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Affordances and Challenges of Written Feedback as Formative Assessment in Inquiry-Based STEM Education

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Affordances and challenges of written feedback as formative assessment in inquiry-based STEM education

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Subject/Problem: Several meta-analyses have shown that formative assessment can positively influence student achievement (see Paper 3 above). One critically important parameter associated with this is the timely provision of useful feedback (e.g. Hattie, 2009). Effective feedback should address three major questions: "what are the learning goals?", "what progress is being made toward the goals?", and "what activities need to be undertaken to make further progress?" (Hattie & Timperley, 2007, p. 86). Only few empirical studies have investigated feedback in relation to formative assessment in inquiry-based STEM education. This is especially true for written feedback. One main finding is that teachers often do not actually tap into the power of feedback– due to a lack of time – and tend to restrict themselves to merely offering marks (White and Frederiksen, 1998) or not providing feedback at all (Ruiz-Primo, Li, Ayala, & Shavelson, 2004). We sought to contribute towards the enhancement of the available research-based knowledge background in this area through exploring the following research questions:

1. To what extent can a specific assessment tool for written feedback guide teachers to diagnose students' needs and level of attainment of a selected competence and provide feedback to the students on that basis?
2. What are the various ways in which students respond to the feedback they receive?

Design or Procedure: We conducted parallel classroom-based research in three different countries (Cyprus, Germany and Denmark). For this, we established working groups in each country, consisting of five to six experienced science teachers and one or two researchers. Each working group undertook to develop an inquiry-based unit that incorporated written feedback as the assessment method in a specific manner. Specifically, the students had to produce a sequence of at least two artefacts, associated with a specific inquiry-related competence. The teacher gave written feedback to the first of these artefacts based on a specially designed assessment tool, related to the competence of interest. Then the students responded by handing in a second (related or similar) artefact. In this study we report on the enactment of the teaching units by 12 different teachers.

The primary source of data consisted of students' artefacts and the corresponding teachers' written feedback. In addition, in most cases students were asked to use, and in some cases reflect on the feedback when working with the next assignment(s). Finally, we conducted post-implementation interviews with the teachers (semi-structured) regarding the viability of and challenges for using written feedback as a formative assessment strategy when teaching inquir. The full feedback data is being analysed using a coding tool that focuses on the degree to which the feedback fully represents (both positively and negatively) the competence in question; the nature of the suggestions for improvement in the teachers' feedback, and the coders' assessment of whether the feedback was consistent with the individual student or student's group's work. In addition, second student artefacts and their reflections are being analysed in terms of the degree to which they used the feedback and the degree to which their second artefact indicates that they have increased their level of attainment vis-á-vis the competence in question.

Analyses and Findings: The 12 teachers gave a total of 207 written feedback comments. The preliminary analysis of 15 instances of feedback from Cyprus (one teacher, one class in the Design & Technology competence) is represented in Table 1.

Table 1: Excerpt of the results from coding one teachers' feedback (15 feedbacks in total) in the subject Design and Technology.

	Examples of codes	**N**	**%**	**Example**
Affective	Non-explicit acknowledgment of what the student has achieved	4	27%	"Very good work, well done".
	Explicit, but partial, acknowledgement of what was achieved by the students	11	73%	"Well done S5, very good work. You have investigated and found important elements of the product!"
Diagnosis	The feedback represents a partially valid diagnosis of students' level	6	40%	
	The feedback represents a valid diagnosis of students' level	9	60%	
Suggestions	Vague suggestions for improvements	7	47%	"Revisit the specification points mentioned in the textbook and make additions, corrections on your task".
	Detailed/specific suggestions for improvements	8	53%	"You can also find and add more (specifications), taking into consideration the following: In the research: • Search in your book and study again the plastic materials. […] • What do you do just before you buy the shoes you like? Do the same with the mobile phone stand and write down your observations. • What do you like in the decoration/aesthetics of the product?"

In 40% of the cases, the teacher's feedback did not cover all aspects of the competence as defined in the assessment tool. In other words, there were cases in which a student evidently did not exhibit the defined traits of the competence in question, but the teacher did not mention this. In 53% of the cases, the teacher provided specific suggestions for improvement, whereas the suggestions for improvements in the remaining 47% were rather vague. The preliminary analyses of the post-implementation interviews suggest the following overarching themes:

- Some teachers found it useful to structure their written feedback using a specifically designed assessment tool that includes a reference to a learning progression. According to one teacher, the tool "really gave more focus to my comments [than usual]" (Danish teacher, upper secondary school).

- Teachers in lower secondary school at times felt that giving written feedback was artificial. Students, in particular in Denmark, at this level were not used to this kind of feedback.
- Giving high quality written feedback often takes a lot of time for the teacher. This can be a source of pressure, since the feedback at times needs to be given between one lesson to the next.
- Some teachers emphasised that students cannot navigate the feedback if it is overly extensive and detailed. Thus both content and form of the feedback are essential aspects for teacher cognisance.

Contribution: As suggested by the preliminary data, teachers may find it useful to structure their written feedback in inquiry-based STEM education using assessment tools that outline the key components of the competence targeted by the instruction. However, they also suggest that for some reason some of the salient aspects of a taught competency are omitted in the feedback. Further, only in slightly more than half of the coded cases, the feedback gave specific suggestions for improvements. The post-implementation interviews with the teachers are being used to shed more light on these findings. In the presentation we will present the full data analysis of teacher feedback, student reflections, and teachers reflections about using written feedback as a formative assessment strategy for teaching inquiry in STEM.

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