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Collaboration, visibility, inclusivity and efficiencies:

A case study of a secondary school in Germany using interactive whiteboards

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Acknowledgements
I have very many people to thank for the opportunity to report on this study. I am indebted to the lead teacher, head teacher, teachers and pupils in a gymnasium in Nordrhein-Westfalen, Germany, and to Peter Claxton in SMART Technologies for providing the technologies and support to enable the study to happen. Without the teachers and learners in the school taking part, who have contributed in so many ways, this study and the work it represents would not have been made possible. It is impossible to list all those who have contributed, but their involvement and work is sincerely and entirely appreciated, and every attempt has been made in this review to represent their endeavours and outcomes as faithfully as possible. Although every attempt has been made to ensure responsible representation, any factual errors or failures lie with the author.

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Introduction

This report provides an overview of the results of a one-year study conducted in a German school (a gymnasium) located in a city in the state of Nordrhein-Westfalen (NRW). While focusing on collaboration as one of the themes of the research, establishing and carrying out the research was also a collaborative endeavour: the school was involved in implementing interactive whiteboard technologies; SMART Technologies provided the equipment and support; and the research was undertaken independently by Lancaster University.

I am delighted that this report can represent the endeavours and efforts of teachers and learners in the school, who largely experienced the uses of these technologies for the first time. I hope the findings will be of interest to practitioners and developers, as well as to researchers who continue to explore the potential of technologies in school settings, for the support of effective teaching and learning practices.

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31st October 2016

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1. EXECUTIVE SUMMARY

Teachers and pupils in the study reported important benefits from using SMART boards and associated technologies. Teachers reported that use of the SMART boards led to greater collaborative discussion, which helped understanding of texts and grammar in English, and specific topics in mathematics. As a result, pupils were awarded better oral marks for their work. Pupils reported that the pace of lessons was increased, which aided their learning and engagement, and resources posted on a virtual learning environment allowed them to revise and review what had been covered in lessons.

These benefits arose when teachers adopted activities enhancing sharing and collaboration. Examples of activities included: expanding the quality of writing; presenting group responses; dividing circles and visualising fractions; matching parts of phrases; using colour to highlight and discuss; and using images and other digital materials to stimulate discussion.

Education in Germany is a state matter, rather than a federal matter. Each of the 16 states in Germany defines and supports its own education system. This in-depth case study, in a German city gymnasium in the state of Nordrhein-Westfalen (NRW), reports evidence gathered across a one-year period. The school has around 930 pupils on roll, with 64 teachers, 9 student teachers and 4 specialist subject teachers who can cover for other teachers on a semi-permanent basis.

The curriculum is different from that in England in that important elements of collaboration have to be developed and assessed by teachers. Ministry guidelines indicate that oral marks have to be awarded separately from written test marks. Pupils are encouraged, even for their final school awards, to plan presentations to 'teach' their fellow pupils and to engage them in learning. Attainment in Germany is not just based on subject test marks; even in the final Abitur (A-level equivalent examinations) teachers mark participation in lessons and subject tests equally.

The school involved was chosen as being 'average' in terms of technology adoption, rather than being 'technology leading'. SMART technologies were recently introduced into the school. Two rooms in the school were equipped with a mobile SMART panel with Notebook and document cameras, while one of the rooms was also equipped with a mobile SMART kapp iQ panel. Classes given access to the technologies spanned the entire age range, from Year 5 (10 years of age) to Year 12 (18 years of age). Subjects taught ranged widely, with most uses in mathematics and English (a modern foreign language).

Across the period of the study, different forms of evidence were gathered: roughly monthly email updates from the lead teacher; interviews with the two main teachers; 3 initial teacher questionnaires; 10 end-of-study teacher questionnaires; 134 initial pupil questionnaires; 134 end-of-study pupil questionnaires; 7 class or pupil group discussions; and 2 lesson observations.

The implementation of the technologies was monitored across the period of the study. The lead teacher used the technologies in lessons and offered training to other teachers within two weeks of the SMART boards being installed. Pupils started to identify opportunities very quickly, and routine practice by the lead teacher happened within a month. The two main teachers were using the technologies in almost every lesson after a matter of weeks.

The two main teachers used the technologies with all their classes. Pupils reacted overwhelmingly positively to the technologies. They were easily able to identify benefits in the vast majority of cases. The main technology that was linked to the boards was a virtual learning environment (VLE) called lo-net^2 (n.d.). Having access to board-work after lessons was particularly well received and valued by pupils across the school. There were no known negative comments or responses from parents or others.

Teachers reported that the SMART boards helped pupils with understanding through visualisation and what was discussed in lessons. Teachers noted more active participation from more pupils, which would positively affect their attainment marks in participation, for some pupils particularly. Teachers said they could more easily share work completed by pupils, enabling greater discussion so that pupils could take on board ideas and thinking of others. Teachers reported that emotional learning was engaged more when different media were accessible, which was not easily possible previously. They noted that inclusion was enhanced; all pupils could be involved more readily – and participation is a key assessment measure for pupils and teachers.

At the end of the study, numbers of positive pupil comments far outweighed numbers of negative or neutral comments: positive (209); and neutral or negative comments (18). Of 134 pupils responding in an open-ended question, they indicated the technologies were benefiting: engagement (75 responses) – over a half; access (73 responses) – over a half; clarity (42 responses) – about one third; efficiencies (21 responses) – about one sixth; and understanding (20 responses) – about one sixth (and had these options been offered as choices, these numbers might have been higher).

Pupils reported significant benefits. Pupils across the age range reported sharing with each other and learning from each other more. Pupils felt they were more motivated to participate and therefore became more active, finding it easier to concentrate in lessons. Visibility was often stated as an important factor – the size of objects shared in lessons was important – they were able to see more easily from anywhere in the classroom, which supported their understanding more. Pupils reported that they were seeing more detail, and that it was possible to hear things more easily when SMART boards rather than compact disk (CD)-players were used. Pupils said that SMART technologies enabled greater fluency and pace of ideas and knowledge progression, as the technologies supported seamless integration and sequencing of different media. Copy writing time was needed less, which was highlighted by many pupils as an advantage, but by a few as a disadvantage.

When learners used interactive whiteboards for collaboration their focus of attention was different from when they were collaborating at a desk. When using an interactive whiteboard, their realm of collaborative influence was much wider; the realm of influence could span the entire class, as pupils could easily see what was on the board, and they could easily discuss and collaborate so that they could contribute to and develop ideas that were built on the board. Pupil descriptions suggested that they saw and uses the SMART boards more as 'pupil territories', whereas chalkboards were regarded more as 'teacher territories'. Teachers reported that pupils wanted to come to the board more, to share their ideas and to contribute to learning endeavour and activities.

The report concludes by offering recommendations for schools and policy makers, and for the company and developers. Some next steps are identified.

2. THE GERMAN SCHOOL IN CONTEXT

2.1 Education in Germany

Education in Germany is a state matter, rather than a federal matter. Germany is made up of 16 states (Länder). Each state defines and supports its own education system. A pupil is required to be within the school system for a minimum of 10 years. The system is largely selective from the age of 10 years when pupils leave primary school.

Teachers are often civil servants, and this is an indicator of expectations of their professionalism. Teachers often remain within a single school for long periods of time. Career development is not generally associated with moving school, but with promotion within a school. A state funds secondary school teachers (town councils fund primary school teachers), school buildings are owned by town councils, and town councils also fund resources (including technology systems). Educational practices have generally been longstanding, including the importance of dialogic learning being recognised within schools and in classrooms. Traditionally, schools have provided education in the mornings, and parents have been responsible for work at home and 'afternoon school' with homework regularly monitored or assessed for completion or understanding.

2.2 Schools in Nordrhein-Westfalen (NRW), Germany

In Nordrhein-Westfalen (NRW), the state with the highest population density, there are 5 government districts (regional authorities) and 54 urban districts (town councils). In total, there were 5,449 state schools and 539 private schools in 2015 in NRW (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2016a). There is a relatively new school inspection system in NRW, but it is quite different from that in England, for example. The system provides feedback for the school on where it stands on average, compared to other schools.

There are 4 broad categories of schools in NRW: maintained (entirely by the state); part-maintained (set up by parental or private groups, 80% funded from the state); independent (fee funded); and international (usually trust funded). An overview of the school system from Year 1 (when pupils are 6 years of age) is shown in Figure 1.

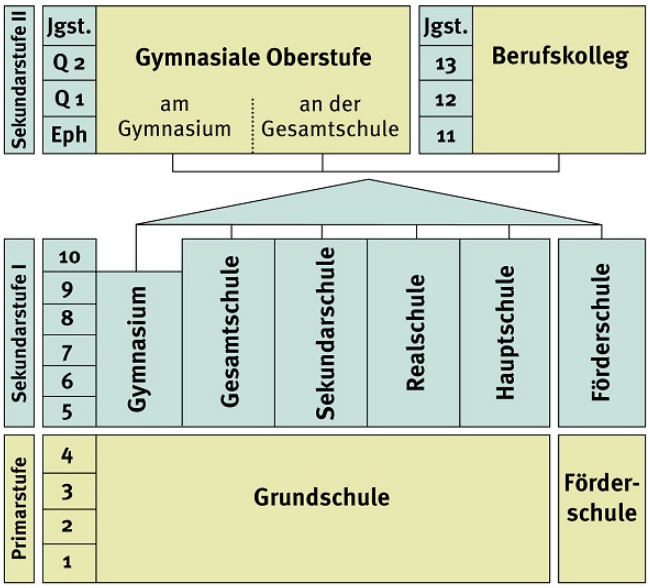


Figure 1: An overview of the school system in NRW, Germany (Source: Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2016b)

2.3 The curriculum in NRW, Germany

The curriculum is common for pupils from Years 5 to 7, and subject guidelines are provided. A school curriculum covers a range of subjects, including German, English, mathematics, geography, history, separate sciences, music, art, sport and separated religions (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2010).

Certain subjects are regarded as core subjects, and from 13 years of age (Year 8), pupils are involved in a system that is increasingly course-based. The recording, handling and reporting of assessment and other data is largely teacher-driven, although the ministry holds some levels of very detailed data (such as pupil ethnic background, and languages spoken at home). Technology-based systems for data have fairly recently been introduced, and are in development in many areas. In assessing pupil performance, teachers must assess (even for Abitur – the equivalent of A-level in England) all aspects of work done by pupils, through 'oral' as well as 'written' marks.

Schools generally need to offer multiple, rich opportunities to support pupils to reflect on what they are doing (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2013a). In mathematics, for example, teachers need to support pupils in their argumentation, discussion, and modelling of mathematics, communicating through verbal and written forms, and using tools such as a graphical calculator, dynamic and interactive tools (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2013b), which would clearly be more difficult to achieve in a computer room than in a classroom with flexible access to technologies.

From Years 5 to 9, pupils will have 2 or 3 written tests in each core subject each semester (half year). These count for 50% of the semester performance mark. The other 50% is an oral mark, which is created in different ways, according to course topic and teacher choice (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2010). According to some all-German websites like national newspapers and Telekom that provide information for pupils and parents, it is apparent that in most German states pupil work in class (including the presenting of homework) counts up to 50%. The criteria used to mark pupil work appear to be very similar in states across Germany, except perhaps in Bavaria, where it is said that oral work does not count as much.

Minor subjects are measured by oral or short test results, while in each core and elective subject there are 2 or 3 written tests each semester (half year). Teachers set the tests, and mark the tests. On average pupils are told about a week in advance when the tests will be held. A pupil must not have to sit more than 2 tests in a week (across all courses). Tests last from 45 minutes (for younger pupils) to 90 minutes (for older pupils in Years 5 to 9) but longer for older pupils. Tests relate to material covered since the previous test or for some subjects from the beginning of the course (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2007).

Ministry guidelines indicate that oral marks have to be given separately, and also, that oral and written marks should not be used to calculate an average. Ministry guidelines indicate that oral marks need to be recorded by teachers, to measure active participation. Teachers determine what to measure; active participation might be measured in a number of ways: answering questions in class; presentations of topics to the class; a presentation of how homework was done; minutes or reports by pupils of their involvement in lessons; and some teachers now set, discuss and mark homework online (via a virtual learning environment), and use levels of online discussion, online homework completion and online review as measures of active participation.

Teachers determine their own test routines and marking schemes. Teachers maintain records in their own ways. Detailed records of oral contributions can be kept by a teacher on paper, separately from written test marks, for example. For Years 5 to 9, for written and oral marks, 50% is regarded as a pass mark. There are 6 grades that are reported: Grade 6 – totally unsatisfactory; Grade 5 – not enough, with obvious gaps; Grade 4 – enough; Grade 3 – satisfactory; Grade 2 – good; Grade 1 – very good.

At 18 years of age, Abitur is the end of school certificate that allows university entrance. In the last two years, learners take 2 advanced (major) and 8 basic (minor) courses each semester (each half-year). Teachers assess these courses, and their marks count towards Abitur. Abitur marks are accrued from semester marks for advanced courses (3 marks for each of the 2 courses), semester marks for basic courses (3 marks for 2 of the courses, and 4 for the other 6 courses), and final examination marks (1 paper test for each advanced course, 1 paper test for a basic course, and 1 oral test for a basic course). For a major topic of English, a teacher might ask pupils to present a topic, so that spoken English can be assessed. For a major topic of mathematics, a teacher might ask pupils to present their homework, to describe how they have done it, and how they have arrived at their answers. Participation in some lessons might be marked (for individual lessons or at the end of a month, for example), and group work contribution could also be marked (using symbols perhaps to denote levels of contribution such as 'nothing noted',' something noted', 'not active', or 'active', for example). Records of completed homework might also be used. Teachers often note pupils who do not answer questions in class, and indeed, before a semester mark (school report) some pupils who might not gain a good oral mark for not answering in class might ask the teacher if they can do a presentation in class to gain marks.

Parents have major roles and involvement in schools. Teachers in schools regard parents as important stakeholders, who can influence key decisions, at classroom, school, local town council, or even regional or state levels. Parents are involved in discussions with teachers during an evening session organised near the beginning of the school year, with additional meetings set up if requested by teachers or parents. Parents nominate a class representative for each class in the school, and this representative discusses points raised by other parents with teachers and with school groups. They are able to discuss school changes, even of a pedagogical nature, with the school, and can vote on changes that are proposed. Parents can support schools and classes, financially, through fund-raising activities. On the other hand, parents are also known to challenge teacher test results, and these challenges can sometimes be referred to the school senior management, to the state ministry, or even lead to a civil law case.

2.4 The German school in this study

The school in this study is located in a city in Nordrhein-Westfalen (NRW). The school is a gymnasium, which caters for pupils aiming to go on to university. The school has around 930 pupils on roll, and 64 teachers, with 9 student teachers and 4 specialist subject teachers who can cover for other teachers on a semi-permanent basis. Teachers are subject specialists, but also have form teacher responsibilities and school-wide responsibilities as they gain increasing experience over time in teaching and administration.

The school year is divided into two semesters. For pupils in Years 10 to 12, the semesters are divided into two quarters for reporting purposes. Marking in those years is done quarterly, while reports are presented at the end of each semester. Subject and course provision is divided into two semesters across the year.

3. THE FOCUS OF THE RESEARCH STUDY

3.1 The rationale for the study

According to Mercier and Higgins (2015), the '4 Ts' of collaborative learning are tasks, technology, teachers, and teams (see Figure 2). The key elements here are concerned with: the approach that teachers take; the tasks they set for pupils; the ways technologies are integrated; and the practices that teams adopt.

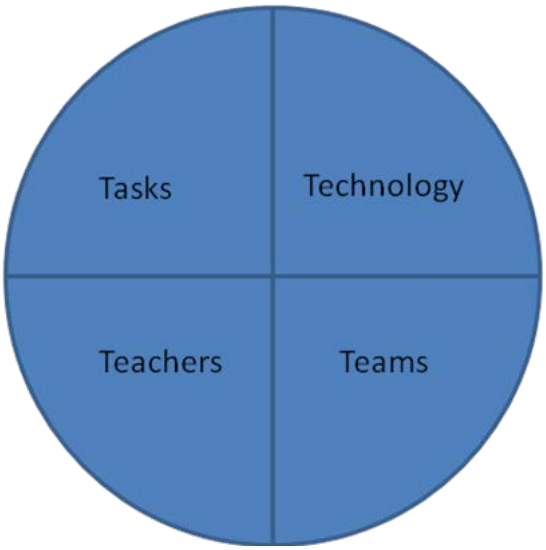


Figure 2: The 4Ts of collaborative learning (Source: Mercier and Higgins, 2015)

Collaborative learning with technologies was described by Stahl, Koschmann and Suthers (2006) as 'an approach where learning takes place through social interaction using a computer or through the Internet, by a sharing and construction of knowledge among participants'. It is the processes afforded by both collaboration and communication through technologies that are important to this form of learning. This form of learning has been defined by some researchers (see Dillenbourg, 1999, for example) as leading to outcomes where the roles and specific contributions of individuals cannot easily be identified. Even from these examples, it is clear to see that a single definition of collaborative learning is difficult to find across the research literature. As Naujokaitiene and Passey (2016) state: "In different research literature, collaborative learning can be described and is embedded in different terms, such as: *cooperative learning, collaborative learning, collective learning, learning communities, peer teaching,* and *peer learning* or *team learning.* The meaning of these descriptions can be understood differently, but they all have a link with collaborative learning."

The importance of collaborative learning (defined widely to incorporate cooperative and dialogic learning) has been identified through a range of research studies, in terms of dialogic learning (for example, Alexander, 2008; Mercer and Littleton, 2007), and collaborative pedagogies in conjunction with others (for example, Bransford, Brown and Cocking, 2000; Donovan, Bransford and Pellegrino, 1999). Even early studies found that 'collaborative learning fosters the development of critical thinking through discussion, clarification of ideas, and evaluation of others' ideas' (Gokhale, 1995).

This importance has long been recognised within educational practice in Germany. In current curriculum guidelines for mathematics (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2013b) teachers need to support critical reflection, concern for social diversity, social responsibility and attitudes, and exchange and communication of mathematical thinking of practice and theory. In English (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2013a), the curriculum is based on active, cooperative and independent learning, and teachers need to support intercultural competence, communicative and intercultural competence skills.

There are three main factors that influence collaboration: visibility; inclusion; and discussion (see Figure 3). Taking further the key points that are raised above concerning the '4 Ts' of collaborative learning, these factors suggest that teachers when considering the '4 Ts' also consider: how discussion will be fostered and enabled; how inclusion will be handled and accommodated; and how visibility of ideas and concepts can be made accessible for all, or as appropriate.

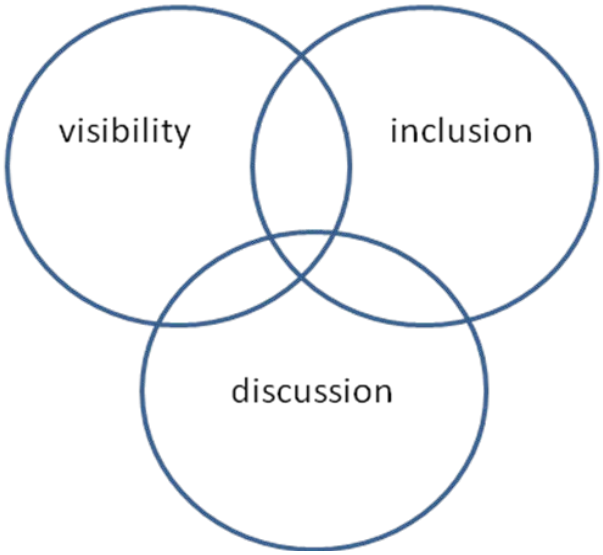


Figure 3: Three main factors that influence collaboration

Teachers, parents and pupils all agreed in their views that SMART technologies and a SMART collaborative classroom helped to improve work as an in-depth case study exploring school improvements showed (Passey, 2015). An Ofsted inspection had placed this school in a 'Requires Improvement' category, indicating that teaching quality varied too much and was considered 'dusty', achievement in English and mathematics was not high, and lessons were often too dominated by the teacher. Evidence was gathered across the width of stakeholders (head teacher, teachers, learners, parents, and external consultant). Using SMART technologies helped to remove the 'dust'; teaching was more diverse, and learning was more exposed. Learner enjoyment increased and was sustained, related to different activities deployed within classrooms. Technologies provided a way of exposing learning, and of collaborating through a 'transitory medium' thus enabling independent work using a 'committed medium' like pen and paper. Attainment data and attendance data both showed positive improvement across the period of the study: the level of absence decreased; and the levels of reading, writing and mathematics attainment increased.

With German schools recognising the importance of dialogic and cooperative learning, this study sought to explore how technologies introduced into a school with previously limited technologies in classrooms might develop practices that would support and enhance collaborative learning outcomes.

3.2 Research questions

The research questions posed at the outset of the study were:

- How will two complementary SMART boards be used, on their own and together?
- How will teachers use them, looking at any difference by subject?
- What will be the pupil reactions to the technologies, and might those technologies support them and enhance their learning?
- How will the technologies work with other technologies?
- How might the technologies support learning and interactions across school and home settings?
- How might visibility and interactivity be promoted and developed?

4. PROCESSES AND METHODS

4.1 Setting up the study

The school involved in this study was deliberately chosen as being 'average' in terms of technology adoption, rather than being 'technology leading'. In most cases, schools take on new technologies and need to explore ways that they can use them, rather than starting from a position of having many technologies that are widely used. To look at this situation, which is regarded as more 'standard' or 'normal', this choice of school was made. One teacher in the school had a strong background in using interactive whiteboards previously (and she became the lead teacher in the school), but most teachers had not had experience with interactive whiteboards or technologies.

The study was designed in a similar way to that undertaken in the study mentioned above (Passey, 2015). However, the school in the study reported here was a secondary school, and at the outset of the study, implementation of whiteboard and associated technologies was on a smaller scale than that in the primary school involved in the previous study. It was intended that the research would explore how two complementary SMART boards could be used, on their own (with two rooms each having an interactive whiteboard), and together (as one of the rooms had an interactive whiteboard and a kapp iQ board). The research would study how the teachers used them, looking at any differences by subject – particularly in English and mathematics, gathering pupil reactions and how the technologies were reported to help them and support different forms of learning, how the technologies worked with other technologies (such as pupil mobiles and tablets), how the technologies supported learning across school and home settings, and how visibility and interactivity might be promoted and developed (taking a socio-cultural perspective, based on Vygotsky, 1978).

Two rooms in the school were equipped with a mobile SMART panel with Notebook and a document camera, while one of the rooms was also equipped with a mobile SMART kapp iQ panel (see Figures 4 and 5). In each room, one main teacher used the resources, and supported other teachers in using them. A number of classes across the age range of the school were monitored from October 2015 to May 2016, focusing on English and mathematics predominantly.

Figure 4: Room 1 equipped with a SMART panel with Notebook, and a mobile SMART kapp iQ panel

Figure 5: Room 2 equipped with a SMART panel with Notebook

Lessons scheduled in Room 1 were: Year 5, biology; Year 5, English; Year 5, mathematics; Year 6, German; Year 6, mathematics; Year 9, biology; Year 9, English; Year 11 (Abitur), mathematics; Year 12 (Abitur), English; and Year 12 (Abitur), mathematics. In Room 2, lessons scheduled were: Year 5, mathematics; Year 6, English; Year 6, mathematics; Year 7, geography; Year 7, mathematics; Year 8, French; Year 9, biology; Year 11 (Abitur), English; Year 11 (Abitur), French; and Year 12 (Abitur), English.

The range of scheduled lessons meant that a wide range of age groups were given access to the technologies, from Year 5 (about 10 years of age) to Year 12 (about 18 years of age), spanning the entire age range of the school. The subjects taught in the rooms also ranged widely, with most uses being in mathematics and English.

4.2 The study approach

The study took an approach that was pragmatic; neither a fully quantitative nor a fully qualitative approach was felt to be able to capture the ways that change and outcomes might occur. So, both approaches were adopted, using mixed methods to gather evidence. These methods involved: regular feedback from the lead teacher on progress with the study (on a roughly monthly basis, via email); survey questionnaires with teachers at the outset of the study, and near the end of their school year; survey questionnaires with pupils at the outset of the study, and near the end of their school year; observations in classrooms; group class discussions with pupils and their teachers.

4.3 Evidence gathered

Forms and levels of evidence gathered across the period of the study (shown in parentheses) were:

- Roughly monthly email updates from the lead teacher.
- Interviews with the two main teachers.
- Initial teacher questionnaires (3).
- Initial pupil questionnaires (134).
- End-of-study teacher questionnaires (10).
- End-of-study pupil questionnaires (134).
- Class or pupil group discussions (7).
- Lesson observations (2).

4.4 Implementation

The implementation of the technologies was monitored across the period of the study. The overall plan, led by the lead teacher, was to install the technologies in two rooms, with a main teacher in each room who would use the technologies for much of their teaching time. Other colleagues would be able to indicate their interest, and use the rooms when available. In this way, two rooms and two teachers would start the implementation, and would support other colleagues in developing practice.

The installation of the equipment happened about two months into the school year. By the end of October 2015, two SMART boards and a kapp iQ board had been installed in the two rooms in the school. The school also received 2 document cameras. The lead teacher immediately started to explore ideas and opportunities. The day after the boards were installed, the lead teacher started to explore software to use. Both ActivInspire and SMART Notebook were considered, and it was decided to use SMART Notebook. It was found that the kapp iQ board posed some initial technical challenges, in trying to pair it to a mobile device, finding out how to save and open new pages.

Some useful facilities were identified very quickly. Based on her previous experience with similar software, the lead teacher explored facilities in Notebook and was soon able to change handwritten notes into text and to edit this, for example, or to show and manipulate fractions visually. She also considered how she would write on the board and, so as not to put her back to the class when writing, she felt it was better to write by hand than to write via a keyboard.

Within a very short time period, the lead teacher was ready to start using the technologies in lessons. After two days, she had found out how to use the document camera, and she had already decided on some of the functionality that she would use in a lesson the following week. She wanted to look at how to expand the quality of text composition by pupils, which she said was difficult without an interactive whiteboard.

During the early weeks, the lead teacher monitored progress in the other room, and supported teachers there with their access and uses. The lead teacher offered training to other teachers soon after the installation, within two weeks of the SMART boards being installed. A certified SMART trainer had contacted the lead teacher, and agreed to run an introductory training session for all interested teachers, scheduled for two months after installation.

Pupils also started to identify opportunities very quickly. Two months after installation, the lead teacher was told by one pupil that it would be 'much cooler' to write on the kapp iQ board rather than the SMART board. At the same time, the lead teacher reported that some of her Year 12 pupils seemed more responsive since the SMART board had been used, and were putting up their hands without being prompted and coming forward more. She found that Year 11 pupils wanted to draw on the SMART board, but did not necessarily want to do mathematics on it.

The lead teacher explored use of the kapp iQ board after two months, linking it to a mobile of one of the pupils, so that the pupil could amend and add to the page from their own mobile telephone. This period of exploration enabled practices to be trialled, but some of these were not taken further, as learning benefits were not clearly arising due to the fact that sudden colour changes when writing on the kapp iQ board, which SMART could not offer an explanation for, were felt to be disrupting lessons at crucial points in the discussion (see Figure 6). The lead teacher continued to find problems with the colour changing from black to red on the kapp iQ board, which restricted her use of it; she thought it might be the black pen that was at fault. This highlighted at this early stage the need for ongoing support with the technologies. Although the last update for the kapp iQ firmware did not solve the problem as expected, SMART report that a further update will address this issue.

At the same time, the lead teacher felt that the kapp iQ board could be useful for inclusion – a boy she taught previously who had visual impairment would have been able to see what was done on the board and enlarge it locally, and a girl in a wheelchair she previously taught would have been able to 'write on the board' from her location rather than having to come to the board itself.

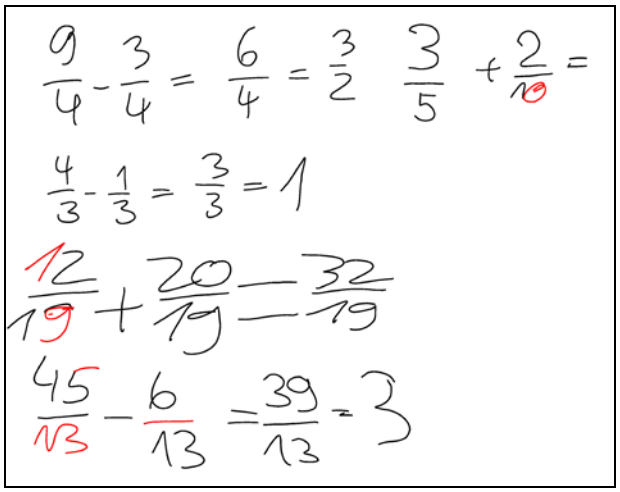


Figure 6: Erratic coloured writing

Routine practice by the lead teacher happened within a month, and after two months she was using the SMART board and the kapp iQ board as two interactive whiteboards; she was not sure at that stage how using the kapp iQ board would offer anything more for her teaching and learning. Additionally, she had noticed what she regarded as good features in the SMART board; for example, shapes being divided into fractional components that could then be coloured. She also found that some classes liked writing on the boards more than others.

The school presented the new facilities to the local press and to primary school pupils and their parents. A month after installation, the lead teacher was involved in a press meeting, with two local papers who were interested in the new technologies. A week later Year 6 pupils agreed to help the lead teacher to show the SMART boards during a Saturday open event, organised for Year 4 pupils and their parents who visited the school prior to making a decision about which school to attend after primary school.

Links to other key technologies were established very early. The lead teacher established links to a virtual learning environment (VLE) called lo-net[2]; she created PDFs from all lessons, then she posted them for pupils to use after the lesson. This practice was very well received by pupils. Pupils continued to gain confidence with the use of the boards; at the same time, pupils in Year 12 were reporting that they liked the use of video in lessons, and they were more focused in lessons.

The facilities were seen by other pupils in the school, who also took interest. After a month, the lead teacher's Year 11 mathematics class received pupil visitors from other classes. They asked to come into her lessons in their free periods. They sat and listened and even took an active and constructive part. It first happened when some of the other pupils in her class were missing due to visits taken out of school, so others who remained in school asked to come into the lesson. Although the lead teacher thought this request was because of the lack of lessons, it continued to happen. The visitors behaved as though they belonged in the lesson, and the teacher wondered if this was due to the presence and use of the SMART boards.

External training happened about six weeks after installation. The lead teacher, two student teachers, and about six other teachers attended. Overall, it was felt to be useful for the other teachers, and the lead teacher found out about some other applications, such as a 'waste bin' (although this was found to be rather large and noisy).

Within four months, other teacher colleagues were showing increasing interest in the technologies. The lead teacher ran two workshops for teachers in addition to the workshop run by the external trainer.

Holiday periods allowed the lead teacher to explore other resources that were accessible online. The lead teacher spent several days over the Christmas holiday watching videos about the SMART boards to get more ideas. She continued to find and use different features, and used the SMART board every day. She started to use SMART Notebook with Shout It Out, for example, enabling pupils to communicate via mobiles with the boards.

Within five months, pupils were starting to consider the use of the technologies and how these were affecting their learning. For example, the lead teacher had an interesting discussion with Year 5 pupils. A few indicated they felt the SMART board was not helping their learning, but it was not clear how their arguments matched the reality of the situation. Taking into account some Year 12 responses, it seemed possible that the pupils might be arguing against the use of the SMART board on the grounds of 'attention seeking' behaviours. She did find, however, that the majority of the class argued against the views of this small number of pupils.

Within eight months, benefits from use were clearly emerging. Certain benefits of the SMART boards were becoming highlighted more: enhancing seamlessness of activities across lessons; giving cost benefit for teachers; and meeting the needs of teachers and pupils. By this time also, it was clear that because of certain technical issues arising, there was again a clear need for ongoing technical contact and support.

5. FINDINGS

5.1 Lesson activities

A wide range of activities were undertaken by the teachers using the SMART boards. These activities are what would be regarded by Naujokaitiene and Passey (2016) as short-term collaborative activities. A number of these, using varied SMART board functionality, are exemplified here.

Expanding the quality of text composition by pupils

Expanding the quality of text composition through collaborative activity involved the teacher and pupils discussing a piece of writing, and then how to expand its quality. Pupils needed to put forward and discuss ideas with each other and with the teacher in this activity; they were involved in dialogic and collaborative endeavour. The lead teacher said that this was difficult without an interactive whiteboard. When projected, it makes more sense, it gives greater visibility and interactivity, you can edit easily, rather than having to add or remove as you would have to do with chalk on a board. She said adding and editing does not work as easily with chalk or OHPs, and it becomes confusing for the learner, as it is more difficult to read or see how the changes are being made. She said this was especially so when creating text with pupils, as you cannot see what is important if there is a jumble of changes across the text. The lead teacher said the pupils enjoyed this activity and wanted to do it again. The lead teacher suggested they create some writing beforehand to do this.

Matching parts of phrases

The lead teacher used the turn-over game in SMART Notebook to match parts of phrases (see Figure 7); this game involved memory as well as understanding how words were formed into phrases that make sense. In this activity, pupils needed to remember position as well as the match of phrases grammatically, putting forward their ideas to others in the class, discussing and reasoning through dialogue. Pupils did not know how to play this game when it was first uncovered. They initially needed to work that out; they thought it was just a memory game, but soon realised it was more than that. So they had to then identify the rules of the game, as well as play it.

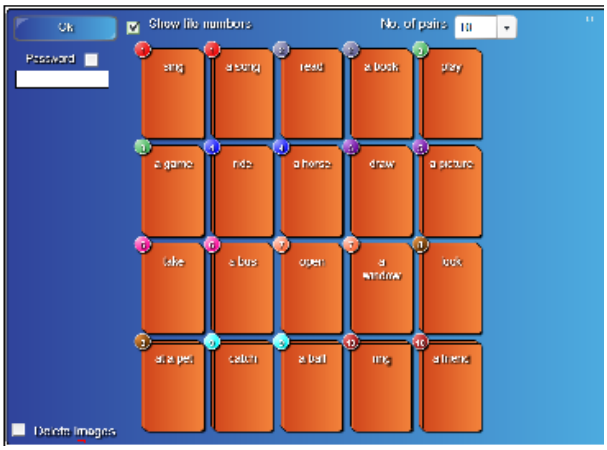


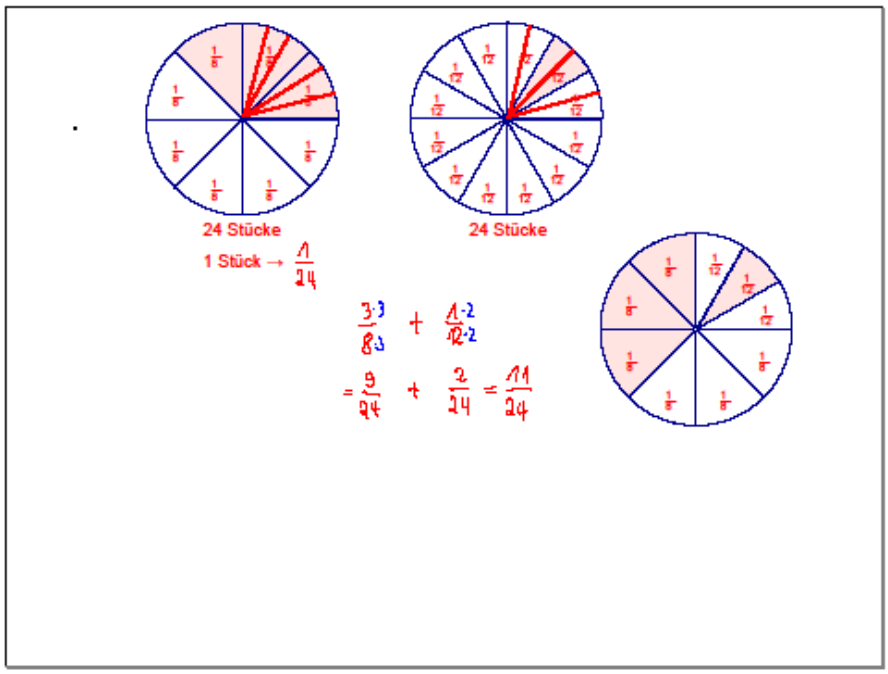
Figure 7: The turn-over game in SMART Notebook

Presenting group responses

A Year 12 English class was divided into two groups, and each had to answer some questions about the play *A Midsummer Night's Dream,* Act 1 Scene1 on one of the two boards, which were moved to opposite ends of the classroom so that the groups were hidden from each other. After the time allocated, the groups then turned the boards around to face each other. Pupils needed to present their answers to others, and then discuss them with the other group and with the teacher; discussion, argument, persuasion, reasoning and analysis were all encouraged in this activity. It was found that there was a good level of overlap in their responses, but nevertheless the exercise generated collaborative discussion. The lead teacher said it was 'brilliant to have two boards – to divide the group, and then ask them to present to the others what they have done'.

Dividing circles and visualising fractions

The lead teacher used the divided circles facility in SMART Notebook to visualise fractions and how they could be added, which required developing a common denominator. She put the visualisation on the board, and asked pupils what it showed. She then asked them to consider how to add three-eighths and one-twelfth. Pupils needed to put forward their ideas, listen to others, reason and reflect, through dialogue and collaboration in this activity. The pupils indicated how to divide the segments so that they contained similar units – twenty-fourths. They were then able to add the two segments together. Afterwards, the lead teacher asked them what they had done mathematically and they were able to tell her – as was shown on the board in the text below the circles (see Figure 8). Pupils indicated that they had understood the principles through this form of visualisation.



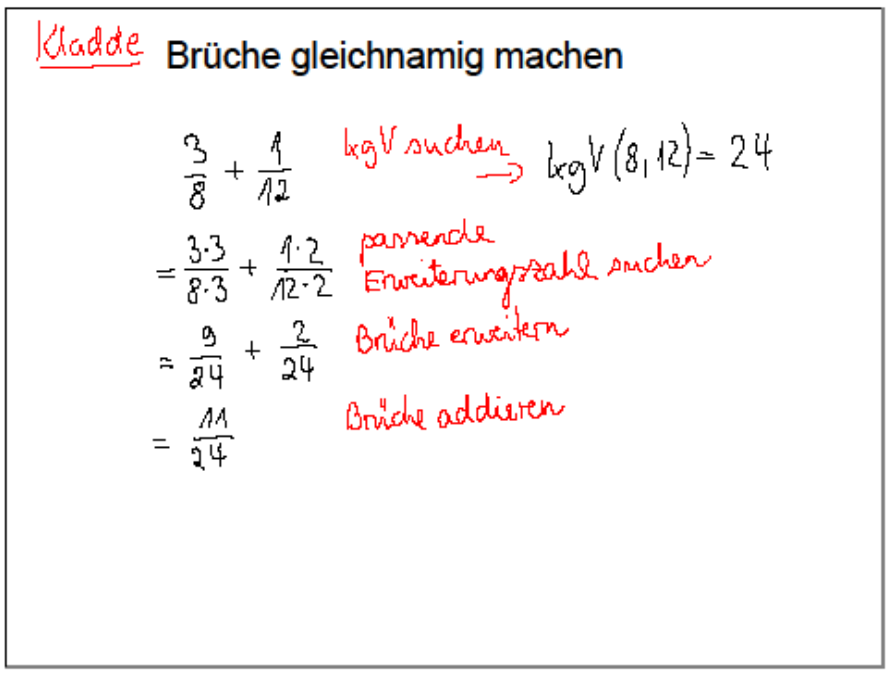


Figure 8: Visualising fractions through divided circles

Using colour to highlight and discuss

Colour was used by the lead teacher to highlight additional detail. In this example, the technology was used to encourage pupils to explain and detail subjects in the curriculum in English (see Figure 9). Pupils needed to expose their ideas to others in the class, who could then pick up and add further thoughts, in discussion with the teacher.

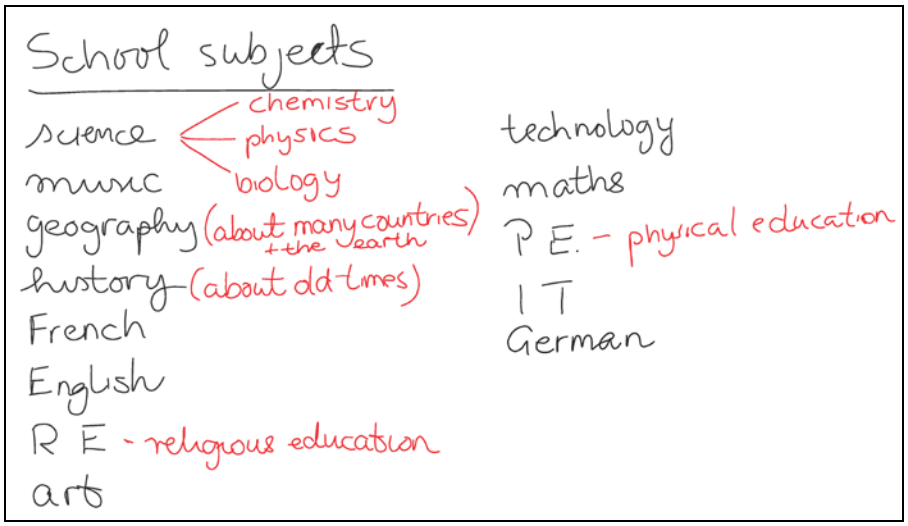


Figure 9: Colour highlighting to encourage explanation and discussion

Images of real-life situations

The main teacher in Room 2 said that she noticed more focus from all the groups she taught in that room. She said the visibility afforded by the technologies was important in this. For example, she used images of Indian slums to illustrate the reality of these to a class – and when she did this, she noted that they were quiet, asked questions, and showed emotions from seeing these images. She said the pupils could recognise what was happening more when they saw the images – and she believed that when emotions were aroused, it was easier for them to learn. She said that words alone could not arouse emotions, so this could not be done in a classroom without appropriate technologies. She found it brought real-life situations into the classroom, and, as a consequence, classes were more involved in lessons when they saw real-life situations – they asked more questions when they were involved emotionally.

Using images and engaging discussion

Visual elements are clearly important. For example, one teacher used a wide range of visual features: she showed short YouTube videos; she could write easily on the SMART board; she showed solutions on the SMART board that the class could discuss; she showed tools like a compass, and demonstrated use to the whole class. In all of these examples, discussion was enhanced, as the visibility of the objects was clear for all pupils, who could contribute their ideas and responses.

Pupil and teacher territories

At an early stage, one pupil in a Year 6 class indicated that it would be more interesting in mathematics if they could do more work on the SMART board, writing and explaining how they did things. This might suggest that the technology was bringing forward in pupils' minds ideas for more collaboration and greater levels of interactivity. A key question would be whether pupils see a chalkboard as a teacher's territory and the SMART board as a shared domain.

5.2 Findings from individual classes

Evidence gathered about each class involved in the study is given in the sub-sections following. In some cases, teacher reports alone constitute the evidence, while in other cases these are supplemented with pupil survey responses, observations, and reports from group discussion sessions. It should be

noted that teacher views about overall perceived levels of involvement of their classes in school, classroom and specific forms of activities are provided in each case in Appendix A.

Year 8, French, Room 2
At the start of the study, the teacher was able to indicate clear expectations. The teacher expected the resources to enable an interactive textbook to be used, to increase motivation and interest in lessons, support visual learning, provide access to YouTube and video-clips, listening to songs and speeches, enhancing listening comprehension, and support access to coloured mind maps and MS PowerPoint presentations. Although this teacher was able to identify ways to use the technologies from the outset, other teachers needed more support and training to be able to do this.

Year 5, mathematics, Room 2
For this class, the teacher reported benefits at the end of the study, saying that the technologies supported pupils in making and doing, offered more visual resources, supported discussion with other learners and working with other learners a great deal, but supported listening to the teacher only a little (indicating a focus towards dialogue and collaboration). The teacher said these younger pupils could handle the board much more easily and quickly than older pupils, and that the main benefits from the technologies were visualisation of homework and exercises, and enhanced focus of attention.

Year 7, mathematics, Room 2
This teacher also reported benefits from visualisation at the end of the study. The teacher felt the technologies supported making and doing, and learning from using visual resources a great deal, but discussing with other learners and working with other learners only a little, and that the technology did not really support listening (indicating a focus towards dialogue and collaboration). The teacher said that some pupils complained about the time it took to setup the technologies at the start of the lesson, but said that this was a difficult age group (although it was found later that this was due to a long-standing technical problem with the board). The teacher said the main benefit of the technologies was in visualisation, especially of homework. The teacher indicated that visibility and engagement went hand in hand. As she said, 'it draws attention', for example, when discussing mathematical functions. With linear functions she said that she could easily show what happened when you change a value; the pupils could see the change in outcomes, and this movement through visibility, when GeoGebra was used, for example, supported pupil understanding.

Year 6, English, Room 2
This teacher highlighted uses for English lessons, expecting the technologies would support listening, doing and making, and using visual resources a great deal, and discussing with other learners and working with other learners a little (again moving towards dialogue and collaboration). The teacher felt that flexibility was likely to be a main benefit of the technology.

The teacher used a variety of functionality and approaches. She used a document camera, showed images and homework, and used the SMART board to pick up on and show how to correct mistakes. Everyone was able to see mistakes and discuss how to correct items, so pupils could discuss the work of others. Presentations were given by pupils, and by showing and explaining, the teacher found that it was easier for pupils to understand. She said they could see more on the board, scroll down, access a new page, and there was no cleaning involved. She could go back to previously saved lessons, and this sometimes helped their reflections on previous learning.

Year 5, English, Room 1
At the start of the study, the teacher felt the pupils would be supported by the technologies a great deal in listening, doing and making, using visual resources, and working with other learners. The teacher felt they would be supported in discussion with other learners only a little, but expected the resources to increase visual stimulation, to increase collaboration, and lead to more active board work.

The teacher reported at the end of the study that enhanced motivation, use of audio and visual input and textual visualisation, being able to use additional forms of exercises, and enhanced pupil involvement and focus during whole class discussions had been main benefits arising.

A discussion with the class supported the teacher's views of benefits arising. Pupils highlighted a range of benefits. They felt it was good that it was not necessary to wipe the board. They felt they did not then get chalky fingers, and that this was better for the teacher too. They said it was possible to see pages from the book and talk about exercises, and to highlight things on the board. They found it 'fun' to write on the board; they said they could hear audio from the board easily, and they found it easier to read what the teacher wrote. They said corrections could be done on the board, and the digital camera could be used to look at posters and talk about them, that the teacher could easily put images on the board, and could use different pens and different colours. They said it was possible to watch online videos, that the matching exercises were interesting, and that it was possible to do many more things on the SMART board. One pupil did say that he found it easier to concentrate on a book or the chalkboard, but it was not clear why this was the case. The brightness could cause eyes to get tired, but this did not appear to be so in this case.

Year 6, mathematics, Room 1
At the start of the study, the teacher indicated how the resources might support this individual class of pupils. The teacher expected the resources to increase attention, pupil interest in the lesson, support more focus, better visual input, and more collaboration.

The teacher reported key outcomes at the end of the study that enhanced motivation, use of visualisation and more focus during whole class discussions had been main benefits arising. Expectations had clearly been met in this case.

Year 9, English, Room 1
At the start of the study, 31 pupils in this class responded to a question about their forms and levels of engagement at that time (see Table 1).

Table 1: Year 9, English, Room 1 pupil responses to forms of engagement before use

Form of engagement	A great deal	A little	Not really	Not at all
Listening	19	8	4	0
Doing or making	12	17	2	0
Observing	14	12	2	1
Discussing	13	12	5	1

At the end of the study, 31 pupils from the class completed a second questionnaire. They all indicated that the teacher was using the interactive whiteboard with them in the class, and they all indicated that they used the interactive whiteboard also. Pupils were asked how much they thought they were involved in different forms of engagement in the classroom. Their responses are shown in Table 2.

Table 2: Year 9, English, Room 1 pupil responses to forms of engagement

Form of engagement	A great deal	A little	Not really	Not at all
Listening	22	9	0	0
Doing or making	10	14	6	0
Observing	12	17	1	1
Discussing	9	14	7	1
Working in groups	8	10	11	2
Working on your own	15	11	5	0
Doing practice exercises	10	17	4	0

These results indicated that this class was initially engaged mostly through listening, and working on their own, with some doing and making, observing, discussing, working in groups, and doing practice exercises. By comparing the two sets of responses (Tables 1 and 2), it appears that since the start of the year, there had been a shift in observing (less 'a great deal'), and in discussing (less 'a great deal'). These shifts, however, arose as a result of only a small number of pupils moving from one category to another.

The teacher reported at the end of the study that the technologies supported listening, doing and making, using visual resources, and discussion with other learners a great deal, but that they did not really support working with other learners any more than before. The teacher felt that a greater focus on what was being discussed, on textbook work, visualisation and audio and visual input, presentation of individual or group work, and the opportunities to include a variety of materials were all main benefits of the technologies.

Responses from the class to an open ended question suggested that they felt the digital technologies were helping them to learn in a variety of ways, through: more interesting lessons (7 responses); watching videos and hearing them was clearer (6); it was easier to see and to understand (5); using the Internet gave access to details instantly (5); there was more variety to the lessons (3); it was easier to participate and discuss as a class (3); they had access to new types of exercise (3); paid attention more (3); the pace was faster (2); there was more opportunity to write on the board (2); less reliance on books and writing (2); they could focus on important things more; and could see the teacher's writing more easily. Using five broad categories in which to place these responses, these were concerned with:

- Engagement (16).
- Access (11).
- Understanding (6).
- Clarity (6).
- Efficiencies (4).

Only two neutral comments were received, pupils saying the board was just a substitute for the normal board, and not really needed.

This class clearly saw a range of benefits in the uses of the technologies. A discussion with the class highlighted that they found lessons more interesting, and they paid more attention. They found the variety that it introduced was interesting, and that they were involved in different forms of engagement rather than just talking about topics. They found they could search for things easily on the internet, and there was more space to write on this board, with no need to erase anything. They found the camera could be used if people forgot their books, and the use of MS PowerPoint and images was felt to be better for visibility, as there was more space to see these than on a poster on a wall. They found the sound produced by the system was loud enough for them to listen to audio, as they had found CD-players were sometimes not loud enough. The short time needed to switch between different types of media being used was important to them.

In terms of learning activities, they reported how the class had created videos, that groups of pupils then presented. They filmed at home using smartphones or video cameras, and used a computer for editing. They were taught how to create a storyboard and screenplay; they discussed their ideas in class, filmed and edited at home, while the presentation and scoring of their results was done in class. In these videos, they used more imagery than speaking – so the images needed to 'speak for them', as they were creating commercials. They reported that in some other lessons they used classlab.com to send messages to the board, so they could discuss things in a different way. They reported how they enjoyed going to the board to do an exercise, which they said saved them time, as they could work with a range of words that they did not need to copy. They found it was easier to highlight words, even in grammar exercises, as this could not be done in books. They said the board offered them more detail, that it was possible to enlarge pictures that showed detail even in the last row of the classroom,

and that they gained a better contextual understanding (such as that with the Martin Luther King speech).

Year 11, mathematics, Room 1
At the start of the study, 19 pupils in this class responded to a question about their forms and levels of engagement (see Table 3).

Table 3: Year 11, mathematics, Room 1 pupil responses to forms of engagement before use

Form of engagement	A great deal	A little	Not really	Not at all
Listening	3	16	0	0
Doing or making	4	9	6	0
Observing	1	15	2	0
Discussing	4	9	4	1

At the end of the study, 17 pupils from the class completed a second questionnaire. They all indicated that the teacher was using the interactive whiteboard with them in the class, and the majority indicated that they also used the interactive whiteboard directly. Pupils were asked how much they thought they were involved in different forms of engagement in the classroom. Their responses are shown in Table 4.

Table 4: Year 11, mathematics, Room 1 pupil responses to forms of engagement

Form of engagement	A great deal	A little	Not really	Not at all
Listening	8	7	2	0
Doing or making	2	12	3	0
Observing	4	10	2	1
Discussing	4	9	3	1
Working in groups	3	0	8	6
Working on your own	0	11	5	1
Doing practice exercises	6	7	3	0

These results indicated that this class felt they were engaged mostly through listening, doing practice exercises, with some doing and making, observing, discussing, and working on their own, with limited working in groups. By comparing the two sets of responses (Tables 3 and 4), it appears that since the start of the year, there had been a shift in listening (more 'a great deal'), and observing (more 'a great deal'). These shifts suggested that there was a higher level of engagement in whole class work.

The teacher reported at the end of the study that the technologies were supporting listening, being involved in doing and making, using visual resources, and discussion with other learners a great deal, but working with other learners only a little. The teacher said the main benefits of the technologies were being able to 'record' the lesson, share it with pupils via the learning platform, being able to go back easily to the previous lesson, being able to use materials beyond the textbook without having to make photocopies, and visualisation and use of resources such as GeoGebra.

Responses from the class to an open ended question indicated that they felt the digital technologies were helping them to learn in a variety of ways: accessing notes from lo-net[2] (7 responses); making it easier to understand functions, 3D graphics, for example (6); leading to more interesting lessons (3); being able to check on progress made in the lesson and checking back on previous work (2); visualising through diagrams, pictures and videos (2); making calculations on the board easier (2); enabling underlining and highlighting; being more involved in the lessons; and there was no need to bring books to school. Using the five broad categories in which to place these responses, these were concerned with:

- Access (9).
- Understanding (8).

- Engagement (4).
- Clarity (3).
- Efficiencies (1).

No negative or neutral comments were received from this class. A discussion with the class highlighted that saving work and its access via lo-net^2 was felt to be particularly helpful. They were able to revisit work on lo-net^2, access it from different devices, the teacher could save important pages, and the class could request the service from the teacher. They said the teacher put extra exercises on lo-net^2 before a test, which was easier for the teacher and the pupils. Pupils did find they had to print worksheets themselves, but they could choose alternatively to look them up online or copy everything from the board in the lesson. As printed worksheets could get lost, they felt it was good to have access to them online. They felt it was easier to revise for Abitur, as they had a chronological record of what had been done in class. Pupils felt that it was easy to draw on the SMART board, to create graphs, to annotate them, either by the teacher or by the pupils, and pupils felt they could go up to the board and use it as they wanted. They felt benefits were associated with anything that needed to be drawn, including examples in functions and geometry. They found bigger equations took more room, and it was necessary to write bigger so that details could be easily seen.

The pupils felt the technologies were time-saving, as it was possible to copy and paste, that having exercises on the board enabled them to be handled faster, that everyone could see them and could think about them at the same time. They found that the quality of video was much better than they had experienced on old television (TV) sets, and they found it was easy to switch from one page to another, and easy to move back to work in previous lessons. Homework was not changed much in their experience, as it could not be done on a computer. If they had questions, they felt it was good for these to be put on the board, so that everyone could know what the problem was. Although technology could fail, they felt that the chalkboard was still there as a back-up. They found that the document camera saved them bringing books. They also commented that although they felt it was difficult at first for the teacher to use the board, all pupils could now do this. They said that teachers needed time to become familiar with the technology.

Year 11, English, Room 2
At the start of the study, 20 pupils in this class responded to a question about their forms and levels of engagement at that time (see Table 5).

Table 5: Year 11, English, Room 2 pupil responses to forms of engagement before use

Form of engagement	A great deal	A little	Not really	Not at all
Listening	2	11	6	1
Doing or making	7	4	5	4
Observing	1	12	1	5
Discussing	5	4	9	2

In this class, at the end of the study, 18 pupils from the class completed a second questionnaire. They all indicated that the teacher was using the interactive whiteboard with them in the class, and they all indicated that they also used the interactive whiteboard directly. Pupils were asked how much they thought they were involved in different forms of engagement in the classroom. Their responses are shown in Table 6.

Table 6: Year 11, English, Room 2 pupil responses to forms of engagement

Form of engagement	A great deal	A little	Not really	Not at all
Listening	10	8	0	0
Doing or making	4	10	4	0
Observing	4	12	1	0
Discussing	9	5	4	0
Working in groups	6	9	3	0
Working on your own	3	12	3	0
Doing practice exercises	0	13	4	1

These results indicated that this class was engaged initially mostly through listening, and discussing, with some doing and making, observing, working in groups, working on their own, and doing practice exercises. By comparing the two sets of responses (Tables 5 and 6), it appeared that since the start of the year, there had been a shift in listening (more 'a great deal'), doing or making (less 'a great deal' but more 'a little'), and in discussing (more 'a little').

The teacher reported at the end of the study that the technologies supported listening, using visual resources, discussing with other learners, and working with other learners a great deal, but in doing and making only a little. The teacher reported that some pupils needed a long time to overcome technical difficulties when working on the board, but that flexibility, visualisation and time-saving were main benefits of the technologies, and they were 'perfect for the upper classes to prepare for their final exams'.

Responses from the class to an open ended question indicated that they felt the digital technologies were helping them to learn in a variety of ways: they could see the text if they did not have a book with them (5 responses); they could create things or work together as a class (4); easily access details through the Internet (4); teachers could send notes from the lesson easily (4); there was more participation and involvement in lessons (4); they could watch videos (3); there was more variety in lessons (3); they could write down key information (2); lessons were more interesting (2); they could concentrate more on answering and discussing rather than copy writing; it was easier to read details from the board rather than just listening to them; easier to understand with video and images; they could highlight important details easily; and they could visualise details, texts, and corrections from homework easily. Using the five broad categories in which to place these responses, these are concerned with:

- Engagement (11).
- Access (10).
- Efficiencies (9).
- Clarity (5).
- Understanding (1).

Three neutral or negative comments were received: pupils saying that the SMART board was used like a normal board; time could be better spent doing practice exercises; and the teacher spent time needing to control the board. Other evidence contrasted with or explained these views, however: pupils reported that the SMART board offered facilities that a normal board did not; time was spent on other important activity; and a technical problem that explained the time spent by the teacher was identified later.

A discussion with the class indicated that only one pupil found it harder to learn with the SMART board, as writing appeared to be less clear, and there was not so much working on paper. However, as stated by other pupils, it is still possible for pupils to write notes; however, pupils in moving to practices with SMART boards might need to be made aware of the fact that they may not be told to write so much, but must take the initiative to do this if they find it useful for their learning.

The integration of media and other tools was reported to be particularly useful. Visualisation and manipulation were felt to offer greater understanding. Pupil responses indicated enhanced interest, integration and interactivity. Exposing learning was identified as being important – opening up work for others to comment on, encouraging discussion. Identifying other benefits, pupils felt that having access to notes from the lessons was useful to review material. The pupils found that there was no rubbing out needed on the board, but that some technical issues arose that had a negative impact.

Year 12, mathematics, Room 1
At the start of the study, 24 pupils in this class responded to a question about their forms and levels of engagement at that time (see Table 7).

Table 7: Year 12, mathematics, Room 1 pupil responses to forms of engagement before use

Form of engagement	A great deal	A little	Not really	Not at all
Listening	15	6	0	3
Doing or making	4	14	3	3
Observing	10	10	3	1
Discussing	2	10	7	5

Evidence from this class was gathered in March 2016, with 24 pupils completing a second questionnaire. They all indicated that the teacher was using the interactive whiteboard with them in the class, and the majority indicated that they also used the interactive whiteboard directly. Pupils were asked how much they thought they were involved in different forms of engagement in the classroom. Their responses are shown in Table 8.

Table 8: Year 12, mathematics, Room 1 pupil responses to forms of engagement

Form of engagement	A great deal	A little	Not really	Not at all
Listening	14	9	0	1
Doing or making	2	16	4	1
Observing	13	9	2	0
Discussing	2	7	12	3
Working in groups	1	4	9	10
Working on your own	3	14	4	3
Doing practice exercises	4	15	3	2

These results indicated that this class was engaged initially mostly through listening and observing, with some doing and making, working on their own, and doing practice exercises. By comparing the two sets of responses (Tables 7 and 8), it appeared that since the start of the year, although pupils had not shifted in their engagement in listening or doing or making, there had been a shift in observing (more 'a great deal' and 'a little'), and in discussing (more 'not really' but less 'not at all'). These shifts arise from only a few pupils moving from one category to another, however.

The teacher reported at the end of the study that the technologies supported listening, being involved in doing and making, using visual resources, and discussing with other learners a great deal, but did not really support working with other learners. The main benefits of the technologies that the teacher identified were being able to go back to previous lessons, providing records for the pupils on the learning platform, and using resources such as GeoGebra.

Responses from the class to an open ended question indicated that individual pupils felt the digital technologies were helping them to learn in a variety of ways: results and details could be saved as a PDF (6 responses); it was easier to visualise and illustrate graphics, texts or functions (5); they were able to see more on one board, such as long calculations (4); no cleaning was necessary, so getting a clear page was easier (4); it was easier to pay attention, making lessons more interesting (3); when a book was forgotten, or details from a book needed to be shown, the document camera could show the relevant pages on the board so everyone could see it (2); images of the board details could be sent to

pupils, for revision (2); it was not necessary to carry books (2); results could be seen again in other lessons; statistics and diagrams could be used more; the pace could be faster; it was easier for everyone to see what was on the board; it helped to structure the content of lessons; it was easy to wipe out mistakes; they could do more than one thing at the same time, such as graphics and calculations; it was easier to write on it; and pictures could be found on the internet very rapidly. Using the five broad categories in which to place these responses, these were concerned with:

- Access (16).
- Clarity (16).
- Efficiencies (3).
- Engagement (3).
- Understanding (0).

Very few pupils were negative about their experiences: some said it was hard to handle the board and there was no advantage, as all could be done on a regular board (6 – although it should be noted that other pupils identified clear ways in which the board facilitated activities that could not be done on a chalkboard); it wastes time when the board freezes; and regular notes are not taken now.

An observation of part of a lesson with this class showed how the SMART board was used in one activity - two girls presented to the class on a mathematical topic. The girls had elected to do a presentation to try to improve their grades in mathematics. The girls used a computer to load their presentation, which offered a review session on analytical geometry, and showed this via the SMART board. Their previously-prepared handwritten work was scanned, shown via the document camera, where they had created questions on the left-hand side, and they used the hide and unhide feature on the right-hand side to unhide answers after the class responded. Pupils in the class were attentive during this session, with the girls taking a full 'teacher' role. When presentation of questions on the SMART board was finished, the girls handed out worksheets, and pupils worked individually on these. The girls went around the class, monitoring what was happening, and answered pupils' questions. After a set time, the girls went to the front and discussed the solutions to the worksheet questions. The SMART board was used to make details of the solutions visible to the class. To support understanding further, the teacher used a three-dimensional object from GeoGebra to illustrate what the class had been working on in their calculations. The visual facility enabled pupils to see the geometrical object from different perspectives, aiding their understanding of the problem they had tackled.

A discussion with two pupils after the lesson highlighted that problems can occur with the SMART board, but that the benefits came through for them more strongly. The pupils liked the fact that work could be saved so they could refer to it later, and that less paper was needed. They indicated that more detail could be put on the SMART board, and that it was particularly helpful for work in geometry and on graphical functions.

Year 12, English, Room 1
At the start of the study, 19 pupils in this class responded to a question about their forms and levels of engagement (see Table 9).

Table 9: Year 12, English, Room 1 pupil responses to forms of engagement before use

Form of engagement	A great deal	A little	Not really	Not at all
Listening	12	6	0	1
Doing or making	3	11	4	1
Observing	5	12	1	0
Discussing	6	8	4	1

Evidence from this class was gathered in March 2016, with 22 pupils from the class completing a second questionnaire. They all indicated that the teacher was using the interactive whiteboard with them in the class, and all indicated that they used the interactive whiteboard directly. Pupils were

asked how much they thought they were involved in different forms of engagement in the classroom. Their responses are shown in Table 10.

Table 10: Year 12, English, Room 1 pupil responses to forms of engagement

Form of engagement	A great deal	A little	Not really	Not at all
Listening	12	8	2	0
Doing or making	5	13	2	2
Observing	8	13	1	0
Discussing	4	15	4	0
Working in groups	4	11	5	1
Working on your own	4	15	1	2
Doing practice exercises	4	10	6	2

These results indicated that this class was initially engaged mostly through listening, with some of all the other forms of engagement. By comparing the two sets of responses (Tables 9 and 10), it appears that since the start of the year, although pupils had not shifted in their engagement in listening or doing or making or observing, there had been a shift in discussing (more 'a little' by proportion).

The teacher reported at the end of the study that the technologies supported listening, being involved in doing and making, using visual resources, and discussing with other learners a great deal, but working with other learners only a little. The main benefits of the technologies that the teacher identified were more involvement, more active participation, and more visualisation when doing text analysis.

Responses from the class to an open ended question indicated that they felt the digital technologies were helping them to learn in a variety of ways: to concentrate more on what was said rather than writing (5 responses); it was better to understand with videos, pictures and presentation software (5); they could revise as it was easy to look things up at home (5); it was easier to compare and work together on highlighting and commenting on texts (5); it was possible to save everything and send it to everyone (4); they could pay more attention as it was more attractive (4); pace had increased so it was easier (4); they could watch short videos that related to content more (3); there was more variety (2); it was clearer on the board (2); they could write on the board and rearrange writing parts; access things sent from mobiles; and there was no need to take notes as these were accessible from the teacher. Using the five broad categories in which to place these responses, these were concerned with:

- Access (18).
- Engagement (9).
- Clarity (8).
- Understanding (5).
- Efficiencies (2).

Two negative comments were received: it was annoying when the board did not work; and writing on a normal board was faster.

A discussion with pupils in the class indicated that there were no real issues identified with uses of the SMART board. Only one pupil felt that writing was limited by using the SMART board. The pupils generally recognised the importance of the ease and seamless movement between media, and the teacher's ability to use the board and its facilities came across as being important. The pupils said it took them 2-3 weeks to get used to the technology. From their experience, they felt the use of SMART boards could be introduced for other year groups, and suggested use from Year 8.

Year 12, English, Room 2

At the start of the study, 21 pupils in this class responded to a question about their forms and levels of engagement at that time (see Table 11).

Table 11: Year 12, English, Room 2 pupil responses to forms of engagement before use

Form of engagement	A great deal	A little	Not really	Not at all
Listening	8	11	2	0
Doing or making	4	12	5	0
Observing	1	13	6	1
Discussing	3	11	6	1

Evidence from this class was gathered in March 2016, with 22 pupils from the class completing a second questionnaire. They all indicated that the teacher was using the interactive whiteboard with them in the class, and the majority indicated that they also used the interactive whiteboard directly. Pupils were asked how much they thought they were involved in different forms of engagement in the classroom. Their responses are shown in Table 12.

Table 12: Year 12, English, Room 2 pupil responses to forms of engagement

Form of engagement	A great deal	A little	Not really	Not at all
Listening	10	11	1	0
Doing or making	10	8	3	0
Observing	6	13	3	0
Discussing	7	9	6	0
Working in groups	15	7	0	0
Working on your own	1	10	11	0
Doing practice exercises	3	7	11	1

These results indicated that this class was initially engaged mostly through listening, doing and making, and working in groups, with some observing, discussing, working on their own, and doing practice exercises. By comparing the two sets of responses (Tables 11 and 12), it appeared that since the start of the year, there had been a shift in listening (more 'a great deal'), doing or making (more 'a great deal'), observing (more 'a great deal'), and in discussing (more 'a great deal').

Responses from the class to an open ended question indicated that the digital technologies were helping them to learn in a variety of ways: making the lesson more interesting (6 responses); visualisation or illustration was better (4); they could access items from lo-net[2] easily (3); listen better to the teacher (2); it was easier to work with texts and homework (2); easy to access lesson items missed or when at home (2); a dictionary could be put on the mobile telephone (2); they could see work easily and discuss with the whole class; not so many copies were needed; they were more involved in the lesson; the teacher could react more easily; and there was no need to write unnecessarily. Using the five broad categories in which to place these responses, these were concerned with:

- Engagement (11).
- Access (9).
- Clarity (4).
- Efficiencies (2).
- Understanding (0).

Two negative comments were received: not so much writing made it harder to learn and remember (5 responses); and writing was more difficult on the interactive whiteboard.

A discussion with the pupils in this class highlighted that, overall, the pupils found the technologies to be helpful for learning. The fact that pupils were being asked to write less was an issue for some pupils, but it was pointed out by other pupils that this could also be accommodated by those pupils – there was nothing to stop them from writing if they wished. Pupils welcomed having saved material that could be reviewed, particularly for examinations, just before Abitur. They liked the fact that a wide range of media could be accessed and sequenced easily (text, images, videos, etc.). Easy and fast changes between resources were commented on, as was a faster pace, moving easily and quickly from

one thing to the next. For some, faster pace was an advantage, while for others it was a disadvantage if they were not able to write notes within the time period. The pupils enjoyed the fact that they could view each other's work, and comment on it as a class. However, they recognised that those not participating might be 'hidden more' when an inclusive discussion was going on. They felt discussion and speaking were encouraged. They even commented that the SMART board had encouraged choice of Abitur examination – oral rather than written. The pupils felt that better visualisation could be used in other subject areas, such as the sciences, geography and media. The greater size of the SMART board, visibility, changing things easily and quickly, and going back to saved work, were highlighted particularly. But recalibration of the SMART board three times a day was highlighted as a time-consuming issue.

6. DISCUSSION

6.1 A model for implementation

The model of implementation adopted by the school has been successful. Both teachers and pupils have reported benefits from the technologies used; and, importantly, there have been no known negative comments or responses from parents or others. It is worth considering the pattern of implementation adopted, therefore, as a possible model for others to consider (shown in outline in Table 13).

Table 13: Implementation model used in this school

Before installation of the technology	A lead teacher was identified, who received training in uses of the technologies and was known to be able to undertake activities in lessons with pupils The lead teacher identified another main teacher to work with
Installation	Two rooms were equipped with appropriate technologies
Immediately following installation	The lead teacher checked the facilities available The lead teacher started using the technologies in lessons as soon as possible
Within two weeks from installation	The lead teacher checked the facilities available in the second room, and monitored progress The lead teacher offered training to other teachers
Within a month from installation	The lead teacher discussed the uses of the SMART boards with pupils, to find out their ideas about possible uses
Within six weeks from installation	The technology facilities were presented to the local press and prospective pupils and their parents The lead teacher ensured that captured screens from lessons were accessible to pupils via a virtual learning environment
Within two months from installation	Uses of pupil mobile devices linked to the technologies were explored Some external training was available
After three months from installation	The lead teacher allocated some time to explore additional details and resources
Within four months from installation	Training sessions for other teachers were run by the lead teacher as needed
Within five months from installation	Discussions with pupils were used to monitor their uses and perceptions of the technologies
After eight months from installation	Evidence of outcomes and benefits were gathered

6.2 Positive and negative responses about the uses of the technologies

Responses from teachers indicated positive benefits from using the technologies. Teachers felt that engagement was enhanced, there was more participation, and pupils had greater ease of access to resources both within and outside the classrooms. Teachers reported that use of the SMART boards led to greater collaborative discussion, which helped understanding of texts and grammar in English, and specific topics in mathematics. As a result, pupils were awarded better oral marks for their work, and in some cases pupils chose oral presentations for their final Abitur work to be examined.

At the end of the study, the numbers of positive and negative comments received from pupils through an open-ended question were: positive (209); and neutral or negative comments (18). It is clear that pupils reported much more positively than neutrally or negatively. Where there were neutral or negative comments, these were often able to be addressed or accommodated, rather than them remaining as persistent issues (except in one case only). In total, 134 pupils responded in the open-ended question, and their responses were categorised as benefiting (and it should be noted that as these were open-ended responses, that other pupils might have added to these numbers of responses had they been provided as options or choices):

- Engagement (75) – over a half.
- Access (73) – over a half.
- Clarity (42) – about one third.
- Efficiencies (21) – about one sixth.
- Understanding (20) – about one sixth.

6.3 Collaboration

Pupils reported that they were sharing with each other and learning from each other more. Short-term learning was seen by teachers as leading to greater understanding in many cases. This is not the same as long-term learning or memorisation, but heightened interest, engagement, interaction and participation were all felt by teachers to be enhancing the prospects of longer-term learning. Pupils reported that the pace of lessons was increased, which aided their focus and engagement. Without the SMART boards, they reported that their focus and attention wandered more. Additionally, resources posted on lo-net[2] allowed them to revise and review what had been covered in lessons.

6.4 Visibility

Visibility was often stated as an important factor. Size of objects presented to a class is important – being able to see more easily. Pupils reported that they were seeing more detail, and that it was possible to hear things easily when SMART boards were used. They reported at the same time the difficulty with seeing detail and having clear visibility with old TVs. Sharing and visibility here are going hand in hand. Visibility enables sharing; pupils comment on the value of sharing work with others, and how the boards enable this through wider visibility across the class.

6.5 Inclusivity

More participation was encouraged. Participation enabled all pupils to be involved, and they said this happened in different activities in English and mathematics. The inclusive environment allowed the class to work more as a whole. Consequently, it seemed that some pupils modelled their work on the work of others. This also had influence on teachers in terms of their planning of lesson activities.

6.6 Efficiencies

Access to resources and lesson notes was highlighted often by pupils as benefiting them. Access to a wider range of resources in class, access to saved work in class and outside class, access to previous work, were all highlighted as being important. The fact that different resources could be seamlessly handled, for example video with other media, was seen as beneficial in terms of time being saved. There was a reported balance in pupil responses in terms of saving time versus wasting time. Pupils saw saving time in terms of copying easily, accessing beyond the lesson, and the ease of movement between media; they saw wasting time arising when there were technology failures, teachers not being able to handle the technology, and undertaking non-useful activities.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

When learners collaborated using interactive whiteboards their focus of attention was different from when they collaborated at a desk. When at a desk (see Figure 10) their attention was focused down at the table, with a restricted realm of collaborative influence (largely two students in this case).

Figure 10: Collaborative realm of influence with desk-based activities

When using an interactive whiteboard their realm of collaborative influence was much wider (see Figure 11). The realm of influence could span the entire class, as pupils could easily see what was on the board, and they could easily collaborate in developing what was on the board.

Figure 11: Collaborative realm of influence with interactive whiteboard-based activities

A number of research questions were posed at the outset of the study:

- How will two complementary SMART boards be used, on their own and together?
- How will teachers use them, looking at any difference by subject?
- What will be the pupil reactions to the technologies, and might those technologies support them and enhance their learning?
- How will the technologies work with other technologies?
- How might the technologies support learning and interactions across school and home settings?
- How might visibility and interactivity be promoted and developed?

Taking each of these in turn, evidence gathered from this study indicated that:

- The two complementary SMART boards were used effectively, both on their own (two rooms each having an interactive whiteboard), and together (as one of the rooms had an interactive whiteboard and a kapp iQ board). The lead teacher supported other teachers, and the boards supported a range of different subject classes in those rooms. The kapp iQ board was mainly used as a second interactive whiteboard, but, nevertheless, was particularly useful for group activity.
- The two main teachers used them in all their classes. The study gathered evidence about uses in English (as a foreign language) and mathematics. Teachers and pupils were able to identify benefits in all cases, across the age range of the school.
- Pupils reacted overwhelmingly positively to the technologies. They felt that they helped and supported their learning. They were easily able to identify benefits, and to suggest alternatives in all but one instance where pupils raised neutral or negative concerns.
- The technologies worked with other technologies (such as pupil mobiles and tablets). The uses with mobile devices were limited, but nonetheless valued. The main technology that was linked to the boards was the virtual learning environment (lo-net^2). Having access to board-work after lessons was particularly well received and valued by pupils across the school.
- The technologies supported learning and interactions across school and home settings. In school settings, these were through engagement, access, clarity, efficiencies, and understanding. Across the school and home setting, the use of lo-net^2 allowed enhanced access, for review, reflection and revision purposes. Teachers reported greater collaborative discussion in lessons, helping understanding of texts and grammar in English, and specific topics in mathematics. As a result, pupils were awarded better oral marks for their work. Pupils reported that the pace of lessons was increased, aiding their focus and engagement. Lesson resources posted on lo-net^2 allowed pupils to revise and review more.
- The value of visibility and interactivity did not need to be promoted and developed for these teachers and pupils. In the context of this school and its curriculum (which assesses oral results equally matched to written results, and where dialogic and collaborative learning are recognised and expected), the use of the boards spoke for themselves in this respect.

7.2 Recommendations for schools and policy makers

In terms of schools and policy makers, the following recommendations are offered on the basis of these and other complementary research findings:

- Consider adopting the implementation model of this school when starting to use interactive whiteboard technologies. Begin with two complementary SMART boards, in two rooms, each having an interactive whiteboard. Identify a lead teacher able to support another main teacher and other teachers.
- Allow teachers to explore uses in their own subject contexts. However, enable discussions at regular intervals, between teachers, and with pupils. Teachers and pupils should consider benefits arising.
- Allow pupils to voice their opinions, about how the technologies have helped and supported their learning. Allow them to suggest alternatives in cases where pupils raise neutral or negative concerns.
- Ensure there is a link between the boards and a virtual learning environment (such as lo-net^2). Allow pupils to have access to board-work after lessons.

- Encourage teachers to develop learning activities that focus on engagement, access, clarity, efficiencies, and understanding. Focus activities at home on access, for review, reflection and revision purposes.
- Allow the boards to 'speak for themselves' in terms of visibility and interactivity.

7.3 Recommendations for the company and developers

In terms of the company and developers, the following recommendations are offered on the basis of these and other complementary research findings:

- Consider suggesting the implementation model of this school when schools start to adopt interactive whiteboard technologies. Beginning with two complementary SMART boards, in two rooms, each having an interactive whiteboard, they should also identify a lead teacher able to support another main teacher and other teachers.
- Maintain contact with the school. Technical issues do arise that need to be addressed, and teachers can make useful suggestions about enhancements to facilities. Establish a 'live chat' line to pick up on issues as they are raised.
- Allow teachers in training sessions and through resource materials to explore uses in their own subject contexts.
- Encourage teachers in training sessions to voice pupils' opinions, about how the technologies have helped and supported their learning.
- Discuss with teachers how a link can be made between the boards and a virtual learning environment (such as lo-net^2).
- Show examples of how teachers have developed learning activities that focus on engagement, access, clarity, efficiencies, and understanding. Exemplify activities at home that focus on access, for review, reflection and revision purposes.

7.4 Further research questions

The case study reported here allowed a number of questions to be answered in the context of a German gymnasium. Similar findings from the primary school in England that was the subject of an earlier study suggest that interactive technologies have an important part to play in the future of teaching and learning for the 21st century. This study has shown that a German gymnasium can successfully integrate SMART technologies into teaching and learning across the age range of its pupils.

No lack of pupil or teacher interest was evident by the end of the study; no diminishing of interest was found. How teachers already using these technologies and those teachers showing increasing interest in using the technologies can be supported in moving forward, widening uses across classes and subject areas, is a key need if benefits identified are to be available to the broader school population. How this can be done most effectively is an important concern for this and other schools.

Positive attitudes of pupils have clearly been identified. The lead teacher in this study found that there were positive attitudes arising from all ages of pupils involved. Indeed, one group of Year 8 pupils, who had stopped using the SMART board when they moved rooms, indicated to her that they regretted the loss. When pupils move classes, or when they move to the next year group and work with other teachers, the effects of changes in access to teaching and learning with the SMART boards and associated technologies are not known. The effects, and how to handle these, are, however, clear concerns for this and other schools.

Consequently, two key research questions particularly worthy of further exploration in this context are:

- How can the school continue to develop its implementation effectively?
- What effect does the removal of the technologies have for those pupils who move into lessons in non-SMART board rooms, and how can the school manage this effect?

Continued collaborative endeavour is needed if such questions are be answered.

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Appendix A:
Teacher views about overall perceived levels of involvement of their class in school, classroom, and specific forms of activities

Year 5, mathematics, Room 2
The teacher reported that pupils enjoyed being in the classroom, enjoyed school, teaching, learning, making progress, being involved, they used technologies at home, and wanted to attend school a great deal, while they did more on schoolwork at home only a little.

Year 5, English, Room 1
The teacher indicated that the class enjoyed being in the classroom, in the school, teaching, learning, making progress, being involved, and wanting to attend school, all a great deal. The teacher said that school work at home and using technologies at home were done a little by the pupils.

Year 6, mathematics, Room 1
The teacher indicated that the class enjoyed being in the classroom and being involved a great deal. The teacher reported that the class enjoyed being in the school, teaching and learning, making progress, doing school work at home, using technologies at home, and wanting to attend school, only a little. In class, the teacher said the pupils were involved a great deal in listening, doing and making, using visual resources, working with other learners, and in discussion with other learners.

Year 6, English, Room 2
The teacher reported that the class enjoyed being in the classroom, enjoyed school, teaching, making progress, being involved, using technologies at home, and wanting to attend school all a great deal. The teacher reported that pupils enjoyed learning and working on schoolwork at home only a little.

Year 7, mathematics, Room 2
This teacher reported that pupils used technologies at home a great deal, but enjoyed being in the classroom, enjoyed school, teaching, learning, making progress, being involved, doing more on schoolwork at home, and wanting to attend school, only a little.

Year 8, French, Room 2
The teacher indicated that the class enjoyed being in the school, teaching, learning, making progress, being involved, wanting to attend school, doing school work at home and using technologies at home all a great deal. The teacher indicated that pupils enjoyed being in the classroom only a little. In class, the teacher said the pupils were involved a great deal in listening, doing and making, and using visual resources, but working with other learners and discussion with other learners only a little.

Year 9, English, Room 1
The teacher reported at the end of the study that the class were using technologies at home a great deal, while they enjoyed being in the classroom, enjoyed school, teaching, learning, making progress, being involved, and wanting to attend school only a little. The teacher reported that they did not really do more on schoolwork at home.

Year 11, mathematics, Room 1
The teacher reported at the end of the study that pupils used technologies at home a great deal, but enjoyed being in the classroom, in school, teaching, learning, making progress and being involved, only a little. The teacher reported that pupils did not really do more on schoolwork at home, or wanting to attend school.

Year 11, English, Room 2
The teacher reported at the end of the study that pupils enjoyed being in the classroom, being involved, and using technologies at home a great deal, but that pupils enjoyed school, teaching,

learning, making progress, doing more on school work at home, and wanting to attend school, only a little.

Year 12, mathematics, Room 1
The teacher reported at the end of the study that pupils used technologies at home a great deal, but enjoyed school, learning, making progress, being involved, and wanting to attend school only a little. The teacher reported that the pupils did not really enjoy being in the classroom, teaching, or doing more on schoolwork at home.

Year 12, English, Room 1
The teacher reported at the end of the study that pupils were involved and used technologies at home a great deal, but enjoyed being in the classroom, at school, teaching, learning, making progress, doing more on schoolwork at home, and wanting to attend school only a little.

31st October 2016

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