‘At the Coal Face’: experiences of computer-based exams

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‘AT THE COAL FACE’
EXPERIENCES OF COMPUTER-BASED
EXAMS

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‘At the Coal Face’
Experiences of Computer-Based Exams

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Abstract

BTL have been working with Edexcel Foundation and the Northern Ireland Council for the Curriculum, Examinations & Assessment (CCEA) to develop a state-of-the-art system to deliver secure computer-based exams.

An initial pilot study lead to the development of a secure exam delivery system based on BTL’s proprietary ExamBase product. This system was used to deliver ‘live’ Basic and Key Skills Tests to over 300 students at a number of Ufi/learndirect and Army centres. These accredited computer-based and computer-marked tests were designed and validated with the same rigour as conventional paper-based tests, and the candidates were awarded real certificates.

The ExamBase system was then used to trial computer-based GCSE-style examinations, in Geography and Science, with over 1,000 pupils. An on-screen marking system for examiners was also piloted during these trials, to support the wider range of question types.

This proven system is now being rolled-out to learning centres across the country, to enable Edexcel and CCEA to offer computer-based versions of the new National Tests in literacy and numeracy. International trials of the ExamBase system are also planned.

This paper provides an overview of the technical design of the ExamBase system, of how exam security is achieved, and of the process for rolling-out ExamBase to a wide number of centres, each with unique technical configurations.

Most importantly, the paper evaluates this computer-based approach to exam delivery, in comparison with a traditional paper-based system, from the perspective of the key stakeholders: the Awarding Body, the learner, the examiner and the test centre.
The paper concludes that computer-based formal testing offers many advantages to candidates, examiners and awarding bodies, compared to the traditional paper-based approach. Increased learner engagement and improved exam security are particularly noteworthy. However, a greater burden is placed on test centres, initially at least, due to the technical demands of computer-based testing, although we suspect that this burden would be significantly reduced as a centre used the system on a regular basis over time.
Introduction

The purpose of this paper is to evaluate the performance of a computer-based exams system that has been used by CCEA and Edexcel to test both school children and adult learners.

Key success factors for a computer-based exam system are: candidate engagement, accessibility, technical reliability, test reliability and validity, security, and the ease with which exam data can be analysed.

The evaluation is based on a series of trials and the subsequent (and ongoing) rollout of the system for real tests. As such, this paper does not consider the theoretical aspects of computer-based testing. Rather it is concerned with the success of this approach to testing, in relation to highly practical considerations, from the perspective of the key stakeholders: the candidates, the test centres, the examiners and the Awarding Bodies. This evaluation makes use of qualitative evidence from the stakeholders, collected systematically, based on their experiences of the ExamBase system.

Project Background

The ‘Paperless Examinations Project’ is an initiative driven by Edexcel and CCEA to pilot computer-based assessment across England and Northern Ireland within the standard qualifications regime. BTL was commissioned to develop a computer-based exam delivery system to support phase 2 of this project (PEP2). This system is known as ExamBase.

The main objectives of the PEP2 project were to:

- prove the effectiveness of the technological solution in delivering computer-based assessment in Basic/Key Skills.
- identify and address pedagogical and technological issues raised by computer-based testing.
- identify learner attitudes to and demand for computer-based National Tests.
- identify effective procedures for candidates and centres in delivering computer-based assessment.
- give a manageable number of pilot centres experience of computer-based assessment with these Awarding Bodies with a view to rolling out computer-based assessment nationally in the near future.

This paper is concerned with two strands of the PEP2 project:

1. The trialling of computer-based GCSE-style examinations in Science and Geography within schools
1,400 computer-based mock GCSE exams were taken in 19 schools in England and Northern Ireland, involving over 1,000 candidates.

2. The piloting of computer-based Basic Skills tests for adult learners at existing learndirect and Army test centres.

Over 300 adult learners took Basic Skills National Tests in literacy and numeracy, under exam conditions, at 13 learndirect and Army centres.

Since the completion of the PEP2 project, a roll-out programme has been initiated to install the *ExamBase* system in hundreds of learndirect and DfES test centres across the country, to provide future access to on-screen versions of the National Tests as part of the Skills for Life project.

**BTL’s ExamBase System – an Overview**

The system is comprised of the four main elements shown in Figure 1 below:

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**Figure 1. The ExamBase System**
1. **Assessment Producer**

   This is a proprietary tool developed by BTL to facilitate the design and production of the exams. Over fifteen standard interactive question types are built-in, and custom questions can be readily integrated.

   Validated exams are posted to the *MicroBoard* website.

2. **MicroBoard**

   This is a dedicated website and supporting database facilities, used for registering candidates and for downloading software and documents, scheduling exams and for storing uploaded results. *MicroBoard* is the ‘gateway’ for data reporting into an Awarding Body’s main examination systems.

   Prior to an exam, the candidate list and the exam ‘paper’ are downloaded from *MicroBoard*.

3. **ExamBase Server**

   This is the software that sits on the server and is used to schedule and administer exams, and to seamlessly download and upload data to/from the *MicroBoard* website.

   After an exam session, marked candidate ‘scripts’ are uploaded to *MicroBoard* (these scripts will be partially marked if some questions require professional marking).

4. **ExamBase Client**

   This is the software that sits on the candidate’s PC; it locks down the desktop, preventing access to other programs, and enables access to the exams.

**The MarkerBase Module**

There is an additional fifth software module called *MarkerBase*. This component is used by examiners to mark those questions that cannot be computer marked; marks awarded by examiners are integrated with the computer-awarded marks.

The integration of *MarkerBase* with the rest of the *ExamBase* software is shown if Figure 2, below.
Figure 2. The MarkerBase Module

Technical Configuration

The standard configuration is to have the client machines connected to the ExamBase server machine over a local network (LAN), and for the server to connect to the MicroBoard website via an internet connection. By running the exams across a LAN, rather than from the internet, system performance is not affected by internet bandwidth or performance.

For test centres without an appropriate LAN configuration, the ExamBase software can be hosted on a remote server, accessed over the internet in ‘real time’ to run the tests. This solution is more susceptible to internet and bandwidth problems.

Exam security

Security is of paramount importance to the success of any exam system. Computer-based exam systems potentially offer greater security than traditional paper-based systems, which are vulnerable at many stages in the exam lifecycle (e.g. papers may be lost in the post). Also, more advanced skills are needed to hack into a computer system. However, the impact of a breach of security is likely to be more serious.

The ExamBase system uses these security mechanisms:

- All data transferred across the internet is both encrypted and uses secure internet technologies (as used for online banking).
All data transferred across the LAN within a test centre is encrypted. Exams are only unencrypted at the final point of delivery, by the client PCs; candidate results are then encrypted on the client PC prior to transmission across the LAN to the server.

Figure 3. Data transfer security mechanisms

In addition, test centres are responsible for ensuring that exam servers are housed securely.

For the purposes of the MarkerBase trials, data was transferred to and from the marking centre on CD-ROM; MarkerBase subsequently ran in a closed LAN environment and the data was therefore not encrypted. However, MarkerBase can equally be connected to MicroBoard via the internet, in which case transferred files are encrypted.

Technical support for Test Centres

During the PEP2 project, BTL was responsible for providing technical support to all test centres. Centres were asked to install the software themselves, but BTL support engineers were on-site to provide assistance where necessary. Mandatory training was provided for all centres, covering:

- Registration and candidate administration through the MicroBoard website
- Installation of the ExamBase software
- Using the system: scheduling and running exams
A similar approach was subsequently used to roll-out the system to a further twenty-nine learndirect centres (by April 2003), to facilitate on-screen National Tests. ExamBase will also be installed at further learndirect centres and at one hundred and twenty DfES centres by December 2003; in this phase of the roll-out centres will be required to undertake a self-installation process.

The Test Centre Experience

Two different types of test centre have been involved in this project: schools, to host the mock GCSE exams, and learndirect/Army centres to host the National Tests.

Running computer-based exams presents a significant challenge for test centres that have previously only delivered paper-based exams (i.e. the schools), or which may not previously have been involved with examinations at all (i.e. the learndirect/Army centres).

All the centres face two main challenges to successfully support computer-based exams:

1. to provide an adequate technical infrastructure; this includes the hardware as well as correctly installed software (in this case ExamBase) and trained technical staff
2. to provide an appropriate exam environment, which allows candidates to work with minimal distractions and with adequate privacy

Providing a reliable technical infrastructure

Experience from the PEP2 project shows that the reliability of the technical infrastructure is of paramount importance and that complete reliability cannot be guaranteed. If the technical infrastructure is unreliable, this may cause an exam session to be interrupted. The ease with which a test centre is prepared for an exam is also dependent on the quality of the existing technical infrastructure, in particular the hardware.

Providing appropriate training and support, to motivate staff as well as to increase their expertise, can increase reliability; however, the provision of adequate PC systems is largely dependent upon levels of funding. Maintenance processes and the availability of spare equipment are also factors that will affect reliability.

Providing an appropriate exam environment

The project showed that setting-up a room ready for a computer-based exam takes longer than for a paper-based exam, as PCs are required as well as desks. It is also showed that it is more difficult to provide an acceptable exam environment for computer-based exams. In particular, it is often difficult to provide candidates with PCs that are spaced sufficiently well apart to minimise the risk of distraction and reduce the temptation to copy. In reality, because there is only one question per screen, the risk of copying is reduced as soon as neighbouring candidates are working on different questions.
Computer-based exams are less scaleable from the point-of-view of the test centre – it is clearly less easy to ‘find' extra PCs to accommodate larger groups than it is to provide additional desks and chairs.

The Schools’ Experience

Paper-based examinations have been a feature of school life for many years and consequently well-defined processes and rules have evolved, covering such issues as security, distribution and data collection. By contrast, computer-based exams are completely new to most schools and the rules and processes for delivering these are still emerging. In addition, schools are not familiar with maintaining 'business critical' IT systems.

A significant transfer of responsibility from administrators to technical staff is required, and the expertise and commitment of the technical staff becomes crucial to the success of the whole enterprise. Within a school there may only be a single person who is able to provide the appropriate technical skills and consequently there is a risk that an exam sitting may be jeopardised if that person is unexpectedly not available – this contrasts with the situation for traditional exams, where the skills and knowledge required to run an exam are more readily transferred when required. This effect would be lessened as computer-based exams became more regular, with administrative staff able to take on tasks such as exam scheduling.

All schools participating in the trials were asked to complete a questionnaire. In general, the schools coped well with preparing for the computer-based exams, although this required significantly more effort than preparing for traditional exams. Analysis of the questionnaires shows that 48% of 60 respondents found the software installation easy or very easy whilst 42% found it difficult or very difficult. Recommendations for making the installation process easier included:

- Provision of a more comprehensive user guide
- The installation guide should provide more advice about trouble shooting and about the additional software and data files required

The majority of respondents (54%) had no problems with the candidate registration process, using the MicroBoard website, and all participating schools managed to successfully trial exams.

The learndirect Centres’ Experience

The learndirect centres have been established to offer computer-based learning. As such, they tend to have a better technical infrastructure than schools and are used to maintaining ‘business critical’ IT systems. However, while these centres have previously provided formative assessment they have not previously provided more formal tests and exams.

The ExamBase software has recently been installed at twenty-nine learndirect centres, ready for learners to take the National Tests. All these centres were asked to complete a
questionnaire. These show that 95% of the nineteen centres that responded found the installation of *ExamBase* either easy or very easy. This is not surprising given the technology-based learning focus of these centres. In addition, all the centres found the registration of candidates on the *MicroBoard* website either easy or very easy.

**Conclusions**

To prepare for computer-based exams requires considerably more effort than preparing for paper-based exams. The risk of disruption to an exam is also greater. However, computer-based exams do also offer a number of advantages to test centres:

- Staff do not have to physically handle large quantities of paper.

- The collection and return of the candidates’ ‘scripts’ is far simpler and less time-consuming. In addition, the effort required is not dependent on the number of exam candidates.

- Exam security at the test centre is improved because sophisticated IT skills and resources would be required to illegally access the exam ‘papers’ or ‘scripts’ on the server.

We believe that as more test centres are set up to deliver computer-based tests a more defined set of rules will emerge that will help the set-up process run more smoothly. In addition, it is likely that centres will in future have to comply with a more focused technical specification, to reduce installation problems and the burden of technical support, and to help increase reliability. A system of technical accreditation for centres would also be valuable.

**The Candidate Experience**

The candidates are the consumers of the computer-based exams. Their response to being tested in this way is therefore vital to the wider use of computer-based testing. The single most critical factor is that the user interface must not be a barrier to assessment – the interface is simply the candidate’s tool (in the same that the pen and paper are in a traditional test) and should not require anything other than the most basic IT skills. Other factors include the candidates’ perceptions of the tests, and the testing environment.

Our work has involved two distinct sets of candidates – 15 to 16 year old pupils, and adult learners - and each set has a different perception of both testing and of using IT. Pupils have grown up with IT, not least in their school lives. Of the participating pupils, over 94% also make use of a computer at home at least once a week, and over 40% access the internet daily. These ‘digital natives’ are generally comfortable with using computers and in many cases prefer typing to writing. The pupils also had no choice about taking the computer-based trial GCSEs, this was just another part of school life.

In contrast, there is a great disparity of IT experience amongst adult learners. Some have much experience of using computers, at home and at work, and are at ease using computers; others have had little or no experience of computers, and some feel intimidated by the technology. In addition, adults taking Basic and Key Skills tests are
doing so out of choice; they have returned to learning to improve their skills and to create new opportunities for themselves.

We gathered feedback from all candidates during these projects, and it is clear that the user interface was not a barrier to assessment for either the school children or for the adult learners. Both sets of candidates appeared to find the interface easy to use, and no candidates were unable to complete their assessment because of it. One adult learner, unusually, had never used a computer before, but was able to start the assessment after just 5 minutes of tuition.

**The views of pupils**

The feedback from the pupils was overwhelmingly positive, with the vast majority (92%) saying that they either enjoyed the tests or found them to be okay. 95% of the candidates found it easy to navigate through the tests.

Common comments included:

  “more enjoyable than writing”  
  “easy to understand questions with animation and diagrams”  
  “attention was kept throughout the test”  
  “refreshing, colourful and much better to do than pen and paper exams”

The comments of pupils who did not enjoy the tests included:

  “no tests are enjoyable”  
  “staring at screen hurt eyes and head”

Of the 26% that indicated that the tests did not run smoothly for them, only 6% said that there was not enough time to answer all questions.

**The views of adult learners**

Ufi was responsible for collating the feedback from the test centres where Basic Skills tests were taken, and summarised candidate responses as follows:

*Candidate reaction to the Literacy and Numeracy tests was exceedingly favourable. Candidates reported enjoying the experience of taking the tests and of participating in the pilot. Many learners reported that they valued the opportunity to gain a formal qualification. Almost unanimously they reported preferring to take an online test rather than a paper test. This was evidenced both in candidates with and without experience of computer based learning.*

There is evidence that many adults found it less intimidating than a traditional exam. For example, two learners at one test centre had previously failed paper tests on 3 attempts but passed on this first attempt using *ExamBase*. They both reported that they were much less nervous at taking the tests on-screen because ‘it didn’t feel like an exam’. For many adults, sitting at a computer was a far cry from the ‘exam experiences’ they remembered from school; for many adult Basic Skills learners paper-based exams are
associated with failure at school, while computer-based exams are not tainted in this way and are seen as new and positive.

Common Concerns

While the candidate experience was an overwhelmingly positive one, some issues that need resolving were apparent. The exam environment presented some problems, with some candidates distracted by their close proximity to each other, and some candidates were particularly distracted by keyboard noise. These issues could be resolved by the use of quieter keyboards and, more completely, by the use of individual cubicles, although obviously there are cost implications here.

Technology failures were the most negative factor for candidates; although these were rare, when they did occur, candidates were not surprisingly annoyed and distracted by them (one candidate’s PC crashed 3 times during his mock GCSE). The vast majority of technology failures were due to PC system problems, rather than ExamBase software problems. This is an issue for test centres, as discussed above. It is worth noting that ExamBase has built-in ‘failsafe’ features: these enable a candidate whose PC has crashed during an exam to move to a spare PC and carry on from the point at which the interruption occurred (a maximum of one minute’s data could be lost).

Conclusions

Candidates liked the computer-based tests and there is evidence that this form of testing may help re-engage adult learners in particular, provided that the user interface does not present a barrier to participation. It is also very important that candidates are not exposed to the frustrations and confusion that can result from technical failures, as this may have a strong negative impact on their perception of on-screen testing.

The Examiner Perspective

The eight computer-based GCSE-style exams included both computer marked questions and professionally marked questions, such as free text response questions. The MarkerBase application enabled examiners to mark on-screen those questions requiring professional marking, and to integrate these marks with the computer-awarded marks. Approximately fifty percent of the marks awarded across all eight papers were awarded by examiners using MarkerBase.

Figure 4 below shows an example professionally marked question from the geography paper, where the candidate has to enter a free text response.

A computer-based marking centre was set up at CCEA in Belfast. A total of ten markers, with a range of backgrounds, took part in the marking process. Most of the ten markers had minimal experience with computer-based tests, but they did all have a basic level of IT skills.
Using MarkerBase

The MarkerBase system enables the examiner to mark ‘scripts’ (assigned by an administrator) in two ways:

1. Marking by candidate: the examiner can go through a candidate’s script on-screen, marking those questions that have not been computer marked (and reviewing the computer marked questions if necessary).

2. Marking by question: the examiner can mark a particular question on-screen for each candidate in turn, before proceeding to the next question.

In either case, the examiner sees each question on-screen just as the candidate left it, and in addition a floating marker panel is displayed (Figure 5). The marker panel describes the marking scheme for the question and provides the mechanism for awarding marks.

The examiners were given a training session in the use of MarkerBase, and had the opportunity to practise.
What did the Examiners think?

The examiners were asked to complete a questionnaire after they had finished marking. Comments from the markers showed that learning how to use the software was quite straightforward and that they were able to start marking scripts with very little practice.

Nine out of the ten examiners found the marking either very enjoyable or enjoyable. However, one respondent did not enjoy the on-screen marking process. The majority found working in a marking centre either very enjoyable or satisfactory, although again, one examiner did not enjoy the experience. However, eight of the examiners stated that they preferred working from home. All ten of the examiners found the software either very easy or easy to use, and all found the training either very useful or useful.

Six of the respondents indicated that they marked by both candidate or by question. Those preferring to mark by candidate, however, liked the option of being able to mark by question where appropriate.

The examiners were also asked to express their opinions in relation to three statements about the efficiency of computer-based marking, and their responses are shown below:
The MarkerBase trials suggest two main benefits:

1. More rapid marking

   No formal processes were used to measure time spent marking but the examiners were asked at various stages of the process about the pace of their marking. Early on all examiners said that it was taking them longer than marking traditional paper tests. However, the speed of marking increased as markers became more experienced and confident with the process. By the end of the marking process it became apparent that electronic marking was as at least as quick as marking paper tests, if not slightly quicker. It was also clear that the examiners with greater experience of IT were quicker at marking scripts.

   The ability to mark by question (rather than marking a whole script) also significantly increases the efficiency of the marking process, and is a clear benefit of the on-screen marking system.

2. More accurate tallying

   One of the aspects of on-screen marking that the examiners liked best was the automatic tallying of marks, including the integration of computer-awarded and professional-awarded marks. The examiners felt that this was a significant advantage over paper-based marking, relieving them of an error-prone task (which has to be checked) and saving them time.

Conclusions

On-screen marking improves the efficiency and reliability of the overall marking process, and is popular with examiners. The system would be even more popular with examiners if they could mark on-screen at home, and this would provide greater flexibility too (MarkerBase can now be configured for internet access).
The Awarding Body Experience

The Awarding Body is ultimately responsible for the success of a particular exam. Consequently, any exam system must successfully address a range of key requirements for the Awarding Body.

Engaging Learners

Clearly Awarding Bodies have a strong interest in engaging learners, both to entice more candidates to take their exams, and to give these learners a positive experience that will encourage further progression.

The PEP2 project has shown that computer-based testing can help to engage individuals that become overly stressed when faced with the traditional examination process. There is anecdotal evidence that computer-based exams are less stressful because they are closer to some candidates’ day-to-day experiences. In particular, young people today are exposed to “on-screen selection situations” computer technology from an early age, and this helps them to respond more naturally to on-screen exams. There is also evidence that exam stress is reduced for some mature candidates who, in some instances, considered that they were taking a “computer test” rather than a Basic Skills test. Being seen to take these tests on computer also appears to have a positive impact on their self-esteem and sense of achievement.

Accessibility

From the awarding body perspective computer-based testing has been seen as a way in which examinations can become more accessible to candidates.

In terms of exam scheduling, computer-based systems offer much greater flexibility. The current ExamBase system allows candidates to be entered for an exam right up until the time of the examination – this would not be possible with the traditional paper-based approach. The system also offers the potential to move to “on demand” testing, in due course, further increasing the accessibility of examinations. For example, students on modern apprenticeships spend much of their time away from their learning institution, and their presence is difficult to predict; an “on demand” testing system would ease the scheduling of tests for this client group.

The way in which we use the available technology has also been an important aspect and the decision to adopt the ‘on screen’ approach as opposed to the ‘on line’ approach has been instrumental in the success and flexibility of the system. This allows tests to be taken in remote or mobile situations. For example, a bus equipped with a suite of PC’s and a small server can now roam from community to community (both urban and rural); individual laptops may be taken out to address the needs of remote farming communities.

Results Generation and Data Analysis

Computer-based testing offers the possibility of the much more rapid feedback of results to candidates. Indeed, once the examinations have been completed they can be instantly marked, if no professionally marked questions are included. However, it has been decided that we may do more harm than good if we feed these results directly to the student on-screen at the end of the exam, particularly at the lower levels. It is nice to find
out you have passed but not so nice if you have to cope with a failure. Instead, feedback will be provided by the individual test centre, which will communicate the results in an appropriate manner. Even so, there is still the potential to reduce the timescales for providing candidates with their results, compared with traditional systems, thereby reducing candidate frustration.

Computer-based systems also offer the potential for richer feedback, to both candidates and test centres. In addition, exam data can be more readily analysed, for example to detect anomalies in the candidate answers. This analytical potential was illustrated during the project, when an unusually high degree of correlation between two candidate’s answers was detected.

Quality Assurance and Security

The processing of exams, from test to certification has, to date, offered significant challenges to Awarding Bodies such as Edexcel. There is the potential for human error at many points in the lifecycle of a paper-based examination. The use of technology has reduced the number of points at which an error can occur but increased the impact of the error.

This means that there is a QA emphasis shift to check the process at different points in order to maintain the extremely high standards demanded by the centres and candidates. Edexcel have worked closely with the verification team to ensure that QA is approached in a methodical way, and have carefully refocused their quality checks.

Security has always been a particular concern, for obvious reasons, and traditional paper-based systems have always been vulnerable to lost or mishandled papers, for example. This project has confirmed the belief that the computer-based approach is significantly more secure due to encryption technology.

Reliability

Reliability is an important issue for an Awarding Body, which wants to be confident that the same answer to a particular question will always be awarded the same mark.

Computer-based exams offer complete reliability for computer-marked ‘closed’ question types such as multiple choice questions and drag-and-drop questions. This is a definite advantage compared to paper-based exams, where even multiple-choice questions are vulnerable to marking errors.

In the case of ‘open’ question types, such as free text responses, professional marking is still required, and therefore marking remains subjective. However, by allowing examiners to mark the same question for all candidates in succession, and by making it easy for examiners to review and re-mark questions, the MarkerBase system does provide the potential for examiners to be more consistent in their marking.

Exam Validity

Ensuring the validity of the computer-based exams is of paramount importance. In this project there were two different scenarios:
1. Translation of paper-based questions to on-screen format

In the case of the National Tests (adult Literacy and Numeracy) it is essential that parity with the alternative paper-based systems is achieved, so that no candidate is either advantaged or disadvantaged by the use of on-screen testing.

In this project we took great care with the translation of the already validated paper-based questions to the on-screen format, to ensure parity. During the trials we correlated the test results from ExamBase with the average pass rates for the paper-based series; the correlation was typically within a few percentage points. We also looked at the difference between cohorts from the same test centre, and again the correlation was within a few percentage points.

2. Development of new on-screen questions

In the case of the mock GCSEs many of the questions were devised specifically for on-screen testing, making use of interactivity that would not be possible within a paper-based exam. For example, in the question below (Figure 6) the candidate is asked to time the car as it moves across the screen, and clearly this could not be replicated by a paper exam.

![Figure 6. A on-screen question that could not be replicated on paper](image)

It was outside the scope of this project to develop fully validated GCSEs, and to do this would require the detailed involvement of the Chief Examiner’s team. However,
no specific obstacles to full validation of computer-based GCSEs emerged during this pilot project.

Another concern, unique to computer-based exams, is the impact of the performance of individual computers. Potentially, a candidate with a ‘faster’ computer would have more time to answer the questions than a candidate with a slower computer. Clearly, this would invalidate the exam process. However, the ExamBase system was able to take account of the differing performance characteristics of candidate computers, and ensured that the time available to candidates to answer questions was always the same.

Conclusions

The PEP2 project is a good example of successful collaboration, involving a number of institutions as well as a technology partner and many test centres. The ExamBase system succeeded in securely delivering a wide range of computer-based exams, and their results, to over 1,300 candidates, and real qualifications were awarded.

Evaluation of the project has shown that computer-based exams are very popular with both school children and with adult learners, and offer the potential for greater engagement. This is perhaps the most important benchmark of success. Examiners too were generally positive about the benefits of on-screen marking, most notably the potential for greater efficiency.

For an Awarding Body, such as Edexcel and CCEA, the project confirmed that there are many benefits, including improved security, faster turnaround of papers and less examiner time. Both Awarding Bodies see the flexibility of computer-based exams as the greatest benefit, offering improved access to candidates, easier scheduling and, ultimately, the potential for on-demand testing. The project showed that valid on-screen tests can be generated relatively easily from existing paper-based exams; however, new on-screen exams using full multimedia question types present a more challenging validation exercise. The effort required to create and validate more innovative and interactive exams is rewarded by the availability of more engaging exams that assess skills and knowledge in more sophisticated ways.

Computer-based exams do, however, place a burden on test centres - initially at least - because preparing centres for on-screen exams is more complex and time-consuming than for paper-based exams; this additional burden is greater for schools than for centres that have been set-up for computer-based learning. For schools running computer-based exams instead of traditional exams there is also a significant shift of responsibility from a larger pool of staff with administrative capabilities to a smaller pool (often only one person) of technical staff. Once centres are running computer-based exams on a regular basis, however, the ‘set-up’ burden is likely to be reduced as staff become more familiar with the process and with the technical configuration. Indeed, over time, well-managed centres may find that there are efficiency gains associated with computer-based exams; however, a more long-term evaluation is required to assess this effect.

The over-arching requirements for the success of computer-based exams are the availability of sufficient numbers of well-maintained PC systems, of appropriate specification, and the provision of a reliable supporting technical infrastructure (including
trained staff) - this requires both adequate funding and good management. Centres that succeed in meeting these requirements are rewarded by their ability to offer learners a more innovative and engaging alternative to traditional examinations, and the security concerns associated with paper-based systems are largely removed.

In summary, the PEP2 project has demonstrated that computer-based examination systems offer a rich seam of opportunity to all the main stakeholders.