Role of technology in promoting formative assessment practices in science classes

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Abstract

This paper reports on two case studies, one in France and one in Ireland carried out as part of FaSMEd, an EU project funded under the FP7 scheme, on the use of technology in formative assessment (FA) classroom practices in mathematics and science. The paper focuses on the role and impact of technology in supporting FA practices in science teaching and learning. The process in this research consisted of a cycle of design, implementation and analysis with teachers, where activities were planned in professional development sessions, carried out by teachers in classrooms and reviewed in meetings both with other teachers and individually. Work with teachers and students centred on exploring and modifying FA practices. Data for the research were collected using the following methods: semi-structured interviews with all teachers (before and after the implementation of a lesson); semi-structured interviews with students with an emphasis on a Q-Sort activity; analysis of video data and field notes from classroom observations; and questionnaires distributed to all students participating in the study regarding their views of science teaching, learning and assessment. The research work within the project leads to the elaboration of a three-dimensional model taking into account the FA strategies, the properties of technologies and the role of actors. This model has been used for lesson analysis and completes the variety of viewpoints coming from qualitative interviews analysed using MAXQDA software. Q-Sort data analysed using PQMethod software, video data using a whole-to-part inductive approach and the questionnaire data analysed using SPSS. Technology helped teachers to enrol in a complete FA process instead of considering some moments, enhancing their understanding of the process. The model used in this research highlights not only the role of the teacher in FA but also the role of peers and the students. Several of the class activities resulted in shifting ownership and agency towards students thereby activating them as the owners of their own learning.

1. Introduction

Black and William [1] define formative assessment (FA) practice in a classroom as “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”. Enabling teachers to build on learners’ prior knowledge and match their teaching to the needs of each learner, represents a powerful means for meeting goals for high-performance, high-equity of student outcomes, and for providing students with knowledge and skills for lifelong learning [2]. Different research studies have highlighted fundamental strategies of effective FA practices:

- S1. Learning intentions and criteria for success should be clarified and shared with students and be focused on students’ process of learning and progress toward goals [3];
- S2. Use a range of divergent assessment techniques, together with realistic, challenging problems and tasks that elicit evidence of student learning and understanding [4];
- S3. Timely feedback, focused on the task at hand instead of marks, should be provided in order to monitor learners’ progressive development, helping them become more aware of where they are going, where their learning currently is and what they can do to move forward [5];
- S4. Teachers should engineer effective classroom discussions, fostering a classroom culture that encourages active involvement of students in the learning process [5];
- S5. Self-assessment and peer-assessment should be encouraged to activate students as both instructional resources for one another and owners of their own learning [4].

Technology has potential to support FA as it can make available to teachers pools of assessment tasks and items that they can embed within lessons and units. It can enable the assessment of those aspects of cognition and performance that are complex and dynamic [6]. The potential for learning in science is sometimes underestimated in activities that are often not problematised (or artificially problematised). Students are often relegated to the position of solving routine tasks and deprived of significant interaction with information and time for discussion and cognitive conflict. A significant part of scientific literacy requires an understanding of evidence and its underlying ideas [7]. Technology can offer opportunities for creating communal knowledge. Technology can enable sending and sharing of information, processing and analysis of information and an interactive environment for learning. These three aspects of the functionality of technology were explored in this research in connection with FA strategies.

2. Research questions

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

3. Methodology

Formative assessment is a complex concept to examine. To facilitate a true explication of the process including the role of the assessor and the functionality of the technology with the five FA strategies, this research used observations, interviews, field notes, questionnaires and video to gather data for analysis. A toolkit of lessons was developed which was implemented with teachers, see http://research.ncl.ac.uk/fasmed/ for details of the lessons and professional development activities. The research work within the project leads to the elaboration of a three-dimensional model taking into account the FA strategies, the properties of technologies and the role of actors (See Figure 1). This model has been used for lesson analysis and particularly to analyse the dynamics of FA within a lesson or in a sequence of lessons. It completes the variety of viewpoints coming from qualitative interviews analysed using MAXQDA software. Q-Sort data analysed using PQMethod software, video data using a whole-to-part inductive approach and the questionnaire data analysed using SPSS.

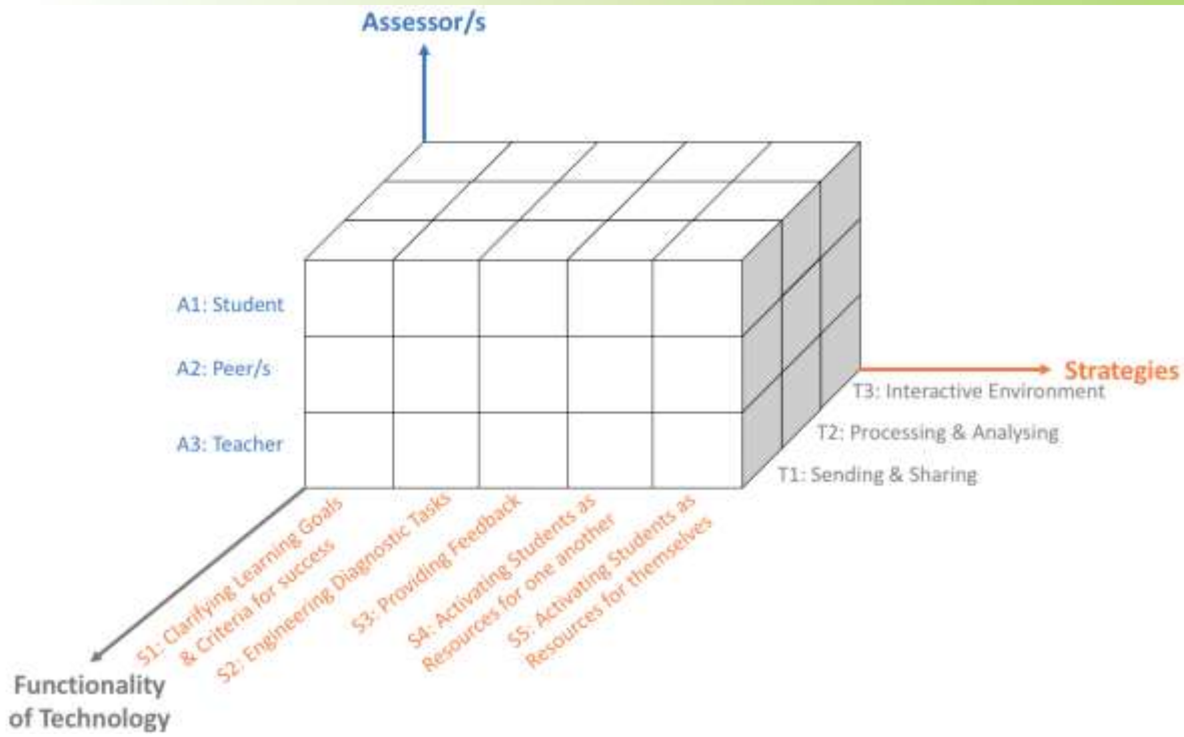

Fig. 1. Theoretical Framework of the FaSMEd project

4. Data

4.1 Case study Ireland

This case is with a teacher of general science, physics, mathematics and applied mathematics. She has been teaching for six years. She is in the 21-30-age bracket and has been working in her current school for three years. The students are a first year lower secondary education mixed ability general science class and range in age from 12-13. There are 11 male and nine female students in the class. Two activities were analysed for this paper, the first was based around increasing student collaboration so as to activate them as resources for one another, and, the second involved promoting students as assessors. The technology employed was iPad applications *Educreations* and *Popplet* and a shared learning space *Schoology.* These were used in a series of lessons. *Educreations* allowed for students to be audio recorded as they shared ideas and screencast their work for the teacher to review after the lesson. The functionality of technology within this application was to process and analyse student thinking. *Popplet* was used to create graphic organisers (or mind maps) on their iPads. The *popplets* created by the students were uploaded to the class shared space. Here they were teacher and peer assessed, activating students as resources for one another. The sending and sharing and displaying and analysing functionality of the technology was evident in all lessons.

The teacher commented on how the technology facilitated discussion and provided a space for feedback from both her and peers during the learning process and after it. She talked about *being able to track their train of thought and help them to move forward with their learning through structured feedback* (Interview, T2). Technology facilitated students to display their work and to analyse it during the learning process and after it. This cohort of students also perceived how the technology by recording their answers and sharing them globally was helping their teacher to provide them with effective feedback and allowing them a safe space to ask questions; the teacher *will be able to know what we don't really know and more people can ask a questions rather than just keeping it to themselves and being scared to talk* (S20).

4.2 Case study France

The originality of this case study comes from the common work done by a science teacher and a mathematics teacher. Both teachers are involved in teacher training and have worked for four years with researchers in different research projects mainly dedicated to interdisciplinary work. They chose to work together in order to help their students to make the link between the mathematics and the physics learning .There are 25 students in this class, 14 female and 11 male, the students range in age 11-12. The core of the activities of this case study is the notion of graph which has been considered by teachers as a boundary object between mathematics and physics: it is a learning object in mathematics and a tool in physics. The classrooms are equipped with Interactive White Boards (IWB) and, teachers used a students response system (SRS) to collect data regarding the students degree of understanding. It allows for quick feedback to the class about the set of answers or to each student about his/her own results. In that sense the couple IWB, SRS supports the implementation of FA strategies in the classrooms: using the “sending and sharing” property of technology, teachers engineered effective discussions within the class, and allowing students to activate themselves as owners of their learning. After having analysed data, teachers encouraged students to become resources for one another by organising a debate about the key notion coming from the analysis of the difficulties.

When interviewed teachers both commented on the role of technology in the implementation of FA strategies even if getting familiar with a new technology is time-consuming: *All this information allows to validate, or not the teacher’s feeling regarding students understanding. It also gives an opportunity for students to situate themselves. It allows also to analyse results on the spot and to take into account students’ difficulties immediately. But also first trials with technology are often at risk and it is necessary to be able to take that upon yourself in front of a class*.For their part, students globally agreed about the interest of technology in their mathematics and science lessons. Teachers also contend that the cooperative learning skills used through the process may enhance understanding in both mathematics and physics.

4.3 Findings

Interviews with the case study teachers and others in both countries indicate that engagement with the project and carrying out activities did have an impact on the development of teacher professional competences. For example, the use of pre-assessment tasks to plan activities and interventions was evident in many classes. There was convincing evidence in relation to the use of technology to generate discussion and to provide focused feedback to students. There was also evidence that the students became much better at: independent working, cooperative learning and also finding different ways to get help rather than just asking the teacher. The sending and sharing functionality of technology cannot be underestimated in how it facilitates the making public (to the class and teacher) and semi public (within the learning group) the private processes of learning, opening up opportunities for processing and analysing knowledge. Students valued this visibility and transparency, suggesting that this helped them learn from each other in a more collaborative and open learning environment. In doing so they developed their self-assessment and peer-assessment skills.

5. Conclusion

Both case studies highlighted that technology isn't a necessary condition for implementing FA strategies, but an astounding accelerator or amplifier of FA strategies. Students had a very positive attitude to using technology. What is possible to implement without technology becomes spontaneous with it. The second interesting finding can be deduced from the dynamics within the three dimensional model: The technological property of “sending and sharing” can be observed in four different FA strategies. At the same time, “processing and analysing” data leads teachers to clarify and share their teaching intentions and the criteria for success as well as to activate students as instructional resources for one other. Finally technology helped teachers to enrol in a complete FA process instead of considering some moments, enhancing their understanding of the process. The model used in this research highlights not only the role of the teacher in FA but also the role of peers and the learner. Several of the class activities resulted in shifting ownership and agency towards students thereby activating them as the owners of their own learning. This change in culture of learning merits further investigation. It must be noted that while the technology provided useful data and an efficient means of communication, the success of the FA strategies was largely dependent on the skills of the teacher in anticipating misconceptions, selecting appropriate topics for discussion and generating purposeful discussion through effective questioning.

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