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(Missed) opportunities for teaching with digital resources: what and why?

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We report on teacher use and appreciation of the distinctively digital affordances of a publisher's mathematics resources for English 11-16-year-old students. The data come from the first year of our two-year study and were gathered through teacher interviews and observations. We show that, as is common with other digital resources, teachers' use is currently under-developed, and we discuss reported reasons for that. We show that, in addition to common technical and familiarity challenges, the demands of preparation for teaching a new curriculum across the age range currently marginalize other teacher development, including for effective use of resources perceived to be well-designed to support that curriculum change.

Keywords: Mathematics, technology, CPD, digital resources

Introduction

We report on part of the first year of a two-year mathematics study focused on the impact of a large publisher's mathematics resources in England. This paper focuses on the impact of the digital 'ActiveLearn' packages. These are carefully-designed digital resources intended to complement use of other elements of the 'Key Stage 3 Maths Progress' and 'GCSE Mathematics 9-1' schemes that between them offer provision for the range of students 11-16. The study therefore adds to the evidence base around teachers' use (and non-use) of digital resources in mathematics.

Background

The resources

Key Stage 3 Maths Progress (MP) and GCSE 9-1 Mathematics (GCSE) between them set out to offer (Pearson, n.d.) "a coherent set of mathematics materials for use in Key Stages 3 and 4" respectively in England, in preparation for the high-stakes GCSE examinations at 16. The resources' structure and progression are intended to be consistent with the 2014 English National Curriculum for Mathematics (DfE, 2014). This is set out in two Key Stages, and schools largely operate differentially over those. The range and scope at KS3 are intended to be common to virtually all young people, but the Key Stage 4 curriculum is conceived at distinct Foundation and Higher levels, the former consolidating and deepening the KS3 curriculum, and the latter designed to give a foundation appropriate to the study of Higher (level 3) school mathematics. The 2014 curriculum includes a renewed focus on problem solving and reasoning. Both MP and GCSE resources include differentiated textbooks and the online ActiveLearn (AL) platform, though schools can decide to buy only one part of the resources. Additionally, there are a variety of practice books and workbooks available.

This paper focuses on the digital resource AL, which has both an online toolkit for teachers and an online student interface. Figure 1 shows the four different components of the digital service (Pearson, n.d.). Schools are recommended to buy the entire package but some schools choose to purchase only a subset. The 'Front-of-

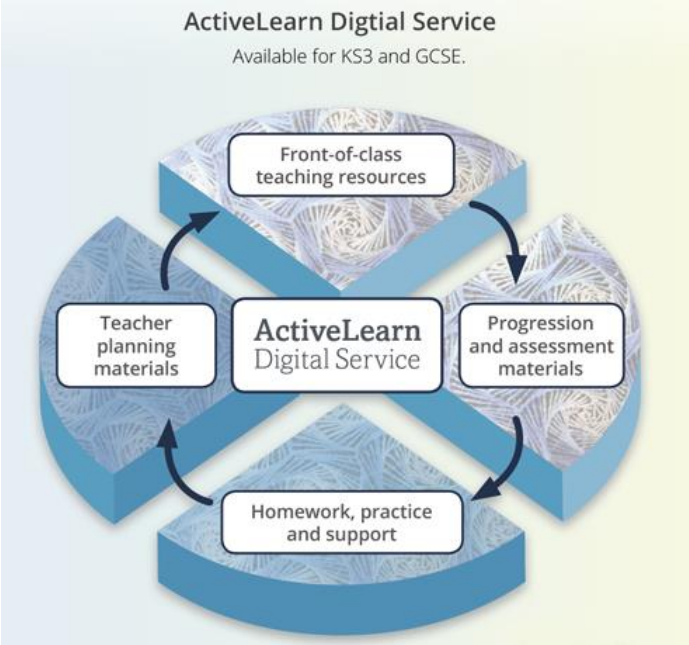

Figure 1: Components of the Pearson ActiveLearn service

class teaching resources' include a digital, interactive version of the textbook that teachers can project, as well as other resources such as videos, through which 'other experts' can be brought into the classroom. 'Homework, practice and support' is the student-facing side that students can use for homework, or extra experience or support at home or school. This component allows clear and quick communication of multiple representations (e.g. tables, graphs), access to an extended textbook (if schools opt in to this) that includes some hints towards solutions, and instant access to answers and feedback; it also allows for formative assessment as it monitors individual progress. The 'planning' and 'assessment' materials are online versions of paper ones, although in the latest update, there are now interactive, hyperlinked lesson plans. Here, we focus on the distinctive digital affordances of the front-of-class and student aspects of AL rather than the planning and assessment support.

AL is designed to meet recommended English practice as suggested by NCETM (2015), whose guidance includes:

> Careful consideration should be given as to how and when technology is used to support learning in mathematics, to ensure it does not detract from the development of essential knowledge and skills (p.4)

The digital textbook for students, while mirroring the appearance and structure of the paper version, expands learning opportunities by offering a range of digital interactions designed to enhance students' skills and understanding and gives personalised feedback. Digital calculators are only used when the focus is not on mental calculation. The digital resources also conform to other areas of NCETM guidance such as setting out to expose and address likely misconceptions and misunderstandings, offering a wide range of tasks and exercises that use deliberate variation, and addressing 'real life' uses of mathematics.

Digital technologies and student learning

There is a large body of research that suggests digital technologies can contribute to student learning, e.g. Higgins, Xiao and Katsipataki (2012) and Drijvers et al. (2016). This highlights the pivotal role of the teacher and the school for successful use, including the need for good teacher pedagogical (including technological) content knowledge. Drijvers et al. (2016, p.25) state:

> In a technology-rich classroom, the teacher will play a pivotal role in crafting effective lessons that capitalize on the affordances of technology (Yerushalmy & Bolzer, 2011). A key to planning and delivering effective lessons is to have good pedagogical content knowledge, which includes deep knowledge of students' understanding and how technology can positively influence this.

Where, and how, then, are digital technologies used to greatest effect? Clark-Wilson, Oldknow and Sutherland (2011) argue that in order to improve the UK's capacity for technological innovation and creativity, we need to focus on high quality mathematics learning - as well as other STEM subjects - with or without technology. However, there is currently limited use of digital technologies in e.g. lower secondary mathematics teaching in the UK (OECD, 2015). Ofsted (2012) also report that technology is underused in mathematics and that its potential is generally underexploited. Use is largely teacher-led and focused on presentational software such as PowerPoint and interactive white board software, which does not by itself seem to affect learning gains (Clark-Wilson et al., 2011). Aspects of AL are purely presentational e.g. the digital version of the textbook. However, AL also aims to harness the potential of technology, e.g. through hyperlinks to supplementary representations or dynamic apps, so the hope is that teachers will go beyond the presentational use when using AL. In this respect, the hyper-linked resources share characteristics of pre-prepared files created in more generic mathematics software such as GeoGebra or Autograph, that can be used to stimulate mathematical exploration and discussion (e.g. Higgins et al., 2012), though they lack the breadth and flexibility of such software. Critically, student resources also offer opportunity for immediate formative assessment of learning.

There are, though, known barriers to use. Clark-Wilson et al. (2011) focus on maths-specific digital tools and packages, including specific software such as that offered by AL, identifying as potential barriers perceptions of digital technologies as an add-on only, school-level assessment practices not accommodating the use of technologies, and inadequate guidance on how to use the tools. They particularly note that even when perception and assessment have changed, continuous professional development always remains important if the potential of digital affordances is to be realised.

This focus on professional development is supported by other research: Drijvers et al. (2016), for example, call for research-based and easily-accessible professional development for deeper teachers' pedagogical content knowledge for teaching with technology (2016, p.25). In Ertmer's (1999) and Bai and Ertmer's (2008) seminal works around first and second order barriers to technology adoption, they also stress the importance of professional development, including training, reflection and collaboration, for changing teachers' ingrained attitudes and beliefs. These form a second-order barrier, while quality of and access to the technology can be first-order barriers. It is the former that are harder to overcome.

The study

This paper reports on some early findings from a two-year Pearson-UCL Institute of Education collaboration funded by Pearson. As such, particular care was taken in ethical justification, to address potential threats to the validity of findings, e.g. by using external-to-Pearson researchers for all fieldwork. Overall, the study set out to begin to understand the motivations for adoption of MP and GCSE resources, how the resources are used and experienced in schools, and the perceptions of their effectiveness in meeting teacher and student needs. Here, we focus on findings around teachers' use of the digital resources specifically. We probed access to those and their impact on learning, asking:

- How is KS3 MP/GCSE Mathematics (9-1) being implemented in schools?
- What are the barriers, if any, for students and teachers in accessing the digital resources?
- Do teachers value the overall content, and specific features of the AL platform and CPD element?

We used a variety of methods (interviews, focus groups, lesson observations, and surveys) with both teachers and students in the first year of the study: here we draw on just the first year's (2016-17) termly interviews with teachers and Heads of Mathematics (HoMs), and Spring term lesson observations. Participant schools were recruited from those using one or both sets of resources, so as to give a variety of key school characteristics, but there is no claim to representativeness. Not all sample schools used both schemes or catered for students at both KS3 and KS4. Shrinkage reduced the original 20 schools to an active 15 from the start of 2017. In the first full year, data was drawn from at least one year 10 class in each school and/or at least one year 7 or 8 class, their teachers, and the HoM, with the intention of following those classes through to the completion of a two-year programme of study. Some HoMs also participated as either the KS3 or KS4 class teachers, and for a variety of reasons, complete intended data collection was not achieved. Table 1 gives an overview of the teacher-related data on which we draw in this paper.

	Autumn 2016	**Spring 2017**	**Summer 2017**
Teacher and HoM telephone interview transcriptions	13 KS3 teachers 21 KS4 teachers 16 HoMs		12 KS3 teachers 20 KS4 teachers 15 HoMs
Semi-structured lesson observation notes, lesson plans		13 KS3 classes 20 KS4 classes	
Teacher face-to-face interview transcriptions		11 KS3 teachers 18 KS4 teachers	

Table 1: Overview of the teacher-related data in the first year of the study

All interviews were recorded and transcribed, then analysed through a thematic analysis in N-Vivo. The overarching themes were based on the research questions (e.g. access and experience of teachers, learner progression, achievement and competence), while supplementary themes derived from open descriptive coding of the range of data. Ethical justification for the study cited evidence that participation in professionally-focused interviews with a knowledgeable other can result in deep

teacher reflection and learning (e.g. Baker & Johnson, 1998), and teachers did express acknowledgement of that in interviews.

Findings

We draw on data related to teachers' use of the AL Digital Service, particularly the distinctively digital elements of the front-of-class and student aspects.

(Under)use of resources

Schools as well as individual teachers within schools reported variable use of the digital resources (and indeed, schools had purchased different subsets of the package), though the overwhelming picture was one of very limited use, illustrated by the following Head of Maths:

> A couple of teachers are taking the lead on ActiveLearn but to be honest we are not using it as much as we could because we go back to the books. We need to evaluate as a team whether or not we are getting value for money for it. (HoM 3, Autumn 2016)

AL was most frequently used for textbook projection on the board, observed in 30 of 33 lessons. In 28 observations that was the only use. Teachers felt those were fairly typical lessons, but many teachers said they would make a decision by topic. While there are interactive elements to the projection of the textbook, observations suggested these are underused, limiting the use of the resource to presentational purposes only. One teacher explained:

> I'm still learning my way around it. I haven't used it as much as I'd like. And, you know, the functionality, I haven't really had the chance apart from I, you know, sometimes use the questions and flag them up on the board so they're just there (Y10 Teacher 7, Spring 2017)

At least 20 of 33 teachers used the AL Digital Service for assigning homework – though with variable frequency. Such use was linked with mixed experiences for students, often marred by technical difficulties. On probing with the schools concerned, it appears those were largely bandwidth challenges rather than being integral to the software - but nevertheless, discouraging for both teachers and students. It also took quite some time and investment for schools to fully incorporate the system into their way of working:

> I used to do it when I first started this year on sort of paper hardcopy sheets. Now ActiveLearn has all been sorted they've got their individual logins and they now will get set weekly ActiveLearn (Y7 Teacher 5, Autumn 2016)

> What we plan to do is pilot it with a few groups in each year and then have feedback of what it is […] Generally you're more familiar with what you use at the moment so I feel like I need to get to using it, have the staff using it to have a feel to have an opinion of whether it could replace it. (Y8 Teacher 10, Spring 2017)

At least 10 out of 33 teachers sometimes used the AL videos with their students and were generally positive about them, as bringing a 'different voice' into the classroom (Y8 teacher 6, Spring 2017).

At the end of the first year of the study, teachers at 9 of the 15 schools also indicated that one of their goals for the upcoming year was to develop and encourage

the use of AL in their schools, and two of the schools even bought additional digital resources. The HoMs at two schools explained:

> We haven't done ActiveLearn yet. I mean, we bought it but we haven't used it. We're going to do it in September so they can access ActiveLearn. We haven't done that yet (HoM 12, Summer 2017 interview).

> We haven't used much of the ActiveLearn part of the resources. So that's going to be a bigger part of the Key Stage 4. We want to make sure that the students can, their homework will be set on ActiveLearn as that is compatible with the content that they use in class (HoM 9, Summer 2017 interview).

Reasons for using ActiveLearn

When teachers do use the interactive elements, reasons given include their reported high quality, their ability to engage students and potential for improving student outcomes through familiarising students with different approaches and engaging them. Some particularly mentioned the videos as useful because they give the students a different authority or explanation. Online homework was also considered to be of good quality and three teachers spoke explicitly of the value they place on the integral formative assessment.

Reasons for not using ActiveLearn

The Spring 2017 interviews suggested the two main reasons for not using the digital resources were teachers' lack of familiarity with its affordances, and challenges with the software functionality (each mentioned by 12 teachers). Other reasons included problems with infrastructure (e.g. white board, internet), limited appropriateness of content (e.g. the homework was too easy/difficult), curriculum pressures of a new and more aspirational curriculum, and maintaining existing classroom habits.

While technical problems are clearly a first-order barrier (and fortunately most were addressed over the year), the lack of teacher's familiarity is a second-order barrier that is harder to overcome. Teachers often said they had not had enough time to get used to the resources. This resulted in some schools hardly using the digital service for the entire year. Teachers commonly reported going through a slow process of independent discovery, dealing with a sometimes-overwhelming choice.

Role of professional development

Professional development opportunities and a strong, solution-focused community in schools have been identified as crucial to overcome this kind of second-order barrier (e.g. Bai & Ertmer, 2008; Clark-Wilson et al., 2011; Drijvers et al., 2016). Study interviews suggested that none of the schools had bought the Pearson CPD resource-linked training, though a handful of teachers had attended some online training or recounted the demonstration of a Pearson representative (which focuses on a technical demonstration rather than pedagogical). Most sample schools, though (at least 9 of 15), claimed collaborative environments: teachers talked about working in teams who share experiences and resources. This was particularly the case as they were adapting to a new curriculum, when sharing knowledge and resources was essential to avoid the changes becoming overwhelming. Some schools had additional meetings around new GCSE topics. These kinds of collaborative sessions, however, tended not to focus on the use of the digital resources specifically, because teachers understandably prioritised new or re-focused curriculum content areas, or emerging new assessments:

time for such development is always an issue, but particularly when teachers are accommodating significant other change.

During the summer 2017 interviews, teachers reflected on the development of their use of the digital resources over the first year of the study. While most teachers (at least 13 of 19 commenting) reported that they developed and increased their use of the AL, at least two started to use the AL less as the year progressed: they again gave as reasons the pressures of coming to work with the new GCSE (with first assessment Summer 2017), with this trumping other considerations.

While many teachers emphasised collaboration within the school, only a minority of teachers (about 16 of 50 involved) reported learning from external events or programmes during the year, and in all but two schools this was limited to the HoM or Key Stage coordinator. Time and costs were quoted as big constraints here. Teachers repeatedly said that given the demands of learning to teach for a new curriculum, 'getting to know' AL was not top of their priorities – but that they fully intended to invest time in getting to know it better as other pressures allowed. In many ways this seems a 'catch-22' situation: these resources are designed to support teachers in opening up more aspirational curriculum goals to students – and yet teachers say they are having difficulty finding time to explore the potential of AL for their teaching, precisely because of the pressures of learning to teach for those aspirations.

Implications and Further Research

Although this study focused on specific materials, asking how and why they were used, as well as probing their impact on learning, the findings may have implications beyond the particular resources to other digital curriculum materials, including those designed for self-supported study, and mathematics-specific apps for exploration and discussion. The study offers evidence that teachers are often not fully using the learning potential of the digital resources invested in, even though those were carefully developed to offer reported widely valued, and varied, learning opportunities. The main challenges appear to be the lack of teacher familiarity, and technical issues, resulting in a slow process of the development of teacher knowledge around their use. This might have been addressed by more external professional development, or else by more targeted internal sessions – but there is a tension with other demands on teacher time.

We suggest that to better harness the potential of such resources, schools must recognise the need to invest time in software-specific professional development – whether bought-in, using AL technical- and pedagogical-focused CPD videos, or via peer-led internal collaborative development sessions focused on the digital resources. In parallel with understanding the technical aspects of the resource, collaboration and development should focus on the pedagogical knowledge around effective use. Teachers need to be confident with the technicalities if the platform is to enhance teaching and learning, but also to reflect on the most effective ways to integrate use of AL into their teaching, if its full potential, complementing the teacher role, is to be harnessed for students' benefit. Those responsible for curriculum change also need to be aware that the introduction of a fully coherent curriculum system (Schmidt & Prawat, 2006) of intended curriculum, assessment, and resources (which in the 21st century must surely include the harnessing of digital resources) – demands for its mature and embedded enactment sustained and informed teacher learning, related to *each* of those aspects, including the effective use of resources. Without that, we have

shown that the demands of preparation for teaching a new curriculum across the age range can marginalize other teacher development, including, paradoxically, for effective use of resources well-designed to support that curriculum change.

Year 2 of the study will probe the evolving extent and depth of use of KS3 Maths Progress and GCSE Mathematics 9-1 digital affordances as the new curriculum and GCSE bed down. It will further explore the ways in which, and reasons why, teachers and students use distinctively digital aspects, and the perceived impact on student learning. Additionally, it will probe what teachers consider Pearson's role should be in supporting them to make a more significant shift towards full use of the potential of AL.

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