dimensions. More specifically, it can be formal-a planned act designed to provide evidence about students learning, or informal-where students learning is evident during the course of a teacher' s daily

activities (Bell & Cowie, 2001; Duschl, 2003; Shavelson et al., 2003). Each type can be characterized in a different manner. In particular, in formal formative assessment information is obtained based on the whole class. It usually begins with students carrying out an activity designed or selected by the teacher so that information may be more precisely collected. The activity allows teachers to focus on key points during instruction, check student understanding (interpreting), and design more targeted the next steps that they must take in order to develop their students' further learning (acting). In usual, formal formative assessment practices take the form of curriculum embedded assessments. These practices focus on some specific aspect of learning, such as students' knowledge about why objects sink or float. Furthermore, formal formative assessment can take the form of direct questioning, quizzes, brainstorming, generation of questions, and the like (Bell & Cowie, 2001). The implementation of this type of assessment is planned in advance by the teachers and it can be conducted at the beginning, during, or end of a unit.

The second type of formative assessment -informal formative assessment- can take place in any interaction between teacher and his/her students. Informal formative assessment can happen anytime and it can also engage whole class, small group or individual interactions, which means that it may occur from any instructional/learning activity (gathering). Therefore, it is embedded and strongly linked to learning and teaching activities (Bell & Cowie, 2001, p. 86). Informal formative assessment not to be planned in advance, because it can happen at any time and there is no specific activity designed for students; however, teachers have the potential to be prepared in advance for this type of formative assessment. Thus, teachers cannot predict exactly when they will be able to gather evidence about students understanding during the lesson of non-planned activities, but they can give students varied opportunities for doing so (e.g., by creating more interactions in class, group discussions, or informal observations). The information gathered during informal formative assessment such as students' comments, responses and questions is impermanent (Bell & Cowie, 2001) and many times is not recorded. Informal formative assessment can be distinguished as verbal or non-verbal. Students' questions are considered as verbal informal formative assessment, while teachers' observations are considered non-verbal informal formative assessment. The time frame for interpreting and acting is more immediate when compared with formal formative assessments. A students' wrong answer or unexpected question can guide to an assessment event which helps teacher to identify a student's misunderstanding. Then, the teacher helps student to overcome his/her misunderstanding using different methods such as responding with a question, eliciting other points of view from other students, conducting a demonstration when appropriate or repeating an activity. Nevertheless, both types of formative assessment (formal and informal) involve gathering, interpreting, and acting on information. The difference

between formal and informal formative assessments lies in how much planning is done and the type of planning required. The interpretation and the acting aspects of the process of the two types of formative assessment are determined by two critical factors –teacher content knowledge and pedagogical content knowledge. The figure below (Figure 1) provides a schematic representation of the two types of formative assessment and gives information about the relationship between them. The processes involved in formal and informal formative assessment are determined using different words like 'gathering, interpreting, and acting' for formal formative assessments and 'eliciting, recognizing, and using' for informal formative assessments (Ruiz-Primo & Furtak, 2004). Other authors have used different names to describe the same processes (Bell & Cowie, 2001; Duschl, 2003). The black boxes between units in Figure 1 represent specific points in the curriculum in which the formal formative assessments are implemented. Both formal and informal formative assessments are connected through the general purpose for formative assessment. The continuous line between the units and informal formative assessment is intended to indicate the continuous nature of this type of assessment.

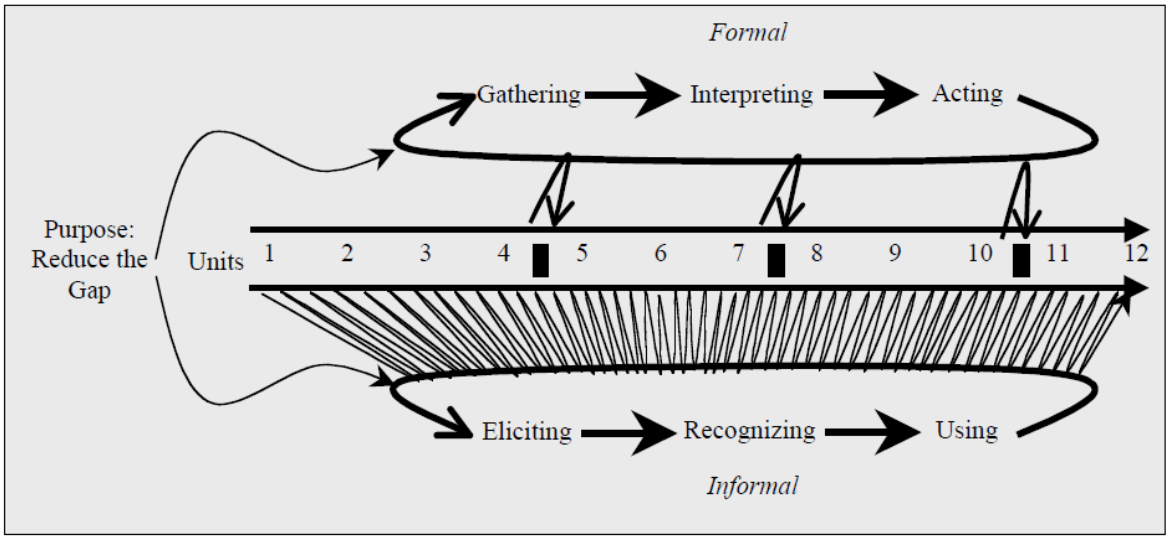


Figure 1. Graphical representation of formal and informal formative assessment.

A basic method/strategy of informal formative assessment which improves students learning is informative questioning (Furtak and Ruiz-Primo, 2005). Informative questioning as assessment for learning in the context of inquiry, gives students information about the correctness or failure of their responses and focuses students' attention on their correct answer, rather than allowing them to explore how they are coming aware of what they know (Duschl 2003). Teachers should avoid the method of asking a question, receiving a response from a student, evaluating the answer, and

moving quickly to the next question. Informative questioning is beneficial both students and teacher. In specific, the targeted actions possible in the informative questioning cycle can help students to understand more clearly how they are thinking about concepts and processes and to lead them to reach inquiry learning goals. As regards the teacher, informative questioning helps him/her to understand students' thinking and provides a basis for action. Moreover, practicing informative questioning is practicing high quality informal formative assessment, which improves student learning. Ruiz-Primo and Furtak (2004) claim that when teachers use informative questioning their students have better performance on several types of formative embedded assessments (e.g., predict-observe explain, open-ended questions) and summative assessments (e.g., performance assessments, predict-observe-explain, open-ended questions) aligned with the learning goals of their curriculum.

Some other strategies are organized by the informal formative assessment characteristics (i.e., eliciting, recognizing, and using information) and the three domains (i.e., epistemic frameworks, conceptual structures, and social processes). The strategies reflect the questions that teachers may ask students to elicit information and the teacher actions that may reflect the recognition and use of information (Ruiz-Primo and Furtak, 2004). Examples of these strategies are presented in the table below (Table 1).

Table 1.
*Strategies for Recognizing and Guiding Assessment Conversations by Dimension and Informal Formative Assessment Components.*

| | **Eliciting** | **Recognizing** | **Using** |
|---|---|---|---|
| Epistemic Frameworks | **Teacher asks students to:** | **Teacher** | **Teacher** |
| | Apply procedures involved in science | - Clarifies/Elaborates based on students' responses | - Promotes argumentation/ Helps students to achieve consensus |
| | Provide responses not based on observations | -Takes votes to acknowledge different students ideas | - Helps relate evidence to explanations |
| | Share/Provide observations | - Compares/contrasts students responses to acknowledges and discuss alternative explanations | - Provides descriptive or helpful feedback |

| | | | |
|---|---|---|---|
| | Make predictions/ Provide hypotheses | conceptions<br>- Repeats/paraphrases students words | - Promotes making sense |
| Conceptual Structures | **Teacher asks students to:**<br>Provide potential or actual definitions<br>Apply, compare/ contrast concepts<br>Elaborate their responses<br>Share students thinking/ classroom | **Same as Above** | **Same as Above** |
| Social Processes | **Teacher asks students to:**<br>Share everyday experiences related to current discussions<br>Share responses not based on observations (e.g., from homework)<br>Share students thinking/ classroom presentations<br>Share/Provide observations | **Same as Above** | **Same as Above** |

### 2.1.5. SUMMARY OF FRENCH PUBLICATIONS ABOUT FORMATIVE ASSESSMENT

In this section we present some research related to the formative assessment that were conducted in France in order to approach this topic from French scope/view too. First of all, we judge appropriate to refer that the initial conception of formative assessment which proposed by Bloom has been enlarged in several directions by researchers working in French. A description/presentation of the main orientations of this enlargement follows.

In the initial conception of mastery learning proposed by Bloom (1968; Bloom et al, 1971), an instructional unit is divided into several successive phases. First of all, teaching/learning activities are related with the objectives of the unit. When students complete these activities, a formative assessment, is proposed to the students. The results of the assessment provide feedback both to the teacher and students and are used as a means for determining corrective measures for students who appeared to have difficulties in the concepts were taught. Additional exercises, different types of instructional material (eg,, verbal vs. visual representations), small-group discussions and computer-based tasks are some forms of the correctives. Nevertheless, in all these cases the aim remains the remediation of learning difficulties identified by formative assessment. All these phases (teaching, testing, remediation) are planned, prepared and managed by the teacher whose goal is to help all the students to master the objectives of the unit.

The characteristics of an enlarged perspective of formative assessment are frequently lie in contrast with those of the approach initially defined by Bloom, as several authors report (in particular, Allal, 1979, 1988; Perrenoud, 1998). In particular, the enlarged perspective supports the integration of formative assessment within each instructional activity, which means that the materials of the assessment should be diversify. In addition to paper-pencil tests, quizzes or worksheets designed to verify whether students understood the content of a lesson, assessment is carried out informally. Teacher's observation, exchanges among students (reciprocal assessment) at various points during an instructional activity, and whole-class discussions are some informal assessment methods.

Thus, a distinction was subsequently made between three modalities of regulation associated with formative assessment (Allal, 1979, 1988): interactive regulation, retroactive regulation and proactive regulation. *Interactive regulation* occurs when formative assessment is based on the interactions of the student with the teacher or other students and/or with material allowing self- regulated learning. Interactive regulation contributes to the progression of student learning by providing feedback and guidance that stimulate student involvement at each step of instruction. *Retroactive regulation* occurs when a formative assessment is conducted after completion of a phase of teaching and allows identification of the instructional objectives attained or not attained by each student. The feedback from the assessment leads to the selection of means for correcting or overcoming learning difficulties encountered by some students. It corresponds to the notion of remediation present in the initial conception of formative assessment defined by Bloom. *Proactive regulation* occurs when different sources of information allow the preparation of new instructional activities designed to take into account differences among students. Innovative approaches to formative assessment often combine these three types of regulation.

The difference between the Bloom's initial conception of formative assessment and an enlarged conception lies in the teacher's role. In specific, in Bloom's conception of formative assessment, the teacher is responsible for the planning and management of each assessment operation, while in an enlarged conception, students have more active involvement in formative assessment through procedures of self-assessment, reciprocal peer-assessment, and joint teacher-student assessment (Allal, 1999).

A key point of the above comparison associated to the aim of formative assessment. Feedback and correction are the basic means in formative assessment in order to allow all (or virtually all) students to attain the instructional objectives. In the perspective proposed in the French-language literature, a much greater emphasis is given to the differentiation of instruction.

After a brief presentation of the main orientations of the enlargement the conception of formative assessment, we will describe some developments in the evolution of work on formative assessment. Four major developments in the evolution of the conception of formative assessment are identified in the French-language literature. These developments are presented in the order of their emergence and each new development has attempted to overcome certain limitations of prior perspectives.

*Focus on instrumentation* is considered the first development in the evolution of the conception of formative assessment. French-language researchers initially adopted the focus on instrumentation that characterized formative assessment. Several collections of instruments were published in different subject matter areas (eg, Marchandisse and Blampain, 1974; Tourneur, Noel and Honclaire, 1975) and general guidelines for the construction of criterion-referenced tests were established (Racine, 1982). Later, more advanced instrumentation was developed based on the computer item banks and systems of "tailored testing" allowing diagnostic error analysis (e g , Dassa, 1988; De Campos, 1990; Leclercq, 1980; Seguin, 1984). Scallon (1988) supported instrumentation of formative assessment claiming that instrument development can take into account the aims and contextual constraints of classroom instruction.

The second development in the evolution of the conception of formative assessment includes the *Search for theoretical frameworks.* The search for theories that can offer conceptual orientation for conducting assessment has been pursued in several different directions in the French-language literature. More specifically, several conference papers and articles described the implications of a constructivist conception for specific subject matters, such as mathematics (Brun, 1979; Thouin, 1993), French (Weiss, 1979), sciences (Thouin, 1982). Simultaneously, new orientations were sought in theories emphasising social and philosophical dimensions of teaching and learning. Another theoretical approach to formative assessment has been proposed by French-language researchers in the areas of "didactics" (Bain, 1988; Chevallard, 1986; Garcia Debanc and Mas, 1987). According to this approach, the assessment is considered as

part of a triadic system which constitutes of the teacher, the learner and the knowledge being dealt with. Schubauer-Leoni (1991) proposed an interpretation of assessment within the framework of the "didactical contract" linking the reciprocal expectations of teacher and learners with respect to a given content area or task.

*Studies of existing assessment practices in their contexts* are the third development in the evolution of the conception of formative assessment. Studies in this direction are related with several phenomena: the interplay between instrumentation and intuition in teachers' practices of formative assessment (Allal, 1983); the fundamental incompatibility between certain instruments of formative assessment and the everyday assessment practices of teachers (Weiss, 1984); the forms of teacher-student negotiation of assessment rules and norms (Chevallard, 1986); the institutional factors affecting teachers' attitudes toward inequalities of students achievement and the effect on assessment practice (Grisay, 1988); the pragmatics of actually doing formative assessment without worrying about doctrine (Perrenoud, 1991); the systemic aspects of assessment that can foster or inhibit the development of formative assessment practices (Perrenoud, 1993).

The last development in the evolution of the conception of formative assessment refers to the *Development of active student involvement in assessment.* Nunziati (1990) and Vial (1995) highlighted the student's role in the formulation of assessment goals and criteria, in the conduct of interactive assessment, and in the construction of shared understanding of what assessment means. Allal (1999) proposed three different but interrelated forms of student involvement in assessment: individual self-assessment, reciprocal peer-assessment, and co-assessment entailing confrontation of teacher and student assessments. A common theme in the French-language literature is that interactive formative assessment, between peers and between teacher and students, constitutes a framework of social mediation that fosters the student's increasing capacity to carry out more autonomous self-assessment and self- regulated learning.

As regard the publications of empirical research in French-language literature, they have been classified in three major categories: experimental studies of the effects of formative assessment; development of instruments and procedures of formative assessment; and studies of teachers' attitudes and practices of formative assessment.

Regard to the first category of research, only two of the 105 articles in the database (which used for this summary) present experimental vs control group comparisons of the effects of formative assessment on student learning. The first study was based on a design comparing mastery learning (with formative assessment) in two history classes to traditional instruction (Huberman, Juge and Hari, 1985). The results showed a positive effect the first trimester however this effect was not maintained subsequently in the second and third trimesters. Various factors which limited the effectiveness of mastery learning, such as the principally institutional constraints and student tendency

to make the minimum effort needed for passing a grade, are discussed in this article. The second study (Gagne and Thouin, 1991) concerned a formative assessment procedure focused on the correction of spelling mistakes (lexical and grammatical) in student texts. The comparison focused on pretest-posttest gains on a spelling test and on a scale measuring student attitudes towards assessment. The results showed a relatively small effect of formative assessment on spelling scores but a substantial improvement of student attitudes toward assessment. In the books we consulted, only one experimental study of the effects of formative assessment on student learning was identified. In this study, Del' Guidice (1999) conducted an investigation in which five groups of 4$^{th}$ grade students received different types of diagnostic assessment and regulation. The results revealed the beneficial effect of the integration of formative assessment in learning situations on immediate learning and on transfer.

For the second category of the research, there is only a limited number of articles (around a half-dozen) which present empirical evidence of the validation of formative assessment instruments. The development of diagnostic instruments for error analysis and regulation of learning in the area of mathematics stands out because this type of instrumentation was the object of a substantial number of studies by Canadian researchers. Research in this area includes a variety of approaches: comparison between different models of diagnostic test construction, estimation of reliability, information on validity, indications about conditions of application (Bertrand et al, 1985); qualitative analysis of computer-based error diagnostics and their didactical validity (Dassa and DeCotret, 1993; De Campos, 1990); critical reflections about the place of computerised systems of diagnostic testing (Dassa, 1988; Dassa and Vazquez-Abad, 1992). Computer-based diagnostic instrumentation in the area of text revision has also been developed (Laurier, 1996) and extended to student self-assessment and self-regulation (Coen and Gurtner, 1999).

Important information comes from studies based on teachers' attitude towards assessment, by using questionnaires or interviews. Canadian researchers used standard instrument development methodology in order to validate scales for measuring teacher's beliefs and attitudes about assessment and student learning (Gadbois et al, 1991; Louis and Trahan, 1995). A questionnaire survey, addressed to 113 Belgian elementary school teachers, showed that teachers were generally favorable to formative assessment. However, research had shown that there was often a gap between espoused teacher's beliefs and classroom practice (Van Nieuwerrhoven and Jonnaert, 1994). Other study conducted by Campanale (1997) using questionnaires and interviews, showed a positive evolution of teacher conceptions of learning and assessment during a professional development programme that focused on the self-assessment method.

The French-language publications on formative assessment have enlarged the knowledge about the conception of formative assessment. The central idea of this conception is the regulation of teaching and learning through informal, interactive assessment and through the use of instruments that are adapted to classroom practice. The work by French- language researchers has led to a diversification and enrichment of the ways of carrying out formative assessment.

### 2.1.6. THE ADOPTED DEFINITION OF THE PROJECT

Based on the results of the literature review, a synthesis of different definitions was done in order to be able to express the way formative assessment in mathematics teaching and learning is defined in our project. Therefore, according to our synthesis, we resulted in providing the following extended definition and description of formative assessment.

"Formative assessment is connected with a concept of learning, according to which all students are able to acquire, at an adequate level, the basic skills of a discipline. The learning passes through the use of teaching methodologies which can respond effectively to different learning times for each student, their different learning styles, and their zones of proximal development. Formative assessment is an assessment FOR teaching and learning. It is part of the teaching-learning process and regulates it. It identifies, in an analytical way, the strengths and weaknesses of student's learning, in order to allow teachers to reflect on and modify their own practices. It allows, in a form of formative feedback, to establish a dialogue between teacher and student and to design educational interventions; It also promotes and fosters the learning of all students through differentiated teaching that ensures each student different rhythms and different teaching and learning strategies, involving at the same time the student in the analysis of own errors/weaknesses and own ability to promote self-assessment and peer-assessment and active participation in the teaching-learning process.

It is intended to give information, feedback and feed forward – in and outside of the classroom – related to the development of mathematical life-skills. In particular, it involves the different components of mathematical learning of the students (conceptual, procedural, semiotic, communicative, problem posing and solving aspects, misconceptions, organization of mathematical experience), the students' beliefs, the students' image of mathematics and of specific segments of mathematics, their behavior and classroom interaction when involved in different mathematical tasks and the outputs of teacher's choices (transposition of mathematical contents, interface between contents and methods)".

Trying to provide a complete and thorough description of formative assessment, we tried to include main points describing the purpose, the techniques and the results of

formative assessment, preserving the relation with the literature review and the main axes of our research. The following table (Table 1) is an effort to deconstruct our definition in relation to our main research axes, for making their correspondence more explicit.

Table 2
Definition of formative assessment in relation to the main research axes

| Purpose | Techniques | Results |
|---|---|---|
| **Teachers** | | |
| assessment FOR teaching and learning<br>• regulates teaching-learning process<br>• establish a dialogue between teacher and student | • teaching methodologies which can respond effectively<br>○ to different learning times for each student<br>○ their different learning styles<br>○ their zones of proximal development<br>• formative<br>○ feedback<br>○ feed forward | • allows teachers to reflect on and modify their own practices.<br>• design educational interventions<br>• the outputs of teacher's choices (transposition of mathematical contents, interface between contents and methods)". |
| **Students** | | |
| • students to acquire the basic skills of a discipline<br>• identify the strengths and weaknesses of student's learning<br>• to give information, feedback and feed forward – in and outside of the | • promotes students' ability for self-assessment and peer-assessment | • learning for all students through differentiated teaching (different rhythms and different teaching and learning strategies)<br>• students' active participation in the |

| | | |
|---|---|---|
| | classroom – related to the development of mathematical life-skills | teaching-learning process.<br>• involving the student in the analysis of own errors/ weaknesses |

Particular elements of our definition are categorized in relation to the main axes regarding the purpose, the techniques and the results of formative assessment. We intentionally do not include the dimension of the teachers' training for formative assessment in our definition, as it is a dimension that has an indirect relation to the application of formative assessment in the classroom.

### 2.1.7. THE POLICY OF EDUCATION AND ASSESSMENT

If policy and training are to be effective, they must deal with teachers' conceptions as much as they deal with declarative or procedural knowledge requirements. The implementation of any new assessment policy, tool, or practice, whether at the national or local school level, needs to take account of the complex structure of teachers' conceptions of assessment to ensure success.

Certainly, the implementation of new standards from professional bodies or state authorities, while well intentioned, may be reduced in effectiveness if teachers' conceptions of assessment remain unchanged or unchallenged, or if teachers remain unaware of their own conceptions. Simply introducing an assessment innovation, as in the hypothetical conversation at the start of the article, even if it is accompanied by appropriate teacher professional development, will not necessarily achieve policy objectives unless the differing, interlocked conceptions of teachers are exposed and addressed. Otherwise, quite possibly few teachers will adopt and utilize the innovation in a manner consistent with the intentions of developers of the innovation.

In other words, assessment policy may be most powerful if structured as a means of giving education professionals self-managed feedback about the quality of their own work. Emphasis on a school-based and managed process of improvement-oriented evaluation of student assessment results is likely to result in educational improvement in the quality of teaching and the quality of student learning outcomes (see for example the SEMO model, Timperley & Robinson, 2002). The development of assessment

policy should include identification of and appropriate response to teachers' conceptions of assessment.

Likewise, teacher professional pre-service preparation and in-service development in the area of assessment needs to take account of teachers' pre-existing conceptions, if it is to be effective in moving teachers toward a desired set of conceptions.

An improvement-oriented assessment policy or practice in that school, without explicit attention to the differing conceptions of assessment held by the teachers, would likely be adopted and assimilated into the pre-existing conception of assessment as something that may be used but ignored.

### 1.3. Assessment policy in each partner country

The following table (table 2) summarizes the theoretical references, regulations and practices of the formative assessment in mathematics for teaching in each partner country.