Teacher Mediation of Classroom Learner Response Technology

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Executive Summary

This close to practice research investigates how 36 primary school teachers in England mediate a newly introduced classroom learner response technology system to shape the learning environment in their classrooms of young children. This technology involves each child having a hand-held device, a pod, with a mini keyboard and screen. The teacher has a data projector and software to be able to receive pupils' responses, monitor them and when appropriate to display them anonymously to the class. The purpose of the study was to focus on teacher strategies and professional learning in response to the affordances of a new classroom technology. The teachers embedded the technology into their lessons so that they became familiar with the use of the new presentation and analysis software and their children became familiar with their class set of learner response pods. The 'pods' are similar to basic 'clickers' but with a small keyboard and small screen, like a simple mobile phone.

Effective classroom teaching is a challenging and complex activity. Imagine a classroom in which the teacher communicates high expectations for all of the children. Where adults and children value struggle as a sign of being close to new understanding and mistakes as opportunities for learning. Where all members of the class are collaboratively learning as a community. Where children can thrive and are able to respond creatively and develop as unique individuals. A classroom learner response system is a strong influence on creating such a classroom learning environment. Learner response systems began perhaps with the traditional 'hands-up', leading on more recently to general indicators such as 'thumbs up' or more informative strategies such as the use of 'mini-whiteboards'. The basic learner response technology of handheld Pods software and data projection investigated in this study include a small keyboard and screen to allow text responses which moves them beyond simple clickers and multi-choice questions.

During the one year project teachers worked through three action research cycles to integrate the technology with their developing beliefs, values, purposes and repertoire of teaching strategies. The data sources include: contextual data about the teachers and their schools; teacher assessments of children; pupil voice; teacher diaries and evaluations of learning tasks; teacher focus groups; and teacher surveys. The teacher researchers were encouraged to experiment with the technology and evaluate the impact on learning and on learners. The technology influences many aspects of classroom practice including engagement, motivation, assessment for learning, collaborative learning, classroom questioning and level of challenge. The findings highlight the tensions teachers face in embedding the technology into their classroom practice. Certainly the technology is broadly popular with both teachers and young children.

Working from a sociocultural perspective, we identified six tensions related to the use of the technology in classrooms. Our analysis identified a tension between the value of prompt automatic feedback provided by the technology and the quality of that feedback. There was also tension between engagement and higher level cognitive challenge. The teachers found that the technology tended to support recall tasks or at least closed tasks and they mainly used it for those kinds of

activities. Teachers found that preparing new resources using the software was time-consuming and they tended to achieve higher level challenge tasks by using the technology in simple ways to enhance paired and whole class interactions. The analysis identified a tension within teaching on mathematics around number fact recall. Teachers found the technology was particularly useful for recall teaching of times tables and helped to make this activity more fun and much more engaging for children. This was counter to the mastery approach to teaching mathematics adopted by at least one school in the study where more flexible development of number sense was valued during mathematics lessons, so the technology was used at another time in the day to do recall test activity. The technology use by teachers did include some interactive discussion tasks that promoted collaborative learning but more than half of tasks tended towards individual work.

The analysis identified a significant tension within the teachers' practice using the classroom learner response technology between developing the pupils as learners and preparing them to perform in national tests. We considered this tension to focus on the contested object of learning (the purpose of education) between the classroom and the wider national policy framework. Despite the agency of the teachers their mediation of the classroom learner response technology is strongly influenced by the wider policy framework of national tests, inspection and school league tables that exists in England.

Based on our study, basic classroom learner response technology, with a simple keyboard and screen allowing text responses, is popular with teachers and with young pupils. This is true for many teachers and children even after a considerable time and arguably beyond any 'honeymoon' period. Such technology has the potential to reduce teacher workload in relation to ongoing recording of pupil assessment data. However, this basic technology lends itself to low level recall tasks and the development of more sophisticated resources within the software provided is too onerous in terms of workload for individual teachers. Further development of classroom learner response technology is taking place with a much greater emphasis on high quality content, of course that has its own set of issues with regard to the quality of teaching and learning. The introduction of such technology needs to be accompanied by professional learning for teachers so that their mediation of the technology is able to resist wider high accountability pressures and focus on the potential of the technology to promote dialogue, collaborative learning, formative assessment with high quality feedback and high expectations and challenge for all pupils.

Teacher Mediation of Classroom Learner Response Technology

1. Introduction

Technology is increasingly present in school classrooms, even in the classrooms of young children. Classroom learner response technology is important because it influences classroom culture and communications including questioning and feedback. Classroom learner response technology began perhaps with the basic 'hands up' approach and includes mini-whiteboards, thumbs up and basic traffic light methods. The classroom learner response technology involved in this study offers a similar but perhaps more powerful approach and is broadly equivalent to the use of smart mobile phones.

This project investigates how teachers mediate classroom learner response technology to influence their teaching strategies and the learning environment. The classroom learner response system was introduced by 36 teachers located in 18 Primary schools in three clusters in England. The technology involved in this study is a system in which individual learners use pods with a keyboard, similar to a mobile phone that allows the teacher to set questions and invite either open text or multi-choice responses. Depending on their chosen purpose and strategy the teacher will either display the anonymised class responses via a data projector for buddy or whole class discussion, or will monitor the progress and responses of individual learners as they continue to work on a series of questions.

Classroom response systems generally use different forms of technology to gather responses from learners to questions posed by the teacher (some teachers may subvert this scenario by requiring learners to develop questions for their peers). With electronic systems the learner responses are collated and are available for display to the class if the teacher chooses to do so, often in the form of a simple graph shared using a data projector. It is helpful to consider electronic classroom response systems as the use of advanced technology to enhance the traditional classroom routine of the teacher asking a question and students volunteering to answer by 'hands-up'. Under the influence of assessment for learning (Black et al., 2003) the well-established routine of 'hands-up' has already been replaced in many classrooms with simple technology alternatives such as dry-wipe mini whiteboards, 'thumbs-up', coloured cards, or other simple signalling methods that have varied levels of anonymity. Considering classroom response systems in this general way perhaps makes them seem to a casual observer merely a mundane, insignificant and routine element of classroom learning, but that would be a huge mistake. Classroom teaching is a difficult practice that looks easy (Labaree, 2000). Classrooms are complex learning environments with varied and sometimes conflicting purposes, usually a fairly large number of often involuntary and varied participants, complex and dynamic relationships, multiple variables at play and only contested measures of learning available. Making a single intervention and thinking that you can measure its impact is naïve and classroom teaching is best understood as a complex inter-related system (Marzano, 2009).

A classroom response system is a critical element of communication that contributes to the overall culture (values and beliefs) and structure (relationships and power) of a classroom and strongly influences processes that underpin learning including feedback, level of challenge, setting of teacher expectations and the development of learner dispositions. John Hattie proposes that teachers daily ask the question: 'what is my impact on learning?' (2012). This question may be usefully extended to become: 'what is my impact on learning and on learners?' so that it includes consideration of learner motivations, beliefs, and dispositions (Boyd, Hymer and Lockney, 2015). This study investigates the implementation and mediation by teachers of a classroom learner response technology and its impact on learning *and* learners. Three areas of relevant literature are considered before outlining the methodology of the study: Existing research on classroom response technology; Assessment for learning; and Questioning in classrooms.

A Complexity Theoretical perspective on classrooms as open systems provides a useful framework because it highlights the point that 'new properties and behaviours emerge not only from the elements that constitute a system, but from the myriad connections among them' (Mason, 2008: 42). Key concepts of Complexity Theory include feedback (positive and negative within an open system), connectedness and emergence. A classroom, from this perspective, is understood to be self-organising, dynamic and emergent. A complexity perspective emphasises the unpredictability of human development, such as introducing technology into a teacher's classroom (Kuhn, 2008). Kuhn warns that focusing on one level of analysis, for example from the levels of national policy framework, school, or classroom, does not reduce the 'multi-dimensionality, non-linearity, interconnectedness, or unpredictability encountered.' (Kuhn, 2008:183). A complexity perspective shifts the focus from 'causation' to 'effects' (Haggis, 2008). In our attempts to understand the impact of the technology on classrooms we should not try to reduce the number of variables considered, but rather accept that multiple variables are linked in multiple ways and are also influenced by external factors. Practice and structure within each classroom will then emerge through an historical process. Complexity perspectives indicate a holistic approach that suggests case study methodology, participatory action research approaches and generating data to provide insight from different stakeholders (Cohen, Manion, and Morrison (2011:34).

The 36 participating teachers involved in this study were based in 18 primary schools in England, located within the demographically diverse areas of London, Barrow-in-Furness and Carlisle. The schools in the sample included an inner city primary school based in one of the most deprived areas of London with a high proportion of EAL pupils, a predominantly white city centre based school in Carlisle and a small village school, providing for mainly middle class and farming families located within the catchment area of Barrow-in-Furness. The teachers were primarily female and 59% of the sample were in the age range 21-30 years. Due to the nature of the schools many of the teachers worked with mixed age classes and had a range of experience from being recently qualified to having leadership roles, which included one primary teaching head.

2. Research on classroom response technology

2.1 Learner Response Technology

This section considers three areas: the use of early electronic 'clicker' voting systems; the development of traditional and low technology classroom response systems; and the technology to be used in the current study. The concept of 'engagement' is considered because this has been the focus of much of the research on clickers in higher education, with some similar investigations also completed in schools. Finally, the principles of 'dialogic teaching' are considered as a theoretical framework through which to analyse the different ways by which the teachers mediate the technology.

2.1.1 Clickers in Large Lectures

Basic electronic classroom response systems, originally using hard wiring, have been in use for several decades. These simple systems were commonly referred to as 'clickers' and by terms such as 'voting system'. In common with Derek Bruff (2009) this report will use the term 'classroom response' to more clearly distinguish our focus on face to face interactions rather than online. The early use of clickers mainly involved students in further or higher education responding anonymously to multiple choice questions during large lectures and was primarily aimed at increasing engagement.

Whilst some of this use of clickers involved individual students responding to multiple choice questions it was often focused on promoting learning through peer interaction, usually in pairs. Dan Mazur, building on ten years of experience in large lectures, developed an approach to using clickers known as 'peer instruction' (1997). A number of literature reviews that include these large lecture studies suggest that using clickers increases engagement in learning, provides useful feedback to teachers and is generally enjoyed by students and teachers (Caldwell, 2007; Fies and Marshall, 2006; Judson and Sawada, 2002; Simpson and Oliver, 2007). Most of the research in tertiary education settings has been based on simple clicker systems and associated use of multiple choice questions. Currently, in higher education and conference lectures laptops, tablets and increasingly mobile phones are being used as classroom response systems relying on Wifi with several options for use of software by teachers or speakers including some free products. In large lecture settings the use of classroom response systems has largely been focused on enhancing student engagement but with some emphasis, informed by social constructivist learning theory, on students learning through peer interaction.

2.1.2 School Classrooms

In school classrooms there has been less use of response systems that depend on electronic technology but a long history of more basic systems including the traditional 'hands-up'. More recently many teachers have used a system of white boards (small dry erase boards and pens) for pupils to show answers to the teacher. Fingers on the chest or other coloured response cards have been used for pupils to respond to multiple choice questions. Other simple signalling routines include use of 'traffic lights' or 'thumbs-up' to indicate pupils' self-assessed level of understanding of a topic. Clearly, it is tempting for teachers to consider low technology learner response systems and so it seems important to identify key differences that a high technology system offers and investigate the significance of these differences for effectiveness of teaching and learning. This is difficult because of the complexity of classrooms with multiple contextual variables, multiple learners and individual teachers all influencing the classroom as a learning environment, alongside the learner response system being used. Despite the considerable body of studies in tertiary education there has been far less research on school classroom use of electronic response systems and this study aims to contribute towards this gap in knowledge.

A recent large scale randomised control trial study of the classroom learner response technology used in our project recently demonstrated little impact on attainment in mathematics and reading (EEF, 2017). This study involved 97 schools and 6,500 pupils aged 9 to 11 years in Primary schools in England. The study found that the technology was generally popular with teachers and children although implementation by teachers was variable. Our smaller project involves younger children and a smaller intervention in terms of teacher training than this large scale study. A general meta-analysis focused on the impact of digital technology in schools on children's attainment identified three issues relevant to our study (Higgins, Xiao and Katsipataki, 2017). First, collaborative use of technology is often more effective for learning, for example working in pairs, but children may need training in effective collaboration. Second, that short term frequent use, for example three times a week, can provide a boost to learning, while sustained longer term use is usually less effective. Third, that teacher training should be at least one day and go beyond a simple introduction to the technology to consider pedagogical implications.

2.1.3 Current Technology

Clearly technology continues to develop but our concern is the teaching strategies and the impact on learning, on learners and on the classroom learning environment. This study involves the use of a classroom response system using 'Pods' (Promothean Active Expression 2) that have a keyboard and so allow text responses to more open response questions as well as to multiple choice. The Pods and the associated software (Active Inspire) enable the teacher to set up the system so that responses may be attributed to individual learners although the display of collated responses on the board is usually kept anonymous. The Pod system may be used in a similar way to clickers to

offer a question to the class but it may also be used to set learners off following a 'self-paced' sequence of questions with the teacher able to monitor progress centrally. The software allows the teacher to retain learner responses to tasks if they wish as part of their monitoring and recording procedures.

2.1.4 Engagement

In the complexity of classrooms, it is difficult to objectively measure learning. Experienced teachers use a combination of sources to gather 'evidence of learning' (Baumfield, Hall and Wall, 2013). Teachers routinely collect and record data on individual pupils such as attendance, behaviour and in-class test results. They also use classroom observation to judge progress in learning and continually note the achievement of particular pupils in learning activities. There are other professional learning activities that perhaps less frequently help teachers to judge the level of learning in their classrooms, for example reflective discussions with teaching assistants or with colleagues following informal and formal classroom observations. The amount of data available easily becomes overwhelming and teachers hold much of it in their heads but schools will use a range of methods and procedures to more formally record judgements of individual pupil learning which are used for a variety of purposes including reporting to parents and to demonstrate school effectiveness to school inspectors and other stakeholders. Teacher judgements of learning progress within a lesson, within a sequence of lessons, and over the medium term such as a school year, are partly informed by their questioning and therefore the classroom learner response technology becomes significant.

In many ways the use of basic clickers in higher education has been predicated on the basis of student 'engagement' and a reliance on a social constructivist theory of learning that such engagement, most often in the form of dialogue with peers as well as whole class discussion including the teacher, will lead to more powerful learning (Mazur, 1997). There has been considerable investigation of engagement in higher education but some work has also been completed in schools (Marks, 2000). The concept of engagement is broad and contested and often considered as including up to four elements: 'behavioural'; 'academic'; 'emotional or psychological'; and 'cognitive' (Sharkey, Sukkyung and Schnoebelen, 2008). Behavioural engagement includes attendance and classroom participation while academic engagement focuses on school work and home work. Emotional or psychological engagement relates to a sense of belonging to school and cognitive engagement is focused on approach to learning including commitment to mastery and aspects of self-regulated learning such as goal-setting and purposeful use of learner strategies. Teachers' conceptions of engagement vary across this spectrum and Harris argues that they may usefully be classified as engagement in learning or engagement in schooling (2011). Some of the 20 teachers in her study in Australia considered engagement to be cognitive and focused on learning while others considered engagement to be participation and focused on emotional experiences. Harris concludes that whilst developing positive affective experiences of learners is a worthwhile goal and is easier to measure, the emphasis of studying and developing engagement needs to focus on students' academic learning.

Despite the contested nature of engagement, and the limitations of a behavioural conception, the gathering of systematic observational data of selected learners within a classroom may be useful in considering the impact of an intervention such as a new teaching strategy or new classroom learner response system. Normally, the observer focuses on the behavioural engagement of a limited number of learners within the class, perhaps five or six students, as this makes the recording of engagement more feasible. This kind of observation data does not measure cognitive engagement but arguably it does provide some insight into the impact of an intervention (Bragg, 2012).

In addition to the distinction between social and cognitive engagement it is also worth considering engagement in relation to motivation. Self-determination theory has developed through a large body of research on motivation and is based on the idea that human beings will naturally tend to pursue fulfilment by seeking and completing challenges (Deci & Ryan, 1985). Self-determination theory considers three conditions to be required to satisfy human needs, the three conditions are: autonomy (being the perceived origin on one's own behaviour); competence (feeling effective within the social environment); and relatedness (a sense of belonging). In considering classroom engagement and motivation teachers may use strategies and structures to support pupil autonomy (for example allowing some level of choice), pupil competence (for example providing feedback), and pupil relatedness (nurturing interaction) (Fried and Konza, 2013). Fried and Konza used classroom observations to study a small number of pupils who had been identified by teachers as having low levels of engagement and related engagement to strategies and structures used by the teachers to nurture autonomy, competence and relatedness. It might be assumed that motivation of a learner leads to engagement but it is also possible to consider how increased engagement might influence motivation (Reeve and Lee, 2014).

Potential questions arise for the current study on classroom response technology: how does such technology and its mediation by teachers influence the classroom learning environment in terms of levels of behavioural or cognitive engagement and how does it influence motivation with regard to autonomy, competence and relatedness?

2.2 Assessment for Learning

Assessment *for* Learning (AfL) developed from an initial literature review (Black and Wiliam, 1998a) and the central claim, that formative assessment is a powerful driver for learning, is still supported by more recent reviews (EEF, 2015) although with the caveat that classroom interventions vary considerably in their effect size suggesting that implementation is not straightforward.

2.2.1 Formative Assessment

The AfL project was strongly influenced by Royce Sadler's theoretical thinking on formative assessment whereby the learner needs to understand the goal being aimed for, compare their current level of performance with that standard and then take steps to close the gap (Sadler, 1989; 1998). Classroom learner response systems clearly connect to key elements of AfL including using questioning to create opportunities for formative assessment and feedback. AfL forms an important part of the theoretical framework required to understand the influence of learning response system technology in the classroom, but it is important to understand the learning power of formative assessment more fully than simply providing prompt feedback to pupils as they

respond to teacher questions. AfL really represents a set of principles for teaching and so this section is informed by a critique or at least of developments beyond the original AfL principles and will consider in turn three sub-sections: beliefs about intelligence; self-regulated learners; and low stakes assessment. It would have been appropriate to also discuss 'questioning' strategies as part of AfL but because this is so central to the use of the technology it is given its own final section of this literature review.

2.2.2 Beliefs about intelligence

It is important to acknowledge that techniques associated with AfL are unlikely to have impact on learning of all pupils unless the teacher skilfully develops a learning environment in which learners are not labelled according to prior attainment but rather that the teacher has high expectations for all learners:

> What is needed is a culture of success, backed by a belief that all can achieve
>
> (Black & Wiliam, 1998b:6).

This belief depends on the teacher having a malleable conception of intelligence, believing that the more you practice the smarter you get, and applying that belief to expectations of their pupils and nurturing the same belief in their pupils. This belief of malleable intelligence is captured by the concept of a growth mindset and Carol Dweck's work shows that this can be developed in learners (1999; 2006) through explicit instruction combined with appropriate teacher strategies (Hymer and Gershon, 2014). A growth mindset classroom is one where struggle and failure are celebrated because those are signs of learning at the edge of current achievement. In nurturing a growth mindset the teacher provides feedback rather than praise. This is because praise, especially directed at the level of the self 'you are such a bright girl', rather than at effort or strategies may tend to develop a fragile learner with a fixed mindset. Avoiding the labelling of learners is an important step in raising expectations for all and the power of this approach has been demonstrated by the 'learning without limits' project (Hart et al., 2004).

Potential questions arise for the current study on classroom response technology: how does such technology and its mediation by teachers influence the classroom learning environment in terms of level of challenge, the attitude towards struggle and mistakes and the development of mindset beliefs by teachers and learners?

2.2.3 Developing Self-Regulated Learners

In England educators often use the term 'developing independent learners' but this has been used widely and in ill-defined ways so that it is more useful to use the term 'self-regulated learners' and self-regulated learning (SRL) (Zimmerman, 2002). The term 'self-regulated learner' links neatly to the term 'self-assessment' which is an important part of AfL but means more than that. Zimmerman summarises self-regulated learning into three stages: plan - do – reflect. Figure 1. provides more detail with the 'plan' stage relating to items 1 to 3, the 'do' stage relating to items 4 to 5, and the 'reflect' stage relating to items 6 to 8 (admitting that item 6 could be part of 'do' or part of 'reflect').

1. Setting specific proximal goals for oneself
2. Adopting powerful strategies for attaining the goals
3. Monitoring one's performance selectively for signs of progress
4. Restructuring one's physical and social context to make it compatible with one's goals
5. Managing one's time use efficiently
6. Self-evaluating one's methods
7. Attributing causation to results
8. Adapting future methods

Figure 1. Overview of self-regulated learning (Zimmerman, 2002).

In addition to this summarised list linked to the three stages of self-regulated learning, Zimmerman adds, almost as an afterthought, a consideration of attitude to practice (at the edge of current ability) and this relates back to the beliefs of learners (and their teachers) which was discussed in the previous section concerning mindset.

The development of the self-regulated learner links strongly to AfL because of its emphasis on developing learners' capacity to self-assess their work (Black et al., 2003). In AfL peer assessment is seen as a way to fully engage learners with success criteria because they have to use those criteria to judge the work of others and this is part of moving them towards being self-assessors. This kind of peer assessment or peer review activity, especially if it leads to discussion involving other learners and the teacher, means that the pupils gain more traction on the intended meaning of the written criteria. Black et al. (2003) focused more on peer assessment whilst Clarke placed more emphasis on the assessment of 'exemplar work' of different quality (Clarke, 2005). These exemplar work examples might come from pupil's in the teacher's previous class and are usually anonymised. Research meta-review of relevant studies suggests that approaches to developing metacognition and self-regulated learning require careful implementation but may have a strong effect size indicating a powerful influence on learning (EEF, 2015).

In an influential qualitative study of Primary teachers in Scotland the intention of the teachers to develop independent learners (self-assessors) as part of AfL practice was labelled as the 'spirit' of AfL (Marshall and Drummond, 2006). Teachers who understood the 'spirit' of Afl developed classroom learning environments that nurtured the development of self-regulated learners. Teachers who did not grasp the spirit of AfL expected success by merely adopting strategies associated with AfL 'off the peg' without considering the social situation operating in their classrooms. In a related study over 500 classroom teachers in the UK responded to a survey about AfL practices and how these related to their professional values (James and Pedder, 2006). James and Pedder argued that the commitment to developing learner autonomy is values-driven. They identified a tension experienced by teachers between their value in wishing to develop autonomy of learners and the pressure they felt to maintain a performance orientation (i.e. teaching to the test).

In more recent work informed by research meta-review evidence John Hattie argues that effective formative feedback should be corrective, timely, criterion-referenced and 'invitational' - meaning

that it encourages self-assessment (Hattie, 2012). This element of 'Invitational' feedback might be slightly frustrating for learners who would prefer a more directive style from their teacher but it can be accompanied by more concrete suggestions, and can be applied at task, process and meta-cognition level (Nuckles et al., 2009), for example:

> **Task Level**: Does this answer meet the criteria?
>
> **Process Level**: What strategies are you using?
>
> **Self-Regulation Level**: What would be the best way of checking your work?
>
> (Boyd, Hymer and Lockney, 2015).

The development of self-regulated learners is central to the AfL project in terms of the value teachers place on it and by the way it may underpin peer and self-assessment activity and help to shape teacher feedback on formative assessment activities. A potential question arises for the current study on classroom response technology: how does such technology and its mediation by the teacher influence values and practice in relation to developing self-regulated learners?

2.2.4 Low stakes assessment

Arguably, the most important learning power at the heart of AfL relates to formative assessment. Formative assessment provides useful feedback for the pupil on strategies to improve their work and for the teacher on how to refine their teaching (Black et al., 2003; EEF, 2015). However, the concept of 'formative assessment' is contested. For example, Perrenoud (1998) argues that assessment only becomes formative when it actually influences the learning process through either pupil or teacher action.

It has been argued that AfL based on Black and Wilam's work (1998a; 1998b; 2003) developed a mistaken conception of formative assessment because it did not consider the formative assessment process to include a 'summative' style judgment (Taras, 2009). Taras points out that to develop transparency through learner engagement with the written criteria and to move learners towards becoming self-assessors, it is critical that a formative assessment process includes a judgment against the success criteria, in other words summative style assessment has to form part of the formative assessment process. This potential confusion around the nature of 'formative' versus 'summative' assessment might be resolved by adopting the terms low stakes and high stakes assessment. Both low and high stakes assessments involve judgment against the criteria. Low stakes assessments need to be formative in the sense that the learner has engaged with the criteria and is provided with feedback against them. High stakes assessment may have their contribution to learning increased by providing feedback against the criteria but their purpose is less focused on driving learning.

A potential question arises for the current study on classroom response technology: how does such technology and its mediation by the teacher influence the frequency and effectiveness of low stakes (formative) assessment opportunities?

2.3 Questioning and Challenge

Teacher questioning has been identified as powerful for learning with strong effect sizes identified in meta-reviews (Marzano, Pickering, and Pollock 2001; Hattie 2012).

2.3.1 Purposes and strategies

Fries-Galtier proposes 9 reasons for a teacher to ask a question (2008):

1. To actively involve students in the lesson
2. To increase motivation or interest
3. To evaluate students' preparation
4. To check on completion of work
5. To develop critical thinking skills
6. To review previous lessons
7. To nurture insights
8. To assess achievement or mastery of goals and objectives
9. To stimulate independent learning

Many of these reasons for asking a question seem relevant to the use of classroom response technology. In addition, there are some basic questioning strategies that teachers may use and which have been associated with AfL:

Planning questions – it is helpful if teachers take a little time to plan questions prior to the lesson as this can raise their quality and impact. This is especially true for key questions and what is sometimes referred to as the 'hinge' question, which is the question that really gets to the big idea or key concept underpinning the purpose of the lesson. A framework such as Bloom's taxonomy may be helpful to teachers in planning questions of increasing challenge.

Open and closed questions – in planning questions some closed questions focused on basic recall of content will be useful but it is also important to move on to open questions that test understanding of concepts.

Thinking time – it is important that teachers allow time for thinking by learners and some famously short typical times between question and expected answer have been recorded with teachers often answering their own questions in order to push on with the lesson.

'No hands-up' – this approach is intended to increase engagement because it means that all learners may expect to be asked to give an answer. This is linked to a general strategy of distributing questions evenly to involve all learners.

'Think – Pair – Share' – has become a widely used strategy with learners turning to their buddy to discuss the question before the class is brought back together for discussion.

Valuing questions asked by learners – it is important, but an ongoing challenge for teachers, to encourage questions from learners and develop a classroom culture in which questions are valued, no matter how basic.

Figure 2. Teacher question strategies.

A potential question arises for the current study on classroom response technology: how does such technology and its mediation by the teacher influence the learning environment in relation to engagement by learners, collaborative learning and attitudes to learner questions and mistakes?

2.3.2 Types of questions

In his book on 'clickers' Derek Bruff distinguishes between 'content' and 'process' questions (2009). It is important to note that the early work based on 'clickers' is mainly referring to multi-choice questions and these have their own design issues. Also, the research and experience were mainly in tertiary education and often in science and maths. Bruff distinguishes within content and process question categories as summarised in Figure 3.

Questions focusing on 'content' of the lesson:

Recall questions – these questions simply check that learners remember basic facts, concepts or procedures. To test this thoroughly in multi-choice questions it is normal to have one or more 'distractors' which are quite close to being correct.

Conceptual understanding questions – these questions require learners to show their understanding. In multi-choice questions it is particularly effective if some of the wrong answers are based on typical learner misconceptions. Sometimes open questioning of learners around a concept may help the teacher to identify the range of misconceptions held. Questions focused on conceptual understanding might ask learners to classify: 'such and such is an example of which of the following concepts' or to select a 'best' explanation from the options provided.

Application questions – learners have to apply their knowledge and understanding to particular situations and contexts. Sometimes the scenario that the question refers to will be provided in a text book or other resource so that the question on the board or given orally can be concise. Some application questions focus on procedures and some on prediction.

Critical thinking questions – these questions are at the higher end of Bloom's taxonomy and require learners to analyse relationships among multiple concepts or to evaluate based on criteria. It is easier to test higher level thinking using open response questions. This is because the reasons students give for their answers is more important than the answers themselves. Multi-choice questions then may be used but mainly to promote subsequent discussion of the possible answers and the reasons why they might be seen as correct.

Questions focused on the 'process' of the lesson:

Learner perspective questions – questions may ask learners to express an opinion or share their experience on a topic relevant to the lesson.

Confidence level questions – these questions may be designed to let the teacher know how the students feel about a key concept in the lesson content.

Teaching evaluation questions – questions may ask learners to express an opinion on how effective the teaching or learning activity have been for them.

Classroom experiments – questions may be used to gather data for further use in the lesson, for example on factual data (how did you travel to school today?) or opinions (which of these school dinners do you prefer?).

Figure 3. A range of questions types from Bruff (2009).

In the use of clickers Bruff (2009) links process questions to what he refers to as 'agile' teaching. This means that the teacher is learning from the questioning and is able to adjust their approach

to respond to the needs of learners. This is the aspect of formative assessment that provides information for the teacher.

Bruff (2009) links content questions to deliberate strategies in the use of clickers. For example, he emphasises the use of clickers to promote whole class or small group discussion. Typically, the teacher will require all students to respond to a planned question. The teacher does not reveal the correct answer but rather displays the graph of responses and asks learners to give their reasons for different answers. It may be necessary to encourage or lead discussion of some of the most popular but wrong answers. Learners should be encouraged to respond and help build answers from others. In this way the use of clickers and a planned multi-choice question may be used to promote dialogue, two way interactions between teacher and learners or between learners. The traditional model for classroom interaction is 'initiation, response, feedback (IRF)' and this can be compared to ping pong between the teacher and an individual learner. A more ambitious model is for whole class discussion which might be compared to basketball, with the discussion moving around the classroom. This requires training for all class members in taking turns and listening. Clickers have been widely used to promote paired work, but they have also been used to provoke small group discussion and in some cases the group just submit one collective answer, perhaps after an initial round of individual responses and followed by a later question requiring individual responses.

A potential question arises for the current study on classroom response technology: how does such technology and its mediation by the teacher influence the types of questions teachers ask and the management of these questions to promote paired and whole class discussion?

2.3.3 Challenge of questions

In planning for progression and challenge when designing their questions for use in the classroom many teachers, often implicitly, consider Bloom's taxonomy of knowledge which classifies thinking into increasing levels of complexity. The original taxonomy is remembered particularly for the six categories of educational goals (knowledge, comprehension, application, analysis, synthesis and evaluation). This broad approach was developed further using verbs and gerunds to capture the way that learners work with knowledge in the 'cognitive dimension' as defined in Figure 4: remember, understand, apply, analyse, evaluate, and create.

Remembering: Retrieving, recognizing, and recalling relevant knowledge from long-term memory. **Understanding**: Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.

Applying: Carrying out or using a procedure through executing, or implementing.

Analyzing: Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.

Evaluating: Making judgments based on criteria and standards through checking and critiquing.

Creating: Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

Figure 4. Revised terms for the cognitive dimension of 'Bloom's Taxonomy' (Anderson and Krathwohl, 2001:67-68).

The revised taxonomy is a practical tool for teacher planning and a simple example of lesson objectives is provided in Figure 5. (Forehand 2014).

Lesson objectives based upon the story of Goldilocks and the Three Bears for each of the six levels of the cognitive dimension:

Remember: Describe where Goldilocks lived.

Understand: Summarize what the Goldilocks story was about.

Apply: Construct a theory as to why Goldilocks went into the house.

Analyse: Differentiate between how Goldilocks reacted and how you would react in each story event.

Evaluate: Assess whether or not you think this really happened to Goldilocks.

Create: Compose a song, skit, poem, or rap to convey the Goldilocks story in a new form.

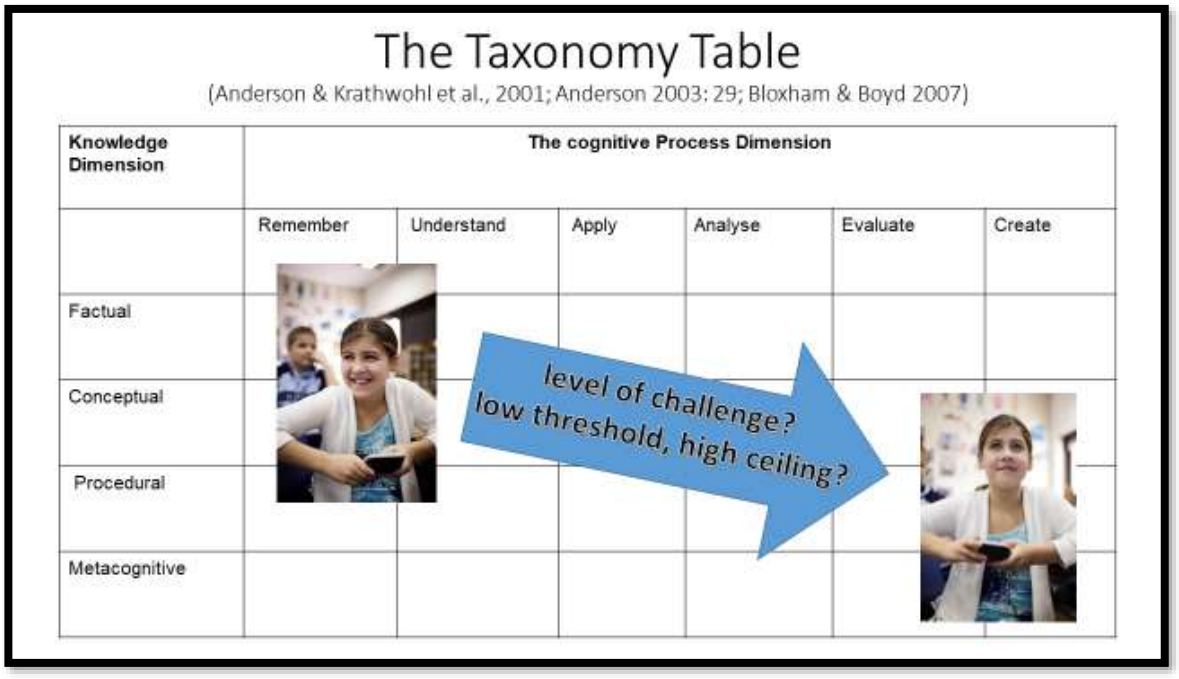
Figure 5. A simple example of the use of the revised Bloom's Taxonomy to identify lesson objectives.

Importantly, the revised taxonomy includes a Knowledge dimension which identifies the type of knowledge to be learned and this may be summarised as:

- Factual: facts a student needs to be familiar with;
- Conceptual: knowledge such as knowledge of classifications, principles, theories, models and structures;
- Procedural: knowing how to do something including techniques, skills and methods of enquiry,
- Metacognitive: knowledge of self and cognitive tasks and methods of learning and organising ideas

The resulting table is show in Figure 6. In planning for lessons teachers might consider a question or a formative assessment activity and position it on the table and justify that choice. They might consider what amendments might shift that question or activity towards the bottom right corner of the table.

Table 1. The revised Bloom's Taxonomy as a table (Anderson and Krathwohl, 2001; Anderson 2003: 29).



The revised taxonomy has proved to be a useful aid to teachers in higher education in the design and evaluation of assessments and consideration of their level of challenge. In considering lesson planning and in particular the level of challenge of classroom questions it appears to be a useful device. The use of basic clickers in higher education in the past has been closely connected to multi-choice questions and it is arguable that this format of question tends to restrict the cognitive level that may be achieved (Bloxham and Boyd, 2007). The design of multi-choice questions is an art in itself. Normally, in designing a multi-choice question for test conditions there may be five possible answers with a correct response and then a 'distracter' plus three wrong responses. The distracter might be based on a common misconception held by students. Experienced teachers with strong subject content knowledge often have a good knowledge of the most common misconceptions held by their learners. Teachers will often use open questions in classroom discussion or in low stakes assessment tasks to reveal the misconceptions held by their learners. The design of multi-choice questions requires teachers to predict in advance the misconceptions likely to be held by their learners in the long term, at a particular level or age, and in the short term at a particular stage in a sequence of lessons. This kind of in-depth pedagogical content knowledge is a particular challenge for Primary teachers in England who are normally 'class' teachers and have to teach the whole curriculum including a range of subject disciplines.

The challenge of designing multi-choice questions that challenge learners at a higher level of thinking on the Revised Bloom's Taxonomy appears to be moderated to some extent when using classroom learner response technology when the question is used as a prompt leading to paired and whole class discussion rather than as an individual learning activity. Provided the question is effective in provoking some incorrect answers then even the children who are sitting comfortably confident that they have got it right might be provoked to think harder. For example, if the teacher chooses not to reveal the correct answer immediately, if they are asked to consider why one or more of the wrong answers distracted some of their class mates, or if they are asked simply to explain their own answer orally. In addition, when designing a multi-choice question for classroom use it seems more reasonable for the teacher to raise the level of challenge, for example by

including one correct response plus three or four distracter responses that are close to correct but not quite right or which are commonly held misconceptions.

A potential question arises for the current study on classroom response technology: how does such technology and its mediation by the teacher influence the level of challenge in the classroom and the level of teacher expectations of all learners?

2.3.4 Dialogic teaching

Dialogic teaching is a classroom approach and repertoire of strategies developed from a body of theory and research focused on talk in the classroom between teacher and student (Alexander, 2008). Dialogue is not merely seen as a way to learn new ideas, but also as a way to learn to think. This theoretical position has been developed from Vygotsky's ideas about the child becoming self-regulative by taking over the communicative and regulative responsibilities provided by the adult (Wertsch, 2008). Arguably, we have sufficient understanding and research evidence to implement effective practical classroom strategies, as Neil Mercer concludes '…adults can guide children in how to use talk effectively, as a cultural and psychological tool, and there is evidence that this can make a significant contribution to children's self-regulated learning and their intellectual development, including the development of their reasoning' (Mercer 2008: 99).

As developed by Vygotsky the 'zone of proximal [potential] development' may seem to imply that the child is learning from the adult. Some of the later work on dialogic teaching considers that children need to develop creativity by tackling problems and focusing on different methods of solving them. From this perspective the teacher or adult may be surprised and learn from the child through open-ended dialogue (Wegerif, 2007). The wider body of work on dialogic teaching includes a focus beyond adult-student interaction to encompass peer dialogue and learning through collaborative groupwork (Chen & Lotan, 2014). With this emphasis on dialogue as learning together, the teacher uses interactive strategies to develop dialogue that produces 'interthinking' (Mercer, 2000) or 'sustained shared thinking' (Siraj-Blatchford et al., 2003: Boyd 2014).

There has been a problem with a shift to whole class teaching, for example as part of the numeracy and literacy strategies in England, but without employing dialogic teaching strategies. With an emphasis on pace such whole class teaching can become teaching by telling and the level of discussion reduced to IRF formats and closed 'test' questions posed by the teacher creating considerable problems, especially for pupils with lower prior attainment (Hardman, Smith & Wall 2003; Kyriacou & Goulding 2004).

There is a considerable overlap between dialogic teaching and key features of assessment for learning with its emphasis on the learning power of feedback in low stakes assessment activities (Black et al., 2003). Dialogue, like formative assessment, provides information for the teacher on how to enhance their teaching and for the learner on strategies to enhance their work. Assessment for learning techniques are not effective unless teachers develop a positive learning environment in which mistakes and struggle are welcome and there is a culture of respect and collaboration (Marshall & Drummond, 2006). Teachers need to develop a 'dialogic climate' for example by negotiating principles for classroom talk (Alexander, 2017: 27). Mercer's rules provide one example (2000: 161):

> We share our ideas and listen to each other
> We talk one at a time
> We respect each other's opinions
> We give reasons to explain our ideas
> If we disagree, we ask 'why?'

We try to agree at the end

These kinds of classrooms rules may be developed to become part of the cultural script of the classroom with a shared commitment to the learning of others. The teacher might ask one person in each group the question or set a group test, with each individual student completing the test, working together, but only one test paper per group being graded.

Respect

Arguably, the weakest area of professional guidance on tackling social disadvantage is around 'classroom strategies'. This is the area that our research and development project is focused on. We need to identify classroom strategies that can be adapted to suit the teaching of the full range of curriculum subjects and that help to overcome social disadvantage.

Ian Thompson argues that a key step in tackling social disadvantage is: 'Challenging deficit ideologies'. He also points out that: 'Stigma and shame are a significant aspect of living in poverty and institutional policies and practice may negatively stereotype, stigmatise and disadvantage those experiencing poverty.' This helps to shape our research focus on to classroom strategies that develop 'respect'.

Effective dialogic teaching requires a classroom environment and ways of working (ways of talking) which support 'respect' for other's ideas. To achieve dialogic teaching the teacher has to train all learners in the rules and culture of talking and listening and developing shared understanding.

However, it is also essential that the teacher selects carefully designed problems and that the teacher and students have an understanding of the nature of the subject discipline that recognises a wide range of contributions. In mathematics Jo Boaler refers to the 'multidimensionality' of maths. In Jo Boaler's study (2008) the students were given fairly open problems that they could solve in different ways, and the teachers valued different methods and solution paths, which enabled more students to contribute ideas and feel valued. But multiple solution paths were not the only contributions that were valued by teachers. When we interviewed the students and asked them, 'what does it take to be successful in mathematics class?' they offered many different practices, such as:

- asking good questions;
- rephrasing problems;
- explaining well;
- being logical;
- justifying work
- considering answers; and
- using manipulatives

This multidimensionality of maths offers more possibilities for 'respecting' the contributions of all students rather than simply privileging speed and calculation. Introducing dialogic teaching across the curriculum will require each subject to identify problem-solving learning activities that lend themselves to solution through dialogic collaborative learning. A meta review of research on dialogue in maths (Kyriacou and Issit, 2008) found a paucity of research but based on 15 identified studies found eight strategies: going traditional beyond teacher initiation – student response – teacher feedback (IRF) approaches; focusing attention on mathematics rather than performativity; working collaboratively with pupils; transformative listening; scaffolding; enhancing pupils' self-knowledge of how to make use of teacher-pupil dialogue as a learning experience; encouraging high quality pupil dialogue; and inclusive teaching. This review found the strongest evidence on impact on learning arose from studies involving training students to take part in effective classroom dialogue. Most studies involving a dialogic teaching intervention have measured success through the quantity and quality of dialogue but

importantly have not considered the 'collectivity' of that dialogue meaning the participation of all students, including those who have experienced social disadvantage (Sedlacek and Sedova, 2017). A study by Chinn et al. (2001) identified an increase in the proportion of student talk compared to teacher talk and an increase in elaborated contributions by students but noted that this increase in dialogue quantity and quality did not occur for all of the observed students.

Despite the development of classroom rules and collective learning culture, even when adapted to a particular curriculum subject such as mathematics, it is still possible that a surface norm, such as 'respect others' ideas', may often be realised in a superficial way (Hofmann & Ruthven, 2018). Hofmann and Ruthven identify four underlying rationales labelled as operational, interpersonal, discussional and ideational, that underpin surface engagement in classroom dialogue. The operational dimension means relating to ways of carrying out mathematical tasks, the interpersonal dimension means relating to ways of treating others, the discussional dimension means relating to promoting discussion and the ideational dimension means relating to the content of the discussions and the mathematical ideas involved. These researchers argue that successful introduction of dialogic teaching to support conceptual learning as well as social engagement means that teachers and students need to change their understanding of the curriculum subject rather than merely adopting a new strategy of classroom talking. This has resonance with the findings of a study by Boyd and Ash showing how teachers introducing problem-solving collaborative activity in Singapore style mastery maths was associated with teachers changing beliefs about strategies (moving away from in-class grouping). Expectations (moving towards a growth mindset position) and about school maths (moving towards a multi-dimensional view of maths) (2018).

2.4 Summary

Within a complex classroom system, changing the approach and technology of provoking and handling learner responses is likely to influence multiple interconnected variables. The four main areas of literature we have considered may be summarised as: engagement for all; assessment for learning; questioning for challenge; and dialogic teaching. Together, these four areas interact to shape and be shaped by the classroom learning environment that each teacher creates. The classroom learning environment includes expectations for behaviours (including for collaboration and dialogue) and for attainment of all learners, attitudes to struggle and mistakes and also orientation towards specific curriculum subjects.

Previous related studies have introduced over-arching metaphors to explain the difference between a classroom in which the teacher is merely implementing particular strategies and one in which the teacher is creating a sophisticated and effective learning environment that integrates those strategies. For example, in a study of Primary teachers in Scotland implementing assessment for learning (AfL) approaches, Marshall and Drummond distinguished between teachers using strategies with limited impact and those who captured the 'spirit' of assessment for learning (2006). These latter teachers had created an effective classroom learning environment that was able to embed the impact on learning of AfL. However, even the study by Marshall and Drummond and their idea of the 'spirit' of AfL does not explicitly embrace the curriculum subject knowledge and identity of the teacher in the complexity of classroom practice. The widely known framework of 'knowing, being and doing' is perhaps a more useful unifying metaphor to capture the complexity of the classroom.

3. Methodology

3.1 Research Design

This research project adopts a qualitative interpretivist approach exploring the dynamics of practice and taking into account participants' perspectives. The study was designed to be a multiple descriptive case study investigating a contemporary phenomenon within its real world setting (Yin, 2014). It has an evaluative dimension because it is not possible to separate the implementation of change of introducing the classroom learner response technology from the impact of the new technology on teaching and learning. Evaluation normally focuses on 'fidelity' in testing the implementation of an intervention but in this study we flip this on its head and focus on the variety of ways that teachers mediate the intervention to integrate the technology with their developing beliefs, values, purposes and repertoire of teaching strategies. There is considerable debate around defining 'case study' as a research approach. We adopt Yin's definition that case study is an 'empirical inquiry that investigates a contemporary phenomenon (the 'case') in depth and within its real-world context' and that it is particularly appropriate when the boundaries between phenomenon and context are not clearly defined (2014). Case study is appropriate to this study of 36 teachers using new technology in their classrooms because we are asking how and why questions investigating a contemporary phenomenon, the introduction of new technology, but with a low level of control over the complex classroom settings. A multiple case study approach offers to provide insight into how and why when there are multiple variables in contrast to intervention studies using randomised control trial quasi-experiments which are likely to suppress variation and teachers' practical wisdom in vain attempts to control variables. A significant issue of incomplete data during the busy summer term has restricted our full development of the analysis as a multiple case study of 37 teachers in their classrooms. Therefore, this report presents a thematic qualitative analysis, it may be possible to pursue a multiple case study based on a partial sample of the teachers in a subsequent paper.

In the style of case study research the project generates multiple sources of data including pupil and teacher perspectives to develop case descriptions. The teachers involved each form a case and their context is considered to be their classroom. However, the classroom sits within a particular school and local community as well as being influenced by the wider educational policy framework in England. The study considers the literature on engagement, motivation, assessment for learning, and classroom questioning, to provoke teacher researcher classroom experimentation with the technology. The study seeks to generalise in the sense of building substantive theory (Thomas, 2013; Punch and Oancea, 2014) so that rather than generalise about how all teachers would mediate the learner response technology we will seek to 'generalize to theoretical

propositions' related to teachers' use of the technology and its impact on their classroom learning environments (Yin, 2014: 21). The research design is informed by teacher action research approaches and adopts a cyclical pattern including three revolutions of data collection and analysis (Baumfield, Hall and Wall, 2013). As a qualitative study the project will adopt an emergent design so that the focus and methods of data collection will be evaluated and develop from stage one to two to three. The intended outputs of the project include a research report, a journal paper and an open access online resource to support teachers in their use of classroom learner response technology.

3.2 Methods

In this project the aim was to be able to track each item of data back to an individual teacher in their classroom within a particular school context. Each item of data leaving the schools was anonymised but labelled with a teacher reference code.

Data collection included the following seven methods:

1. **Contextual data** on the school, biographical data about the teacher and some indicators of the children in their class - collected by online teacher survey. As part of the school contextual data the assessment policy documents for each school were gathered during term 2 simply by collecting anonymised electronic policy documents via one teacher at each school. Also, teachers submitted anonymised teacher assessments, in the varied formats used by each individual school, of children in their class for the beginning of term 1 and the end of term 2.
2. **Teacher diary** over two weeks to gain a measure of the frequency of use of the classroom learner technology (the Pods), for different types of learning activity, by each teacher over a period of time, sampled towards the end of term 1 and again towards the end of term 2 - collected by online teacher survey.
3. **Teacher review of learning activities** using the Pods – teachers self-selected and reviewed 3 learning activities, completed towards the end of term 1 and again towards the end of term 2 - collected by online teacher survey.
4. **Pupil voice data** using a sad face - smiley face prompt sheet and then teachers encouraging the children to record their feelings towards using the Pods using drawing and writing on the back of the sheet – collected in term 2 face to face in the classroom by teachers.
5. **Teacher focus groups** focused on the emerging findings to develop collaborative analysis – gathered in term 3 at face to face research team meetings. The research team had some concerns about the effectiveness of the focus groups in gathering teacher perspectives and so a basic form of Nominal Group Technique was used to gather additional teacher perspectives about the technology as a teaching tool – gathered in term 3 at face to face research team meetings.
6. **Teacher professional inquiry** was completed by individual teachers or small groups of teachers during term 3 to pursue issues of classroom practice or children's learning with the PoDs that had arisen during the project.

More detail on each of the 6 methods of data collection is provided in this next section:

1. **Contextual data – teacher, class and school**:
   - One teacher researcher in each school completed a template to provide a descriptive summary of their school in terms of pupil roll, staffing, governance, urban / rural geographical location and catchment, and most recent external inspection outcomes.
   - Individual teacher researcher biographical details were gathered by online survey to include: gender; years of experience as a qualified teacher; subject leader or other role within school and a simple self-reported level of expertise in the use of IT to support learning in the classroom.
   - Each teacher researcher also provided in the online survey a descriptive summary of their class of children in terms of number, attendance, gender, free school meal status, special educational needs (SEN) status, and English as an additional language.
   - One teacher in each project school provided, in anonymised form, the school policy on assessment including marking work and monitoring pupil progress.
   - The teacher researcher made a copy of their baseline class 'teacher judgments' for January, the beginning of term 1, in Maths and English and anonymised the records using pupil numbers. The equivalent list of teacher judgements was copied in July at the end of term 2 of the project. The records varied from one school to another in format and technical detail.

2. **Pupil voice survey:**

During term 2 of the project teacher researchers gathered pupil voice data to consider their perspectives on using the technology. A hard copy handout was provided to each pupil during class time to gather pupil perspectives about the technology. A rather simple scale, suitable for the youngest children, from sad to happy was used with three prompt questions that were read out by the teacher and pupils were asked to make a mark to indicate their feelings in response to each question. Pupils were then encouraged to use drawing and writing on the back of the sheet to express their feelings about using the PoDs. This produced approximately 800 individual pupil responses

3. **Teacher Diary Data**

Each teacher was sent, by email, a link to an online survey. They completed the diary entry each day for two weeks (second half of term 1) and by a weekly diary entry for two weeks (second half of term 2). The teacher diary entry data helped to give insight into the patterns of use of the Pods and software that emerge during the study and how this varies between teacher researchers. The teacher diaries provided an overview of the frequency, duration and broad design of activities using the technology.

The questions on the survey may be summarised as follows:

- Teacher researcher individual code
- Day and date of this diary entry / Did you use the technology during today? yes / no (if not go to question 9)
- Please give details of the FIRST time that the technology was used during today? Describe briefly in your own words how you used the technology, add the time of day, duration of activity (including the follow-up discussion) and the topic (making clear, if appropriate, the curriculum subject)
- Please give details of the SECOND time that you used the technology during today? Describe briefly in your own words how you used the technology, add the time of day, duration of

activity (including the follow-up discussion) and the topic (making clear, if appropriate, the curriculum subject)

- Please give details of the THIRD time that you used the technology during today? Describe briefly in your own words how you used the technology, add the time of day, duration of activity (including the follow-up discussion) and the topic (making clear, if appropriate, the curriculum subject)

- Please give details of any further times that you used the technology during today? Describe briefly in your own words how you used the technology, add the time of day, duration of activity (including the follow-up discussion) and the topic (making clear, if appropriate, the curriculum subject)
- Please comment overall on your use of the technology during today (even if you did not use it!). Why did you use (or not use) the technology today? How did it influence your teaching and the classroom learning environment? How did today reflect your professional learning and development over time in relation to the technology?

4. Teacher Learning Task Reviews

Each teacher received, by email, a link to an online survey for the learning task review. This data provides insight into the differing designs for learning tasks that teacher researchers develop and use with the technology and how they evaluate the impact of these activities in relation to pupil engagement, activities and challenge.

Each teacher self-selected three learning activities that they felt best illustrated the widest range of different ways in which they had used the technology during the previous weeks. Teachers were asked to complete the review of the task as soon as possible after the event so that their reflections would be more likely to be fresh.

For each learning task review the survey questions may be summarised as follows:

- Teacher researcher code / Day and date of the learning task
- List or outline the intended learning outcomes
- Briefly describe the task and how it used the technology
- Did the task ask individual pupils for an initial response or answer?
- Did the task share the 'whole class responses' with the class e.g. as a graph or list?
- Were the responses of individual pupils kept anonymous to the rest of the class?
- Were pupils asked to discuss group responses in buddy pairs or small groups?
- Were the class responses discussed in a teacher facilitated whole class discussion?
- Were the pupils asked the same question, or a similar question, again later in the lesson?
- Briefly explain in your own words the sequence of how you used the technology and the flow of questions, feedback and discussion.

5. Teacher focus groups:

In term 3 focus groups were used to generate collaborative analysis data. Teachers were presented with a concise summary of the emerging analysis and asked to respond. Nominal group technique was used with two groups of teachers partly because in the focus groups teachers seemed somewhat reluctant to challenge the emerging findings. Nominal group technique was used to more directly generate additional teacher perspectives data at this stage of the project.

6. Teacher professional inquiry:

In term 3 of the project, term 3, the teacher researchers pursued individual or small group teacher professional inquiry into selected aspects of the impact of the technology on their classroom strategies and learning environment. The core research team provided guidance and approved the use of suitable ethical approaches, methods of data collection and analysis.

3.3 Ethics

The ethical risks within the project are mainly around participating teacher researchers because the data relates to their classroom practice. Teachers will be invited to give formal consent for their data to be included in the research and have a right to withdraw at any time. Children will be told briefly about the research, with adjustment for different age groups, and will be asked orally for their consent when they have completed a pupil perspective template (annotating the drawings) or completing a simple survey using the technology. The ability of young children to give informed consent is a contentious issue but because the risks for the children are low in this case – for example they are not being interviewed – then oral consent is considered to be sufficient. The teacher judgments data is a more difficult issue and in this case it seems reasonable to consider gaining formal parental / carer consent. However, subject to us gaining ethical clearance (the project outline goes to an ethical panel as part of University procedures) we have decided not to obtain signed parental / carer consent forms. Rather, we plan to send a letter to parents with contact details for the teacher researcher and principal investigator, making clear their entitlement to ask questions and that they may instruct the school to withdraw their child's data from the research project. Ethics is not merely a matter of gaining formal ethical clearance, it is an ongoing issue for us during the project and requires us to monitor ongoing situations and respond appropriately where ethical risks or issues arise. Our general approach is to engage with the British Educational Research Association (BERA) ethical guidelines available at https://www.bera.ac.uk/wp-content/uploads/2014/02/BERA-Ethical-Guidelines-2011.pdf and to continue to discuss and monitor ethics throughout the project. A research ethics framework is particularly helpful within the high accountability context of schools.

4. Findings

This section outlines the qualitative data analysis. Selected teacher quotes from the data are provided to illustrate the themes generated during analysis.

4.1 School and Teacher Context

The sample of schools was wide in terms of their location (urban, suburban, rural) and in terms of the social mix of their catchment area (working class / middle class). The sample also included some schools with high levels of children with special educational needs and high levels of English as an additional language. The sample of teachers was wide in terms of their age and their years of experience. All of the teachers self-reported reasonable confidence and experience of using IT to enhance learning in the classroom. This is likely to have influenced their recruitment to the project and must be considered throughout the reading and interpretation of findings. The classes being taught were across the Primary age range in England from 5 year olds to 11 year olds with most of the children involved between the ages of 6 and 9.

The sample includes a varied range of schools, teachers and children but not in proportions representative at national level, for example for England. This means that in interpreting the data there is a need to seek variation and identify outliers as well as highlighting similarities. This is good practice in qualitative research and aligns with a complexity perspective on classroom practice.

4.2 Teacher Diary Data Term One

Most teachers (35/36) responded with completed diary entries. The diary data suggested that teachers were typically using the Pods once a day. Some teachers or teachers on some days used them up to three times.

The vast majority of learning tasks were self-paced activities mostly in maths. The maths tasks focused on basic skills and key facts such as times tables and number work. In English there were a considerable number of self-spaced tasks focusing on SPaG.

There were ad hoc tasks which mainly centred on the use of English. A mixture of questions and images were used to generate word banks. Often this was extended into noun or verb phrases, sometimes this additional task did use the Pods.

Some use of ‘hybrid’ tasks was identified. The Pods were used along with other more traditional approaches to teaching and other physical resources. One frequently used hybrid method was to combine the Pods with Big Maths. In particular CLIC activities seemed to be involved in this.

Teachers used questioning across a range of curriculum areas in order to formatively assess children’s knowledge and understanding of key concepts. Questioning was often used in English, particularly when discussing character development. Questioning was also used in other curriculum subjects such as Science. Sometimes this was in the context of practical choices such as the children nominating a prize winner.

4.3 Teacher Task Review Data Term One

An initial group of 27 task reviews were submitted online by teachers during the first half of April. This initial qualitative content analysis provides some insight into the design of learning tasks used by teachers at this early stage of the project. It includes the general evaluation by teachers of the tasks in terms of impact on learning. For each task reviewed teachers were also prompted to comment on engagement, on the self-determination theory elements of autonomy, competence and relatedness, and finally on level of challenge.

4.3.1 Design of learning tasks

The majority of tasks (19/27) involved a significant element of whole class discussion, usually by discussing and evaluating shared responses to ad hoc tasks. The majority of these tasks seemed to consist of a common task, for example a question or task posed on the screen or spoken by the teacher, which all children tackled as best they could. These activities relied on differentiation by support during discussion of the question or more often through discussion of the varied responses. The support came from peers and the teacher and sometimes a teaching assistant. Within this group just three tasks seemed to be truly using the 'peer instruction' approach of asking the same hard question repeatedly, for example three times, spread through the lesson, with paired discussion and some teaching activity in between.

A minority of tasks (8/27) involved a significant element of individual self-paced work, usually with some whole class element of introduction and plenary and in some cases informal paired work was mentioned. Some of these tasks presented increasingly more challenging questions to the children and in one or two cases children could self-select where to start or skip to a harder section if they were finding it too easy.

Teacher comments indicated that both types of task design were, in their judgment, leading to higher attainment. Sometimes with self-paced activity teachers claimed good progress of individual children. In the ad hoc activities teachers felt that many pupils benefited from sharing of vocabulary and ideas and therefore worked at a higher level.

4.3.2 Feedback / formative assessment

Not surprisingly perhaps, teachers frequently (31) highlighted feedback as a positive aspect of using the learner response technology. Some of these comments were referring to feedback during discussion with peers or the teacher but many comments focused on instant feedback provided via the pods:

> Immediate feedback to children, they knew right and wrong answers…Children could correct as they went as opposed to waiting for teacher feedback
>
> ((Task 3 1Gf Kitty Maths- To work out fractions of amounts (Learning objective taken from school learning ladders)).

Many teachers (14) commented on formative assessment that was useful to inform them, as teachers, of pupils' misconceptions or struggles and pointed out the advantage of being able to monitor this more easily using the technology:

> Children received instant feedback, marking completed for the teacher and analysis provided, children were able to correct work as they went as opposed to waiting for

> teacher feedback, freed up the teacher to allow them to work with children who were having specific difficulties, teacher could track progress during lesson and address any difficulties…
>
> (Task 3 2Gf Claire To divide 2 or 3 digit numbers).

Formative assessment, in terms of providing feedback to children and to the teacher seems significant. However, it is worth considering the quality and level of feedback involved. The feedback is constrained to task level (rather than including feedback at process level – focusing on strategies to improve ways of working or at metacognitive level provoking self-assessment). However, feedback in some task designs includes seeing the answers of other children and this does provide more sophisticated feedback than simply right / wrong responses. Feedback in some task designs includes peer and teacher feedback on answers and by involving children in evaluation activity this may arguably reach process and metacognitive levels of feedback.

4.3.3 Anonymity

The anonymity of responses sent via the pods is claimed in the literature to avoid inhibitions of students. However, this may well be the case with multi-choice questions in large groups of older students. The issue of anonymity seemed more nuanced according to the perspectives of teachers of these young children in smaller classes of around 30 pupils.

Some teachers identified the benefit of anonymity in that it increased the confidence of the children and engaged all children in responding, compared for example to 'hands up'. For example, in response to the SDT prompt on autonomy, competence and relatedness:

> All answers were anonymous helping competence. They were also all collected and displayed helping relatedness. They were also able to answer freely and truthfully due to it being anonymous which helped autonomy
>
> (Task 2 1Kf Laura To have a better understanding of e-safety).

And responding to the engagement prompt this same teacher considered the pods to have very positive impact on responses and confidence:

> I found all children were really engaged with the task, particularly my reluctant writers. Children who would normally groan at the idea of writing were happily texting in ideas. It also provided vocab for them to 'magpie' [collect ideas from others] which helped with confidence issues. In addition, it motivated my higher ability writers to pull out all the stops and send in something really good!
>
> (Task 1 1Kf Laura I will be better at writing an adventure story I will be better at describing the setting).

In some classrooms however, the teachers detected social issues around the sharing of responses that have errors, including spelling errors:

> …spelling errors sometimes caused amusement, when writing on whiteboards children are able to uplevel/edit/improve but once submitted children were unable to change [their responses using the pods]…potential of embarrassment of putting inappropriate words/language up, children lacking in confidence when sharing ideas…
>
> (Task 1 2Fg Claire To describe a setting).

The impact of the Pods on the learning environment is perhaps to highlight social relationships and rules that previously existed.

4.3.4 Level of challenge

Teachers often rated their task involved 'remember' and other lower levels in the cognitive process domain. However, sometimes the question on the pod was quite basic but the teacher felt that the conceptual learning occurred in the dialogue discussing different responses:

> …remember previous learning and recall existing subject knowledge, after the activity they had to show understanding of the concept by applying what they had learnt in relation to the concept cartoon. Had to justify their thoughts before and after the activity, including why they had changed their initial responses…
>
> (Task 2 1Gf Kitty To understand why stars are not visible during the daytime and address misconceptions surrounding this).

Teachers considered that a similar pattern occurred in some other kinds of pod tasks. The first pod task began at the level of description, but the the teacher points out that they had to understand description and then construct descriptive phrases. But the highest cognitive level was in evaluating the sentences produced by other children.

> The children had to understand how to describe Mr Twit and understand how to use the words to make expanded noun phrases. Children also had to 'evaluate' the sentences on the board by providing improvements for their peers work
>
> (Task 1 1Hf Kate To write a character description using expanded noun phrases).

In some tasks the teacher felt the children were basing their decisions on 'remembering' facts or ideas from previous teaching' and in this way the pod task may be viewed as formative assessment:

> …children had to remember what they had already learnt about light and shadows in order to decide if the statements were correct/incorrect
>
> (Task 2 1hf To understand how a shadow changes size).

Even if the teacher felt the pod questions provoked a higher cognitive process level such as 'analysis', still they recognised the added value of the discussion of responses:

> This task looked at factual analysing as the children had to decide which of the answers were correct (thinking about what is the correct answer as well as which applies to their life). It stimulated much thought but wasn't above their capabilities and provided good discussions over e safety
>
> (Task 2 1Kf To have a better understanding of e safety using a quiz).

One task included data collection, eye colour, and then went on to ask questions about the graph produced. This demonstrated a similar pattern of raising the level of cognitive process from an easier entry level question.

Teachers evaluating self-paced tasks felt that differentiation provided by self-choice or self-levelling tasks was effective in challenging all pupils:

> The leveling system on the software allowed all children to be appropriately challenged during the session. All of the children were able to contribute throughout the session therefore engagement was high.
>
> (Task 1 2am to interpret data from a bar chart).

One teacher prepared and set a sentence completion task for the whole class and subsequently felt that it was too easy for some children who then waited for others to complete it.

4.3.5 Constraints

Some teachers (7) commented on the issue of children waiting whilst others took longer to compose and submit an answer, such as a phrase or sentence to an open ended question. Another issue raised compared the use of mini whiteboards to the technology. The whiteboards are seen as better at allowing editing before submitting an answer. Finally three teachers mentioned the possiblity of silly answers being posted although only one said that this had actually happened.

4.3.6 Summary

The teacher diary entries reveal some patterns of use of different kinds of tasks within a range of curriculum and a full analysis will be useful in identifying patterns of use. Clarification of different styles of task is needed to ensure more accurate data entry. Some development of the data entry process would be useful.

The teacher reviews of learning tasks provided some insight into task design and perceptions of learning impact:

- Many teachers are using 'ad hoc' questions to provoke paired or often whole class discussion of shared answers and they see that discussion as feedback to provoke learning and also as differentiation by support
- One or two teachers are using the 'peer instruction' method of repeated attempts at the same question without revealing the correct answer, with paired discussion, teaching and learning activity, or class discussion in between attempts
- Some teachers are building a sequence of open-ended related tasks on the technology, for example requiring descriptive words, then noun phrases and finally sentences…
- Some teachers are using 'self-paced' questions and these get progressively harder or the children self-select their starting point and level of challenge, teacher see this as effective differentiation by task
- There were some constrasting opinions from different teachers concerning the making of errors in spelling or incorrect answers – some cases this might be a source of amusement but in others was more supportive
- In one or two classrooms teachers felt that children may have constrained the ambition of their answers to avoid the worry or 'embarrassment' of not spelling words correctly – in other cases teachers felt the children really embraced the anonymity and also the opportunity to share so stretching children on lower and higher prior attainment

4.4 Teacher Diary Data Term Two

By this time the teachers and their classes had been using the learner response technology for 5 months.

Table 2. Summer term Phase 2 teacher diary results - based on 36 one week entries (incomplete data).

Mean	1.6 per day
Minimum	0.4 per day
Maximum	5.4 per day
Median	1.4 per day
Maths recall tasks	37%
Spelling Punctuation and Grammar (SPaG) recall tasks	14%

This simple count of diary entries per day, calculated as a mean across the sample of teachers gives an indicator of frequency of use of the technology after six months of its introduction to the classroom. The purpose of collecting this second round of teacher diary data was to gain an estimate of frequency beyond the period of any 'novelty' or 'honeymoon' period. The teachers submitting data at this time (n=18) were using the technology more than once a day. This included variation within the sample of a small number of teachers using the technology just two or three times a week and a small number of teachers sometimes using it up to five times a day.

The diary data also allowed the research team to interpret the types of task that teachers were using the technology for. Maths recall was clearly the most frequent type of task (37% of tasks recorded) and much of this was basic testing of memory recall of the times tables. A significant proportion (14%) of tasks recorded focused on recall of spelling, punctuation and grammar (SPaG). This means that at this settled stage of introduction of the technology around half of the tasks it was used for were testing recall, although it must be pointed out that sometimes the recall activity itself would be used to provoke goal-setting, reflection and in some cases buddy-talk to discuss successes and errors.

Unfortunately, the timing of this period of data collection put it close to the end of the academic year, which in England is mid-July. The main government attainment tests are completed in May / June and after this time many Primary schools in England tend to broaden the curriculum and begin to include a more varied programme of activities including day visits and residential trips. This created a challenge for teacher researchers because they did not have a two week period completely in the classroom and this is likely to lower the mean frequency of using the technology.

4.5 Teacher Task Review Data Term Two

During phase 2 of the project, the second term, teachers and their pupils had been engaging with the classroom learner response technology for a considerable period and any kind of novelty or honeymoon effect seems likely to have worn off. Teachers were asked to select three learning activities, classroom tasks, in which they had used the technology and to critically evaluate them.

The number of their responses in each curriculum subject does not provide a fair indication of frequency, the diary data is more suited to that. However, as part of the review the teachers were prompted to comment on how representative the task was of their practice and this provides some indication of frequency. Teachers chose to review tasks from maths, English and other subjects in roughly equal proportions although with slightly more maths and English than other subjects. In making this distinction we defined English tasks through the explicit focus on some aspect of spelling, punctuation or grammar. In a small number of cases these were difficult to distinguish from tasks in other subjects that focused around writing activities. Perhaps more significantly than frequency, teachers appeared to favour particular ways of using the technology within different curriculum subjects.

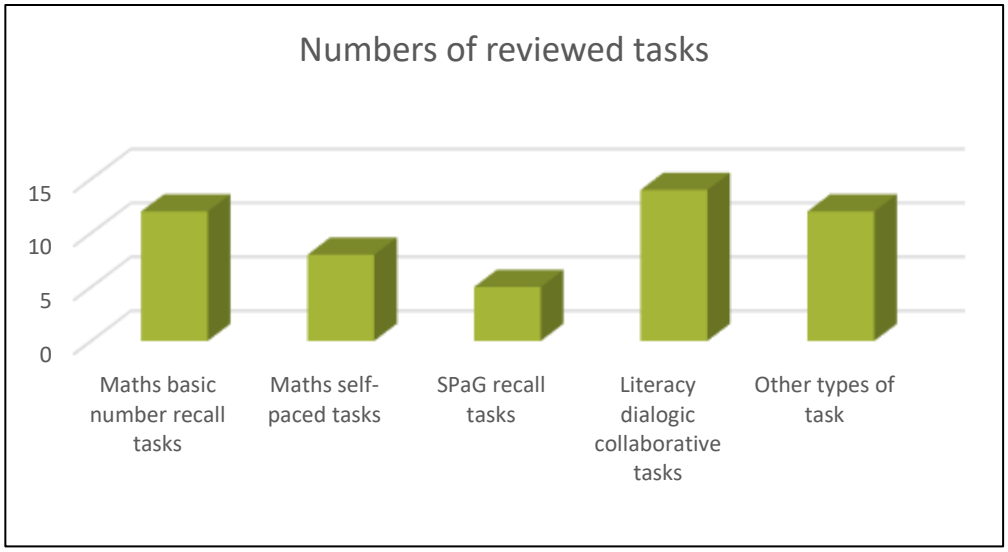


Figure 6. Numbers of reviewed tasks.

For example, in maths teachers reviewed many tasks that focused on testing and developing recall of times tables or key number facts. Often this involved individual work by pupils, although in about one third of such tasks reviewed the teacher did make some reference to a limited amount of paired or whole class discussion. The teachers reported high frequency of this kind of short focused task in maths, referring to between twice a week to every day. The regular use of recall tasks on times tables and key number facts is not surprising and this would be a typical feature of these classrooms before access to the learner response technology. It is worth noting however the comment of one teacher whose school is implementing the Maths, No Problem! mastery approach scheme, who described the separate use of the technology for times tables and stated that: 'This activity is typical of how we use the devices in maths as the Maths No Problem approach that our school uses does not allow for the use of devices in normal maths lessons'. The mastery approach in South Asian influenced schemes such as Maths, No Problem! involves exploratory collaborative learning through paired and whole class discussion. The teacher's perception of a conflict between the mastery approach adopted across the school and the use of the learner response technology reveals a pedagogical tension. Only a very small number of reviewed tasks using the technology in maths were focused around sharing ideas and provoking discussion or collaboration. The teachers did review 'self-paced' tasks in maths that moved beyond times tables and key number facts. This is where the children were working on a set of problems individually, but in some cases with some level of paired discussion possible. The children are often working in their exercise books but submit answers via the Pods and this provides them with basic feedback, correct or incorrect, and enables the teacher to monitor progress across the class and offer individual support, as required.

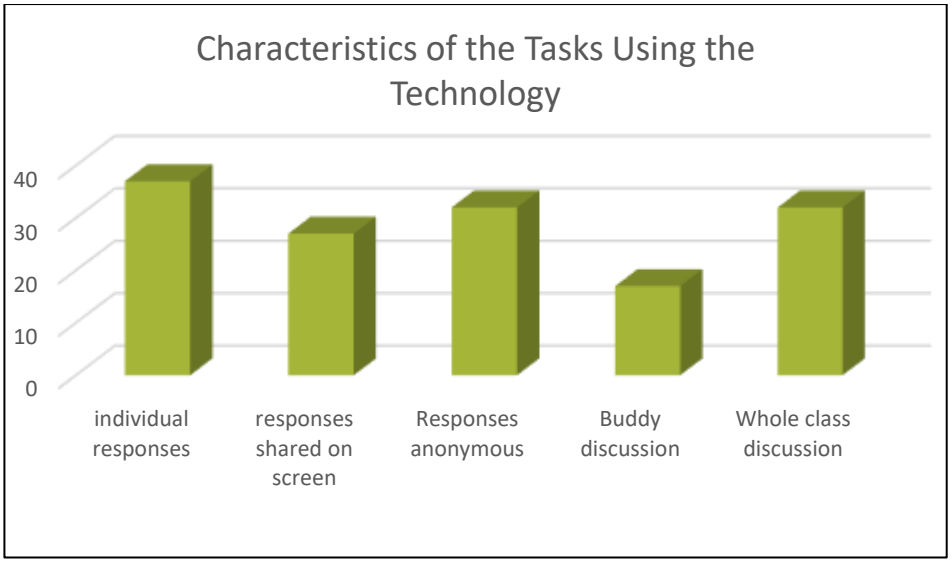


Figure 7. Characteristics of the tasks using the technology.

In the curriculum subject of English all of the tasks reviewed by teachers involved some level of sharing ideas, collaborating or peer review. This provided a strong contrast with the maths tasks. One teacher described the design of a task in English as 'open ended' and perhaps this captures the different way that teachers see the subject of English compared to maths. The teachers then design a learning activity that uses the technology to support self-paced individual learning or more collaborative discussion based learning. Two of the tasks reviewed in English were comparable to the short sharp focused self-paced maths tasks involving times tables and key number facts. These English tasks focused on testing and developing specific aspects of spelling, punctuation or grammar.

In 'other subjects' examples of tasks reviewed included curriculum subjects of geography, history, art, philosophy and science. All of these tasks were designed to provoke discussion in pairs or as a whole class.

4.6 Children's Voice Analysis

During term 2 of the project teacher researchers gathered pupil voice data to consider their perspectives on using the technology using a sad face - smiley face line chart prompt sheet in the classroom and then teachers encouraging the children to record their feelings towards using the Pods using drawing and writing on the back of the sheet. This simple scale was suitable for all ages and abilities of children to record their response to three prompt questions that were read out by the teacher. Pupils were also given the opportunity to use drawing and writing on the back of the sheet to express their feelings about using the PoDs. This produced approximately 800 individual pupil responses.

The data were analysed in two ways:

The line charts asked individuals to record their response to three questions. Children recorded their response by marking on a line from 'agree' to 'disagree'. These responses were transferred onto a master sheet for each cohort and to summarise the pattern of the responses for all cohorts using a simple 'eyeball' method.

The children were asked to draw or write a response about using the Pods. These comments were listed for each cohort and the comments were grouped into themes arising from the data for each cohort and then summarised across cohorts.

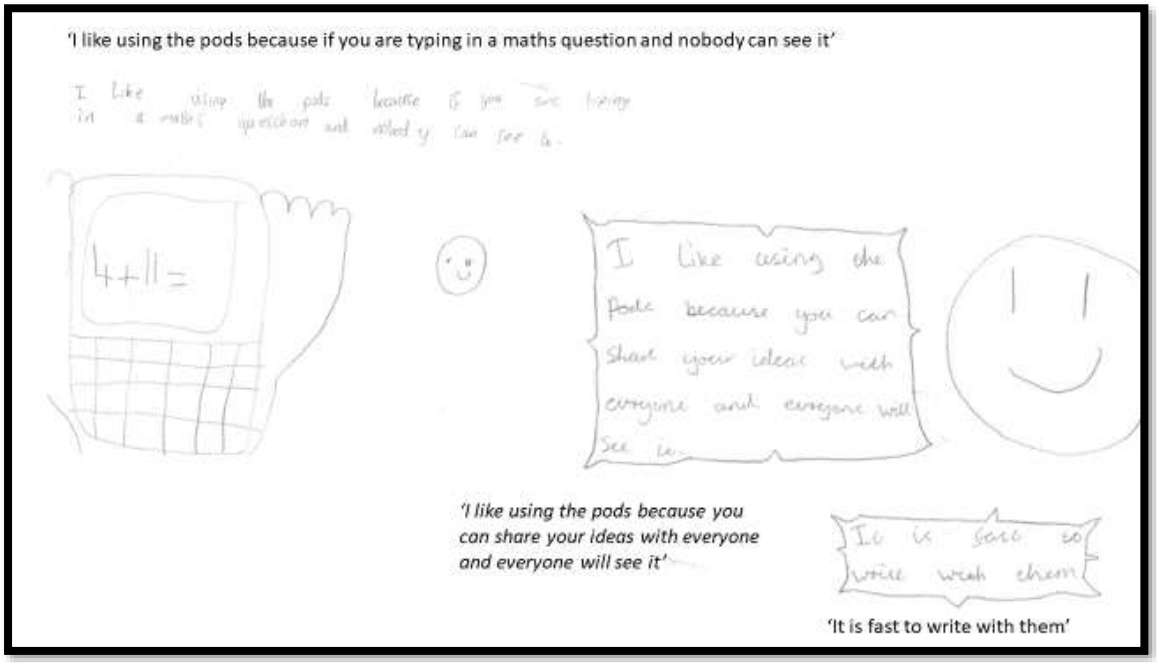


Figure 8. Examples of pupil responses to the classroom learner response technology.

Summarised findings from the line charts

Using the Pods in lessons is fun: Responses in most cohorts were typically at or towards the 'agree' end of the scale with few at 'not sure' and fewer at 'disagree'. This would suggest that most children in the survey enjoyed using the Pods in their lessons.

I like sharing my answer with everyone: Overall, there were large groups at 'agree' and slightly smaller groups at 'don't know' and small numbers at 'disagree'. In general, cohorts tended to cluster towards 'agree' but there was a long 'tail' of responses across the cohorts towards 'disagree'. The variable number of children who expressed dislike of sharing answers suggests that the classroom environment is an important factor in how children respond to this feature of Pod use.

You can give your best answer and it doesn't matter if you make a mistake: Responses in most clusters showed large groups at 'agree' with smaller groups at 'don't know'. Some children disagreed with this statement but as with the previous statement, this would appear to be influenced by wider classroom environment factors.

4.6.1 Findings from the written responses

The written responses varied across cohorts and it is unsurprising that it appeared that older, more confident writers provided lengthier and more detailed comments on the use of the Pods. Overall, the comments across the cohorts were generally positive and reflected a diverse range of ways that the Pods were used in class. Respondents made positive comments about them being used for quizzes and in-lesson tests, giving opinions to the teacher, and sharing ideas with other children and children recognised that such activities could be applied to any subject. Children most frequently commented

on the Pods being fun, allowing repeated responses and providing immediacy of answer. A clear message from the written responses was that the pods were used frequently, they were motivating and fun to use and they helped learning.

At the same time, a smaller number of children in the sample expressed negative opinions about the Pods. These children tended to centre largely on the exposure of their 'mistakes' to public view within the class and there were a small number of children who resented other children 'copying' ideas or

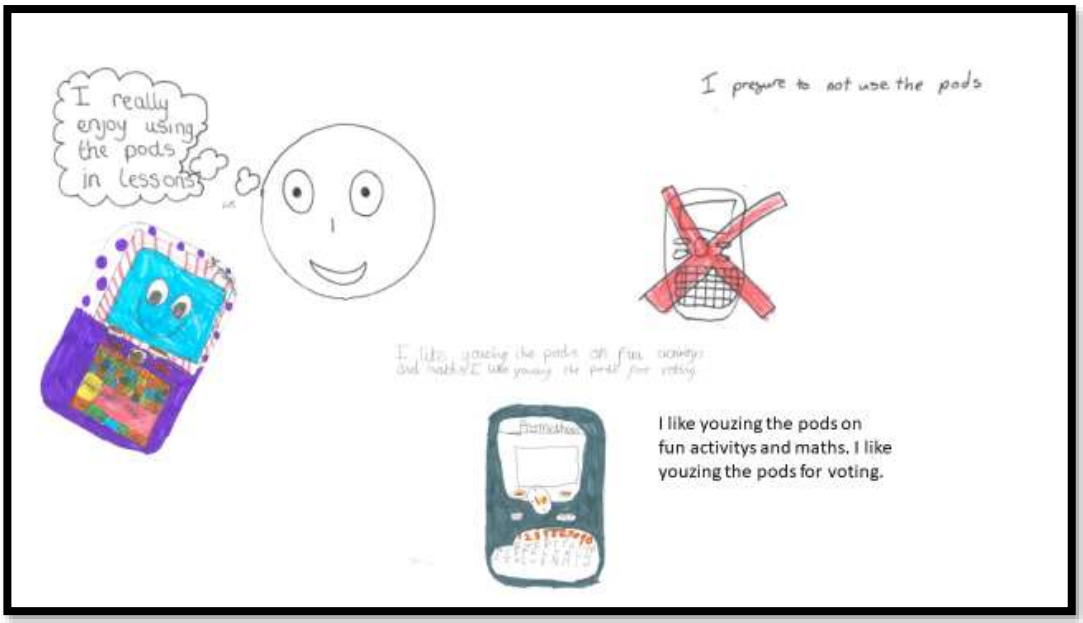


Figure 9. Examples of pupil responses to the classroom learner response technology.

answers. However, this aspect would appear to be related to the wider classroom environment because although a number of cohorts contained children who made such complaints, one cohort contained many children who saw this as a key advantage of how Pods were used in their class. In this cohort, many children enjoyed the opportunity to share ideas and learn from others through discussion of their work, including offering (and receiving) suggestions to improve or correct their work. This would suggest that Pods may be most effectively used where the wider classroom environment reflects practices and beliefs associated with sociocultural theories.

The written comments from the children provided evidence that teachers used Pods in a diverse range of ways but also revealed hints that variation in how they were used reflected broader differences in educational practice. For example, children in one class (2IF) included a number of comments with the phrases 'word seed' and 'brain boxes' which suggests that the teacher had considered how to use the technology and how to engage the children in their use in a way that other classes didn't. In this cohort, children's comments were noticeably more positive than in any of the preceding cohorts and over 21 of the 26 respondents made expressly positive comments about the Pods or their use. Similarly, children in cohort (1Mn) made a number of comments to suggest that the Pods had led the teacher to adapt his teaching methods. Examples of this included 'not having to put up hands to answer questions', 'hand not getting sore from writing' and preferring the Pods to worksheets. Children in this cohort explicitly referred to using Pods to 'magpie' (garnering ideas from other children's work and applying them to one's own work), correct mistakes and improve work. This suggests that effective use of the Pods combines overt teaching of how to best use the technology that goes beyond the functional use of the equipment along with matching the features of the technology to metacognitive skills such

as risk-taking, learning through mistakes, flexibility and to using the Pods within a sociocultural or social constructivist approach to teaching and learning.

4.7 Teacher Focus Group Analysis

Thematic qualitative analysis of the focus group data generated in term 3 of the project identified three interconnected themes: engagement for all; assessment for learning; and collaboration and dialogue. These are presented here with illustrative quotes from teachers.

4.7.1 Engagement for all

Overall, the teachers report a very positive response from using the technology in terms of engagement of children in their class:

> …I find that my, the percentage of the children that engage with the question or that will answer a question has increased steadily as the time I've used them has gone on…

This engagement is seen by teachers as influencing the keen children:

> …a lot of the children in my class are desperate to tell you the answer and you haven't got time to go round and ask everybody the answer…so they all get to have a go at putting the answer on.

But it also encourages the more reluctant and brings them into the lesson, including providing information for the teacher on their thinking:

> …it encourages the more reluctant ones who kind of do sit back in discussion time and don't put their hand up - they have to give an answer so you can kind of see what they're thinking…

In this way the theme of engagement overlaps with formative assessment and with the issue of anonymity:

> …I've found that it encourages more of my reluctant learner to have a go in that sense in doing it because they know that the rest of the children aren't going to see that it's theirs.

Perhaps with older children this encouraging aspect of the technology is even more important. This longer quote from a year 6 teacher is worth considering in full because it strongly relates to the classroom as a learning environment:

> I've found, especially for my lower 'ability', it's been amazing. Children who are in Year 6 that struggle with spelling particularly they wouldn't write anything on a whiteboard or they would write something really basic because they'd be worried they'd spell it wrong and they don't want to hold a whiteboard up and everyone to see them holding that response, whereas on the pods these particular children have been much more open to trying to make it the best sentence they can, rather than just writing their own basic sentence that they can spell so they're quite happy for it to go on the board with lots of words that are incorrectly spelt because no one knows it's them because there's a couple of children in the class that have got the same issue so they're really happy to try their best to put a really good sentence in there and send it off on the screen. It's an amazing sentence and yes there are spelling mistakes but the children in the class don't go 'oh well that's spelt wrong. Who was that?' There's not that atmosphere in the classroom so they're happy to - not that there is with

> whiteboards but they just, they feel happier to take that risk and to send something off that they wouldn't have previously and then if there's something that's really good, the children are like 'oh that's amazing. Whose is that?' and the child, if they want to, will say 'oh it's mine' whereas if they don't want to they just don't say it and no one says anything so it's worked on both ends of the scale in my classroom really well.

The teachers compare the technology to their previous and in some cases ongoing use of mini whiteboards:

> …one of the things that they're [pods are] better for than a whiteboard is the children sitting next to them can't necessarily see…what they're writing whereas if it was on a whiteboard there'd be a group of maybe three or four that had the same wrong answer because some of them had got the wrong answer and two or three of them had copied it, whereas on a pod it's harder to do that because it's obviously a much smaller screen.

Teachers suggest that repetition of a task is not seen by children as onerous or boring when using the pods and an element of competition, with themselves or with other children, comes into play when using the technology:

> I've found that in my class that the children want to improve each time if we repeat an activity and it's finding a quick way to do that to check on their assessments that are on my computer.

Despite the passing of time, long beyond the phase of the pods being a novelty, the teachers are reporting during term 3 of the project that the technology helps to engage a wide range of children in the classroom.

4.7.2 Assessment for learning

In the focus groups, the teachers did not generate a great deal of data around formative assessment and feedback although they did consider the limitations of feedback using the technology. However, it is important to note that in the nominal group technique 'providing feedback', the simple fact that the children get instant right or wrong feedback during self-paced activity was seen as the highest scoring factor. This was seen as providing instant feedback, but also saving teacher time on marking, and guiding the teacher to intervene.

Some issues were raised around the limitations of simple right or wrong feedback from the technology and teachers mentioned strategies to extend this:

> …rather than just saying "yes, you've got it right" or "actually no, the answer's this", using it in a more - an approach where they can share it with their partner or something so you would say "brilliant. That's the correct answer. Explain to your partner how you worked that out" or you know maybe it would be to challenge someone to something else. "Can you think of a question for your partner that is similar to this one?"

In designing self-paced tasks teachers identified the need to think carefully about building in useful feedback:

> …I think that the important part is what you programme in for it to give as feedback because…you won't get around all the children but if you've got a good sentence in the feedback about how they could approach it in a different way, then that encourages them to

evaluate their own learning and the way that they've approached the question.

In addition to right or wrong feedback from the technology, teachers recognised the value of peer feedback, for example on mistakes:

> I think especially if you put them up on the board, especially the higher children can kind of comment on mistakes and then the lower children can kind of listen to them and they can kind of almost teach the lower ability what's wrong with their sentences or what they maybe need to add in or even some of them with the higher abilities, they can discuss how could they up level that sentence; what could they improve? So I think they quite often learn from their mistakes using the pods.

This peer feedback is seen by some teachers as helping to develop self-assessment and encourage goal setting by some pupils:

> One of the other things as well is, basic as it may seem, is that some children actually use the pods to 'uplevel' their own work which they wouldn't normally do within a workbook because they're so conscious that it's about to be posted to the board so capital letters and commas that would usually be missing or full stops tend to appear and you're like 'oh gosh I didn't know you knew how to use them'. But it's because of that sort of publicity aspect of it that children almost feel safe because names don't have to appear next to it but they're also conscious still that actually their work is going to appear and somebody may go 'well that sentence is missing a capital letter; that one's missing a full stop' so those children that would normally be a bit blasé about it, start uplevelling it without even having to think.

In order to raise the level of thinking and learning, and to mitigate the limitations of right wrong feedback, teachers explained how the technology would be used alongside hard copy more traditional notebooks and recording of working out:

> You don't just have to use them as a pod themselves either because they can use it as a question base but then they could actually show their thinking and their working in a hard copy if you like so they could have a jotter book and then they've answered the question on the pod but they've actually shown all their working within their jotter so that you can see their thought process and so can they so that they can then explain how they've done it.

Despite the potential benefits of anonymity the situation is often more nuanced and teachers feel that the children value the choice of anonymity but sometimes choose to reveal their ownership of a particular answer or of a score in a task:

> Especially with tables in my class because their times tables are now better than they were, they seem better to share the results at the end of our tables test, they ask me to put the levels on the board and they say 'oh well done such and such, you've done really well' so they don't actually want it to be anonymous anymore because they want to share how much progress they've made.

The teachers seem to acknowledge that the technology is shaping the classroom learning environment, for example in terms of valuing mistakes as learning opportunities:

> I actually find, with my particular class, that as we've used the pods more and more they're actually keen to know about themselves. They're not seeking anonymity I don't think; they

> actually understand that it's OK to make mistakes; that they actually learn from their mistakes.

Overall, the assessment for learning element of the technology is valued by teachers in terms of providing feedback, reducing marking workload for teachers, and enabling monitoring and effective targeted support for children who are struggling. However, teachers also identified some limitations of the technology and developed strategies to mitigate these.

4.7.3 Collaborative learning and dialogue

The teachers comment on the way that the technology supports collaborative learning, especially when using 'whole class' questions. The borrowing of ideas from other children is often referred to as being a 'magpie' by collecting ideas from others:

…they all send something and it comes up on the screen, the children will sometimes look at the answers up on the board and they'll think 'oh hang on, maybe I could add that into my own' so it gets them thinking about their own answers and how they could they improve their answers and how can they use that and kind of take other ideas from other children to help improve their own work…

Sometimes this is in the direction of children with lower prior attainment borrowing from higher prior attainment children:

> …the higher ability ones would use the phrase or would use the adjective that was new to the class, that it was the middle to lower ability ones who were then putting it into their writing and the higher ability ones weren't using any of the phrases that they'd come up with so it was helping - it's almost like peer teaching almost - try this phrase or try that…

But in some cases children with high prior attainment were surprised by new words and responded by working with them to understand and properly use them:

> They do quite often come with new words that they've then sort of put into sentences which sort of makes sense and then the higher ones, you can have that discussion of what does it actually mean? Go and find it in the dictionary and then sort of how are we going to sort of build the sentence around the word rather than just throwing it randomly into a sentence.

Some teachers felt that identifying low threshold, high ceiling questions was a challenge and this reflects their hesitancy in using whole class teaching:

> I think it can be tricky with ad hoc questions to - because using the pods, obviously you have pretty much everyone working on the same question, with self-paced ones obviously you can set different levels for them. With an ad hoc you need to word it in a way that it's accessible to everyone but then the higher level thinkers can then push themselves to develop better answers so it's difficult sometimes to come up with a question that will do that for every single subject. Sometimes it lends itself to that; sometimes it doesn't.

And in this way some teachers see the benefits of collaborative learning as primarily of benefit to the children of lower prior attainment.

> …for example in writing, sometimes children think well what's the point of me using a colon or whatever it is? Why am I being asked to use this? Where if it's on the board and some people have used it and some people haven't, it gets the children having that discussion as to 'oh well actually that sentence is really good. Why is it?' 'Ah well they've used a colon' and it gets them into thinking about the purposes of certain things which is kind of that higher level discussion.

Teachers consider anonymity to be generally helpful in developing sharing of answers by children and this seemed to apply across the age range from year 1, five years olds, to year 6, ten year olds:

> I find that the [year 1] children like it, especially the ones that aren't as confident about their answers and they're a bit worried about getting it wrong, because they know that nobody's going to know that it's their answer, especially in Maths they're more likely to have a go at a question they would not normally have a go at; they'd just not do it because they were too worried about it whereas they're actually having a go and they don't mind if they get it wrong; it doesn't matter.

Although with older children they understand that despite anonymity with the other children, the teacher knows their answers and mistakes:

> I find [with year 6] that they have confidence that it's anonymous from their friends and they have confidence that I won't say who has given a particular answer but they don't have any confidence that I won't personally look at who's given which answer, so they still don't feel that it's completely anonymous because they feel that I'll be able to see who's written what so as far as risk taking I don't particularly think it encourages that because they still think my teacher's going to see my answer, but in terms of anonymity from their peers then I think it encourages them to share something with the class that they would share with me anyway but not to share anymore with me.

Overall, teachers recognise the value of the technology in creating collaborative learning and promoting dialogue, but this is sometimes in tension with the value they place on differentiation by task.

4.7.4 Limitations

Teachers identified limitations of the technology. The predominance of closed questions, the frustration of children when a minor error creates a 'wrong' answer, the fiddly nature of the keyboard for younger children in particular, and that it is time-consuming for the teacher to construct more sophisticated tasks. There is also a tendency, noted by teachers, for the technology sometimes to create a need for speed, pupils enter their answers promptly and then are unable to develop them further.

4.8 Nominal group technique results

The nominal group technique results complement the focus group analysis and the full outcomes are presented in Table 2.

Table 2. Summary of the teacher nominal group technique analysis.

Factor title and total teacher votes	Raw data comments from teachers on components with votes	Teachers rank order for factors and comment from analyst
Assessment and feedback 143	Immediate feedback for children 9 Instant feedback support and prompt children to ask for help 8 Children get immediate feedback 7 Self-paced activities are great for self-assessment 7 Can allow for and provide instant feedback to children 7 Immediate feedback for every child 7 Instant feedback to pupils 6 Children receive instant feedback and reduces marking ☺ 6 Instantly able to see children's contribution allowing feedback 3 Allows pupils to self-assess / self-mark their own work 9 Save children's responses which would be lost on whiteboards 8 Method of assessment 8 Quick form of assessment to inform intervention 7 Allows teacher to intervene when needed, not next day after marking 6 Data can be saved to show progress 7 Save marking time 9 Quick and easy to see questions / areas where children are struggling 6 Data produced instantly 5 Good for assessment 4 Allows peer feedback on a larger scale 4 Results collected and stored immediately, no marking! 3 Assessment records easily accessed 3 Teacher can access easily on screen – can see how each child is doing 3 Easy to access, look at screen 1	Feedback – Rank 1 Helps to provide formative feedback for children and reduces the marking workload of the teacher. Works through instant right / wrong feedback during individual work but also by informing the teacher of who is struggling so that they can give feedback. Formative feedback as diagnostic for teacher and for recording progress with reduced workload benefit.
Engagement 58	Anonymity so children confident to have a go 8 Highlights which children are actively engaged 5 Increase engagement of lower attainment pupils 5 Novelty gets children doing unenjoyable tasks 4 Tech sparks children's interest and engagement 4 Different, enjoyable way of learning 3 May decrease confidence eg name on board 2 Immediate engagement of disaffected pupils 2 Giving confidence in using tech independently 2 Encourages reluctant writers 2 Encourages accuracy in English (spellings etc) 2 Can improve confidence 2 After a while children are getting bored 6 Easy to spot 'active' children 6 Slowing down higher attaining as they wait 5	Engagement – Rank 2 Encouraging and engaging for many children, but some perception by teachers of frustration for high attainment pupils.
Pace 49	Better suited to some subjects 9 Slow typing impacts on time during lesson 9 Children can work at their own pace 7 Slows down lessons that may have been quicker 7 Work at own pace during self-paced questions 6 Not as quick as in white boards for literacy 5	Pace - Rank 6 Some slowing of pace during whole class work but benefits for

Factor title and total teacher votes	Raw data comments from teachers on components with votes	Teachers rank order for factors and comment from analyst
	Can be slower than individual mini white boards 4 Allows response from all children quickly 2	inclusion and self-paced activity.
Basic Skills 40	Good way to practice basic skills eg times tables 10 Helps build speed eg times tables and arithmetic 8 Consolidates basic skills in maths /SPG 7 Good for times tables practise 5 Some children gain confidence on pods compared to whiteboards 4 Opportunity to quickly revisit key concepts 3 Children become more familiar with keyboard 3	Basic skills – Rank 3 Valued for basic skills practice.
Technical 36	Children frustrated if input errors mean no marks 9 Technical issues at start or half way through 7 Limited characters for children to write fully 6 Limited characters for responses 5 Limited characters and space on screen 3 Not always accurate - typos or submit in error 4 Some training needed for children 2	Technical - Rank 4 Some technical limitations: slow typing on small keyboard, input errors leading to no mark, limited characters, and occasional system problems at the start or during lessons.
Collaborating 35	Not all children enjoy sharing their ideas 11 Lower attaining children magpie ideas 9 Visibly sharing ideas to prompt discussion 8 Some good ideas shared by others 7 Able to share ideas quickly 3 Harder to copy from other learners 2	Collaborating – Rank 5 Promotes sharing ideas but with some tensions identified by children.

The nominal group technique results seem particularly important because they highlight teacher recognition of assessment for learning as the key contribution of the technology to their classrooms. The results also show relatively low priority given by teachers to collaboration and dialogue.

Would we be right to assume that teachers are primarily forming their views based on their experiences and observations in the classroom during day to day practice? If they are informed by public knowledge such as the literature then perhaps teachers in England are more aware of the research evidence base for impact of formative assessment and less aware of the evidence base on collaborative learning and dialogue? Is it possible that the high accountability policy framework, with huge emphasis on attainment in public tests, tends to focus teachers on assessment and monitoring rather than on classroom culture, collaboration and dialogue?

5. Discussion

The classroom learner technology lends itself to instant feedback on closed recall test type activities and many teachers take advantage of this by employing the technology for frequent individual tasks, in many cases using the technology at least twice a week and in some cases every day, on times tables and number facts as well as less frequently on spelling, punctuation and grammar. In about one third of these learning activities there would be some buddy talk, but this was usually incidental rather than an explicit element of the teachers' strategy. The focus group analysis provided some insight into the use of the technology for these learning activities which in effect are recall 'tests'. The technology seems to help make repetition acceptable and even fun. The use of the technology involves getting ready, perhaps some informal discussion during activities and then debriefing of some kind that may help to make the 'text' itself seem less summative and more formative in nature. The children know that the teacher knows their mark but the process of recording is automatic and so perhaps becomes less visible and therefore less significant. Teachers reported children choosing to reveal their marks and becoming more relaxed about anonymity. This finding around use of the technology for recall connects to the wider point that use of the technology does not seem to have suffered from 'Pod Fatigue'. The teachers and their children do not seem to have enjoyed the novelty of the technology and then become disillusioned as it became more familiar. Rather the technology has found a place in the classroom as just part of 'what we do'. The use of the technology for individual activities created some tension for one teacher whose school had introduced a Singapore mastery maths approach which encourages exploratory problem-solving through buddy dialogue and whole class discussion. This teacher did however use the technology for practice of times tables but not in his scheduled maths lessons 'because my school's Maths - No Problem!™ approach does not allow for the use of the pods in 'normal' maths lessons'.

Teachers also used the technology for self-paced individual learning with the children in maths often working in jotters to show their working and reporting the answers to questions via the technology to get feedback and allow teacher monitoring. These self-paced tasks were not specifically designed to encourage pupils to talk to each other but rather as individualised learning with any classroom dialogue only occurring incidentally, for example during set up or debrief of the learning activity. The teachers particularly focus on assessment for learning when identifying the benefits of using the technology, with particular emphasis on the children getting instant feedback but also in relation to self-assessment and to the gathering of assessment data for teacher monitoring during the activity and for recording progress in the longer term. From the teachers' perspective the self-paced activities were effective for engagement and for learning power. Teachers used the ready-prepared materials provided alongside the technology but found the preparation of their own materials somewhat onerous and the limited amount of ready-prepared materials seems to have placed a lid on the use of self-paced activities by teachers. The teachers used hybrid activities, where the children are basically working with traditional materials and showing their working in a jotter but reporting their final answers to each question via the Pod. This hybrid activity may be seen as a work around by the teachers in response to the lack of suitable prepared materials.

The teacher focus group analysis indicated their belief that 'engagement' is a key benefit of the technology. This was also present in the teacher nominal group technique analysis although in this case assessment for learning, in particular the way that the technology supports formative assessment through instant feedback, was especially highlighted by teachers alongside increased 'engagement'.

Whilst the teachers did particularly highlight formative assessment as a benefit of the technology they were aware of the limitations, for example in terms of the quality and impact of feedback. Feedback via the technology that consists of 'correct or incorrect' was recognised as of value, but of limited value, and the role of the teacher was seen as important in providing more informative feedback, that was likely to provide strategies for improvement or provoke metacognition:

…I think that the important part is what you programme in for it to give as feedback because…you won't get around all the children but if you've got a good sentence in the feedback about how they could approach it in a different way, then that encourages them to evaluate their own learning and the way that they've approached the question.

In addition, teachers recognised the learning power of peer feedback and of peer dialogue and this was expressed in their continuing use of the technology in more collaborative learning activities.

Collaborative Learning Activities

- Initial tasks for English involved sharing ideas, collaborating or peer review
- Follow-up tasks self-paced individual or more collaborative discussion
- Tasks in geography, history, art, philosophy and science promoted dialogue
- Voting Activities - A small number of tasks involved using the technology simply as a voting tool to make practical decisions, contributing to classroom dialogue and collaboration beyond learning activities within curriculum subject discipline areas

Tensions in Practice

In working to synthesise the analyses of different sources of data we applied the sociocultural theoretical framework and identified six tensions related to the use of the technology in classrooms (Engestrom, 2000; Engestrom, 2001):

1. *Quality of Feedback*
   The technology on its own provides useful prompt feedback but it is only at a low level – right / wrong. Our analysis identified a tension between the value of prompt automatic feedback and the quality of that feedback. The teachers focused on the value of the technology in relation to assessment for learning but also recognised to varying degrees the limitations of the technology in terms of feedback. They did not connect buddy talk or whole class discussion of right or wrong answers with formative assessment and rather positioned it as 'collaborative learning'.

2. *Engagement*
   The teachers found that the technology did support pupil engagement, at least at a behavioural level. However, our analysis identified a tension between achieving children's engagement and setting them higher level cognitive challenges. Teachers in our study valued the technology in engaging pupils but recognised that when used for self-paced activity rather than whole class collaborative activity it was limited to tightly structured tasks or reporting by pupils of final clear cut answers rather than of their reasoning. The teachers found that the technology tended to support recall tasks or at least closed tasks and they mainly used it for those kinds of activities.

3. *Time*

The teachers were able to create new digital resources using the software provided as part of the technology package. However, they found this time-consuming and therefore mostly used the limited resources provide along with the technology or used hard copy resources and designed only simple tasks within the software itself. The teachers aimed to achieve higher level challenge by using the technology to enhance paired and whole class interactions that required creative thinking by the teacher but did not involve too much time on practical development of the resources.

4. *Teaching Mathematics*

Although we were using thematic qualitative analysis that should not mean that we ignore individual cases or outliers as they may provide insight. An individual teacher in the study explained that the use of the technology for times tables recall tasks was not considered as compatible with the school's Singapore Maths influenced mastery approach to mathematics lessons which emphasises the development of fluency alongside conceptual understanding. He did use the technology for times tables but at another time of the school day separate from 'mathematics' lessons. This single case highlights a tension between rote learning and a school's development of an explicit subject discipline pedagogy. If you simply learn by rote that 8x7=56 and memorise that as a number fact then no doubt it will be useful in solving more sophisticated problems in mathematics at some point. However, if you have good number sense and then need to recall 8x7, then you might use strategies other than memory recall, for example you might think of 7x7=49 and add 8, or calculate 10x7=70 and subtract 14. Jo Boaler argues that learning times tables through rote learning is likely to create a false understanding of the nature of mathematics as a subject and the misleading idea that fast recall of maths facts is a clear sign of a good mathematician (Boaler, 2015). The vast majority of teachers in our study, in particular acknowledging the influence of the newly introduced times tables tests for Primary pupils, justified frequent, often daily, recall times tables tasks as a pragmatic and necessary element of teaching mathematics and welcomed the technology in making that more engaging for pupils.

5. *Learning Community*

Our analysis identified a tension between the technology and the classroom learning community. The technology includes the possibilities of individualised working and collaborative working and the balance between these two influences classroom culture. Overall the teachers used the classroom learner response technology reasonably frequently and about 50% were recall tasks requiring only low levels of cognitive challenge and involved pupils working mostly as individuals. Other tasks were self-paced with pupils reporting answers via the technology and largely working individually. This kind of work was valued by teachers because they could use existing resources, such as a hard copy worksheet, and yet benefit from the technology by pupils receiving automatic feedback and the teachers being able to monitor progress across the class via a tablet or computer. Other tasks using the technology, a minority, were designed by teachers to share ideas, promote dialogue and support collaborative learning.

6. *Performance Orientation*
   The analysis identified an overall tension within the teachers' practice using the classroom learner response technology between developing the pupils as learners and preparing them to perform in national tests. This finding is in line with the tension identified in the survey based study on assessment for learning implementation by James and Pedder (2006). We considered this tension to focus on the contested object of learning (the purpose of education) between the classroom and the wider national policy framework. Despite the agency of the teachers their mediation of the classroom learner response technology is strongly influenced by the wider policy framework of national tests, inspection and school league tables that exists in England.

6. Conclusions

Based on our project basic classroom learner response technology, with a simple keyboard and screen allowing text responses, is popular with teachers and with young pupils. This is true for many teachers and children even after a considerable time and arguably beyond any 'honeymoon' period. Such technology has the potential to reduce teacher workload in relation to ongoing recording of pupil assessment data. However, this basic technology lends itself to low level recall tasks and the development of more sophisticated resources within the software provided is too onerous in terms of workload for individual teachers. Further development of classroom learner response technology is taking place with a much greater emphasis on high quality content, of course that has its own set of issues with regard to the quality of teaching and learning. An influential study on the implementation of formative assessment demonstrated the need for teachers to grasp the 'spirit' of assessment for learning, meaning that they used the strategies but also worked to create a positive classroom learning environment (Marshall & Drummond, 2006). The introduction of such technology needs to be accompanied by professional learning for teachers so that their mediation of the technology is able to resist wider high accountability pressures and focus on the potential of the technology to promote dialogue, collaborative learning, formative assessment with high quality feedback and high expectations and challenge for all pupils. Our analysis suggests that a particular classroom technology may offer affordances towards particular forms of learning. Teachers need to be critically aware of ways in which their workplace context might make those affordances tempting but not necessarily aligned to their broader curriculum aims.

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