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Abstract

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Teachers’ formative assessment practices: The case of an IBME-centered course

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In Geneva canton (Switzerland), a special course has been designed to deal with problem solving. Within one 45-minute period per week, teachers have to improve students’ problem solving competencies and to assess them frequently. In order to assess students’ problem solving competencies, most teachers use grids of criteria with a summative purpose. The global objective of our research is to find out if and how using such a tool can also foster formative assessment processes.

In this paper, we present an exploratory study focused on teachers’ formative assessment practices. In order to do so, we study the practices of a teacher giving this IBME-centered course and show how she uses formative assessment in her teaching practices.

Keywords: Formative assessment, summative assessment, problem solving, IBME, teachers’ practices.

A course dealing with problem solving

In French-speaking Switzerland, the shared curriculum for compulsory education insists on the importance of problem solving in mathematics education in order to make students familiar with inquiry based mathematics education (IBME). The aim is to promote students’ scientific processes of thought. But as Dorier and Maass say “inquiry based mathematics education remains quite marginal in day-to-day mathematics teaching” (2014, p. 303). That is why in Geneva canton, a special course called mathematics development has been created to focus on and develop students’ problem solving competencies. Students aged 13-14 years old (grade 8) with a scientific profile are involved. Within one 45-minute period per week, teachers have to improve the students’ problem solving competencies and at the same time, assess them frequently.

This course is subject to many constraints and raises two fundamental questions in mathematics education: how to foster and how to assess students’ problem solving competencies? Thus it is necessary to identify what problem-solving competencies are and consequently what students are expected to learn and to know.

IBME and problem-solving competencies

In the French mathematics teaching tradition, problem solving has been seen for many years as a means to develop specific mathematical content and knowledge (Brousseau, 1998). For the past couple of years, however, many countries, and especially European countries, have been emphasizing problem solving in mathematics and inquiry-based mathematics and science education (IBMSE) as a learning goal for its sake. The European Rocard’s report (Rocard et al., 2007) promotes a wider implementation of IBMSE in classrooms as a tool to make sciences and mathematics more attractive to students. Nevertheless, this increasing interest in IBMSE has not been followed by a concise and commonly shared definition (Dorier & Garcia, 2013). If we are to summarize, it
refers to a student-centered paradigm of teaching mathematics and science, in which students are invited to work in ways similar to how mathematicians and scientists work. This means they have to observe phenomena, ask questions, look for mathematical and scientific ways of how to answer these questions (like carrying out experiments, systematically controlling variables, drawing diagrams, calculating, looking for patterns and relationships, making conjectures and generalizations), interpret and evaluate their solutions and communicate and discuss their solutions effectively. (Dorier & Maass, 2014, p. 300)

**Intended learning outcomes of IBME**

The goal of IBME is to make students work in a way similar to the one of mathematicians and to make students familiar with a scientific approach to solve problems. For Hersant (2012), a scientific approach cannot be considered as a relevant learning goal, especially because it is unclear, non-unique and too ambitious. Thus the intended learning outcomes of IBME are not so easy to interpret and implementing IBME in classrooms remains a crucial issue. If we look at institutional instructions of the *mathematics development* class, teachers are invited to propose *open-ended problems* (Arsac, Germain, & Mante, 1991) to students, which is, in France and in French speaking Switzerland, a traditional way of introducing students to IBME. An *open-ended problem* is a problem which has a short text, has no obvious solution and method, deals with students’ familiar conceptual domain and enables students to make the problem their own. Facing such a problem, students should learn different strategies. It aims more generally at both establishing scientific debate rules and developing a scientific approach following the pattern of *try - conjecture - test and prove*. But according to Hersant (2010), what gives this approach a scientific dimension is not only the existence of trials, conjecture and proof but the articulation among these. She also emphasizes that there is no unique scientific approach. The first goal is not so clear, neither is the second. Debate rules can indeed refer to logical rules (several examples don’t prove a proposition, a counter example is sufficient to disprove a conjecture, etc.) or to social rules (listen to the others, etc.). Consequently, curriculum and instructions about *open-ended problems* do not seem to be sufficient to help teachers to define what is institutionally expected about students’ problem solving competencies.

Identifying what we want students to learn and to know about problem solving is still a problematic issue. The identification of the intended learning outcomes from IBME is by no means obvious even for teachers, and the danger is that students might not be aware of what they are supposed to learn and to know. That is why IBME learning goals should be at the midst of specific discussions with students in class. Even though such discussions should also be encouraged when acquiring a more classical mathematical knowledge, it is all the more important in the case of IBME.

**Problem solving narration activity**

To assess students’ problem solving competencies, teachers have to be able to access what students did in order to solve the problem and especially what solving strategies they used. That is why the *problem solving narration activity* (Bonafé et al., 2002) has been institutionally chosen as a means to assess students. It can be defined as a new contract between students and teachers in which students have to explain the best they can, how they solved, or tried to solve, the problem (including mistakes, wrong ways, dead-ends, help they received…) and teachers have to assess students on these and only these points and especially not take into account the fact whether students found the right answer or
not. With this activity, the fact that students have to explain all the strategies they tried and all the ideas they had to someone else, presupposes that they are capable to do so firstly to themselves. They have to reconstruct their reflection and make a synthesis of which strategies were effective, which one were wrong ways or led to dead-ends, etc. In that sense, it can emphasize students’ reflection about what solving problems in mathematics means, about their own problem solving competencies and it can encourage the development of para and proto-mathematical knowledge. Problem solving narration activity as a scheme used principally for summative assessment can also foster students’ problem solving competencies and assume a formative function. This last observation leads us to consider the assessment of problem solving competencies, not only with summative purpose, but also with a formative purpose.

**Assessing students’ problem-solving competencies**

According to Allal (2008) assessment is summative as soon as a synthesis of the competencies and knowledge learnt by the student at the end of his curriculum is established. Thanks to the distinction made by Scriven (1967) and then by Bloom (1968) between summative and formative assessment, Black and Wiliam give the following definition:

Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited (Black & Wiliam, 2009, p. 9).

The notion of feedback is a key component of formative assessment. Formative assessment contains “all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities” (Black & William, 1998, pp. 7-8). Another key component of formative assessment is that students understand the target of their work and that they grasp what is expected (Harlen, 2013). But it means that “students need to have some understanding of the criteria to apply in assessing their work” (Harlen, 2013, p. 17). Once again, the necessity of specific discussions with students about assessment criteria and about what they are expected to learn is emphasized.

To classify classroom formative assessment, Shavelson et al. (2008) are using a continuum, that ranges from formal embedded assessment to informal, on the fly formative assessment. It means that formative assessment does not take a unique form but that it can be planned or not, it can refer to formal tools to collection of data or not, etc. Adopting this point of view, formative assessment can be considered as a practice integrated within the learning process (Lepareur, 2016). Referring to formative assessment about IBME is all the more relevant that the practice of formative assessment, through teachers and students collecting data about learning as it takes place and feeding back information to regulate the teaching and learning process, is clearly aligned with the goals and practice of inquiry-based learning. (Harlen, 2013, p. 20)

These definitions of summative and formative assessment enhance that identifying assessment according to when it occurs (after a phase of teaching vs within a teaching activity for instance) or how it occurs (paper-pencil test vs worksheet for instance) seems less relevant than distinguishing assessment according to its function. But it does not mean that these two principal functions of assessment (summative and formative) cannot coexist. Thus some researchers (Allal, 2011; Harlen,
2012; Shavelson et al., 2008) argue that they can coexist in what Earl (2003) calls *assessment for learning*. The same assessment activity can serve to summative and formative purpose. It means that data collected by the teacher can be used to give students a mark but also to improve learning and teaching. On the other hand, for Shavelson et al. “formative assessment could serve summative needs” (2008, p. 298). In our research, we deal with teachers’ practices in the *mathematics development* class. Our objective is to find out if and how using an assessment tool as a grid of criteria, firstly with summative purpose, can also foster formative assessment processes. In this paper, we focus only on teacher’s formative assessment practices. For that, we study the practices of a teacher giving this IBME-centered course.

**Teachers’ formative assessment practices**

**Context of the research**

The teacher whose practice we are going to analyze, was a member of a one year commission, created in September 2015, and gathering another teacher and ourselves. The purpose of this commission was to give teachers of *mathematics development* classes a common tool to assess students’ problem solving competencies with both summative and formative purpose, and consequently to ensure common expectations about IBME (from teachers, and more globally from schools). To do so, we have been working for one year to elaborate a grid of criteria aiming to assess students’ *problem solving narration activity*. This development of the tool was mainly based on teachers’ expertise. Indeed, teachers have implemented the grid in their class, and according to their experiences, we adjusted, removed and added some criteria. Nevertheless, we dealt with an existing tool elaborated by the Geneva team in the wake of the PRIMAS project and were careful to take into account some research results (as those of Hersant (2010)). The grid in its final version summarizes criteria related to five dimensions of such an activity: presentation, narration, research, technique and modelling. These dimensions induce expected qualities. For instance, the modelling dimension is characterized by two criteria: “Appropriation of the problem: rephrase the problem in French and/or express it with drawings, diagrams, tables” and “Use of pertinent mathematical tools and theories, strategies”.

So, this teacher whose practice we are going to analyze has been reflecting on the intended learning outcomes of this IBME-centered course and on the summative assessment of problem solving competencies, for one year, thanks to the meetings with the other members of the commission. She used the grid elaborated by the commission, in her class, principally with a summative purpose. However, thanks to our hypothesis that summative and formative assessment can co-exist, we would like to see if she also referred to formative assessment, thanks to specific discussions with students about criteria, and feedback related to their production. That is why we analyzed her formative assessment practices.

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1 Available at [http://www.primas-project.eu/fr/index.do](http://www.primas-project.eu/fr/index.do)
Theoretical framework

To characterize teachers’ formative assessment practices, we referred to criteria elaborated by Lepareur (2016). She defined five strategies: eliciting goals and criteria (S1); managing discussions and activities which can produce some evidence of effective learning (S2); giving feedback to students which make them progress (S3); helping students to be responsible for their learning (S4); helping students to be a resource for their peers (S5). Even though her research dealt with science and mathematics teachers’ formative assessment practice, in our case, we only study mathematics teachers’ practices. In that sense, we made some adaptations about key words and sub-strategies she defined. The table 1 is the grid we used to characterize the mathematics teacher’s formative assessment practices. The T is used for the teacher, S for the students.

Methodology

We video recorded two consecutive periods of mathematics development given by this teacher, member of the commission, at the end of the school year. The nine students of the class were working in four groups (3 groups of 2 students, 1 group of 3). They were working on two problems related to the introduction of algebra. At the end of the second period, students had to give a narration about the problem they were working on to the teacher. Consequently half of the second period was devoted to the narration and students were invited to use office software to write their research down. To interpret data and make it relevant with our theoretical framework, we transcribed all interactions occurred in class for both lessons (about 67 minutes) and classified interactions according to strategies and sub-strategies defined in the table 1.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Key words</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Goals</td>
<td>S11</td>
<td>T explains the goals of the activity.</td>
</tr>
<tr>
<td></td>
<td>Criteria</td>
<td>S12</td>
<td>T explains the intended learning outcomes, what will be assessed.</td>
</tr>
<tr>
<td>S2</td>
<td>Progress in activity</td>
<td>S21</td>
<td>T collects information about students’ progress in the activity.</td>
</tr>
<tr>
<td></td>
<td>Strategies</td>
<td>S22</td>
<td>T collects information about strategies used by S.</td>
</tr>
<tr>
<td></td>
<td>Understanding</td>
<td>S23</td>
<td>T questionnes S about their understanding of the goals.</td>
</tr>
<tr>
<td></td>
<td>Knowledge</td>
<td>S24</td>
<td>T takes information about previous S’ knowledge.</td>
</tr>
<tr>
<td></td>
<td>Self assessment</td>
<td>S25</td>
<td>T helps S to situate themselves in relation to assessment and success criteria.</td>
</tr>
<tr>
<td>S3</td>
<td>Feedback (what students have to do)</td>
<td>S31</td>
<td>T gives an information to make explicit what S have to do left.</td>
</tr>
<tr>
<td></td>
<td>Feedback (how students can do it)</td>
<td>S32</td>
<td>T provides explicit information about how S have to do it, to move on.</td>
</tr>
<tr>
<td>S4</td>
<td>Responsabilisation</td>
<td>S4</td>
<td>T emphasizes S’ ideas, gives them independancy to access resources.</td>
</tr>
<tr>
<td>S5</td>
<td>Interactions (group)</td>
<td>S51</td>
<td>T encourages S to discuss with others members of their group. Peers are seen as a resource.</td>
</tr>
<tr>
<td></td>
<td>Interactions (class)</td>
<td>S52</td>
<td>T integrates S’ propositions and encourages others to react on.</td>
</tr>
</tbody>
</table>

2 Translated from Lepareur (2016).
Table 1: Grid of analysis of formative assessment practices, adapted from Lepareur (2016)

For instance, during the following interaction between the teacher and a student, we can see that the teacher tries to make the student explains his strategy.

Teacher: Yes but how did you find this?
Student: I made a lot of stuff.
Teacher: But try… what did you do? It’s interesting to know how you were thinking.
Student: I made all of this but like everything in reverse.
Teacher: Yes so the first step. What did you do at the first step?
Student: 24 minus 7.
Teacher: Yes, you went backwards in your calculations. Yes. It’s a good idea. Doing backward calculation is in fact a lead.

In that case, we identify a formative assessment practice, according to the strategy S2 “managing discussions and activity which can produce some evidence of effective learning“ and more specially the strategy S22 “collecting information about strategies used by students”.

Results and analysis

We found out 44 episodes when formative assessment strategies occurred thus we can say that this mathematics teacher refers frequently to formative assessment in her practice. We identified 4 times the strategy S1; 25 times strategy S2; 10 times strategy S3; 3 times strategy S4 and 2 times strategy S5. The figure 1 illustrates the percentage of apparition of each strategy. To summarize, we can notice that the teacher refers to every strategy (S1, S2, S3, S4 and S5).

On top of that, she uses principally the strategy S2: “managing discussions and activities which can produce some evidence of effective learning”. It represents more than half of the strategies of formative assessment used by this teacher. The strategy S3 which refers to “give feedback to students which makes them progress” is also used frequently, about one time out of four.

But if we look deeper, we can see that each sub-strategy is not used with the same frequency (figure 2). We can see that for the strategy S1 related to the goals and criteria, the teacher only explains the goals of the activity (S11) but not the criteria of assessment or the intended learning outcomes (S12). This lesson occurred at the end of the year so we can make the hypothesis that by then students knew well what they were expected to do.
The most represented sub-strategy related to “discussions and activities which can produce some evidence of effective learning which is used frequently” (S2) is “collecting information about strategies used by students” (S22). It appears 19 times. It is also the strategy that occurs the most, all categories taken into account. The only other significant strategy dealing with S2 used by the teacher is “taking information about students’ progress in the activity” (S21). So the teacher focuses on where students are in the activity and what they have done to get there.

Then, for strategy S3 about feedback, the two ways; “provides information to make it explicit what is left for the students to be done” (S31) or “how they have to move on” (S32) are represented, but the second one more than the first one. The idea is that this teacher helps students both knowing what they have to do but even more how they can continue. For the last strategy (S5) dealing with interactions, the teacher focuses on discussions within the groups. The absence of strategy S52 about “the integration of students” can easily be explained by the fact that during these two lessons, students only worked in group, without any collective classroom discussion.

Conclusion

We can say that this mathematics teacher refers frequently to formative assessment in her practices (44 times during a 67 minute-lesson). She uses a very large set of formative assessment tactics; eliciting goals and criteria; managing discussions and activities which can produce some evidence of effective learning; giving feedback to students which make them progressing; helping students to be responsible for their learning; helping students to be a resource for their peers. But she uses principally formative assessment to manage discussions and activities which can produce some evidence of effective learning, and especially, she collects information about strategies students use. The feedback she provided to students is mainly about how they can continue, how they can do what they have to do to solve the problem. The only strategy which does not appear is this related to explanation of criteria and expected learning outcomes. We can make the hypothesis that it has been at the core of a discussion in the first part of the schoolyear. In that sense, it should be interesting to focus on what happens at the beginning of the schoolyear and to study how teachers explain and negotiate the intended learning outcomes with students.

To conclude this paper, we can say that this exploratory study shows that formative assessment seems to be relevant for this teacher in order to foster her teaching practices in the case of an IBME-centered course. It is, nevertheless, necessary to enlarge the study, in order to compare and expend or not the results, and to have more information about how teachers refer to formative assessment. On top of that, we can imagine that working with teachers about these strategies could foster their formative assessment practices.
References


