MoodleQuiz: Learner-generated Quiz Questions as a Differentiated Learning Activity

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Declaration

I declare that the work described in this document is, except where otherwise stated, entirely my own work and has not been submitted as an exercise for a degree at this or any other university.

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Abstract

Asking good questions is an important skill to foster as a means for learners to develop higher level thinking skills (Ciardiello, 1998). However, questioning in the classroom is typically the prerogative of the teacher, leaving little room for learners to develop their own questioning skills. With large mixed ability classes the norm in Irish primary education, a verbal approach to learner question-posing activities is not practical, but an activity where questions are composed by learners working in small groups, creating structured questions of types already familiar to them, may have the potential to improve learners' ability to ask questions.

Learners become familiar with a number of structured question types (e.g. Multiple Choice, Cloze) in textbooks and worksheets from quite an early age. A number of studies have explored single learners using technology to create Multiple Choice questions, often with secondary goals of individual assessment and/or peer review in mind (Denny, Luxton-Reilly, & Hamer, 2008; Yu, Liu, & Chan, 2005), while others have focused on the learning benefits from the process of collaboratively creating the questions (Arthur, 2006; Ciardiello, 1998; Fellenz, 2004), with less emphasis on assessment or technology. This study seeks to combine the two approaches, using technology to facilitate a collaborative constructivist pedagogy in creating questions, but with emphasis on supporting a differentiated learning approach, suitable for the Irish mixed ability classroom.

The research question therefore posed in this study is: Does in-class activity around (technology-mediated) learner-generated quiz questions support differentiated learning? To answer the question, an intervention is designed using the principles of collaborative constructivism and the affordances of the Microsoft Word word-processor and the Moodle Learning Management System.

A qualitative research method was employed, and data gathered from semi-structured interviews with teacher and learner participants, a learner questionnaire, structured observation of the intervention and review of the questions created.

A case study was conducted with the teachers and pupils of two urban, mixed ability 6th classes in separate primary schools in Dublin. Analysis of the data collected in both cases suggests that the activity supports and engages learners of all abilities. The findings show that less able learners created structured questions in a collaborative constructivist manner, with little assistance required from the teacher, and more able learners created more complex question types.

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Abbreviations

CAA	Computer Assisted Assessment
GIFT	General Import Format Technology
HOTS	Higher Order Thinking Skills
HTML	HyperText Markup Language
LAMP	Linux Apache MySQL PHP/Perl/Python
LMS	Learning Management System
MCQ	Multiple Choice Question
PHP	PHP: Hypertext Preprocessor
PPT	Pencil and Paper Test
QTI	Question and Test Interaction
SAT	Standard Aptitude Text
VBA	Visual Basic for Applications
VLE	Virtual Learning Environment
XHTML	eXtensible HyperText Markup Language
XML	eXtensible Markup Language
XSLT	eXtensible Stylesheet Language - Transformations

1

Introduction

Large mixed ability classes are the norm in Irish primary and (to a lesser extent) secondary education. While "the importance of making due allowance for individual difference" is acknowledged in principle in the Irish Primary School Curriculum (NCCA, 1999), in practice, making such allowance is becoming more difficult for teachers, due to the increasing class sizes and decreasing resources enforced by less favourable economic times. This study explores learner-generated quiz questions, an intervention that may have some potential as a whole-class activity that recognises and supports individual difference, without demanding superhuman effort of teachers.

Asking questions is an everyday part of school life. In the classroom, most questions are asked by the teacher, often to assess student learning, or perhaps simply to assess whether they are paying any attention. If "True learning is characterised not so much by the answering of questions as by the asking of them" (UNESCO, 1980), teachers are learned indeed, but how many questions does a student ask in a day? And how many of those are asked during school? Students asking questions should be a 'good' thing, but if they ask too many questions, it can become, or seem to become, disruptive, interrupting the flow of a lesson. Asking good questions however, is an important skill to develop in all learners (Ciardiello, 1998). Too much time is spent teaching learners to *answer* questions rather than ask them. It is a strange irony that today, many societies (or rather economies) are demanding that learners are prepared for the 'new' knowledge economy by being taught to be more enquiring, innovative and entrepreneurial in thinking, while at the same time, are still, and even increasingly, using formal, question-answering, assessments to enforce higher educational performance.

> *Curricula and assessment mechanisms should promote critical thinking, entrepreneurship and innovation*
>
> (NCC, 2009)

Before learners can ask good questions, they must first learn how to ask questions, and also learn what good questions are. Creating questions is not a trivial task however

(Pritchett, 1999), and is a skill that must be developed. Exploring how to develop this skill in the classroom is the purpose of this study. To this end, a technology-mediated artefact has been developed to support learners in creating a range of structured question types, of the forms that learners have already encountered.

Much research on questions for assessment is available, for example (Brown, Race, & Bull, 1999; Bull & Dalziel, 2003), and these have been reviewed to help design a range of suitable question types and structures for use by learners. However, the environment within which the artefact will be used is an important factor to consider in the design. The artefact is intended to be used by learners in the school classroom, where there is a wide range of ability and readiness between different learners. Therefore, there is a need to support learners at different stages of readiness, by providing appropriate supports to help the less able, and also by differentiating the process so that an appropriate level of challenge is provided to the more able (Tomlinson, 1999).

1.1 Research question

The primary question posed in this study is the following.

- Does in-class activity around (technology-mediated) learner-generated quiz questions support differentiated learning?

This primary question is addressed by asking the following sub-questions, which are intended to explore and illuminate the primary question.

1) Do learners of different abilities engage with the activity?
2) Are more able learners challenged to create richer questions?
3) Do less able learners get enough support to create questions?

These questions all encompass the more general question: "Where is the learning value in this activity?" A further question arises in relation to the issue of using the activity in a wider context:

4) What are the pedagogical and practical challenges involved in the activity?

This question attempts to identify issues that might constrain the wider use of the intervention. Although not explicitly targeted in the data collected, an attempt will be made to highlight and address some issues, based on the data analysed.

1.2 Outline of thesis

- **Literature review**

  The literature review identifies and examines a number of areas relevant to the study. The structure of quiz questions, both at the individual question level, and to some extent the collective item bank level, are reviewed, to inform the implementation of the artefact. Other recent research in the area of learner-generated quiz questions is examined, to situate this study in a broader context. Finally, these areas are analysed from the perspective of differentiated learning, and aspects that support differentiation are discussed. This informs both the design of the class-room intervention and the required features of the technology mediation.

- **Design of the artefact**

  The design chapter describes the technical implementation of the artefact, which comprises two components: firstly, Word templates and macros to assist in the question authoring process, and in the conversion and import of the questions into a Moodle LMS; and secondly, Moodle LMS software enhancements, to support the integration of Word and Moodle.

- **Research methodology**

  The implementation of the intervention is described in the methodology chapter, and the reasons for adopting the case study approach discussed. The data analysis methodology is also described in this chapter.

- **Data analysis**

  In the Data Analysis chapter, the data sources are examined in the light of the research question and sub-questions, to ascertain whether the intervention was successful. Data sources include the questions created, observations of both the researcher and the teachers involved, and interviews with the participants. Some discussion of the findings is also presented in this chapter.

- **Findings and conclusion**

  Finally, in the conclusions, the main findings are discussed and summarised. Areas where further research would be beneficial to explore the intervention in more depth are suggested, and other areas where the artefact could be applied or extended are discussed.

2

Literature review

This review begins by considering the role of questions in learning, and how learners can be supported in posing questions. It then reviews a number of learner question-posing studies, as well as web-based and other technology-supported question authoring systems. Finally these systems are analysed to inform the design of a differentiated learning activity around learner question posing.

2.1 Questions

Teachers ask 300 – 400 questions in a typical day, according to a study quoted by Brualdi (1998), or 43 to 76 per hour, depending on the subject, according to Kerry (1998). Kerry extrapolates this to suggest that teachers may ask an astonishing 2 to 4 million questions in their career. Students, however, ask very few questions, for various reasons, including discouragement by teachers on the one hand, and social pressures by classmates on the other, according to studies quoted in Chin, Brown & Bruce (2002).

Nonetheless, teacher-originated questions have long been an integral part of the school classroom. Perrott (1982) quotes a range of studies as far back as Stevens in 1912, counting the number and types of questions asked by teachers in a typical day. Somewhat surprisingly, considering the advances in educational research, Perrott states that in most studies, over 60% of questions, both at the start of the century and more recently, are low-level, fact-based questions derived from the textbook. Kerry concurs, and further suggests that most of the remainder, 12% – 30%, are related to classroom management, while only 5% – 10% are higher-order questions according to Blooms Taxonomy (Krathwohl, 2002). Does this matter to students learning? Perhaps not in the way one might expect. Gall (1984) considers two reviews of the same series of experiments measuring the value of lower and higher order question types, which came to opposing conclusions regarding the relative value of such questions in improving student achievement. She suggests that the apparent conflict could be explained by differences in the student populations used in the experiments. The lower order questions were more effective for younger (primary level) or less able learners, while the higher order questions were more effective for older

(post-primary) and more able learners. This suggests that in mixed ability classrooms, a broad variety of question types need to be used to encompass the range of abilities of the students. It is worth noting however, that Kerry cautions against the mistake of targeting lower order questions, usually requiring short closed response or recall answers, exclusively at less able learners, while directing higher order, more open questions at more able learners.

What is the purpose of questioning? Many different reasons have been identified for asking questions in class (Kerry, 1998; Kyriacou, 2007; Morgan & Saxton, 1991), though Kerry provides the most detailed explanation. They can be categorised into a number of areas: cognitive (e.g. "To encourage a problem-solving approach to thinking"); diagnostic assessment (e.g. "To monitor the extent and deficiencies of student learning"); engagement (e.g. "To stimulate interest and awaken curiosity"); and social/constructivist (e.g. "To help students learn from, and respect, one another"). While these are laudable and important goals, a considerable degree of skill, practice and experience is required by teachers to achieve them, and this is the subject of Kerrys' and other practical books targeted at teachers.

Morgan & Saxton (2006) take a slightly different perspective, and categorise questions into three types by intended function: eliciting information, shaping understanding, and supporting reflection. This approach has origins in the ReQuest one-to-one questioning system for improving reading comprehension (Manzo, 1969), which involves teachers and learners taking turns to read a passage from a book, and ask each other questions on it. An even earlier reading strategy is the SQ3R self-questioning system proposed by Robinson in the 1940s, which works by having learners quickly Survey a text and define a set of Questions which might be answered by it (Huber, 2004). In both these highly structured approaches, the learner actively asks or composes questions, rather than simply answering them. Baljathy (1984) suggests that self-questioning is a key skill in reading for comprehension activities.

In the whole-class scenario, however, publicly asking or answering questions is a very different activity. Kyriacou points out that speaking in class is an emotionally high-risk action for students, and so the classroom climate is an important factor in encouraging students. Many students evade involvement in asking or answering questions, and develop effective strategies to do so. Teachers are always under time pressure, and tend

not to focus too much on one individual if they haven't responded adequately, as this seems unfair on others. Students naturally know this too. So if learners don't ask questions in class, and also often avoid answering them, what can be done?

2.2 Scaffolding

A broader approach to the problem is to provide support to learners to understand questions and their purpose at a meta-cognitive level. King (1994) describes a system of 'guided cooperative questioning', an intervention in which second-level learners were provided with prompt cards containing pre-defined question stems (e.g. "What are the strengths and weaknesses of …") as a means to prompt them to create questions related to a topic of study. They then asked and answered each others' questions in small groups. The question stems were designed to support higher order (comprehension, analysis, evaluation, etc) questions, rather than just recall. The prompt cards were a form of scaffolding, supplemented by training given by the teachers in classifying questions into "memory", "comprehension" and "connection" types. Ciardiello (1998) used a similar system of training in question categorisation, supplemented by prompt cards, in his "Ask a Good Question" instructional model to assist learners in creating questions across a range of cognitive levels.

More recently, the idea of scaffolding learners in question-creating and answering activities has been the focus of a number of studies, with different types of scaffolding support, collaborative/constructivist and/or technology-mediated.

In Fellenz (2004), the author describes a Multiple Choice Item Development Assignment (MCIDA), whereby learners (initially alone, but later in small groups) on an undergraduate business course were required to prepare Multiple-Choice Questions (MCQs), including feedback and the chosen cognitive level, as out-of-class assignments during a course of lectures. Similarly, Arthur (2006) describes an activity where small groups of third-level learners were assigned to collaboratively create a quiz of 6 to 8 MCQs based on a single lecture in a course of study, in the week following that lecture. Each quiz was then completed on paper by all members of the class the following week as a revision exercise, and was also the subject of classroom discussion. In both these studies, the group nature of the assignment promoted a collaborative constructivist approach, providing a degree of scaffolding that Fellenz in particular noted as being important.

These interventions were primarily paper-based, although the questions were prepared using a word-processor.

In contrast to the paper-oriented approach, Chang, Huang, Tung, & Chan (2005) report on AGQ (A Good Question), where they used Tablet PCs in a post-graduate classroom assignment to allow learners create, share and peer-review MCQs wirelessly. After a lecture, learners worked alone to create one item based on its content, and then dispatched it, initially anonymously, to two other learners, who reviewed and commented on it. The three students then combined into a group, and chose two of the questions for submission as a group. Although this is ostensibly a collaborative approach, a significant element of competition is involved, as it implies winners and a loser in each group. The study seemed to be an effort to investigate a suitable activity for a technology-mediated interaction with Tablet PCs, rather than a purposeful use of questions as a pedagogical strategy to aid learning.

2.3 Technology-supported question posing activities

If creating questions is a meaningful activity, can it be usefully supported by technology? This section examines a number of approaches to scaffold the creation of questions by learners using technology to aid the process.

One project designed to support learner-generated questions is described by Barak & Rafaeli (2004). The Question-Posing Assignment (QPA) activity is similar to the MCIDA, but supported by a custom-developed technology platform, the Questions Sharing and Interactive Assignments (QSIA) (Rafaeli, Barak, Dan-Gur, & Toch, 2004). QSIA supports a much broader range of question types than merely Multiple Choice, and also provides for peer review and rating of questions by other learners within the class. This approach was driven by the underlying concepts of four pillars of knowledge-building: generation, sharing, assessment, and management. The questions were also intended to be harnessed so that they could be used by learners as a revision resource. For this reason, review and rating of questions was considered a significant element of the QPA, so that 'good' questions could be easily identified.

A very similar approach is described in later work, both in the PeerWise system (Denny, Luxton-Reilly, & Hamer, 2008), also for third-level learners, and in the Question-Posing and Peer Assessment (QPPA) system (Yu, Liu, & Chan, 2004), designed for

primary level learners. The pedagogical underpinnings of these types of system are defined most clearly in Yu, Liu & Chan (2005), and encompass three distinct elements. In the cognitivist element, learners actively engage in processing and organising the information relating to the question stem, key, distractors and feedback. The social constructivist element is learners engaging with each other to practice on, assess and rate their peer's items (although not in creating the items, which is organised as a solitary activity). The third and final element is the social modelling aspect, where learners view the items their peers have constructed, and in combination with the comments and ratings, identify exemplars which they can learn from by mimicking.

All three of these web-based systems (QSIA, QPPA, and PeerWise) emphasise the peer-rating feature of the systems, and the latter two both provide explicit ranking of the questions on leaderboards within the system. This is a somewhat strange design decision, because one of the findings mentioned in the earlier QPA work (Barak & Rafaeli, 2004) on which these were based, is that learners simply did not use the rating facility 'against' their own classmates. While peer-review and rating of quiz items are valuable learning activities in themselves, it seems difficult to design an intervention in which learners would be comfortable in criticising, however constructively, their own classmates and friends. This researcher's personal experience in peer-reviewing others' assignments for the course also bears this out.

This issue arises because of the ambitious and ultimately conflicting goals of the systems. In addition to providing learners with a scaffolded approach to creating questions, the authors also aspired to use the question-posing assignment for assessment purposes, requiring each learner to create their own questions, and therefore actually prevented learners from constructive collaboration. The review and rating aspects, while intended to be collaborative, are likely too adversarial in nature to be used in practice. The systems also ranked questions according to various criteria, further forcing students to compete rather than collaborate with each other, in an attempt at providing a motivation to 'win'. In spite of this, learners using the QPPA system were actually observed creating questions in a collaborative, constructivist way:

> *"… asking for clarifications for a specific term, inquiring about different ways to frame a question, arguing over options for their plausibility with other peers, …, were norm behaviors exhibited during the activity."*

Yu et al. (2004)

Barak & Rafaeli (2004) also reported that students surveyed after the QPA activity perceived that it supported individual but not team learning, hardly surprising considering its design. While technology-supported question-posing systems have the potential to engage learners in active learning in principle, the design of the activity must be carefully thought through if it is to be done in a collaborative rather than competitive way.

2.3.1 Non-web-based question authoring systems

The question-posing systems reviewed above, and LMSs or dedicated CAA engines such as Questionmark Perception, all provide a web-based editing interface. LMSs and CAAs also provide an import facility that supports a variety of structured formats, such as IMS Question and Test Interaction XML format (IMS-QTI, 2005), other XML formats, and structured plain-text formats.

While there are many approaches to creating and maintaining quiz questions, only two merit serious consideration for use by learners with limited IT skills: web forms, and custom Word tables. Excel spreadsheets and structured plain-text formats such as Aiken (Moodle, 2006a) and GIFT (Moodle, 2006b) were discounted as they do not provide sufficient authoring support.

Word tables have generally been used at the large-scale item bank development level, where there have been many initiatives to develop shared repositories of questions for particular subject domains such as science, engineering and medicine. Three major UK-based item bank repositories all used Word templates to author items: E^{3}AN (Electrical and Electronic Engineering Assessment Network) (Wellington, White, & Davis, 2001); UMAP (Universities Medical Assessment Partnership) (UMAP, 2003), OCTAVE (Optimising Computer-Assisted and Traditional Assessment in Veterinary Education) (Head & Ogden, 2006). Questionmark also supports a Word table format (Questionmark, 2009).

Other Word-based authoring templates have also been defined that do not use tables, such as the commercial products WimbaCreate (Wimba, 2008) and Respondus (Respondus, 2009), free Moodle-specific Word templates (Lengyel & Herdon, 2008; Yatskovsky, 2006), and others such as eTEACH (Litzkow & Moses, 2005). These templates

use colour-coding instead of tables, and seem designed for more expert and frequent users.

One major advantage of Word over web-based systems is that the question format looks very similar to how it appears in a quiz. This benefits all authors, but a familiar visual appearance is likely to be important for inexperienced, younger, and particularly less able learners. In contrast, the Moodle LMS Multiple Choice Question authoring web form, for example, is approximately 4 screenfuls, or 2 A4 pages, in length. In addition, Word has other useful features, such as spell-check, copy and paste, save, keyboard accessibility, and undo/redo, as well as simply being more familiar to most learners. From an artefact development perspective, Words' Visual Basic development environment is at least sufficient to allow additional scaffolding of the authoring interface to be included, which could assist learners by managing the creation of the complex structures, required to support all the quiz item components.

However, one significant disadvantage of Word is that extra steps are required to process the Word file before its questions can be used interactively. For most of the reviewed systems, this involves both a conversion step to translate the Word file to an intermediate file format (usually XML), and a provisioning step to import the intermediate file into the LMS.

2.4 Question types and characteristics

Many types of quiz question (called 'item') have been defined in the Computer-Assisted Assessment (CAA) arena (Paterson, 2002). The most important characteristic of most item types is that they can be scored automatically, rather than requiring manual teacher grading. As a consequence, most items use some form of closed response, where the right answer must be selected from a list, and this allows learners to guess. This issue militates against the asking of higher order questions with open-ended answers, and therefore there is some debate about their value (Bull & McKenna, 2004). On the other hand, there is general agreement that *creating* good closed response items is difficult, and requires both a considerable degree of skill, and a good knowledge of the topic (McKenna, 2001). There are many resources providing guidelines for item construction (Bull & McKenna, 2004; Frary, 1995; Harvey & Mogey, 1999; Kehoe, 1995; Pritchett, 1999).

Within the category of closed response questions, there is a range of simpler and more challenging question types, from True/False and Multiple Choice to Matching and Multiple Answer (one or more correct answers). The compound Cloze (or gap-fill) question type can be composed of a series of simpler Multiple-Choice selections, and is more challenging again.

The Multiple Choice item is by far the most commonly-used item format (Bennett & Nuthi, 2008), presumably due to its long history, in spite of the wide variety of other formats now supported by LMSs and assessment engines. MCQs have a number of components: a **stem** (the question or statement), a **key** (the correct answer), 3 or more **distractors** (wrong answers), and different types of **feedback**: for the key, each distractor, and possibly for the item as a whole. The True/False question is essentially a simplified form of MCQ, with one pre-defined key and distractor.

Obviously, the quality of the distractors is critical to creating items that test the learners' knowledge. In Bull & McKenna (2004), the most important characteristic of distractors is that they must be plausible. Plausible distractors force learners to think about the options available, and exercise judgement in answering. Therefore they must be closely related to the question stem, and are often considered more difficult to write than the correct answer.

The other main component of MCQs is feedback. Although optional, good feedback can greatly improve the learning potential of an item, if each distractor provides useful information so that when a learner chooses a wrong option, an immediate message can be displayed, that explains why the answer is wrong, and possibly points to where to look for the correct answer.

Gibbs & Simpson (2004) discuss the characteristics of effective feedback, and suggest a number of necessary conditions, including timeliness, relevance and appropriateness. The structure of MCQs offers the capability to satisfy many of the conditions, if the feedback is well-written and specific to each option. In Head & Ogden (2006), the authors specify three components of information they included in feedback, which is presented to learners after answering a quiz item: for distractors, an explanation of why that option is not correct, a hint to the correct answer (but not the answer), and a reference for further study; for the key, a clear indication that it is the correct answer, some further

information, and a reference for further study. A well-written MCQ with good feedback is likely to encourage learners to try out each answer in turn, just to see the feedback.

In addition to the closed response question types mentioned above, a number of simple open response question types are also amenable to automatic grading, and are supported by LMSs: open questions with short unambiguous text or numerical answers, such as "In what year did…?" or "Who is the Taoiseach?". These question types have fewer components, and are structurally simpler than MCQs, but the answers must be carefully worded to allow for similar alternative answers, variant spellings, etc.

2.5 Differentiated instruction / discussion and analysis

Previous sections reviewed the areas of the role of questions, and research on learner-generated questioning activities. This section considers these areas from the perspective of differentiation of instruction in mixed ability classrooms.

Differentiation is a strategy for meeting the needs of learners by adjusting a number of curricular elements to suit particular learner characteristics, such as readiness, interest, or learning style (Tomlinson, 1999). The curricular elements are: content – what is to be learned, including the resource materials; process – the activities used to help learners make sense of the topic; and products – the outcomes that learners create to demonstrate their learning. One further element of differentiation is environment – organisation of space, the atmosphere of the class, protocols, etc. This discussion focuses on the process element, and considers how a technology-mediated question-generating activity can be differentiated for learners of different abilities.

Probably the most useful aspect of questions is that the types of question familiar to learners from even quite an early age is quite broad, ranging from the simplest True/False type to the most complex Cloze or short answer or numerical question type. This has a number of implications. Firstly, learners already have a reasonable level of understanding of how the final question should look and operate, as they are used to them from reading textbooks and workbooks already. As a result, they can use modelling to create questions similar to ones they have already encountered. Secondly, by offering learners a choice of which question type to create, they can exercise a fair degree of control over which type to choose, and can start with the simplest type, in order to achieve some level of comfort and familiarity with the creation process. Later on, they can tackle more complex question

types, in order to provide themselves with a moderate level of challenge. Alternatively, they can omit optional elements of questions such as feedback initially, and start to add them in later. This gives a natural way for learners to self-select types in a tiered fashion, or for the teacher to assign tiered tasks to learners based on their ability.

Although the items created will normally be based on particular topics on the curriculum, it is quite possible to allow learners create questions based on their own interests too, further putting them in control of their learning, and thus improving motivation.

The activity can be carried out in a collaborative constructivist way by organising learners into groups to work together, according to some criterion such as similar ability, interest, readiness, etc. This approach mirrors the group strategy adopted by both Fellenz and Arthur, rather than the sole learner strategies adopted by many of the web-based question posing systems. As a group activity, this also offers learners a variety of different modalities in which to work. Learners will be involved in speaking and listening to others in the group, and most will be reading and writing/typing at different stages too.

The use of a regular tabular structure for organising individual components with clearly labelled and positioned boxes for each, as used in many of the item bank generation projects, offers a high level of scaffolding for creating the complete item, and will be particularly supportive of less able learners.

The use of a technological affordance, rather than paper, to scaffold learners in creating questions offers a number of benefits for differentiation. The attraction of using computers for the activity will increase motivation for many younger learners, and the ability to test questions electronically after creating them will facilitate iterative improvements and corrections. Selecting different question types should be easy, and avoid a requirement to keep a stack of different paper templates available to learners. By having the work in progress appear on screen, it should be possible for a number of learners in a group to view a question in its current state easily and facilitate discussion on and improvements and corrections to it. Using a slightly more familiar and standard word-processing application, rather than a custom web-based application, should also benefit learners by enabling the editing interface to present the question in a format that is

familiar to the learner from prior experience, and also similar to how it will appear when activated.

The approach taken by a number of authors, described above, of having learners create questions for their own and their peers use in formative assessment, has the potential to engage learners in very active learning. It should enable them to practice their higher order thinking skills in defining 'good' questions which challenge their peers when taken as formative assessment, but also force them to develop a deeper and richer understanding of the topic in question. To quote Fellenz, speaking of the power of the Multiple Choice Item Development Assignment:

> *"The MCIDA was designed to be, and has proven to be, much more than an assessment tool; it is first and foremost a teaching and learning tool."*
>
> (Fellenz, 2004)

How can this be achieved? The tools employed to create quiz items, as reported in the research, vary widely, from pen and paper submission of items at one end of the spectrum, to the use of Tablet PCs at the other. At both these extremes however, the authors mention significant disadvantages, most notably getting the technology to communicate, in the case of the Tablet PCs! While this is not a problem for more traditional paper 'technology', the disadvantages of this approach are also significant, including: administrative workload in managing the items submitted directly to the teacher by the learners; transcribing those items considered good enough for re-use; and the major limitation that the items are not available for all learners for peer-review, modeling, assessment.

The most sensible option seems to be a middle path, making some use of a technology-mediated intervention suited to the particular characteristics of the typical educational environment. This should lie somewhere between the use of advanced technology with all the uncertainties that entails, and the ultra-conservatism of sticking with paper, which severely limits the re-usability of the items. What would such a technology-enhanced learning artefact look like? This is discussed in the next chapter.

3

Design of the MoodleQuiz artefact

The literature review in the previous chapter considered a number of issues around the design of a differentiated learning activity encompassing learner-generated quiz questions. In this chapter, the design of the artefact is described, and the main design decisions considered.

3.1 Design decisions

The main technical design decisions for this study were as follows.

- The Moodle LMS was used as the question engine, to both store and present the quiz questions.
- Microsoft Word was used as the authoring interface for learners.
- Tables were used to scaffold the question creation process.

3.1.1 Use of Moodle LMS as question engine

The Moodle LMS is an open source project, built using the LAMP (Linux, Apache, MySQL, PHP) architecture. It is probably now the most widely used LMS, because of its low cost and social constructivist educational philosophy, and also its easy customisability. Moodle was chosen for this study because of its: a) free availability; b) support for managing and presenting banks of quiz questions, and c) facility to import questions in a simple XML vocabulary called Moodle Question XML. Although not a formal elearning standard such as IMS QTI (IMS-QTI, 2005), this format is easy to create, and can be both imported and exported from Moodle.

3.1.2 Use of Microsoft Word editor

Although Moodle has facilities to allow the creation and management of quiz questions via a web form-based GUI, this interface was considered unsuitable for younger learners. Among the main disadvantages: the web form for entering a question is extremely elongated, spreading over 4 screenfuls, so the whole question cannot be viewed at any time; the web form is visually unlike how Multiple Choice questions appear; and the

interface is only available online, therefore a permanent Internet connection is required. For these reasons, an alternative editing interface was preferred.

Many free authoring interfaces for creating item banks were identified, including custom proprietary tools like Hot Potatoes, plain-text editors for simple structured formats such as Aiken, GIFT, and WebCT text files, and customisations of more standard applications such as Microsoft Word and Excel.

- Plain-text formats do not provide any scaffolding for learners, and require learning arcane syntaxes, so were ruled out for these reasons.
- Although Hot Potatoes became available for free in 2009, and provides scaffolded support for the required question types, questions have to be stored in separate files, and each file must be uploaded to Moodle separately. While Hot Potatoes can also convert questions into a set of HTML pages for a quiz, in this case each learner must assemble the quiz manually from the saved question files, so this interface has many of the same complexity issues as Moodle itself.
- Microsoft Excel was discounted because it is unlikely to be familiar to younger learners.

Word-based interfaces seemed to offer the best combination of ease-of-use and customisability (using VBA), and are used in a number of large-scale item bank development projects such as E^{3}AN and UMAP (Head & Ogden, 2006; UMAP, 2003). Word is familiar to many learners at all levels already, and building on this prior knowledge, as well as extending their knowledge by introducing the use of Word for a new purpose, was chosen as the most user-friendly option possible. Words' customisability through VBA and the Visual Basic Editor also make the development of scaffolding supports for question creation relatively straightforward.

3.1.3 Use of tables

Both the E^{3}AN and UMAP Word templates use tables to control the location of item bank components. However, these templates sometimes use an elongated multi-page layout, even for very simple questions. For example, the E^{3}AN Multiple Choice question template uses page 1 for the question, page 2 for distractors, page 3 for the answer and page 4 for feedback. UMAP has two templates, a 6-page Extended Multiple Choice Question (EMQ)

and a simpler 1-page Multiple Choice Question (MCQ), but the simpler MCQ does not support feedback for each distractor.

One Word template is designed specifically for converting to Moodle Question XML (Yatskovsky, 2006), has a compact layout, and has a simple toolbar for adding questions, but it does not use a table layout. This template is suitable for experienced users, who have prior knowledge of the Moodle question GUI, but does not provide much scaffolding support for new users or younger learners.

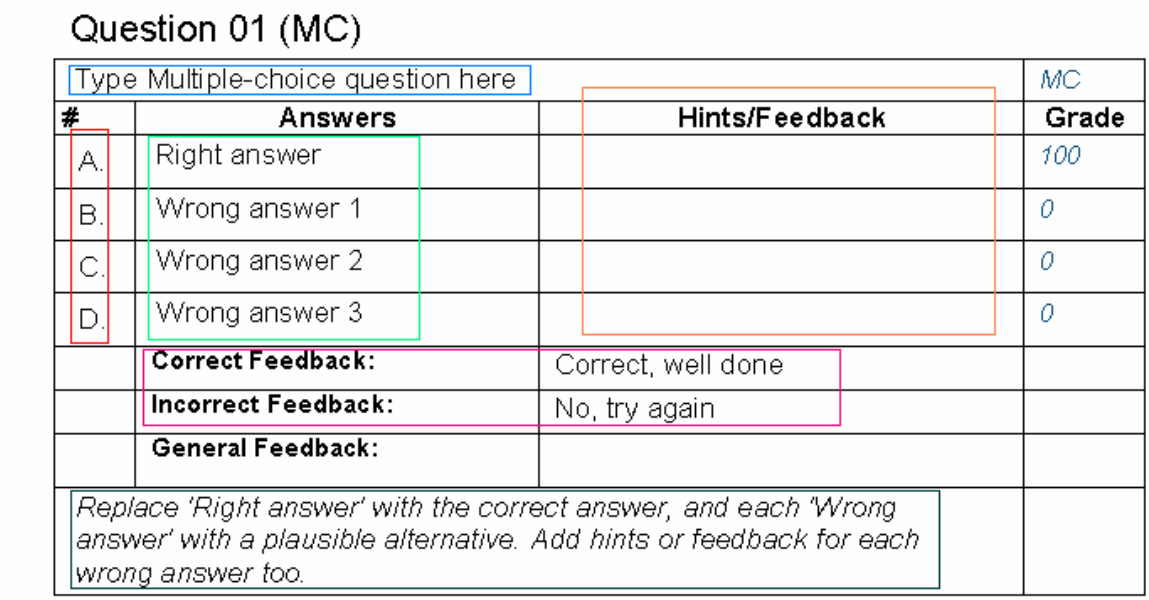
Based on a review of the various existing Word templates and their strengths and weaknesses, a table layout was decided as the most user-friendly approach: it can be compact, include unobtrusive hints and instructions for learners, have default values automatically filled in, and have clear labelled boxes for each component of a question.

3.2 Implementation

The previous section discussed the major design decisions underlying the development of the artefact. This section describes the main implementation details of the artefact. Much of the artefact was re-used from an earlier pilot study, and so the main additional work involved improvements to the user interface, and support for the complex Cloze question type.

3.2.1 Table layout

The layout of the Word table to support the input of all the components of the question is designed to mimic, as closely as possible, the layout of printed Multiple Choice questions already familiar to learners. Some adjustments were made to an earlier prototype, to improve its behaviour in Word. The final table layout is shown in Figure 3-1.



Question 01 (MC)

Type Multiple-choice question here			MC
#	Answers	Hints/Feedback	Grade
A.	Right answer		100
B.	Wrong answer 1		0
C.	Wrong answer 2		0
D.	Wrong answer 3		0
	Correct Feedback:	Correct, well done	
	Incorrect Feedback:	No, try again	
	General Feedback:		
Replace 'Right answer' with the correct answer, and each 'Wrong answer' with a plausible alternative. Add hints or feedback for each wrong answer too.			

Figure 3-1: Multiple Choice question table layout

Quite a number of small improvements were made to the original table layout to make it more comprehensible and robust, based on participants' comments, and on analysis of the questions created by learners.

- The question stem was moved inside the table in a heading row from a heading style outside the table, so that if the table breaks over to another page, the stem is repeated on the second page. This takes advantage of a nice feature of Words' Print view that repeats table heading rows at the top of each page in a multi-page table.
- The letters before each option (A, B, C, D) were placed in a separate column, each in their own cell, rather than as list enumerators in the answer cell, so that learners don't accidentally delete them when adding in correct answers.
- The headings for the answer and feedback cells were changed from "Option" to "Answers", and "Feedback" to "Hints/Feedback", to simplify the terminology.
- The default contents of the answer cells were changed from "Option 1", "Option 2", etc. to "Right Answer", "Wrong Answer 1", "Wrong Answer 2", etc, again to simplify terminology.
- The instructions for each question were placed inside the table at the bottom, instead of outside at the top, to keep them visible but unobtrusive. They originally appeared between the question (in a heading) and the table, and cluttered the interface.

- The name of the question is added automatically in a heading style before the table, when the table is created, and includes the default text "Question" plus a type indicator (e.g. MC) and a sequential number. The question name is not important to learners, and originally cluttered up the table with an extra row, so it was moved. However, it is important when the questions are being managed online in Moodle by a teacher, when assembling a quiz.

  Teachers can assemble all learner questions by exporting them from Moodle into a single Word file, for example to create an assessment from a selection of questions, or edit/correct good questions. Using a Word heading style to label each question means that some of the management features of Word can be harnessed. For example, the questions can be navigated easily using the Document Map feature, and quickly moved around and re-categorised using the Outline view, as shown in Figure 3-2.

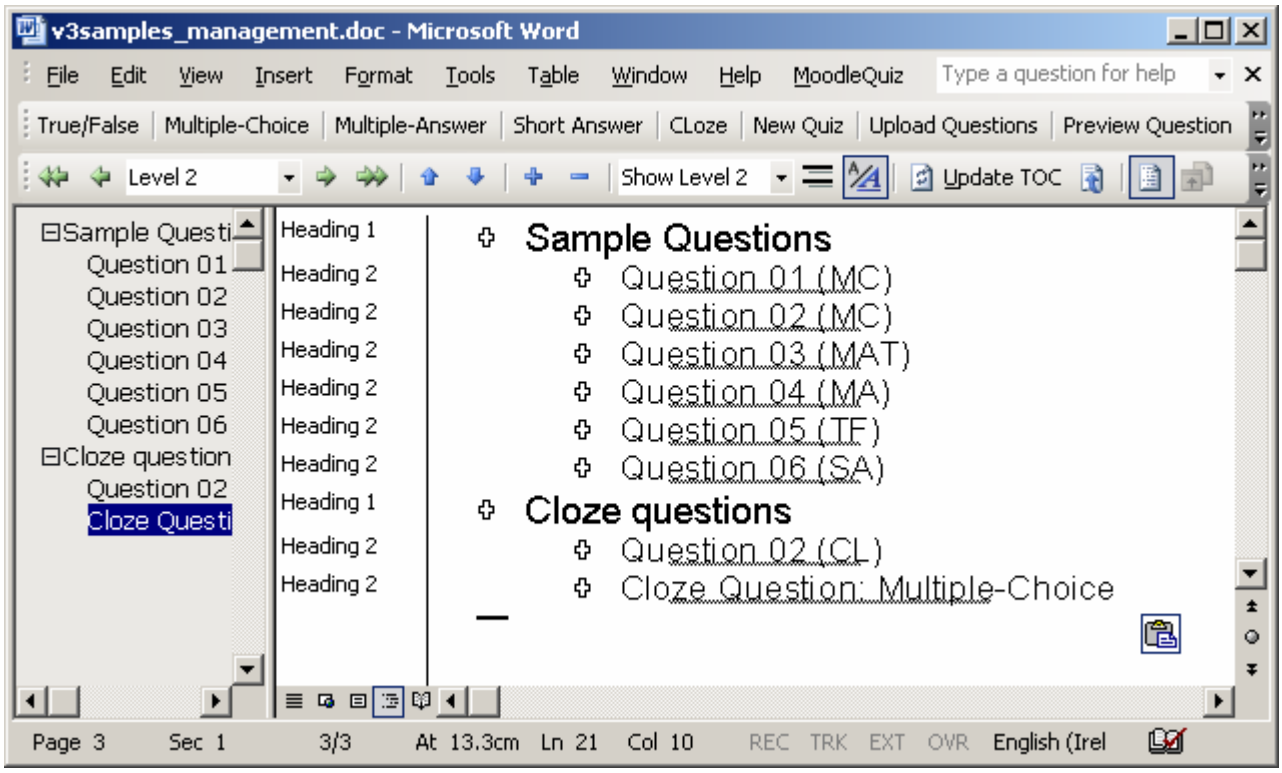


Figure 3-2 Outline view with Document Map and Style area enabled

3.2.2 Cloze question layout

The Cloze or gap-fill question type is significantly more complex to create than other question types. For this reason, it was important to include this type in order to challenge more able learners. The basic presentation of printed Cloze questions is a sentence with some words replaced with lines, for example:

"…and that government ___ the people, ___ the people, and ___ the people shall not perish from the earth."

When presented on a web page, Moodle offers two options to replace each line, either a drop-down menu or an empty field.

Figure 3-3: Cloze question presented using drop-down menus

Using a drop-down menu makes the question closed response, and therefore somewhat easier. Using an empty field makes the question open response, and therefore considerably more difficult.

Although the Moodle Question XML vocabulary supports the Cloze question type (called Embedded Answer in Moodle), the syntax required to enter the code to implement each of the drop-down menus does not use XML syntax. Instead it uses a more arcane text-based format requiring significant duplication of text (Moodle, 2008), as shown in the raw text required to implement Figure 3-3 (bold added for clarity).

"and that government
{1:MULTICHOICE:%0%by#Incorrect~%0%for#Incorrect~%0%in#Incorrect~**%100% of#Correct**~%0%through#Incorrect ~%0%with#Incorrect} the people,
{1:MULTICHOICE:**%100%by#Correct**~%0%for#Incorrect~%0%in#Incorrect~%0%of~#Incorrect%0%through#Incorrect~%0%with#Incorrect} the people,
{1:MULTICHOICE:%0%by#Incorrect~**%100%for#Correct**~%0%in#Incorrect~%0%of#Incorrect~%0%through#Incorrect ~%0%with#Incorrect} the people,
shall not perish from the earth."

In the text above, the contents of each dropdown menu is enclosed in accolades ({}), and denoted by the keyword "MULTICHOICE". Within the accolades, individual menu items are separated by the tilde character (~), and each menu item has three components:

a score, the text to display, and feedback. The score is "%100%" for the correct answer, and "%0%" for wrong answers. Feedback is preceded by a hash symbol (#).

Entering this text by hand is tedious and error-prone, to say the least. To make the question format simple enough for learners to type in, the rich-text facilities of Word were employed, using **bold** to represent each item to be replaced with a drop-down menu, as shown in this example.

> "… and that government **of** the people, **by** the people, **for** the people, shall not perish from the earth."

This simple syntax means that learners are able to create the question type. It does require significant code in the background to transform it into the required Moodle syntax, however. The transformation process automatically merges all of the words in bold into each drop-down menu. There is a facility for directly including feedback specific to each item, by adding it after a hash character (#), for example "government **of#Excellent** the people". However, this was not mentioned to learners, as it would add needless complexity. Instead, the general feedback items in the table are re-used as the same feedback for the correct and incorrect answers within each menu item. For learners and many teachers, this is more than adequate, and highly sophisticated users can use the hash notation if they wish. In order to maintain the same general layout of all tables, the standard answer rows are still included in the table, and support the inclusion of additional distractors. These distractors are added to each of the drop-down menus, so that the chance of a 'process of elimination' strategy is negated. In this case, there is no 'correct' answer row, and the letters are omitted from the table column 1, in the hope of reducing any confusion. Figure 3-4 shows an example.

"… and that government **of** the people, **by** the people, **for** the people, shall not perish from the earth."			*CL*
#	**Wrong Answers**	**Hints/Feedback**	
	through	No, too long	
	with	No, no w's allowed	
	in	No, that's out	
	Correct Feedback:	Correct, well done	
	Incorrect Feedback:	No, try again	
	Partially Correct Feedback:		
	General Feedback:	Abraham Lincoln, Gettysburg address	
Use bold for Multichoice, italic for Short Answer, and Underline for Numerical items.			

Figure 3-4: Question table for Cloze question including extra distractors

Similarly, the convention of *italic* is used to represent the open response version of the question, for example:

> "… and that government *of* the people, *by* the people, *for* the people, shall not perish from the earth."

This is then converted into the corresponding open response question in Moodle syntax.

> "… and that government {1:SHORTANSWER:%100%of#Correct, well done} the people, {1:SHORTANSWER:%100%by#Correct, well done} the people, {1:SHORTANSWER:%100%for#Correct, well done~*#No, try again} the people, shall not perish from the earth."

This produces the Moodle presentation shown in Figure 3-5.

"… and that government [ ] the people, [ ] the people, [ ] the people, shall not perish from the earth."

Figure 3-5: Cloze question with open response fields

A third Cloze input option, Numeric, is also supported by the template and code, but is not intended to be used by learners, as it is only useful for maths.

3.2.3 Word templates and toolbars

A Word template compatible with Word 2002 and Word 2003 was reused from a prior pilot study. Because the user interface for Word 2007 is very different from Word 2003, and uses an XML-based 'Ribbon' interface, the Word 2003 template is not completely compatible with Word 2007. Toolbars and menus do not display by default. For this study, one of the schools had standardised all PCs on Word 2007, and the other had a number of PCs running Word 2007, so a Word 2007-specific version of the template was developed. The Word 2007 Ribbon interface is shown in Figure 3-6. Luckily, the same VBA code can be used by both Word 2003 and Word 2007. The only additional code required for Word 2007 is one additional function to map items in the Ribbon to underlying functions in the VBA. Also, since the style presentation is stored in a separate styles-only Word template (*moodleQuiz.dot*), the same styles file can be used for both.

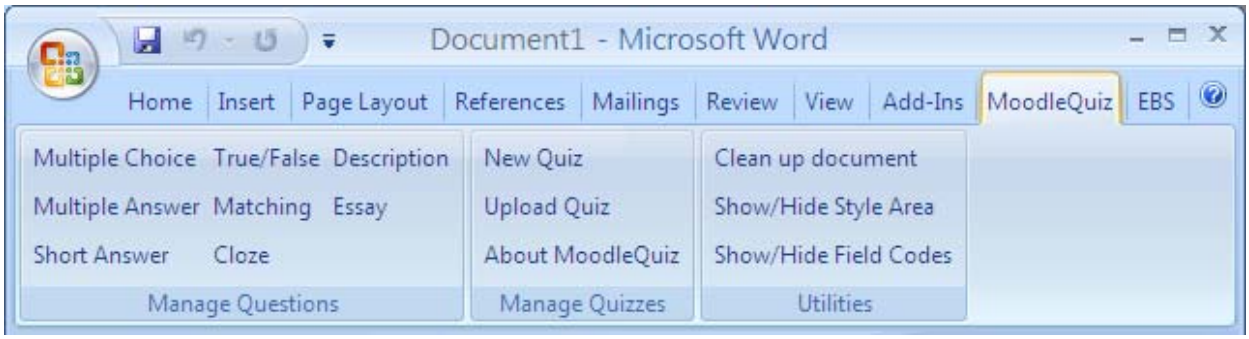


Figure 3-6: Word 2007 Ribbon interface

The vertical screen height for the Ribbon interface is always the same, so although it would have been clearer to space out the buttons across the screen, it would have left a lot of empty space, so the tighter row and column layout was used instead. In hindsight, the additional commands (for Essay questions, Descriptions, and formatting) were a mistake, and they have now been removed.

One problem (still unresolved) with the Word 2007 template is that VBA is considerably slower to execute in this environment. When a toolbar button to insert a new question is clicked, a complete new table is displayed in about 4 seconds when using Word 2003, but the same operation, using the same VBA function, takes about 12 seconds when using Word 2007 on the same PC. It is not clear why this happens. Also with Word 2007, the Word window goes blank for a couple of seconds just before the new table is inserted, which is disconcerting for learners.

In addition to developing a Word 2007 version of the template, the original Word 2003 toolbar was re-organised to display question types in order of increasing complexity from left to right (following comments from participants), and to add in buttons for the extra added features, and the final version is shown in Figure 3-7. The new buttons ("Upload", "Preview") were deliberately kept short so that the toolbar buttons all appear on screen. "Preview Current Question" would be clearer, but would not appear on lower-resolution screens.

Figure 3-7: Word 2003 toolbar

3.2.4 Word-Moodle integration

Earlier pilot prototypes of the Word template required learners to use a web browser to log in to the Moodle website and go to the question import page in order to upload questions. For the intervention, each user's PC was prepared beforehand to be already logged in to the Moodle website and on the correct page, so that participants did not have to go through the many steps required. The problem with this approach is that it significantly increases the setup time prior to the activity. In the final version of the Word template, the upload process was fully integrated with Word, by developing a VBA macro to log in to the Moodle server automatically. This makes the upload process much easier, as learners simply click on a button to have the currently open Word file uploaded to Moodle, converted into Question XML format, and the questions imported into the Moodle question bank. Figure 3-8 shows the dialog box displayed when a set of questions in a Word file is successfully uploaded, converted into XML, and imported into Moodle. The dialog box simply contains a large web browser field showing the relevant Moodle web page.

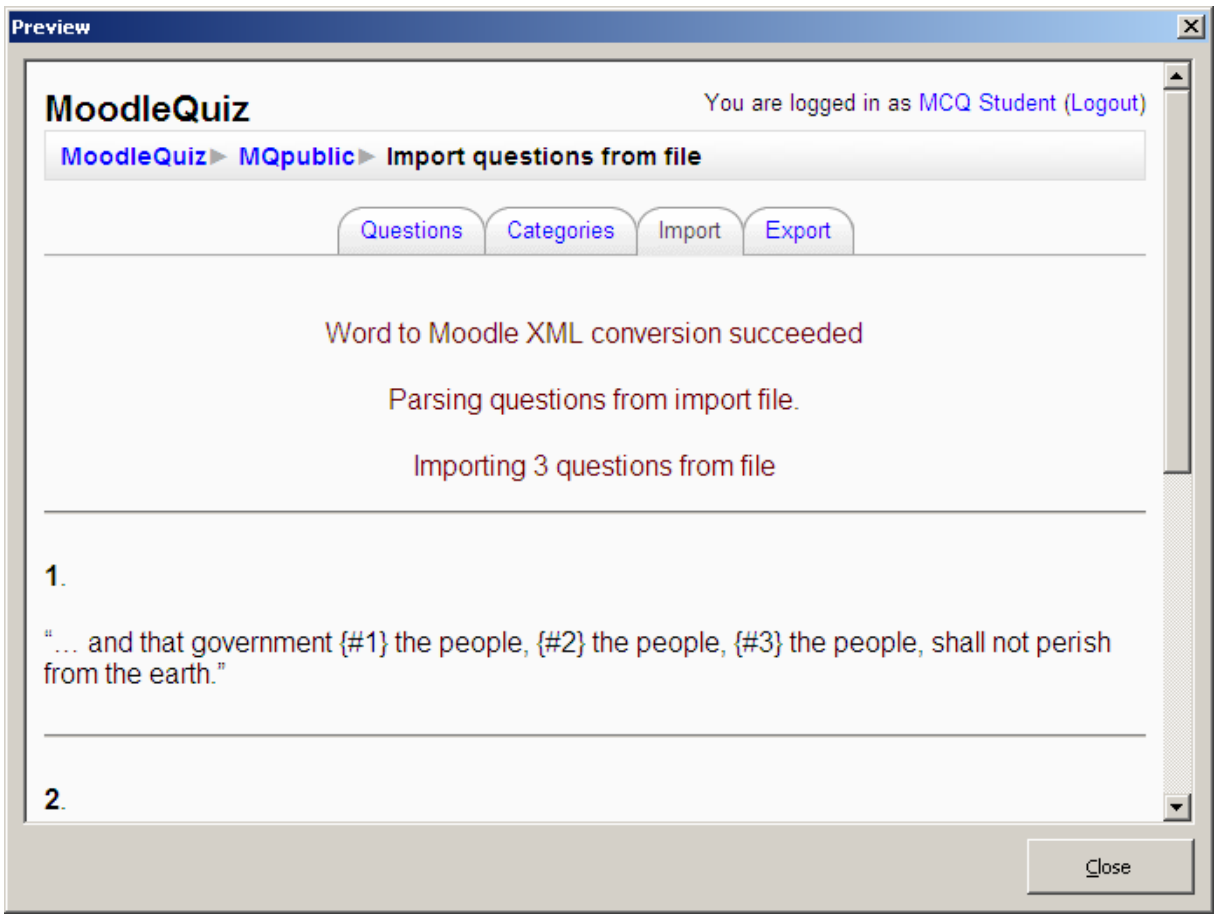


Figure 3-8: Upload questions dialog box in Word

In addition to the upload feature, a small further enhancement was developed to enable learners to preview the current question in Moodle, simply by clicking on a toolbar button. In this case, the Word file is uploaded, along with the sequence number of the table in which the cursor is currently placed. When the Word file is converted into Question XML format, instead of all the questions being imported, only the question matching the sequence number is. This question is then presented using the Moodle question preview facility.

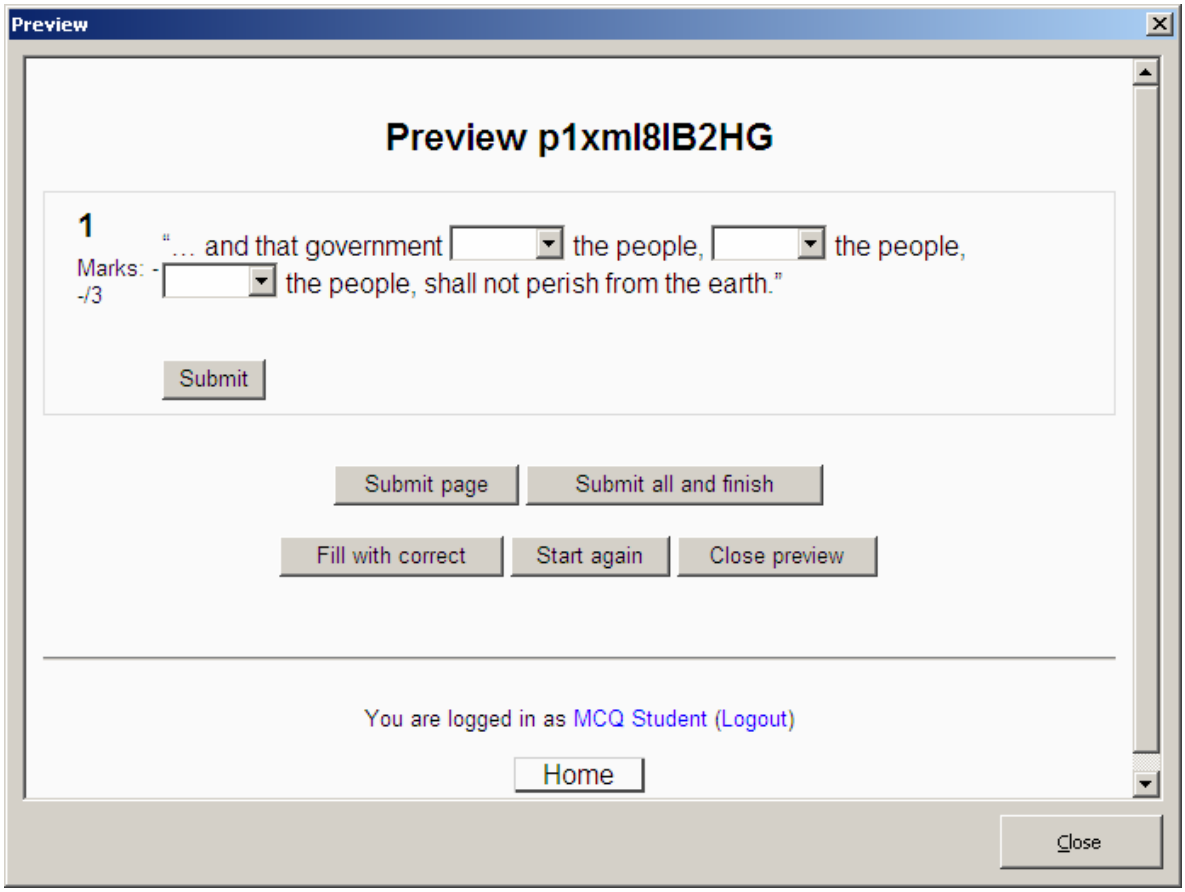


Figure 3-9: Preview question dialog box in Word

This feature provides additional scaffolding for learners, as they can easily and independently test and re-test their question until they are happy with it, without the need for teacher intervention. Learners can check the question interactions within the dialog box, to ensure feedback is displayed as expected.

The Preview facility is not as fast as it should be however, as it takes about 25 seconds for the question to appear. In addition, there is a problem with the implementation, whereby the learner is prompted to manually log in to Moodle the first time they do a preview. Significant recoding of the VBA application would be required to fix this issue.

3.2.5 Moodle server code

The Moodle server code consists of a combination of PHP and XSLT code residing on the Moodle website in a folder within the question module (*/question/format/wordq/*). In addition, there is some XSLT code on a 3rd-party Word to XML conversion server, YAWC Online (www.yawconline.com). This code could also reside on the Moodle server, but for convenience, was kept on the conversion server. Reliance on a 3rd-party commercial

service is far from ideal, but for the purposes of the research, represented the path of least effort to achieving the desired goal. Figure 3-10 shows a schematic of the upload and translation steps involved in the process.

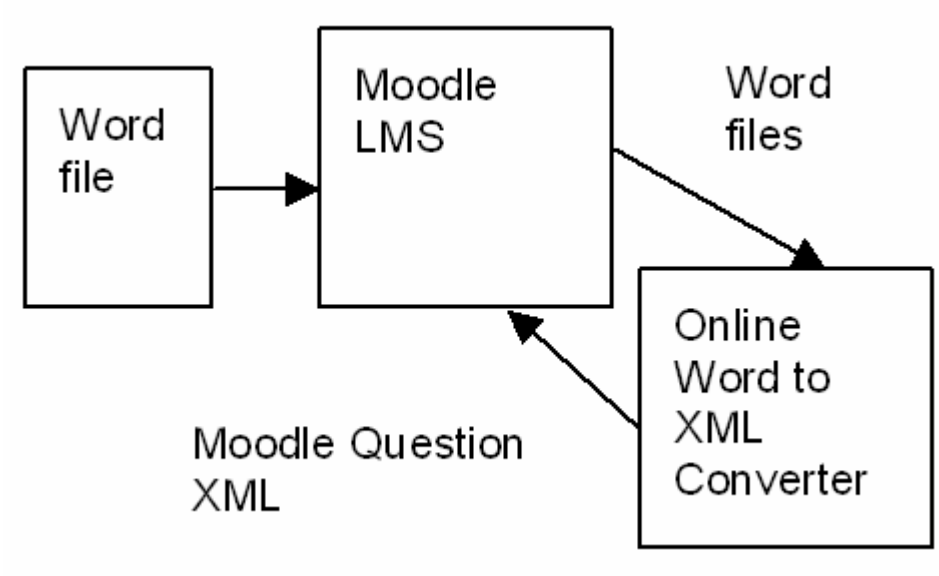


Figure 3-10: Architecture of MoodleQuiz system for uploading Word files

The Moodle server code was mainly re-used from an earlier prototype. However, additional PHP scripts were developed to support the integrated Upload and Preview facilities within Word. These scripts automated the multi-step process required to upload files, which is as follows: browse to website, log in, go to question import page, select import format, select file for upload, click upload. Because Moodle uses a mixture of HTTP GET and HTTP POST directives to complete these steps, automating the steps was eventually completed with assistance from a more able other (a work colleague), who implemented the Upload process using the PHP CURL package to solve the problem. With that in place, the researcher was able to extend the code to implement the Preview process too.

Unfortunately, this code is not suitable for public distribution. However, now that the process is much better understood, it should be possible to implement a much cleaner and more elegant solution, where the steps are automated within VBA in the Word template, rather than on the server side. Microsoft have just released the Office Add-in for Moodle (Microsoft Education Labs, 2010), which does this using .Net technology. Such an approach will also solve the earlier issue regarding manual login to Moodle for the first Preview.

4

Research methodology and implementation

A case study methodology was used in this study. This chapter discusses the rationale for selecting the case study approach, and describes the background to the implementation, the data collection instruments, and other aspects of the study.

4.1 Research design

> *Case study is study of a singularity conducted in depth in natural settings.*
>
> (Bassey, 1999).

A case study approach was selected as the most suitable research methodology for this project. Within the case study types, this study is a *theory-seeking* case study, as defined by Bassey (1999), equivalent to Yins' (2009) *exploratory* case study. In the literature review, it was noted that there is little research into the area of learners posing their own questions as a useful activity in differentiated learning. There is also no mention of question generation as an activity in a range of standard texts on differentiating instruction. While there are a number of studies of learner-generated quiz question activities, whether created with the assistance of a computer-mediated interface or not, the issue of differentiation is not explored in these studies.

With so little literature background to rely on, it was decided that a case study, examining a single case, in its natural setting of a school, with learners and their normal teacher, was the most appropriate approach. The hope was that at the end of the study, it might be possible to make what Bassey calls a 'fuzzy proposition' about its value in an educational context. If such a proposition could be defined, another outcome would be that the outline of a future, more in-depth, study might become clearer.

4.2 Design decisions

This section discusses the rationale for some of the design decisions made in selecting learners for participation in the study, the subject topics for questions, and the question types to be available.

4.2.1 Learners

Both primary and secondary level learners were potentially available to participate in the study. Learners in 3rd level education were not considered, although many of the research studies on technology-mediated learner-generated quiz questions in the literature covered these students. 3rd-level students were excluded from consideration due to the difficulty of identifying a suitable candidate course and lecturer in the limited time available. Differentiated instruction may also be less important at third-level than at earlier levels.

Since a certain amount of keyboarding skills are required to be able to use the technology artefact, only 6th-class pupils (11-12 year olds) at primary level were considered as suitable candidates, while only pupils **not** doing end-of-year state examinations at secondary level were considered, as arranging the activity with these pupils would be difficult. Selecting a secondary school with an existing Moodle installation was also considered, since Moodle is one of the components of the technology artefact, but there was no real advantage to be gained from it, with regard to the issues under investigation.

In the end, primary school classes were chosen for this study, based on convenience, and also because of the greater freedom at primary level for teachers to select subject areas for the quiz topics.

4.2.2 Subject

The purpose of the study, and the focus of the activity and associated technology artefact, is not geared to a particular subject, but towards an activity which could potentially be used across a range of subjects. Some consideration was given to identifying a subject more suited to the study, but ultimately, it was decided to allow each teacher to select a topic based on work they had recently done in class.

4.2.3 Question types

Moodle supports the importation via an XML file of a range of common question types, and the artefact makes use of this XML import facility, so only those question types supported by the Moodle Question XML vocabulary can therefore be supported. The question types range from simple True/False through to complex Cloze and Calculated questions. Making a variety of question types available is one of the ways that differentiated learning may be facilitated, as some question types are easier than others to

create questions for. In order to ensure that more able learners had complex question types available to challenge themselves, the following types of question were implemented.

- True/False (closed response)
- Multiple Choice (closed response)
- Multiple Answer (closed response)
- Matching (closed response)
- Short Answer (open response)
- Cloze with drop-down selection of answers (closed response), or Short Answer (open response) fields

Numerical and Calculated questions are specific to maths, and so were not included, as it was felt that for the selected learner educational attainment level, they would not be suitable. In addition, the structure of these question types is quite different from the others, and a different table format might be confusing for learners.

4.2.4 Grouping strategy

In order to facilitate the examination of differentiated learning within the activity, teachers were requested to group participants in pairs of similar ability prior to the intervention. Pairs rather than larger groups were chosen so that each participant would have the opportunity to use the computer, and also to ensure that each learner participated fully in the activity. In each class, however, one group had three members to avoid learners working alone.

While grouping learners of similar ability was considered appropriate for the purposes of the study, multiple iterations of the intervention would need to vary grouping strategies. An alternative would be to group learners according to their interests in non-curricular topics.

4.3 Data collection

In the case study methodology, a number of instruments are usually defined, in order to enable a fuller picture of what is typically a complex phenomenon to be gained. In this case, the following qualitative and quantitative data sets were collected.

- Post-activity learner questionnaire

- Learner interviews (semi-structured, recorded)
- Teacher interviews (semi-structured, recorded)
- Formal and informal observation by facilitator
- Document analysis of questions created by learners

4.3.1 Observation protocol

An observation checklist was defined to record significant events during the activity, so that they could be recorded. A number of classroom observation texts were consulted to help identify a useful but non-intrusive process for observation (Simpson & Tuson, 2003; Wragg, 1999). The unit of analysis of the observation was a group of learners. The original plan was to observe 3 different groups for a period of 5 minutes each, at different stages of the iteration in each class. However, only two observations were actually carried out in Class 1. The groups to be observed were pre-selected by the class teacher, and consisted of groups of less, average, and more able learners.

The observation recorded the characteristics of the group, rather than the individual learners. The following characteristics were chosen for recording:

- Level of involvement/engagement with the activity of the group, using a simple scale - Low, Medium or High;
- Level of comfort of the learners, using a scale of Low, Medium or High;
- Level of collaboration between the learners, using a scale of Low, Medium or High;
- Activity of the learners: On-task actions, Off-task, or Other actions.

More explanation on the definitions of different levels in the scales is included in Appendix B. The purpose in selecting these characteristics was to establish whether participants at all levels of ability were able to, comfortable with, and engaged with the activity.

The observations were recorded by ticking boxes with a pen, on a pre-printed table, with the headings shown in Table 4-1. One dry run using the checklist was carried out using a video-recorded classroom lesson sourced online (Teachers TV, 2009). Observations were recorded by observing a group for 20 seconds to assess each characteristic, and a further 10 seconds to record the characteristics on paper. Although good practice suggests a higher frequency of recording, in reality this was not achieved

because of a lack of experience by the researcher. The observation of each group was carried out for a period of 5 minutes, resulting in approximately 10 observations per group.

Table 4-1: Observation protocol recording sheet sample

#	ID	Involvement				Comfort				Activity (Task)				Collaboration		
		Lo	Med	Hi		Lo	Med	Hi		On	Off	Other		Lo	Med	Hi
1	A															
2	A															
3	A															
4	A															
5	A															

4.3.2 Questionnaire

A post-activity questionnaire (see Appendix C) for learner participants was designed, with a mixture of closed response and open questions. The closed response questions were mainly Likert scale questions to establish whether participants found different aspects of creating questions easy or difficult. Given the age of the children, the open response questions simply asked them what they liked best and least, and also if they had any other comments. An analysis of the participant response was then carried out to identify and code common themes.

4.3.3 Interviews

A schedule of questions (see Appendix D) for the class teachers was defined and given to the teacher prior to the activity taking place. This was to allow them to observe the activity with some idea of the type of issues under study. The interviews with the teachers were then conducted based mainly on the schedule of questions. Each teacher interview took approximately 30 minutes.

No schedule of questions was defined for the learner participants, and a more unstructured format was adopted. Each of the groups observed using the observation protocol was also interviewed in a group interview, so that learners representing a mix of abilities were heard from. Two groups from Class 1 and 3 groups from Class 2 were interviewed.

All the interviews with both learner and teacher participants were audio recorded and transcribed. Interviews with learner participants were conducted with a Special Needs Assistant from the class present.

4.4 Procedure

4.4.1 Participants

The participants for the study were selected based on a convenience sample, where the researcher had personal links with the chosen schools, who agreed to facilitate the research. Both schools are situated in the urban area of Dublin, one in a more affluent and the other in a more deprived area of the city. Both classes of participants were mixed gender and mixed ability, and there is also a strong multi-cultural and multi-ethnic mix of children, some of whom speak English as a second language.

4.4.2 Ethics

Ethics approval to carry out the research was gained through a formal process defined by the Research Ethics Protocol (Research Ethics Committee, 2009), put in place by the School of Computer Science and Statistics. The Schools' Research Ethics Committee was supplied with the following documents prior to the start of the fieldwork component of the research.

- An Information Sheet describing the nature of the research, the data collection methods, data protection issues, etc. Three variants of the Information Sheet were prepared, one each for student and teacher participants, and a further variant for parents/guardians of student participants. Copies of the Information Sheet are included in Appendix A.
- A Consent Form, again in three variants, for parents/guardians, student participants and teacher participants. Copies of the Consent Form are included in Appendix A.
- A copy of the student participant questionnaire.
- A copy of the schedule of questions prepared for the teacher interview. See Appendix D.

Following receipt of approval from the Research Ethics Committee, the Information Sheet and Consent Form were distributed to participants in the schools. The signed Consent Forms from participants and parents/guardians were collected prior to the beginning of the activity. Participants were also informed that they could withdraw from the activity at any time.

In both classes, all the class members participated in the activity. Had some class members chosen not to participate in the research component, the researcher decided in conjunction with the class teacher to have those learners create quiz questions in their own groups, but not to collect any data from them. In this way, those learners would not feel penalised for not participating.

Although post-activity interviews were recorded for transcription purposes, the iterations of the activity in each class were not recorded, either via audio or video, due to ethical considerations.

4.4.3 Duration and schedule

Following consultation with the class teachers, it was decided to run the sessions as a single long activity, rather than a number of short sessions over a more extended period. This was partly for practical reasons related to access to the schools computer room, and also in order to best fit in with the normal class work of the teachers. The activity was planned to split into two 45-minute periods, before and after the normal short morning break, so that participants got a chance to get some fresh air. The following schedule was defined and shown to the class teacher beforehand, to help in guiding the activity in each participating class. However, it was not intended to be slavishly adhered to, and in practice, some steps were shortened and others lengthened, as appropriate to the circumstances.

Table 4-2: Detailed planned time schedule for intervention

Start	End	Task
09:40	09:45	Welcome all Participants and get them seated in their groups
09:45	09:50	Introduce activity and demonstrate a quiz question in Moodle, explaining different parts (question stem, right answer, plausible wrong answers), using example created by meta Participants if possible
09:50	09:53	Show Word quiz question toolbar and demonstrate how to add a Multi-Choice question, showing different boxes for each component.
09:53	09:55	Explain challenge: create a collection of quiz questions that will be used to test out another class
09:55	10:10	Participants create 1st MC quiz question
10:00	*10:05*	*Observe group A using observation checklist*
10:10	10:15	Pause activity, and demonstrate Matching, Multiple Answer quiz questions, and suggest Participants try them
10:15	10:30	Participants resume creating question
10:20	*10:25*	*Observe group B using observation checklist*
		Break (15 minutes)
10:45	10:50	Demonstrate Short Answer and Cloze question, and suggest Participants try them

Start	End	Task
10:50	11:05	Participants resume creating question
10:55	*11:00*	*Observe group C using observation checklist*
11:05	11:15	Stop activity, demonstrate uploading, get groups to upload and convert questions, and test them out online
11:15	11:20	Distribute questionnaire and get Participants to fill it in
11:20	11:25	End activity, collect questionnaires, thank Participants, and remind them of interviews
11:25	11:30	Get initial feedback from teacher on activity

4.4.4 Pilot study

A pilot study was not explicitly undertaken as part of this research. However, some prior work in an earlier project with technology-mediated learner-generated quiz questions did strongly inform the research, as it suggested that the area of differentiated learning was a significant factor in the activity.

5.

Data Analysis

This chapter summarises the findings of the research, following analysis of the data collected from observation, documents and interviews. The original research question was:

Does in-class activity around (technology-mediated) learner-generated quiz questions support differentiated learning?

A number of sub-questions arising from this main question were defined as follows:

1) Do learners of different abilities engage with the activity?
2) Are more able learners challenged to create richer questions?
3) Do less able learners get enough support to create questions?

These questions all encompass the more general question: "Where is the learning value in this activity?" A further question arises in relation to the issue of using the activity in a wider context:

4) What are the pedagogical and practical challenges involved?

This question is important to address if the artefact is to become more widely used. Although not explicitly addressed in the data collected, an attempt will be made to answer it, based on the data analysed.

5.1 Sub-question 1: Do learners of different abilities engage with the activity?

Analysis of the data strongly suggests that most participant groups engaged with the activity. In both settings, the participant interviews and questionnaire responses support this finding. The general tone of the participants' responses was very positive. Based on the data, there are 3 main reasons for this engagement.

- The participants liked working in groups, and being able to talk to classmates while doing the activity;
- they liked using the computer to do the activity; and

- they enjoyed creating questions, both because it was something new for them, and because of the challenge involved.

The combination of a novel and challenging but nonetheless do-able activity, with a collaborative approach, scaffolded by technology, made the activity engaging for participants across a range of abilities and interests. This finding is supported by many of the data sources collected.

5.1.1 Collaboration

Collaboration is a widely used approach in teaching, based on theories of constructivism and Vygotskys' Zone of Proximal Development (1978) in particular. Small groups of learners working together provide a form of scaffolding for each other, and appreciation for this support is reflected in the data.

5.1.1.1 Participant interviews

All the participants have prior experience working in groups in class, usually based around the table they are sitting at. In interviews, participants were asked if they thought working in groups helped them in the activity, and most agreed that group work is better for learning, quite apart from the social aspect.

> *Yes because you can get stuck on your own and you get it done quicker when you're in a group as well.*
>
> Participant 2-5B

> *Because if you have someone, if you get a bit wrong then you have someone to say like that's wrong, like if you don't know it's wrong.*
>
> Participant 1-2A

> *Because you don't have to do it all on your own, and then when you're with someone they can always help you out, like if you don't know it they might know it.*
>
> Participant 1-1A

Participants perceived that working in a group context allows work to be reviewed, and mistakes to be pointed out, by any group members in a non-critical way, as part of a co-constructed learning process. In contrast, in those studies where there were built in formal, technology-supported peer review and rating systems, learners reported grave discomfort with commenting on others work.

5.1.1.2 Participant questionnaires

The collaborative aspect was hardly mentioned in questionnaire responses by participants in Class 2, but was identified by a number of participants in Class 1. In addition to sharing ideas, participants liked communicating with their classmates, and even teaching each other how to do things on the computer.

> *"You got to let out your ideas and let other people see your ideas".*
>
> Participant 1-3A

> *"I liked the way we got to write all the answers ourselves and I liked working on the computer in pairs."*
>
> Participant 2-13A

> *"Chating in pairs talking with my friends and deciding what questions to put an how to and it helped me to learn and teach other how to do things on the computer."*
>
> Participant 1-2A

> *"Getting to talk with your friend"*
>
> Participant 1-5B

Some participants welcomed the opportunity to exchange ideas and knowledge with their classmates, not in a show-off way, but in an interaction among equals.

5.1.1.3 Teacher observation

The teachers also observed that the collaborative approach worked well for the activity, even within groups where some friction might have been expected.

> *From what I saw, everybody was working together, even in the groups that might have fought, they still worked together. They found a way around it; they could take it in turns then, if they were fighting.*
>
> Teacher 1

Teacher 1 also mentioned that the nature of the activity and size of the group helped, because with pairs of participants, they could take it in turns to type in whole questions, or even different parts of questions, such as the stem, key and distractors, and they didn't get bored waiting a long time for the other to finish before they got a chance at typing. (The participants spent around 10 minutes creating each question on average.) Small

group sizes also mean that it is more difficult for reluctant learners to sit back and be carried along by the others.

Teacher 2 believes that the collaboration worked well because the groups had learners at similar levels of ability, rather than in mixed ability groups.

> *I thought that the fact that they were in ability groups for it, kind of led them to be able to, kind of, work at their level, work with peers at their own level and then they in turn create questions at their own level*
>
> Teacher 2

Ability grouping of participants was a successful strategy to introduce the question-creating activity to learners. Other strategies, perhaps interest-based groups, might be required in successive iterations in order to provide some variation.

5.1.1.4 Researcher observation

Based on the observation protocol data, participants exhibited behaviour consistent with collaboration within groups and engagement with the activity. Table 5-1 shows the combined observations in relation to collaboration across the 5 observed groups, and indicates that the groups were collaborating at a medium or high level most of the time. "Collaborating" in the context of the observation was considered to be mainly talking and discussing questions, and participants being attentive to each other, such as one watching what the other was typing. Although the observation was far from rigorous, due to researcher inexperience, nonetheless the preponderance of 'Medium' and 'High' values recorded does provide a broad flavour of the collaborative nature of the interactions between participants within and even across the groups.

Table 5-1: Collaboration observed within selected participant groups

Time Interval	Group 1-1	Group 1-7	Group 2-5	Group 2-9	Group 2-13
1	Medium	Medium	High	Medium	Medium
2	Low	High	Medium	High	High
3	High	High	High	High	High
4	Medium	High	High	Medium	Medium
5	Medium	High	High	Low	Low
6	High	Medium	Medium	Low	Medium
7		Medium	High	Medium	Medium
8	Medium	Medium	Medium	Low	High
9	Medium	Medium	High	Medium	Medium

Time Interval	Group 1-1	Group 1-7	Group 2-5	Group 2-9	Group 2-13
10		Medium	High	Medium	High
11		High	High	Medium	High
12		Medium	High		Low
13		Medium	High		High
14		Medium			

In Class 2 group 9, a slightly lower level of collaboration was observed, with 3 of the 11 observations points noting a low level of collaboration, and only one noting a high level. Somewhat gratifyingly, one of these participants subsequently 'confessed' in the post-activity interview that she didn't do any of the typing, perhaps validating to a small extent the quality of the observation record itself.

This group was considered by their teacher to be of somewhat lower ability. Both of these participants were familiar with computers, having access at home, and one used Word to write stories for himself, so unfamiliarity with the technology was not an issue. This group also created the lowest number of questions (3) within either of the classes, and even then, one question was incomplete. Notwithstanding this, these participants claimed to have enjoyed the activity and would like to do it again.

5.1.2 Use of computers

Creating quiz questions can be quite easily done on paper, and even the Word templates used to create the quiz questions could be printed off so that learners would have prompts to fill in all the different required parts for each question. However, the mere fact of doing the activity on computer gives it some added cachet.

5.1.2.1 Participant interviews

All the participants interviewed believed that the activity was 'better' done on a computer. When asked if they would do it on paper, they somewhat reluctantly agreed it was possible, but without any great enthusiasm. Doing the activity on paper would be second best, but a number of participants felt that preparing questions on paper beforehand would be helpful, as a prelude to typing them into the computer.

Using computers adds to the engagement for younger learners, as it is quite novel for them. It also provides them with an authentic, purposeful task to carry out on the computer, resulting in an interactive question. While novelty would not be a factor for

older learners, the convenience of using a computer to prepare and submit a question-creation assignment would remain. If they already use Microsoft Word for preparing other types of assignment such as essays, then it is quite natural to use it for questions too.

5.1.2.2 Participant questionnaires

Many participants in both classes liked using the computer, and over half of Class 2 explicitly described the activity as 'fun' in the questionnaire. Some participants mentioned 'typing' as what they liked best about the activity, which can be considered a proxy for saying they liked using the computer. Others explicitly mentioned using the computer as their favourite part.

> *I would like to do it again because I like using computers and I like making and doing quizes.*
>
> Participant 1-10A

> *I liked about quizes because they help you to learn, and it is very fun on computers.*
>
> Participant 2-3B

One environmentally aware participant pointed out that using computers reduces consumption of pen and paper.

> *I like the way that it lets you make your own questions and it also saves pens and paper if you do your tests and quizzes on the computer.*
>
> Participant 2-5A

Another felt that they learned a bit about using the computer while doing the activity, and some participants didn't consider it 'work' at all.

> *"It was very educational. I am not very good at computers but I know how to do that now."*
>
> Participant 1-10B

> *We didn't get to do work in class. And also creating quiz questions*
>
> Participant 2-2B

> *I liked it because it was easy and we got time off school work.*
>
> Participant 2-15B

At a practical level, using the computer is intrinsically more collaborative than using pen and paper, particularly at primary level, because the person typing typically looks at the keyboard to type, rather than the screen. Their partner can then inspect what appears on the screen to make sure it appears correctly, dictate what to type, spell-check, etc. When using paper, learners each write on their own page, and it isn't practical to have a partner provide the same level of interaction. One participant explicitly alluded to collaborative working on the computer.

> *I liked the way we got to write all the answers ourselves and I liked working on the computer in pairs.*
>
> Participant 2-13A

In spite of the generally positive view of using computers, there were quite a number of suggestions for improvement of the technology aspect, so the participants were quite discerning. A number of participants felt that adding the questions to the website could be easier (it could), while others pointed out that the website (i.e. the Moodle LMS) was not attractive to children, and could do with more colours and pictures.

> *Make the website more colourful so it will attrack the kids to use it.*
>
> Participant 1-2A

It is worth noting that the participants had certain expectations for the Moodle website presentation of the completed quiz questions, such as colour and pictures, but did not have the same expectations for the Microsoft Word interface, so it seems they are conditioned by their prior use of the web to expect more website pizazz, but don't transfer this expectation back to their use of Word.

5.1.2.3 Teacher observation

Both teachers introduce basic IT skills, including Microsoft Word, to 6th class learners, and therefore thought that the activity was very suitable for them. It might not be suitable for younger learners, as although they are familiar with certain educational computer software, they do not start to use Microsoft Word, at least in a school context. The Cloze question type requires the use of character-level formatting (i.e. bold and italic), which was new to them, and so Teacher 2 had to show them the toolbar buttons to apply this formatting.

Teacher 1 pointed out that it is not only the learners who need some prior experience of computers and Word:

> *…And to make sure, I suppose, the teachers know how to use it as teachers can be a bit IT scared.*
>
> Teacher 1

This issue points to the need to provide a variety of different learning resources with the question creation tool: for learners, for teachers with prior IT skills, and for teachers with less IT skills.

5.1.3 Challenge

The 3rd aspect of the engagement of participants relates to the challenge posed by the activity. Participants had a number of different challenges to contend with: a) using the computer keyboard and mouse input mechanisms; b) using the features of the Word template to create and manage questions, and understanding and selecting from the different types of question format available; c) thinking up appropriate quiz questions and answers related to the chosen topic; and finally d), entering question text, answers and feedback in the appropriate places in the table.

5.1.3.1 Participant interviews

There was little agreement among the interviewed participants as to what was the more challenging part of the activity. Most were reasonably familiar with PCs and also somewhat familiar with Word, so did not find that aspect a problem. Some participants thought that identifying questions was the most difficult part, while others, even within the same group, thought the answers were harder to devise.

> *When you think of the questions beforehand, then you go down to the computer room and type them, then you sort of run out of ideas for questions. You think, oh, we're going down to the computer room today, to type the questions, then you think of all the questions, and then when you're actually down there, even though you have a history book you like forget, you run out of ideas for questions and answers.*
>
> Participant 2-5B

However, his partner felt that thinking up answers was harder than thinking up questions. Other participants relished the challenge of figuring out questions, and identifying where each component of the question needed to go.

I thought it was real… like you had to do loads of quizzes, and you had to figure loads of stuff out, and you didn't know which one to go into, and you had to figure it all out.

Participant 1-1A

Participants also distinguished the varying levels of difficulty between the question types. The True/False question is easiest, since you don't have to think of plausible wrong answers, just a suitable question.

The multiple choice questions that was a bit hard but the true and false and all was easier.

Researcher: True/False was easy. Was there less typing? Why was it easier?

No, it was just hard. You said that you had to pick like good answers, answers that people are not going to know.

Participant 1-7A

5.1.3.2 Participant questionnaires

Participants recognised that creating the questions was not easy, and many relished that fact, citing it as what they liked best about the activity.

"You got to think for your answers".

Participant 1-11A

"We get to use the things we know and it was a bit of a challenge to think back on what we've learn."

Participant 2-2A

You can make your own questions and you can make them as hard as you want to be. I liked writing the feedback.

Participant 2-5B

One significant theme that emerged from the responses as to what they liked best was a sense of satisfaction at meeting the challenge of creating the questions, and seeing them

appear in a real online quiz at the end of the activity. There was also satisfaction that they did all the work themselves.

> *The best was going back and learning about Alexander and that we had to do everything by ourselves*
>
> Participant 2-12B

> *I liked the way we got to write all the answers ourselves and I liked working on the computer in pairs.*
>
> Participant 2-13A

In both sites, the teachers and researcher provided only minimal assistance to the participants once each question type was introduced and explained, as the scaffolding provided by the table layout Word seemed to be sufficient for learners to successfully enter the required information.

Although most of the challenges are relatively mechanical, with only thinking up questions as the more intellectually demanding, nonetheless they all add up to quite a significant effort. From both interviews and questionnaire responses, it is clear that most participants were not overwhelmed by these challenges, but rather derived satisfaction from successfully negotiating them.

5.1.3.3 Teacher observation

Both teachers noted that there were lots of challenges at different levels for the participants, and this was one of the key enablers of differentiation. Apart from the issues mentioned above, Teacher 1 pointed out that among other things, formulating the correct grammar for a question also poses a challenge for learners.

> *Yes, how to phrase a question, even the true and false questions. Some of them couldn't do that, to know how to write it out, and then thinking of wrong answers, that were tricky or funny, so you could tell them I want you to give the right answer, and then in one of the boxes think of a funny wrong answer, and then think of a reasonable wrong answer, and then think of one of your own.*
>
> Teacher 1

Teacher 2 believes that the variety of question types, starting with the simple True/False and familiar Multiple Choice suits less able learners, who can stick with

creating fact-based questions around these types, or stretch themselves more with the Matching question which, although not used much by the participants, is still quite familiar to learners at this level. This question type probably was not explained well enough for some of the participants to successfully create such questions. In addition, the chosen curricular topic did not lend itself to this type of question. This teacher also identified the challenge for more able learners of integrating the various components together to create a new curricular object:

> *For the high achievers I thought they really loved it, I thought it gave them a huge chance to test their IT skills mixed in with something else which the curriculum tries to do with the whole integration idea that you can craft curricular things….*
>
> Teacher 2

The issue of grammar and question phrasing is also mentioned in the literature on creating item banks (Pritchett, 1999), as being one of the areas that creators need to develop a facility with, so that questions make unambiguous sense, and the right answer is not given away by a telltale grammatical usage such as 'a' or 'an'.

The facility of the activity to integrate different components of the curriculum together (grammar, IT skills, and the topic about which questions must be created) and create a new curricular object, is an attractive feature from the teacher perspective, and may encourage learners to be more aware of good grammar.

5.1.3.4 Questions created

There are many examples of questions where participants demonstrated that they rose to the challenge of creating good quiz questions. As a general point, one crude metric is that 8 of the 10 learner groups in Class 2 attempted to create a Cloze question, certainly the most difficult type. Figure 5-1 is a good example of an open response Cloze question, devised by Participant group 2-12.

Option	Feedback
Alexander's teacher was *Aristotle*. He taught him *literature* and *politics.*	
PE	No , hard luck
Art	No , to bad
Irsh	No, keep trying

Figure 5-1: Cloze question by group 2-12

There is one slight weakness in the question, related to how Moodle scores it, which is that the correct answers *literature* and *politics* are actually interchangeable in order, but Moodle would require them to be inserted in the order typed. Many other Cloze questions created by participants also had the same problem.

Participant group 2-8 managed to devise quite a good factual timeline-based Matching question, shown in Figure 5-2, even though the Matching question was not explained that well, and the material did not really lend itself to such questions.

Option	Target
13 year's	He got Aristotle as his teacher
20 year's	His father was murdered by his own officer
21 year's	He became king of Macedonia and Greece
33 year's	He died from a mosquitoe which carried the disease malaria

Figure 5-2: Matching question by group 2-8

In this intervention, the participants were explicitly requested to create each type of question, rather than voluntarily choosing to do so. However, in a more normal setting, the teacher could still direct certain groups to create particular question types.

5.1.4 Perception of activity

Learner participants had a positive perception of the activity, and often described it as 'fun' and 'cool'. While this is not strictly educationally valuable in itself, it does at least mean that learners might be favourably disposed to engaging with the process of creating questions. This attitude is likely to be sensitive to learners' age and prior experience, as the attraction of the technology-mediated nature of the artefact would probably become less of a factor, the older the learners are, and the more experience with technology that they have. Nonetheless, at 6th-class primary level, where learners have gained enough experience with technology to be able to negotiate the activity, and at most secondary schools, where integration of technology as a device is still quite limited, the mere use of technology in an educational context is likely to be a significant factor in positive perceptions of the activity.

5.1.4.1 Learner participant interviews

The learner participants interviewed all were positive about the activity, and would like to do it again. Some liked it primarily because of the novelty of using computers.

It was fun because it was a bit funny and I learned how to type fast.

Participant 1-7A

And I also learned how to type faster as well.

Participant 1-7B

Even though this group thought creating questions was hard, particularly thinking up good answers, it still didn't seem like work. They also would like to do it as homework in the homework club, as long as they could do it with someone else to help, rather than on their own at home.

Participant group 1-1 liked the quiz aspect, because they are familiar with quizzes on TV, and particularly liked creating a quiz on their own topic, Man. Utd. In this regard, ending the activity by allowing learners choose their own topic was a masterstroke, because like any good show, it leaves them begging for more.

There is clearly scope to differentiate the activity by learner interest, perhaps by grouping learners with the same interest, and having them create questions about it.

5.1.4.2 Learner participant questionnaires

The learner participants were asked what they liked best and least about the activity, and all could find positives, from simple pluses such as getting to talk to classmates, or simply typing on the computer, to the pleasure of being able to write any answers, including funny ones, if they liked. Only a few participants could identify negatives, such as problems uploading questions to the website at the end, and the lack of colour and pictures on the website. Perhaps some participants might have been over-enthusiastic in their praise, but that hardly seems a crime.

I suggest that should continue this program for all schools in all the country's I hope they liked it very much we liked every part of it.
Thank you!!!!

Participant 2-16A

One participant pithily, and correctly, observed:

"It took long enough"

Participant 1-2C

On the other hand, another participant in the same group felt the opposite, and wanted more time.

> *I like all about it. But I didn't like that I dident got more time to do more [stuff(?)]*
>
> Participant 1-2A

In normal circumstances, of course, no teacher would attempt two consecutive lessons. Teacher 2 noted that he would be inclined to approach it by first having learners prepare questions of a particular type on a particular topic in class, and then bring the class to the computer room for a short sharp session where they would enter and upload the questions, and perhaps do a resulting quiz.

5.1.4.3 Teacher participants

Both teacher participants expressed a very positive perception of the activity, and could immediately see applications of a quiz-question creation activity beyond the more factual based subjects. Teacher 2 already asks learners to create questions as a classroom device for maths, so he saw the artefact as a natural extension of his own current practice. He also liked the holistic benefits of the intervention, combining a number of key classroom teaching strategies.

> *And then the other, the buzzwords at the moment are: the differentiation, the collaborative learning and the integration.*
>
> Teacher 2

Teacher 1 thought it was a good assessment tool, because it was clear what level of confidence learners had in their answers.

> *They were very engaged the whole way through, and it was a great way to assess their learning, because you could see what factual information they actually knew, and were confident of the answer, rather than questions that they might have thought they knew the answer to, but weren't confident that they knew the answer.*
>
> Teacher 1

This was the case in this particular intervention because the learners did not have access to a textbook to check their answers though. However, this was an omission on the teachers' part, as he had forgotten to ask the participants to bring their books to the computer room.

While the activity could certainly be used as a type of assessment, this would seem to put much more pressure on learners, and might greatly reduce the level of engagement, in particular for less able learners perhaps.

Both teachers felt that the range of question types available to learners was an important enabler of differentiation, because less able learners could choose to create fact-based True/False and Multiple Choice questions, while more able learners could stretch themselves by attempting Cloze and Multiple-Answer questions.

Both also suggested starting the activity by introducing the (easiest) True/False questions first, and working up to the more difficult question types. In both classes, the participants were shown Multiple Choice questions first, and asked to create one, and only later were True/False questions introduced. The Word template interface also suffered from a similar defect, and both suggested placing the button for True/False questions to the left of the toolbar, with buttons for questions of increasing complexity placed in order to the right.

5.1.4.4 Questions created

Participants created a total of 66 questions in Class 1, and 56 questions in Class 2, during the activity. While the totals are not significantly different, the breakdown of questions by topic is more interesting. Participants initially created questions based on the topic chosen by their teacher, but towards the end of the activity, they were encouraged to choose their own, non-academic, topic, and create some questions related to that instead. This stage of the intervention was not timed, but amounted to about a quarter of the total time available for creating questions. The breakdown of questions by topic is shown in Table 5-2.

Table 5-2: Number of questions created by topic

Group	Teacher-chosen		Learner-chosen		Total
	N	%	N	%	
Class 1	41	62%	25	38%	66
Class 2	47	84%	9	16%	56

In Class 1, participants created a very large number of questions once allowed to pick their own topic, both relative to the total time available, and relative to the participants in Class 2. The main topics chosen by the participants in Class 1 were The X-Factor (the final of which had just finished on TV) and football. This burst of activity, at the end of what

was a long 2-lesson period, demonstrates quite a level of engagement by the participants, and shows how positively they viewed it.

The participants of Class 1 are less able overall than those in Class 2, so this is also an indication that for less able learners, aligning the topic more towards their own interests is likely to result in increased engagement. This is in fact one of the principles of differentiated learning instruction, so the measurable difference in output is consistent with the underlying theory.

5.2 Sub-question 2: Are more able learners challenged to create richer questions?

The first sub-question outlined the evidence supporting the finding that participants at different levels of ability engaged with the activity to a reasonable extent. In this sub-question, the evidence is examined to consider how more able learners responded to the activity. Ideally, more able learners would/should create more questions, and/or questions that are somewhat more sophisticated in one or more of a number of respects. For example, the questions these learners create might be harder to answer, requiring a deeper level of knowledge, demonstrating some level of mastery of the chosen topic. They might choose question types that are more difficult to devise, such as the Cloze question type, or for some topics, the Matching question; or less familiar to learners daily experience, perhaps the Multiple Answer question. Finally, they might create questions that rank higher in Blooms' Taxonomy, demonstrating more than factual recall.

The data collected is not fully amenable to answering this question directly. It was not possible, and anyway not desirable, to label each participant group according to its ability. Therefore the questions and the questionnaires cannot be simply categorised as belonging to more or less able learners. However, for the purposes of choosing interviewees and groups for observation, each teacher did nominate a number of groups, at what they considered different levels of ability, so some of the more able groups (group 1 in Class 1 and group 5 in Class 2) are known. Their work can be therefore assessed directly, and can be compared against that of the known less able groups within the same class. The teachers also observed the activity and were able to gain an impression of how different groups approached the questions.

In addition, indirectly, the created questions and the questionnaires can be examined even without *a priori* knowledge, and the work of the more able learners should also emerge, if, as hoped, the activity does indeed provide a platform for differentiation. However, given the limited duration that the participants had to create questions, not too much data can be expected to emerge from this source.

5.2.1 Questions created

The participants in the more able Class 2 created a total of 56 questions, of which 17 (30%) were of the more complex types and 70% the simpler types. Table 5-3 shows the breakdown of questions according to both topic and type, for Class 2.

Table 5-3: Question types and topics created by Class 2

	Topic Choice			Question Type						Total
Group	Teacher	Learner		MC	TF	MA	MAT	SA	CL	
2	5	1		2	2	0	1	0	1	**6**
3	6	1		2	2	1	0	1	1	**7**
5	8	0		4	3	1	0	0	0	**8**
8	4	1		1	2	0	1	0	1	**5**
9	2	1		2	1	0	0	0	0	**3**
10	4	1		3	0	0	0	1	1	**5**
12	6	0		4	1	0	0	0	1	**6**
13	3	1		1	1	1	0	0	1	**4**
15	4	3		2	2	1	0	1	1	**7**
16	5	0		2	2	0	0	0	1	**5**
10	**47**	**9**		**23**	**16**	**4**	**2**	**3**	**8**	**56**

The 70/30 split between simpler and more complex questions is slightly higher than the 80/20 split of Class 1, although probably not that significant. Most groups did choose to attempt a more complex Cloze question, demonstrating that they were capable of meeting the challenge.

In Class 1, the more able Group 1 created a total of 8 questions, 5 on the topic of New Zealand, and 3 on their own topic (football and the X-Factor). The number of questions created is slightly above average. They created 2 Multiple Choice, 1 True/False, 1 Short Answer, and 1 Multiple-Answer question that were all correctly formatted and grammatically consistent. In addition, they also created additional Multiple Choice questions that were incorrectly defined as Multiple-Answer questions. The questions are among the more difficult questions created by the class. They are also generally quite clear, and the answers contain quite plausible or at least relevant distractors. The Multiple

Choice question shown in Figure 5-3 is quite difficult, and does demonstrate some mastery of the topic.

What is the poi?	
#	Option
A.	Pom pom
B.	Stick
C.	Tattoo
D.	Language

Figure 5-3: Multiple Choice question by group 1-1

The Multiple-Answer question in Figure 5-4 is an example of an appropriate selection of question type, although the group later seemed to always choose this type, even for Multiple Choice questions.

What sports do they like to play		MA
#	Option	Grade
A.	Rugby	50
B.	Football	50
C.	Hockey	0
D.	Basketball	0

Figure 5-4: Multiple Answer question by group 1-1

In the True/False question they created, they understood the format well enough to make the question a statement rather than a question, "The tallest mountain in new zealend is mount cook", which not all participants were able to do, and they were also one of only 2 groups which attempted the Short Answer question.

While it is clear from the questions they created that this is one of the more able groups, is this also evidence that they created richer questions? Not necessarily, but it is at least arguable.

Group 5 from Class 2 created 8 questions, joint highest within their class; this included 4 Multiple Choice and 3 True/False questions, and 1 Multiple-Answer question. The Multiple Choice question in Figure 5-5 is a fair example of the type of question created, and shows that this group seemed to focus most of their effort into devising humorous feedback for each answer. It does also demonstrate some mastery of the format however, in that they understood the purpose of the Grade column, as they placed the correct answer in row C rather than the default row A, but correctly changed the Grade value

accordingly. Each question had instructions on where to place the correct answer, which they were confident enough to ignore.

	What was Alexander the great killed by?		*MC*
#	**Option**	**Feedback**	**Grade**
A.	A spear	Nearly, but they missed	*0*
B.	Starvation	You're thinking about his army	*0*
C.	Mosquetoe	Yes but it wasn't a pretty sight.	*100*
D.	Persian lion	No,he never encountered any.	*0*

Figure 5-5: Multiple Choice question by group 2-5

All in all, the questions created by this group do not support a 'Yes' answer to the sub-question.

So much for the questions created by known able participants. Did other questions provide any evidence of able learners rising to the challenge? Clearly this is a matter of subjective judgement, but at least one question from Class 1 seem to this researcher to at least demonstrate a reasonable level of mastery of the activity, in choosing a more difficult question and applying it in a natural way. While the vast majority of participants included the question "Who won the X-Factor?", group 1-10 displayed some imagination in choosing a Matching question type to pair the acts and their mentors, as shown in the question in Figure 5-6, and also managed to spell most of the names correctly. This researcher has to confess however, that he has no idea whether the acts are paired with the correct mentors!

	Match the people with their mentors		*MAT*
#	**Option**	**Target**	
A.	Daniel	Louise	
B.	Joe	Danny	
C.	Jedward	Cheryl	
D.	Stacey	Simon	

Figure 5-6: Matching question by group 1-10

Group 1-6 asked a simple question but chose excellent distractors, as well as getting the answer right.

	What is the biggest country in the world?		MC
#	Option	Feedback	Grade
A.	Russia		100
B.	China		0
C.	America		0
D.	Canada		0

Figure 5-7: Multiple Choice question by group 1-6

In Class 2, group 2-10 chose a Cloze question with the Short Answer, i.e. open response, variant. This ensures that the answer is not simply presented as an option from which to choose. The question also included two further components, the subjects taught, making the question considerably more difficult, as it requires spelling correctly too.

	Alexander`s teacher was *Aristotle*. He taught him *literature* and *politics.*		CL
#	Option	Feedback	Grade
A.	PE	No , hard luck	
B.	Art	No , to bad	
C.	irsh	No, keep trying	

Figure 5-8: Cloze question by group 2-10

Overall, however, there does not seem to be clear and conclusive evidence within the available created questions dataset to support the contention of the sub-question, that more able learners are challenged to create richer questions. This is probably not surprising, given that the participants were completely new to the activity. More research with the same participants, over a number of further sessions, might provide more insight into this issue.

5.2.2 Participant questionnaires

A number of themes are apparent from the questionnaire responses to the question of what participants liked best. Some liked using the computer, some liked collaborating ('talking'), and some liked answering the questions in the quiz at the end. Quite a number responded that creating the questions was what they liked best, including, in each class, one of the known more able learners.

> *You can make your own questions and you can make them as hard as you want to be. I liked writing the feedback.*
>
> Participant 2-5B

That you make your own quiz questions

Participant 1-1B

Again, no conclusion can be drawn from this limited sample, but perhaps it is broadly supportive of the possibility of more able learners being appropriately challenged.

5.2.3 Teacher interviews

Both teachers expressed a general view that the primary differentiation factor offered by the artefact is that more able learners can master the more complex question types, and they would in fact direct more able groups to attempt these question types, rather than simply allowing them to choose whatever type of question they would prefer.

…the better ones will get onto harder questions, and weaker ones will just get stuck with the easier questions, but they'll all get work done.

Teacher 1

that's what I would do next I suppose would be to start with asking the true or false questions, get them to do one or two of them and then get certain groups to continue on true or false and ask others to move onto something else.

Teacher 2

Both teachers also said that if using the activity on an everyday basis, they would set assignments based on question type, starting with the easiest (True/False), and stepping up through to the most difficult. This type of approach, making allowances for less able learners, can be easily adapted to learners' current readiness level, so that they have the time to master each type. As learners improve, they can then move on to more difficult questions.

5.2.4 Participant interviews and observations

Observations of the more able groups 1-1 and 2-5 displayed high levels of collaboration and involvement, and remained on-task throughout the observation period. However, this can only be considered as corroborating evidence of engagement and diligence, rather than anything deeper.

Table 5-4: Group 2-5 observation record

Interval	Involvement	Comfort	Activity			Collaboration
			On	Off	Other	

Interval	Involvement	Comfort	Activity			Collaboration
			On	Off	Other	
1	Medium	Medium	D			High
2	Medium	Medium	T			Medium
3	Medium	High	D			High
4	High	High	D			High
5	Medium	High	D			High
6	Medium	Medium	T			Medium
7	High	High	T			High
8	Medium	Medium	T			Medium
9	High	High	D			High
10	High	High	D			High
11	High	High	R			High
12	High	High	T			High
13	High	High	D/T			High

Table 5-5: Group 1-1 observation record

Interval			Activity			
	Involvement	Comfort	On	Off	Other	Collaboration
1	Medium	High	T			Medium
2	Medium	High	T			Low
3	High	Medium	T			High
4	Medium	Medium	T			Medium
5	High	Medium	T			Medium
6	High	Low	T			High
7	High	Low	F			
8	High	Medium	T			Medium
9	Medium	Medium	F			Medium

5.3 Sub-question 3: Do less able learners get enough support to create questions?

The last sub-question considered how more able or ready learners perceived and coped with the activity. This sub-question considers how less able learners perceived the activity. The data analysis suggests that the vast majority were more than able to create a number of quiz questions, and were able to do so with little or no support from the class teacher.

The Word template seemed to provide enough scaffolding to the participants to enable them to create the questions, even though there was initially confusion about some of the terminology used. The visual layout of the table, showing A., B., C. and D. in a column, with boxes in which to type in text, provided enough visual cues to learners, even though some of the labels in the boxes used words unfamiliar to the learners, such as ‘Option’ and ‘Feedback’.

5.3.1 Participant created questions

There was a wide variation in the number of questions created by different groups, but the groups created an overall average of 6 questions each. Table 5-6 shows the number of questions created by learners in the less able Class 1, where the groups created just over 7 questions each, with 78% of questions being of the simpler True/False and Multiple Choice type and 22% more complex types.

Table 5-6: Question types and topics created by Class 1

	Topic Choice			Question Type						Total
Group	Teacher	Learner		MC	TF	MA	MAT	SA	CL	
1	5	3		5	1	1	0	1	0	***8***
2	3	1		2	0	1	1	0	0	***4***
4	6	3		4	3	2	0	0	0	***9***
5	3	2		4	1	0	0	0	0	***5***
6	6	4		6	3	1	0	0	0	***10***
7	5	3		4	4	0	0	0	0	***8***
9	7	4		5	2	1	2	1	0	***11***
10	3	3		3	1	0	2	0	0	***6***
11	3	2		1	3	1	0	0	0	***5***
9	**41**	**25**		**34**	**18**	**7**	**5**	**2**	**0**	**66**

Clearly these participants had sufficient support, both technical and because of collaborative working, to create plenty of questions.

The less able participants in Class 2, group 2-9 (as identified by their teacher) created 3 questions. However, the less able participants in Class 1, group 1-7 created 8 questions, 4 Multiple Choice and 4 True/False. There is therefore no obvious correlation between the number of questions created and the ability of the group, but since other less able groups were not identified, it is not possible to explore this further. The organisation of the activity on the day would not have suited less able learners, because a wide variety of different question types were introduced in a short period of time, giving them too little time to fully comprehend them. More able learners would have been at an advantage, but group 1-7 seems to have adopted an effective strategy of sticking to well-understood question types, and using humour, particularly in the questions created on their own chosen topic (of which they created 3). This is shown in Figure 5-9, where they chose the names of Special Needs Assistants within the school as distractors.

	Who's The President Of Ireland?		MC
#	**Option**	**Feedback**	**Grade**
A.	Mary McEleese		*100*
B.	Linda		*0*
C.	Ashling		*0*
D.	Ross		*0*

Figure 5-9: Multiple Choice question by group 1-7

This less able group were clearly able to participate in the same activity as all other learners, and were able to achieve similar levels of output without assistance from the class teacher.

In Class 2, the less able group 2-9 did not produce many questions, but successfully formatted a Multiple Choice question and provided plausible distractors, a considerable amount of feedback, including appropriate general feedback, with good spelling, even if their geography remains a little suspect, as shown in Figure 5-10.

	What age was Alexander when he conquered London?		MC
#	**Option**	**Feedback**	**Grade**
A.	20	Yes he became the king of London at the age of 20!	*100*
B.	21	No he had other places to conquer.	*0*
C.	19	No he did not because his father was still alive.	*0*
D.	18	No he was not fit to be a king.	*0*
	Correct Feedback:	Correct, you're smart	
	Incorrect Feedback:	No, sorry you're cheating ways are incorrect	
	General Feedback:	He was very young to be king only because his father had died.	

Figure 5-10: Multiple Choice question by group 2-9

This group also started work on a Matching question on the topic of football, and although they didn't complete it, it does indicate that they felt comfortable enough with the activity to attempt a more difficult question type.

In summary, there is evidence that less able learners were able to master the simpler question types at least, and one group was both able and motivated enough to produce an above average volume of questions, while the other seemed to focus more on completing all the components of each question, with detailed feedback included.

5.3.2 Participant interviews

The less able participants expressed strong positive feelings about the activity, and considered it engaging. Group 2-9 thought using the Word template was quite easy, and felt thinking up questions was also quite easy, but thinking up answers was hard. They also had quite strong views on the website, and made many suggestions for improvements to make it more engaging, such as adding colours and pictures, and offering clues with questions, such as a 50:50 option.

> *Researcher: Would you like to do it again?*
>
> *Yes, it was piles of fun.*
>
> Participant 2-9A

This group made use of the other supports available to them, such as the printed set of sample questions (supplied to Class 2, but not Class 1), and the reference materials they brought with them, and they believed that these extra supports were essential to their ability to do the activity. (The printed sample questions could be further improved to show not just the question in the Word table format, but also a screenshot of the same question as presented by Moodle.) They modelled their own created questions on questions they had seen in a prior test by their teacher, and used the reference book to look up distractors to complete the required components of the Multiple Choice question type.

Group 1-7 collaborated well during the activity, and said in the interview that they shared most aspects of the activity, including typing questions, thinking up questions, and deciding which questions were suitable. This group felt that printed materials would have helped them, but unfortunately this class had no such materials available during the activity.

They also suggested that it would be 'better' to write the questions out first, and then type them in, so that they could prepare questions before going to the computer room. This approach would also lend itself to collaborative preparation as homework in an after-school Homework Club, which they would like to do, if it was instead of rather than additional to other homework, since they get too much already. Increased preparation time is also more suitable for less able learners in general, as it reduces the time pressure they may feel.

5.3.3 Participant questionnaires

The participant questionnaires do not provide directly usable data to assist in answering the sub-question, but the comments about what they liked least, and general comments, may provide an indication of some of the difficulties, more likely to have been encountered by less able learners. There were surprisingly few negative comments, and only 3 participants across the two groups commented that they found it 'a bit confusing'. Others commented that it was hard to think of questions, which can be seen as a positive.

A number of comments were useful and valid criticisms, and two issues were mentioned by a number of participants: the attractiveness of the website could be improved; and the uploading of questions could be easier.

5.3.4 Teacher interviews

Both teachers thought that starting with the simplest type of question (True/False) and working up through to the more complex question types would suit weaker learners best, because they could gain practice at the simpler ones, and only move on when ready, or stick with simpler questions. They also recommended placing the question types in ascending order of difficulty in the toolbar, so that learners could work from left to right in doing the questions. The template used in the intervention actually had Multiple Choice rather than True/False as the first question type, and this question type was also demonstrated first during the intervention.

Before the intervention, Teacher 2 showed the recorded screencast demonstration, which showed how to create a Multiple Choice question. On the basis of this demonstration, his class thought that it would be too difficult for them. Neither computer room had a projector, so it was also not possible to demonstrate how to create questions during the intervention.

In spite of all these issues, the participants, including the less able ones, quickly got the hang of the table layout for questions, and were able to work productively, so the activity was more difficult to explain than to do.

Three of the points (order of question type in intervention, order of types in toolbar, type of question demonstrated in the screencast) are easily addressed, and in fact the template itself has already been updated.

The nature and role of screencasts in preparing for the activity is more complex. In principle, many screencasts could be created, one for each question type, but it may be more important to create multiple screencasts for each of the simpler types, geared for different levels of learners, different modalities, and different elements of the question-making process. An alternative to screencasts may be to prepare more detailed printed documentation. A simple set of examples was prepared for Class 2, because of the lack of a projector, and these worked well and were frequently referred to by the less able group.

Another point made by Teacher 1 was that phrasing the questions correctly was difficult for the less able learners. The activity requires certain grammatical conventions, such as making a statement in the True/False question stem, rather than a question. Although Word has a built-in spelling and grammar checker, learners at primary level are not familiar with how to use them.

5.4 Sub-question 4: What are the pedagogical and practical challenges involved?

The previous sub-questions considered a number of issues around the value of learner-generated quiz questions as a differentiated learning activity, when combined with a technology-mediated artefact. This sub-question considers the broader issues around implementing such an activity in a classroom environment.

5.4.1 Practical challenges

Obviously, access to a Moodle LMS installation is a prerequisite, but given the low cost of hosting LAMP-based servers, and also dedicated Moodle hosting companies (even in Ireland), this is not insurmountable. At present, however, there is almost no adoption of LMSs at Irish primary school level, and only very limited adoption at secondary level. The situation in the UK is considerably more advanced however, with almost half of primary schools using some form of LMS, and Moodle the 3rd most popular by installed base (Dodson, 2007). Presumably schools in Ireland will slowly adopt LMS technologies, and given the limited funding available, a free LMS such as Moodle is quite likely to become widely adopted. At worst, a single Moodle server could be shared among a number of schools, each with their own private courses configured.

Assuming access to a Moodle server, schools need broadband Internet access, but this is no longer a major barrier, as all urban and most rural schools in Ireland have nominally

at least 1Mbs broadband access. Some rural schools have satellite connections, which are considered unsatisfactory however (Department of Education and Science, 2009). Schools also need Windows computers, and again this should not be a problem, as most schools have standardised on Windows PCs, with some version of Microsoft Word.

Given Windows and Word, the MoodleQuiz Word templates should be easy to install, and no problems were encountered in either school used in the research. Installation was easy in the school for Class 2, as their computer network is managed and supported by a specialist IT contractor, and all PCs have a standard configuration and run Microsoft Office 2007. Installation was more problematic in the school of Class 1, as the PCs are not managed centrally, and three different versions of Word (2002/XP, 2003 and 2007) were encountered, but the templates installed and ran OK on all versions.

Continuous broadband access during the activity is not essential, as learners are working mainly within Word (this is an advantage of the Word-based approach), although it is required to upload questions. Prior to the activity in Class 2, the Internet was in fact unavailable due to wider network problems, but by the time the participants were ready to upload questions, it was back again.

If learners manage to create and upload quiz questions, it is important that they then get an immediate opportunity to try to answer them in a real quiz, as a closing activity. Teachers must therefore be capable of assembling quiz questions into a quiz. Creating a quiz in Moodle is not completely trivial, but a simple screencast demonstration, and written procedure checklist, should be enough for teachers to learn the steps required. Moodle has a facility to randomly select a given number of questions from an item bank, so if 20 learners upload 5 questions each, the teacher could request that 10 random questions are selected for each instance of a quiz. This would mean that all learners would see a selection of questions from the entire class, and everybody's questions would appear in one quiz or another. This is preferable to the teacher having to select questions from different learners, as some bias may come into play. The random selection would also be much quicker to set up, ensuring that the learners were not waiting long before they could start the quiz.

There should be no need for learners to have their own individual accounts provisioned in Moodle, because the quizzes should not be part of any formal assessment,

and a whole class could use a single login for uploading files. However, Moodle does not permit a single learner to instantiate a quiz multiple times, so a set of generic account names, already enrolled on the class course, would be required to allow a class of learners carry out the quiz activity together.

Although learners were highly motivated to create quiz questions, many commented that the Moodle website was boring and lacked colour and pictures. Many younger learners are conditioned to expect multi-media interactive experiences on the web, and static quiz questions may become dull quite quickly. To counteract this, it would be useful to present questions in a more engaging format than the Moodle default. A possible approach could be to harness some of the many Flash-based quiz games that have been developed especially for children. Some of these games read in quiz questions from an external XML file. It should be possible to develop a facility to convert questions from Moodle Question XML format into one of these custom formats fairly easily, since only a simple XSLT script is required to convert one XML vocabulary to another. One particular example is the "Who Wants to be a Millionaire?" game, based on the TV programme (Davies, 2007). It is a free, Open Source Flash application, which closely mimics the sounds and imagery of the programme, and would be an engaging way of presenting Multiple Choice quiz questions. Unfortunately this format is limited to Multiple Choice questions though.

While adding sounds would make a quiz more engaging, a problem would be that in a computer classroom environment, headsets rather than speakers would be required, or the noise would be unbearable. Headsets may not be available in a dedicated computer room, but are more likely to be available in a classroom environment, where a computer might be located.

An alternative to the whole-class activity approach would be for a teacher to use an in-class computer instead, and allocate small groups of learners to do the question creation activity on a particular subject while other groups are engaged in other activities on the same subject. For example, one group could create maths questions while other groups did other maths-related activities.

Access to a projector is highly desirable to demonstrate how to create quiz questions, but it is not essential that the projector is in the computer room, if learners are shown the

process in the classroom beforehand. Printed examples of each question type being used are a good substitute, especially for less able learners.

5.4.2 Pedagogical challenges

At the pedagogical level, the activity offers many opportunities for variation, and can be integrated into a range of different subjects. However, for many larger class sizes, it may not be practical to bring a whole class to the computer room in one cohort, either because of a lack of equipment (2 learners per PC is probably the most desirable ratio, to ensure each gets a turn at typing), or for supervisory reasons.

Dividing a class into two cohorts might have advantages, as each cohort's questions could be tried out by the other, and a score kept introducing a competitive element. In this situation, or alternatively where there are two classes in the same year (E.g. 6th class), they could compete against each other to create the hardest, funniest, or 'best' questions, with Moodle keeping score.

Selecting groups by ability in order to ensure that all learners in each group are able to contribute and learn may be an issue for some teachers. Could the activity be re-designed to use mixed ability groups? Teachers could alternate grouping strategies to support more able learners teaching other less able learners particular skills. For example, a learner who is familiar with the standard computer keyboard could be paired with a learner who is not, so that they can help the other improve typing, showing them where the keys are, how to type capital letters and punctuation, etc. Learners who have demonstrated mastery in particular question types, such as matching questions, could also be paired with other learners at a lower readiness level, so that they would learn from a more able other, harnessing Vygotskys' Zone of Proximal Development theory.

Learners could also be grouped by interest to create questions based on non-curricular topics, football, for example. At primary level however, this might break down predominantly on gender lines, which might be undesirable.

Learners may become bored with the activity if it is used for only one subject. The activity is quite generic, however, so it could be used in almost any subject. It may be particularly suited to the thematic approach now quite widely used in Irish primary education, and in fact, a thematic rather than narrower subject approach was chosen by both teachers involved in the intervention.

One variation might be getting all learners to pose one question type on a particular theme, or comprehension-type questions on a particular book that was read, or a play, or a piece of art or music.

6

Conclusion

Creating questions using a computer offers a number of features, or affordances, that enable collaborative constructivist learning in a variety of ways.

- The computer modality assists collaboration. While one learner types, the other can watch what is happening on screen, or can follow the fingers to find out where the keys are. Both learners can clearly see the 'canvas' (the screen) at the same time, which would not really be true of a paper-based equivalent. Since there is only one keyboard, the learners have to explicitly manage turn-taking, whereas on paper, both could have their own pens, and this would make it more likely that they would work independently, losing the benefits of collaboration.
- The consistent table layout for entering the components of each question provides a scaffold. The tabular layout of all the component parts of the question, each with its own place, in a layout similar to how the questions would appear on-screen or in print, each component cell adjacent to related information (feedback corresponding to an answer in the same row, all feedback in the same column, all answers in the same column), helped learners fill in all the boxes appropriately. The table and all its components were visible on the screen at all times, helping learners to keep focused; suitable cell labels, column headings, and instructions were included, and default information filled in automatically, minimising repetitive typing. This design avoids some of the main problems with Moodles' web-based forms for question creation.
- Using a standard word processor builds and reinforces existing skills/knowledge. Participants in both schools were already somewhat familiar with Microsoft Word, so using it as a tool helped reinforce that skill, and built upon it. It introduced tables, so they also learned something new which could be used later with other work.
- Converting questions into Moodle quizzes added an interactive and fun element, that learners engaged with. Doing things on the computer adds some cachet to even the most mundane subjects. The Preview facility gives a measure of 'instant gratification'

and adds immediacy, so that learners can measure their progress as they go, and self-test the results of their work without a long delay, and independently of the teacher.

6.1 Research question

The principal research question asked: "Does in-class activity around (technology-mediated) learner-generated quiz questions support differentiated learning?", and four sub-questions were posed to help in answering it.

- **Do learners of different abilities engage with the activity?**

  Participants of all abilities were clearly enthusiastic and engaged during the intervention, as observed by both teacher and researcher, and also expressed satisfaction with most aspects of the activity in their post-intervention questionnaire responses and interviews.

- **Are more able learners challenged to create richer questions?**

  Most of the groups in the more able class successfully created even the most complex Cloze question type, and the class created a significant percentage of more complex question types.

- **Do less able learners get enough support to create questions?**

  The artefact provided sufficient support, that less able learners were able to create questions without requiring much support from teachers. The less able class created slightly more questions on average than the more able class, and in particular, created many more questions related to their own interests.

- **What are the pedagogical and practical challenges involved?**

  There are a number of practical challenges to using the MoodleQuiz artefact: management of large classes may preclude use of computer facilities as a class cohort; access to a Moodle LMS server is required, and teachers will require enough IT literacy and confidence to assemble quizzes. However, none of these issues are insurmountable.

  At a pedagogical level, teachers will need to choose topics appropriate to different question types, and vary grouping strategies to ensure that less able learners are not always grouped together.

6.1.1 Unexpected results

One unexpected finding of this study was that the participants in the less able of the two classes where the intervention took place were motivated to create a large number of questions, once given the freedom to choose a non-curricular topic of their own interest. The literature on differentiation does suggest that addressing learners own interests is an important technique in engaging them in their own learning, so perhaps it should not be too surprising. Nonetheless, the burst of energy and enthusiasm that arose when the participants were given free rein is one of this researcher's abiding memories.

6.2 Limitations

This study is an in-depth exploration of a particular case in its setting, using two sites, about which some 'fuzzy generalisations' are made. Limiting the case to two sites has the advantage of allowing a more in-depth data analysis. However, a broader study encompassing a larger number of sites would be needed to add further validity to the findings.

The study also focused on a single age-group, 11 to 12 year olds, in a primary school setting, where using technology in an educational context still has a significant novelty value. It is not certain that the level of engagement observed across all abilities of the participants would be repeated with an older learner cohort, particularly less able older learners.

Finally, only a single iteration of the intervention was carried out. The level of engagement among participants may not continue across multiple iterations, once the novelty wears off.

6.3 Suggestions for further work

6.3.1 Future research

Further research should be carried out to address the limitations of the study already mentioned. A wider study, encompassing a range of learner age groups and settings, with question-creation interventions repeated over an extended period of time, would enable a much broader picture to be formed of the efficacy of the artefact in engaging learners of different abilities over the longer term. Such a study might also consider the potential for inter-class and/or inter-school collaboration, perhaps through sharing of question banks and online quizzes.

On a different tangent, the collaborative constructivist pedagogy supported by the intervention could be applied in a number of particular subject domains, for example mathematics or a modern foreign language (Kavaliauskiene, 2003). The efficacy of the artefact in supporting learner authentic knowledge construction in one of these more specialised domains should be tested.

6.3.2 Extending the artefact

The technology artefact developed for this study has a relatively narrow scope: text-based questions. However, the underlying principles of constructivist collaboration, and integration of ICT into the curriculum, can also be applied to other activities.

One relatively straightforward addition might be to extend the Word template to support an FAQ building activity. In this scenario, learners would define a question, and then provide a single detailed answer, such as explaining a concept in their own words, describing a process, or simply defining a term. Moodle already has a Glossary tool and a Glossary XML import facility, so this shouldn't be technically difficult.

A more general improvement would be to internationalise and localise the authoring interface to support languages other than English. This would make the artefact more suitable for use in the increasing number of primary and secondary schools in Ireland where Irish is the first language of instruction (gael-scoileanna), in secondary schools to support foreign language learning, and obviously, in non-English speaking countries.

A far more ambitious extension, and perhaps only appropriate for older learners, would be to support mathematical notation. Word 2007 has a built-in equation editor which simplifies the input of equations, although it remains a somewhat tedious task. The equations are internally stored in an XML format, which can be converted into images on import into Moodle, or translated into the MathML XML vocabulary (W3C, 1998), and displayed directly by browsers. Pedagogically, the benefit of such a facility might be quite significant, if it allowed mathematics students to avoid the need to learn one of the many arcane ASCII-based electronic mathematical notations based on TEX (Knuth, 1986). It is also a fascinating technical challenge that could greatly simplify and enhance the adoption of mathematics on the web, which remains a conundrum, even after more than 10 years.

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Appendix A

Ethics approval letters and forms

A.1 Parent/Guardian Information Sheet: Learner-Generated Quiz Questions

Dear Parent/Guardian,
The children of 6th class are invited to participate in computer-based learning activities to devise quiz questions based on subjects they have studied on the standard school curriculum. The topic of the quizzes will be decided by the class/subject teacher, and is likely to include subjects such as History, Geography or English. The purpose of the intervention is to add a digital dimension to an existing standard classroom practice (revision), and explore the childrens' ability to construct quiz questions that can be used to aid their revision and learning of the subject.
The activities will take place during normal school hours with the class/subject teacher present to supervise and observe, and will last approximately one hour. Up to three quizes may be created over a period of a number of weeks in December 2009. The children will work in small groups of two or three, within their own class, and use computers to write and edit quiz questions. The questions will be uploaded to an Internet-accessible website, running the Moodle Learning Management System, but access to the site will be password-controlled, and limited to the children themselves during the activity.
The intervention is being facilitated by a researcher, a postgraduate student on the MSc. (Technology and Learning) course, run jointly by the School of Education and School of Computer Science, Trinity College, Dublin. Immediately after the learning activities, children will be asked to fill out a short questionnaire about the intervention, to explore how they perceived it, and record their experiences. A day or two after the activities, some children will be asked to take part in a group interview with the researcher and teacher, to explore responses to the questionnaire in more detail. They will also have an opportunity to ask any questions about the project. A voice recording of the interview will be made in order to enable later transcription and analysis, and the interview will last for one hour or less.
All information that is collected by the researcher (quiz questions, questionnaires, interviews) will be anonymised and stored in accordance with the Data Protection Act at Trinity College, Dublin. In the unlikely event that information about illicit activities should emerge during the intervention, the researcher will follow the school's child protection policy and inform the relevant authorities. There may be lectures, conference presentations or peer-reviewed journal articles published as a result of this project, and direct quotes from participants may be included. However, neither the children nor the school will be identified.
Permission for the project to take place in the school has been given by the principal and board of management. Your child's participation can only take place with your permission. Participation is voluntary and you may withdraw your child from the project at any time for any reason without penalty and any information already recorded about your child will be removed.

If you have any questions before, during or after the project, please do not hesitate to contact the researcher, Eoin Campbell (campbeeo@tcd.ie, 086-4029829). If you are happy for your child to participate in this research, please sign the consent form attached and return it to the class teacher at your earliest convenience.

A.2 Student Information Sheet: Learner-Generated Quiz Questions

This information sheet is to be read by the child or to the child by their class teacher. The teacher may choose to paraphrase the text for younger children. (This section will be omitted for the child)

You will be taking part in a series of learning activities in school, using computers to create quiz questions on a subject decided by your teacher. During the activity a researcher from Trinity College, Dublin will be collecting information for a research project. The aim of the research is to find out about how best to use quiz questions in schools with children. If you agree to participate in research about this activity, then the quiz questions you write on the computer will be recorded. You will also complete a questionnaire when the activities are over, to find out about what you thought of it. After the activity, some of you will take part in a short interview in a group with the researcher and your teacher, which will be recorded with a voice recorder.
If you agree to participate, this information will be stored at Trinity College and used in the research, but all names will be removed so no one will know who said what. If the researchers find out about any illicit activities during the activity they will have to tell the authorities (Principal). The results of the project are likely to be written up for MSc. theses, lectures, conference presentations and journal articles, but no one will be able to identify you.
If you don't want to take part in the research project you don't have to. You can still take part in the quiz question activity but none of your information will be recorded and will not be used in the research. There is no problem if you choose to take part now but change your mind later, just tell the researcher or your teacher.

A.3 Parent/Guardian Consent Form

I, _____ (name of parent/guardian), consent to _____ (name of child) taking part in this research project.
I have been provided with an information letter which outlines the activities my child will take part in, how data will be collected and stored and how I can contact the research team. I understand that I may withdraw my child from the project at any time should I wish to do so. I understand that participation is fully anonymous and that no personal details about my child will be recorded. I understand that if I, my child or anyone in my family has a history of epilepsy then I accept the risk of my child proceeding with this study.

Signature of parent/guardian: _____
Date:.....

Researcher: Eoin Campbell, student in MSc. (Technology and Learning), Trinity College, Dublin
TCD Student ID: 08260717
Email: campbeeo@tcd.ie
Phone: (086) 4029829

Signed: _____ Date:.....

A.4 Participant Consent Form

I _____ (name of student) agree to take part in this research project.

I have read, or had read to me, information about the project and know how information will be collected and stored. I understand that I can choose not to take part in the research at any time.
Data Protection: I agree to Trinity College, University of Dublin storing and using my information from this project.

Signature: _____ Date:.....

_____

Researcher:
Eoin Campbell, student in MSc (Technology and Learning), Trinity College, Dublin
TCD Student ID: 08260717
Email: campbeeo@tcd.ie
Phone: (086) 4029829

Signed: _____ Date:.....

A.5 Teacher Consent Form

I, _____ (name of teacher), consent to taking part in this research project.
I have been provided with an information letter which outlines the background to the project, know how information will be collected and stored and how I can contact the research team. I understand that I can choose not to take part in the research at any time. I understand that I may withdraw from the project at any time should I wish to do so. I understand that participation is fully anonymous and that no personal details about me will be recorded. I understand that if I have a history of epilepsy then I accept the risk of proceeding with this study.
Data Protection: I agree to Trinity College, University of Dublin storing and using my information from this project.

Signature of teacher: _____
Date:.....

Researcher: Eoin Campbell, student in MSc. (Technology and Learning), Trinity College, Dublin
TCD Student ID: 08260717
Email: campbeeo@tcd.ie
Phone: (086) 4029829

Signed: _____ Date:.....

Appendix B

Observation protocol form and sample recorded form

B.1 Observation Protocol

Eoin Campbell, campbeeo@tcd.ie, (086) 4029829

This document describes how observation of the activity will be carried out. The purpose of the observation is to record the actions and behaviour of learners in the group, to see if the activity engages all the learners, if they find it moderately challenging, and if they can succeed at the task by working in a collaborative way within the group as a support mechanism. These are characteristic of a well-differentiated activity.

B.2 Observation schedule

Three different groups will be observed for a period of 5 minutes each, at different stages of the activity. The groups will be formed by matching learners of similar ability together. Each group will be chosen in consultation with the teacher, to cover a range of abilities: a low, medium, and higher ability group.

There will be two (preferably) or three (if computer resources are limited) learners in each group. The observation will record the characteristic of the group, rather than the individual learners. [Is this advisable, or should individual learners be observed, perhaps on an alternating basis?]

Observation will be quantitative rather than qualitative. Each group will be observed for an interval of 10 seconds, and the following 10 seconds will be used to record each characteristic, using a combination of simple scales and categorisations. The observation will continue for a period of 3-5 minutes.

The observation will record the following characteristics within each group:

- Level of involvement/engagement with the activity of the group, using a simple scale - low, medium or high

- Level of comfort of the learners, using a scale.
- Level of collaboration between the learners, using a simple scale.
- Activity of the learners: on-task actions, off-task, or other actions.

B.3 Observation checklist

The following table will be filled in for each observation period. A tick will be placed in the appropriate box within each characteristic group

Time Interval	Group ID	Involvement				Comfort				Activity (Task)				Collaboration		
		Lo	Med	Hi		Lo	Med	Hi		On	Off	Oth		Lo	Med	Hi
5)	A															
6)	A															
7)	A															
8)	A															
9)	A															

B.3.1 Involvement

Degree of engagement of the learners with the activity.

- **Low:** not engaged, slow pace of working, looking around, waiting for help, talking off-tasks.
- **Medium:** engaged, talking about questions, good and bad answers, looking up reference materials, slow to medium pace of working.
- **High:** animated and interested, talking about questions, good and bad answers, looking up reference materials, high pace of working.

B.3.2 Comfort

- **Low:** not sure what to do, stressed about how to do it, looking for assistance, afraid to fill in table cells with text in case it is wrong.
- **Medium:** reasonably sure of what to do, but relatively slow pace, carefully considering each step.
- **High:** clear on what the activity is, discussing which question type to use, what constitutes 'good' questions, distractors, feedback.

B.3.3 Activity

In addition to classifying whether learners are engaged in on-task actions associated with the activity, a note of the type of action will also be recorded, using the notation below.

- **On-task actions:**

  T: Typing text into question
  R: Referring to textbook or reference material
  L: Looking at other groups screen
  D: Discussing question within the group
  G: Talking about questions to other groups
  A: Asking teacher for support
  L: Listening to teacher
  W: Waiting for teacher support, or while teacher reviews typed question input

- **Off-task actions:**

  C: Chatting about something other than the activity
  B: Behaviour not related to activity

- **Other:**

  O: Other actions not classified above

B.3.4 Collaboration

- **Low:** little talking on task, creating questions separately, one learner not participating, one learner doing all the work.
- **Medium:** learners talking on task, some discussion of questions, roles (typist, factchecker) remain the same, little knowledge construction.
- **High:** discussing questions, assigning and exchanging roles (typist, factchecker), ideas for questions discussed, ideas coming from all learners, knowledge being constructed.

B.4 Activity and Observation Schedule

Start	End	Task
09:00	09:30	Installation and configuration of software in computer room (Facilitator only)
09:30	09:35	Welcome all learners and get them seated in their groups
09:35	09:40	Introduce activity and demonstrate a quiz question in Moodle, explaining different parts (question stem, right answer, plausible wrong answers), using example created by meta learners if possible
09:40	09:43	Show Word quiz question toolbar and demonstrate how to add a Multi-Choice question, showing different boxes for each component.
09:43	09:45	Explain challenge: create a collection of quiz questions that will be used to test out another class
09:45	10:00	Learners create 1st MC quiz question
09:50	***09:55***	***Observe group A using observation checklist***
10:00	10:05	Pause activity, and demonstrate Matching, Multiple Answer quiz questions, and suggest learners try them
10:05	10:20	Learners resume creating question
10:10	***10:15***	***Observe group B using observation checklist***
10:20	10:40	**Break (20 minutes)**
10:40	10:45	Demonstrate Short Answer and Cloze question, and suggest learners try them
10:45	11:00	Learners resume creating question
10:50	***10:55***	***Observe group C using observation checklist***
11:00	11:10	Stop activity, demonstrate uploading, get groups to upload and convert questions, and test them out online
11:10	11:15	Distribute questionnaire and get learners to fill it in
11:15	11:20	End activity, collect questionnaires, thank learners, and remind them of interviews

B.5 Sample recorded observation protocol form

Time Interval	Group ID	Involvement			Comfort			Activity (Task)			Collaboration		
		Lo	Med	Hi	Lo	Med	Hi	On	Off	Oth	Lo	Med	Hi
1.	13		/			/			C			/	
2.				/				T					/
3.		/				/						/	/
4.		/				/			C			/	
5.			/			/			G		/		
6.			/		/							/	
7.		/				/			C			/	
8.			/			/		T					/
9.			/			/		G				/	
10.				/			/	T					/
11.				/			/						/
12.			/				/	G			/	/	
13.			/				/		C				/
14.													
15.													

Appendix C

Participant post-activity questionnaire

Project: Learner-Generated Quiz Questions
Participant Questionnaire

Note: you do not have to answer all questions. Ignore those questions you prefer not to answer.

1. How easy or difficult it was to create each type of question?

Question Type	*Very Easy*	*Easy*	*Neither easy nor difficult*	*Difficult*	*Very Difficult*	Did not use
Multiple Choice…….	□	□	□	□	□	□
Multiple Answer…….	□	□	□	□	□	□
Matching……	□	□	□	□	□	□
True/False……..	□	□	□	□	□	□
Cloze (Fill-in-the-blanks).	□	□	□	□	□	□
Short Answer…….	□	□	□	□	□	□

2. How easy or difficult it was to create each part of a question?

Question Part	*Very Easy*	*Easy*	*Neither easy nor difficult*	*Difficult*	*Very Difficult*	Did not use
Question text…….	□	□	□	□	□	
Correct answer…….	□	□	□	□	□	
Incorrect answers……..	□	□	□	□	□	□
Correct answer feedback….	□	□	□	□	□	□
Incorrect answer feedback..	□	□	□	□	□	□
General feedback…….	□	□	□	□	□	□

3. How much did creating questions help you to learn?

Didn't help at all…… □
Helped a little…….. □
Helped quite a lot……... □
Helped a lot……. □

4. What did you like best about creating quiz questions?

5. What did you like least about creating quiz questions?

	Yes	No	Don't Know
6. Would you like to create questions again?	□	□	□
7. Would you like to create questions as homework?	□	□	□
8. Would you like to create questions using paper forms instead of using the computer?	□	□	□

8. Do you have any other comments?

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TCD Student ID: 08260717
Email: campbeeo@tcd.ie
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Appendix D

Schedule of Questions for Teacher Interview

These questions will be discussed in an interview after the exercise has been completed.

A. Learning

1. Did the children learn in this exercise?
2. Was the exercise pitched at the right level?
3. In what way did the exercise enable learning?
4. Were all the students actively engaged in the exercise?
5. Did the exercise allow for differentiation between students with different levels of ability?

B. Utility

6. Did the technology help the groups work together?
7. How well did the groups work in the exercise?
8. What was the overall quality of the questions created?
9. Was the explanation of the technical processes adequate?

C. Applicability

10. How could the artefact (Word template) be improved to better support learning?
11. Would the activity be useful as a paper-based in-class exercise?
12. Would the activity be useful as a (paper-based) homework exercise?
13. Would the activity be useful (as is, or adapted) for younger classes?
14. Any other comments?

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Appendix E

CD-ROM Contents and Moodle Details

The following files are included in the CD-ROM contained in the sleeve at the back of this thesis.

- Thesis in Word and PDF format
- MoodleQuiz Word template installation files (Word 2003 and Word 2007)
- MoodleQuiz Moodle LMS plug-in module PHP/XSLT code
- Narrated Flash screencast of MoodleQuiz installation process
- Narrated Flash screencast of MoodleQuiz question creation, preview, and upload process

Moodle LMS

The Moodle LMS used in the intervention is available at either of the following addresses:

- http://www.Moodle2Word.net/
- http://Moodle2Word.xmlw.ie/

The following account details can be used to access the website and the public course called MoodleQuiz.

- Teacher role login/password: mcq / Word2mOdle
- Student role login/password: mcqstudent / mcq

The Moodle site also permits self-registration as a student role using your own name.