Assessing IBME with Summative and Formative Purpose

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Abstract

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Reference


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ASSESSING IBME WITH SUMMATIVE AND FORMATIVE PURPOSE

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In Geneva canton (Switzerland) a course deals especially with inquiry based mathematics education. During 45 minutes a week, teachers have to foster students’ problem solving competencies. More exactly, the aim is to install scientific debate rules and to encourage students to use scientific processes of thinking such as the pattern of “try - conjecture - test and prove”. Meanwhile teachers have to assess students frequently. For that, the problem solving narration activity has been chosen as a means to assess students’ problem solving competencies. But assessing such productions remains problematic. So our main concern is about how assessment based on problem solving narration activity can strengthen students’ problem solving competencies. In that way, we are trying to know teachers’ practices about assessment in this particular context and are working with two of them to develop a tool for assessing students on their problem solving competencies for both summative and formative purpose.

A SPECIAL COURSE DEALING WITH IBME

In French-speaking Switzerland, the shared curriculum for compulsory education insists on the importance of problem solving in mathematics education and promotes inquiry based education (IBE). Moreover, in order to stress the strong link between mathematics and life sciences, these subjects are included in the same field and have general instructions in common. The shared goal is to promote students’ scientific processes of thinking. However, a distinction is made between mathematics and life sciences especially about the role of modelling. Mathematics’ teachers are encouraged to focus on problem solving to make students familiar with inquiry based mathematics education (IBME). 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 support the integration of IBME in class. Students aged 13-14 years old with a science profile are involved. During these 45 minutes per week,
teachers have to improve the students’ problem solving competencies and at the same time, assess them very frequently (about one time every four lessons).

This course, subject to many constraints, raises a crucial question that is at the core of our research: how to assess students’ problem solving competencies? The strong link between assessment of students’ learning and what is taught and how it is taught leads us to look deeper into the nature of problem solving. Thus we can wonder what the intended learning outcomes of IBME are.

**PROBLEM SOLVING COMPETENCIES**

The increasing interest in inquiry based science education (IBSE) introduces manifold definitions. If we are to summarize,

IBSE means students progressively developing key scientific ideas through learning how to investigate and build their knowledge and understanding of the world around. They use skills employed by scientists such as raising questions, collecting data, reasoning and reviewing evidence in the light of what is already known, drawing conclusions and discussing results” (IAP, 2012, p.19).

Most definitions of IBSE are not so practical, that is why choosing problems students will tackle is still a main matter of concern for teachers. Institutional instructions of mathematics development invite teachers to propose open-ended problems (Arsac, Germain and Mante, 1984) to students, which is, in France or 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 enables students to find an easy but not sufficient method. Facing such a problem, students should learn different strategies. It aims more generally at both installing scientific debate rules and developing a scientific approach such as the pattern of *try - conjecture - test and prove*. According to Hersant (2010), what gives this approach a scientific dimension is not only the existence of trials, conjecture and proof but their articulation. She also emphasizes that there is no unique scientific approach. The first goal is not so clear, nor the second. Indeed debate rules can refer to logical rules (several examples don’t prove a proposition ...) or to social rules (listen to the others …). Consequently, identification and explanation of the intended learning outcomes from IBME, by no means obvious even for teachers, should be at the midst of discussion with students in class.

**IBME ASSESSMENT**

**Problem solving narration activity**

Striving to identify what students have to learn about IBME is all the more crucial that teachers have to assess not their mathematical knowledge but their problem solving competencies. In order to give teachers an access to students’ research, *problem solving narration activity* (Bonafe and al., 2002) has been institutionally chosen as a means to assess students. *Problem solving narration activity* 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 that students found the right answer or not. Students have to explain all the strategies they tried, all the ideas they had, and in that sense it can emphasize their reflection and encourage development of para-mathematics knowledge. In that way, *problem solving narration activity* as a scheme used principally for summative assessment can also foster students’ competencies and assume a formative function.


**Coexistence of summative and formative assessment**

According to Allal (2008a) 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 function of assessment, Black and Wiliam (1998) talk about formative assessment as soon as it is possible to get information, feedback, about the gap between students’ real level and the one they have to achieve. 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, p.7-8).

The French community, considering formative assessment in an expanded way, deals instead with the notion of regulation (Mottier Lopez, 2012) that takes into account feedback, but also adaptation that can be provided to teaching and learning. Even if these two principal functions of assessment seem clearly distinct, some researchers (Harlen, 2012; Allal, 2011) argue summative and formative assessment can coexist in what Earl (2003) calls **assessment for learning**. Teacher can use feedback from formative assessment to acknowledge students’ competencies and reciprocally, information from summative assessment can be raised to support learning and teaching regulation.

**Resorting to a tool to assess students for summative and formative purpose**

But whatever its function, assessment activity implies “the generation, interpretation, communication and use of data” (Harlen, 2013, p. 7). Data used by teachers to assess students about IBME are mostly judged “in relation to criteria, in which the standard of comparison is a description of aspects of performance” (Ibid., p.7). Criteria are considered as ways to look at the students’ production according to expected qualities (Gerard, 2010). Perhaps even more than for other mathematics’ topics, defining criteria to assess students’ problem solving narration activity is difficult and deserves particular attention. It must refer to problem solving competencies but also to communication skills. If criteria remain at general level, teachers also need to define indicators related to each criterion. Indicators, more specific than criteria, make the evaluator aware of what he has to look for in the students’ narration.

According to Allal (2008b), using an assessment tool as a grid of criteria may help both controlling the action of the evaluator and amplifying his judgment skill. Teachers can use a tool to assess students about their problem solving narration activity, which can be a grid of criteria and indicators. Referring to this tool, teachers can assess students in a summative purpose more efficiently. Moreover, teachers can get some feedback from students and then adjust teaching in order to improve learning.

**Student responsibility about assessment**

Many researches demonstrate that the more students are involved in their assessment, the more competent they are. In that way, they can assess themselves (self-assessment), assess a peer and compare each other (peer-assessment), assess themselves and compare it with teachers’ assessment (co-assessment). One key component of formative assessment is that students understand the target of their work and that they grasp what is expected (Harlen, 2013). Using a grid of criteria can let students become more responsible about their assessment since they can compare their production to
expected qualities of narration, and get feedback about what they do and what teachers expect them to do. It will help them to play an active role in assessment and to regulate their learning.

STATE OF TEACHERS’ PRACTICES ABOUT ASSESSMENT OF IBME

To better understand teachers’ practices about assessment in the particular context of the course on mathematics development, we submitted an online questionnaire to teachers currently giving or having given this course in the past few years. It deals with three main subjects: problems they give to students, assessment of problem solving competencies and problem solving narration activity. We received and analyzed 61 complete answers (over 100 expected).

A first interesting point is that teachers do not know their colleagues’ practices. It is all the more surprising that the course of mathematics development involves only about 700 students and 50 teachers a year. The small population involved and the specificity of this new subject of teaching might lead us to believe that teachers work in a collaborative fashion, especially when they work in the same school, and that they know their colleagues’ practices well. According to the results, it is far from being the case. However it is problematic, for example when a student is moving in and out of schools during the school year, because what is expected from him in the course in his new school is not necessarily the same as in his previous school. On top of that, teachers say that assessing such open-ended activities is more complicated than assessing usual students’ mathematical work and that they suffer from a lack of assessment tools.

To tackle those issues, a commission gathering two teachers of mathematics development and ourselves was created in September 2015. The purpose of this commission is to give teachers of mathematics development a common tool to assess students about their problem solving competencies with both summative and formative purpose and consequently to ensure common expectations about IBME (from teachers, and more globally from schools).

DEVELOPING A TOOL FOR ASSESSING PROBLEM SOLVING COMPETENCIES FOR SUMMATIVE AND FORMATIVE PURPOSES

Previous work about the assessment of IBME

To develop this project, we dealt with an existing tool elaborated by the Geneva team in the wake of the PRIMAS1 project. Their collaborative work led to a grid of criteria aiming at assessing problem solving narration activity in the context of the course of mathematics development. For that purpose, the team studied grids of criteria teachers use in their classes and used them to evaluate numerous students’ narrations in order to highlight the major criteria and the ones that lacked.

Thus, they noticed that criteria linked to narration competencies were as numerous as those linked to problem solving competencies. Nevertheless we know that such an activity can easily be turned away from its original purpose. Indeed, even if communication skills are important to develop, we have to be careful that students do not only focus their attention on their narration, but also on the problem they have to solve. Asking students to write out a narration describing their research has to stay a means to access and develop students’ problem solving competencies and cannot become a goal in itself. But we know that many students (especially the first times they are confronted with problem

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1Promoting Inquiry in Mathematics And Science Education Across Europe. Available at http://www.primas-project.eu/en/index.do
solving narration activity) only focus on describing everything they do without dealing with relevant mathematics content. To prevent that risk, the group emphasized criteria related to problem solving competencies more than those related to narration or presentation.

They also defined five dimensions (presentation, narration, research, technic and appropriation), which induce ways to look at students’ production, and criteria related to each dimension, which describe expected qualities of the production. Keeping in mind that the grid has to be an efficient tool to assess a large set of problems, they defined criteria at a general level. Then, teachers individually have to adapt the grid to the problem students are working on, to remove some criteria and to specify indicators related to criteria.

**Adaptation of the existing tool**

In order to ensure that dimensions are relevant and that criteria are efficient, exhaustive and well worded to assess students on their problem solving competencies, teachers of the commission have used the grid during one year in their class.

In order to do that, teachers have assessed each students’ *problem solving narration activity* relatively to the grid. Then depending on their experience we adjusted the grid, clarified terms, added and removed criteria. The cycle occurred several times until we fixed the tool. To summarize, we simplified the description of some criteria to make it easier to understand for students, we took out some criteria which seem to be too particular to apply to most of problems and we added criteria which were lacking. The next step was to get some teachers who were not involved in the commission to use the grid in their class, in order to ensure the tool is also efficient in another school, with another teacher. The grid we are using at the moment is the following one.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation</td>
<td>Care</td>
</tr>
<tr>
<td>Narration</td>
<td>Clarity (text is easy to read and consistent)</td>
</tr>
<tr>
<td></td>
<td>Consistency of narration: each step has a beginning, a development and a conclusion (why do I do this, how do I do it and what is the conclusion?)</td>
</tr>
<tr>
<td></td>
<td>Comprehensiveness and links between steps (all steps are described, and in the right order)</td>
</tr>
<tr>
<td>Appropriation</td>
<td>Rephrase the problem in French and/or express it with drawings, diagrams, tables</td>
</tr>
<tr>
<td></td>
<td>Clearly explain the goal (and keep it in mind all over the research)</td>
</tr>
<tr>
<td>Research</td>
<td>Translate the problem with mathematics terms, express the problem in a mathematical way</td>
</tr>
<tr>
<td></td>
<td>Follow a lead, have a strategy</td>
</tr>
<tr>
<td></td>
<td>Make relevant trials, and try to eliminate randomness</td>
</tr>
<tr>
<td></td>
<td>Articulate trials, conjecture and proof</td>
</tr>
</tbody>
</table>
Take into account consequences of a step before moving on to a new one or concluding

Use relevant mathematical tools and theories

Question the mathematical solution relative to the context of the problem (is the mathematical solution valid in this context?)

Table 1: Grid established by the commission

On top of that, at the beginning of the school year, teachers of the commission distributed the grid to students who were allowed to use it to compare their work with the expected performance during regular work but also during tests.

Teachers base their feedback about students’ production on the grid. Thus, both students and teachers, refer to the same tool to discuss expectations about problem solving competencies. It is all the more interesting that according to the results of the questionnaire, most teachers of mathematics development assess their students thanks to explicit criteria but only a small number are having specific discussions with students about these expected performances. Giving teachers and students a common tool to assess and compare production to expected qualities should help to encourage such discussions.

First conclusions

At the moment, we have only analyzed discussions between teachers during the commission’s work sessions. The first conclusions are that referring such an assessment tool supports negotiations between teacher and students about purposes of IBME. It helps teachers to better understand what they want students to do and to learn. It is not obvious for students to understand how teachers take into account criteria and dimensions to assess their narration. Some students think that each criterion has to appear in their production and in the same order than in the grid. Moreover to emphasize problem-solving competencies, teachers have chosen to adapt the notes scale during the year. They lend more and more weight to research and technic instead of narration.

We will soon receive and analyze all the productions of some students assessed by teachers relative to the grid since the beginning of the school year. On top of that, during our presentation, we will analyze in depth teachers’ practices about assessment of problem solving competencies, thanks to data collected through the video recording of three lessons of mathematics development.

Continuation of the project

In a second phase, we would like students to assess themselves or peers in relation to these criteria. Indeed, the results of the questionnaire tell us that teachers of mathematics development would like to involve students in their assessment but they don’t know how to go about it. We think that referring to the grid could help them to play a more active role in their assessment and help them to regulate their learning. It could encourage students to take the criteria as their own and to understand more deeply what is expected from them. Finally, referring to the same grid during the entire year can make them aware that they are becoming more and more competent.
References


