Role of technology in promoting formative assessment practices in science and mathematics classes

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This paper will report on a professional development (PD) course designed and implemented by researchers in Maynooth University Ireland as part of the FaSMEd project (Formative assessment in Science and Mathematics Education[1]). This project researched the use of technology in formative assessment (FA) classroom practices. In this paper, we describe the design of the professional development process, present the research methods and results, and in discussing the results, pose a hypothesis connecting changes in teachers' knowledge to the changes in their FA practices. We conclude the paper by situating the importance of this work more broadly.

INTRODUCTION

Formative assessment (FA) has gained prominence throughout education policy and practice internationally as a method of gauging and improving student learning (Black & Harrison, 2004; Leahy, Lyon, Thompson, & Wiliam, 2005; Wiliam, 2013). FA refers to the process used by teachers and students to recognise and respond to student learning *in order to enhance that learning, during the learning* (Cowie & Bell, 1999, p. 32). It requires teachers to process information gathered from students in real time, adjust teaching accordingly, and provide effective feedback for pupils to move forward in their learning. Recent changes to lower secondary education in Ireland have highlighted the central role of FA and technology in developing students' skills and capacity for lifelong learning. Mathematics education in Ireland has undergone major change since the introduction of a new mathematics syllabus in 2008. The main aim of these changes has been to focus on student sense making, problem solving and conceptual understanding, in tandem with a call for more real world applications and the use of technology (Jeffes, Jones, Wilson, Lamont, Straw, Wheater, and Dawson, 2013). Science education is now undergoing similar change as part of the development of the Junior Cycle initiative in lower secondary education in Ireland with emphasis being placed on FA (Department of Education and Skills, 2015). One of the aims of the new science curriculum is to focus on the quality of the learning taking place using a collaborative approach to increase students' motivation and to develop their key skills. This research project set out to provide conditions for teachers to develop as a professional learning community. Developing a learning community is not easy and each is unique and formed in different ways to varying degrees of success.

LITERATURE REVIEW

Formative Assessment and the role of technology

Black and William define formative assessment (FA) practice 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

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taken in the absence of the evidence that was elicited (2009, p.9)

Different research studies have highlighted the fundamental strategies of effective FA practices such as:

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;
S2. Use a range of divergent assessment techniques, together with realistic, challenging problems and tasks that elicit evidence of student learning and understanding (Swan, 2005);
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 (Looney, 2010);
S4. Teachers should engineer effective classroom discussions, fostering a classroom culture that encourages active involvement of students in the learning process (Looney, 2010);
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 (Swan, 2005).

Technology can enable sending and displaying of information, processing and analysing of information and act as an interactive environment for learning. These three aspects of the functionality of technology were explored in this research in connection with FA strategies outlined above.

Teacher professional development

There is a considerable amount of literature on professional development, teacher learning and teacher change. Timperley and colleagues, highlight the importance of creating dissonance or cognitive conflict in teachers' thinking in order to bring about changes in their practice. They need to confront what they are doing at present and see better alternatives, rather than layering new thinking onto old practice (Timperley, Wilson, Barrar and Fung, 2007). This is especially important in the development of FA, as many pedagogical practices used may appear familiar to teachers. It is evident from the literature that changing practice is a very complex process, Day contends that professional development consists of *all natural learning experiences and those conscious and planned activities which are intended to be of direct or indirect benefit to the individual, group or school,* and which contribute to the quality of education in the classroom (1999, p.4). It is the process by which, teachers review, renew and extend their commitment as change agents to the moral purpose of teaching (Day and Gu, 2007). Day and Leitch (2001) advise that professional development must give a central role to the emotional dimension of teachers' selves, as teaching requires motivation, commitment and emotional attachment, and this *requires a deep knowledge of self as well as student* (p. 414). At the heart of all professional development endeavours with schools and teachers must be an enhanced experience for learners.

Building on what literature described as effective professional learning, work with teachers in this project had the following key characteristics:

- Workshops were interactive and activity-based, encouraging participants to develop their own thinking on FA to encourage individual and collective professional development of skills in real situations (Conneely, Girvan and Tangey, 2012).
- Workshops focused on pedagogical practices to enhance student learning.
- Key readings were provided for participants to engage with research underpinning

the pedagogical practices advocated in order to promote reflective professional enquiry.

- Participants were encouraged to share practice in both a formal and non-formal way during professional development events, to encourage collaboration focused on learning and teaching.
- Participants were encouraged to think and plan how they could develop formative assessment, to build on existing practices, and to explore new practices using a do, review and redo cycle, promoting reflective enquiry.
- Participants were encouraged to discuss FaSMEd classes with their students and to be explicit on FA skills they were developing so that students were focused on their own role in learning and in the research (Cochra-Smith, 2001).
- Participants were encouraged to view each other's practice and to give feedback so as to promote mutual respect, trust and support.

This paper will focus on how collaboration within a group of teachers can foster professional learning of the individual and how this impacted on their practice in teaching, learning and assessment. Wenger (1998) described a 'community of practice' as a group of people informally bound together by mutual engagement, shared experience and passion for a joint enterprise. The joint enterprise here was the implementation of FA practices and technology was one of the tools used to encourage collaboration and professional learning.

METHODOLOGY

Professional Development (PD)

Thirteen teachers from three schools participated in four PD sessions with the researchers throughout the 2014/2015 academic year. The sessions were between three and five hours long and were followed up by school visits and informal conversations following classroom observations. Between sessions, teachers shared their reflections and student work on Schoology[2]. This sharing of practice between sessions encouraged peer support and professional sharing and learning.

Typically, sessions began with the participants sharing their experience of teaching the classes using the FaSMEd toolkit (see www.fasmed.eu). It was important to interrogate these inputs and to explore the complex nature of FA development, so as to avoid the surface or layering-over treatment of the toolkit. Teachers got to experience toolkit lessons in PD sessions, and, to get familiar with the technology with their peers and teachers from the other participating schools. They then planned for how they would teach the lessons with their students and made suggestions for changes and for timing of the lessons in their local context.

Data Collection and Analysis

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 (Wiliam & Thompson, 2007), this research used a mixed methods approach. The research work within the project led to the elaboration of a three-dimensional model taking into account the FA strategies, the

[2] Schoology is an online learning environment that allows teachers to create and manage academic courses for their students. It provides teachers with a method of managing lessons, engaging students, sharing content, and connecting with other educators. For more information see the *Beginners Guide to Using Schoology*.

properties of technologies and the role of actors (reported elsewhere). Qualitative interviews were analysed using MAXQDA software. Q-Sort data were analysed using PQMethod software, video data using a whole-to-part inductive approach and the questionnaire data analysed using SPSS. Figure 1 provides an overview of the project and data collected.

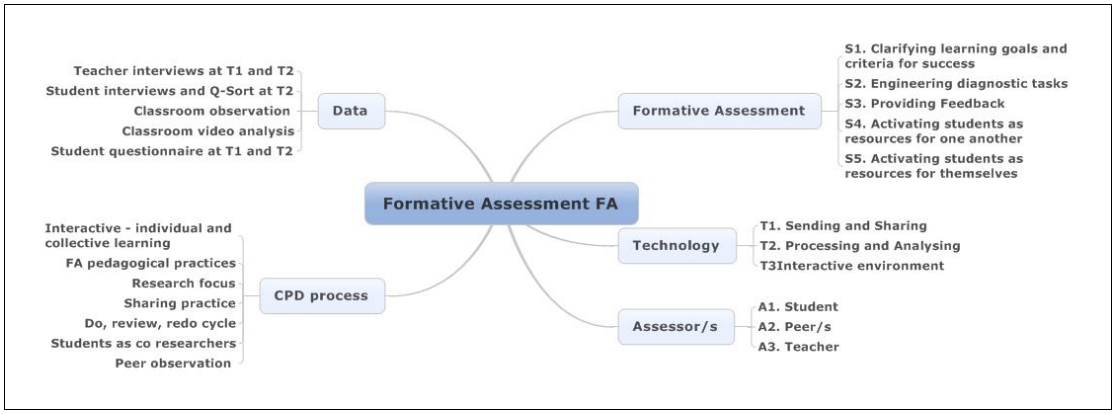

Figure 1: Overview of the research project and data collected.

FINDINGS

Interviews with the case study teachers and others indicate that engagement with the project and carrying out activities did have an impact on the development of teacher professional competences and this in turn led to enhanced formative assessment practice in the classes. Three key characteristics of the professional development were cited as being significant for the teachers:

- Development of professional skills in a collaborative environment
- Observation and feedback on teaching
- Supporting materials and tools

Development of professional skills in a collaborative environment

There were different levels of collaboration throughout the project. At school level there were two science and two mathematics teachers involved which encouraged professional sharing. At project level there were thirteen teachers involved and two university facilitators representing another professional group. The on-line supportive platform also encouraged professional sharing. While it may be beyond the scope of our data to suggest that each of these constituted a community of practice; they did go some way toward doing so. Teachers talked about how having time to discuss materials with colleagues was useful, and about how they helped each other to navigate the complexity of integrating technology into their teaching. There was also evidence for teachers crossing boundaries between different communities, where mathematics teachers and science teachers used common lessons to teach topics such as graphing. In many ways the university researchers where playing the role of brokers in this process, providing feedback after lesson observations and on-line on the Schoology platform (Wenger, 1998).

> I found it (PD) very helpful, particularly the day we were here (in her school) we met up with the other teachers, saw how they were getting on, it was very helpful. It made you reflect I suppose on your own practices. (Maths Case Study Teacher)

There was evidence from analysis of pre and post teacher interviews of the teachers

having developed an enhanced understanding of FA. They moved from describing FA as a tool or an addition to learning, for example, *I use traffic lighting with my students,* to describing how students responded to feedback, how they participated in discussions in groups while solving a problem, how they struggled with giving and receiving peer feedback and so on. This shift in professional language at post project interviews was evident with all participants.

Observation and feedback on teaching

Teachers felt they had benefited from participation in the PD sessions and illustrated how the structure of the FaSMEd professional development was better than the conventional PD that they were used to where the focus is often on covering content rather than focusing on pedagogy and learning.

> I would say other professional development I have done would be focused more on the syllabus and different ways of setting up an experiment ...rather than looking at how students are learning, how can we help them learn, what techniques you can use in the classroom to help them learn. (Science Case Study Teacher)

In particular teachers responded very positively to the professional development event that required them to observe and video each other's class, after which they were to have a discussion on their questioning skills with their peer. Classroom observation supported this perceived impact of the professional development process with lesson observations noting increased wait time, use of discussion and use of higher order questioning in subsequent lessons. This is notable as teachers' use of questions is highly resistant to change as it is what Oliveria terms a highly routine practice (2010).

Supporting materials and tools

Teachers reported liking that supporting materials were provided and that these could be adapted to suit the culture and context of their classrooms. They were provided with examples of applications to use with their technology and could adapt or adopt these to suit their needs. The sharing of expertise here was very notable with participants of differing levels of expertise enhancing the transfer of new knowledge across boundaries. In addition, the use of the online platform meant that teachers had to share their experiences and examples of their students' work. This acted both as a motivator and an accountability measure. Teachers felt they had to try out the materials and share their experiences and it also provided a platform for them to compare and contrast their experiences with similar tools. Technology helped teachers to enrol in a complete FA process instead of considering some moments, enhancing their understanding of the process.

CONCLUSION

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. While this change in culture of learning merits further investigation, it does provide evidence for change in participating teacher's professional practice. 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. The use of feedback from peers and from researchers enhanced this professional learning.

The teacher's professional knowledge of FA and how technology could be used to enhance its use in science and mathematics was increased through the project. The role of developing professional learning communities both in schools and between schools, and between schools and the university was central to the success of this project and merits further exploration.

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