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Framework for the analysis and comparison of e-assessment systems

Pedro Isaias
The University of Queensland

Paula Miranda
Escola Superior de Tecnologia de Setúbal, IPS, Portugal

Sara Pífano
Information Society Research Lab, Portugal

The use of technology within the education sector affects many aspects of the learning process, including assessment. Electronic assessment presents many advantages over traditional paper based methods and it is being widely used by teachers and educational institutions. The progressive acceptance and use of e-assessment has resulted in the development of a panoply of e-assessment systems. This paper aims to propose a framework for the analysis and comparison of e-assessment systems, to support the selection of the most suitable assessment instruments. The proposed framework is composed of eight criteria, variety of design options, scalability, security, access and usability, feedback features, personalisation, cost and interoperability, which were overall validated by the viewpoints of educational experts via an online questionnaire.

Introduction

The establishment of good assessment practices is crucial for the success of learning and teaching and the use of technology has been proven to enhance assessment at many levels (JISC, 2007). Generally speaking, e-assessment refers to the use of technology to assist the assessment process.

E-assessment presents a variety of benefits over paper based mechanisms, namely a decrease in cost (James, 2016), marking automation (Ras, Whitelock, & Kalz, 2015), adaptive testing (Fluck, Pullen, & Harper, 2009), increase of assessment frequency (Sclater, 2007) and the ability to assess higher number of learners (Jordan, 2009). As it happens with any technology, its implementation is not free from challenges: incapacity to evaluate high-order thinking competences (Fluck et al., 2009), lack of security in the delivery of e-exams (Miguel, Caballé, Xhafa, & Prieto, 2014) and the inappropriateness of technological infrastructures (James, 2016).

The design, delivery and evaluation of e-assessment activities are supported by a wide range of technologies and tools. Teachers have the possibility of using Web 2.0 platforms such as blogs or wikis, virtual environments like Second Life (Crisp, 2011), e-portfolios, computer based quizzes (Jordan, 2013) and e-assessment systems. The development of e-assessment systems began in the late 1990's to assist the accomplishment of regular assessment for a high number of students. Since then, these systems have become increasingly complex and they are being used not only as assessment instruments, but as tools for the enhancement of learning (Gusev & Armenski, 2014).

This paper begins with the description of the proposed framework for the evaluation of e-assessment systems and the theoretical foundation of each of its elements. It then discusses the methodological aspects of the empirical research and presents the results of the online questionnaires. A brief discussion of the findings and their implications concludes the paper.

Framework for the evaluation of e-assessment systems

The growing interest and investment in e-assessment draws attention to the systems that have been and are being designed to create, deliver and evaluate e-assessment activities. With the existing variety of e-assessment systems it is important to have parameters that can guide their selection. The framework that is proposed in this section aims to provide the criteria to analyse and compare e-assessment systems.

Despite the fact that "an e-assessment system… is only as good as the content on it and the vision and skill of its users." (JISC, 2007, p. 39), there are aspects that pertain to e-assessment systems themselves that are determinant for high quality e-assessment and prevent the detrimental impact of "straight jacket software systems" (Whitelock & Brasher, 2006, p. 500). This framework will be focusing solely on the characteristics that concern the systems

themselves. Hence, it excludes aspects relating to the efficacy of the questions and assessment activities in general, the competences of the teachers and students, the appropriateness of the technological infrastructures of the institutions or any other aspects that are external to the systems.

The framework that this paper proposes derives from a review of existing research within the area of e-assessment and it combines contributions concerning e-assessment systems' characteristics and principles for effective assessment and e-assessment. This framework is composed of eight criteria (Figure 1): variety of design options, scalability, security, access and usability, feedback features, personalisation, cost and interoperability.

Figure 1: Framework for the evaluation of e-assessment systems

Variety of design options

When deciding what e-assessment system to use it is important to examine the type of assessments it supports (Oakleaf, Belanger, & Graham, 2013). Variety is a requirement of good quality assessment. Hence it is an added value to use several assessment instruments (surveys, portfolios, rubrics) (Buzzetto-More & Alade, 2006) and an assortment of techniques, namely self and peer assessment (Gaytan & McEwen, 2007).

It is crucial that they provide an ample selection of question types (Hillier & Fluck, 2013; Mackenzie, 2003), namely to widen the range of skills that can be evaluated (Usener, Majchrzak, & Kuchen, 2011). The possibilities that e-assessment provides in terms of designing assorted and authentic assignments, namely through e-portfolios, games and simulations, allow the evaluation of competences that would be more difficult when using other methods (Jordan, 2013). Furthermore, e-assessment systems should have several features for the edition of questions, namely grammar and spell checkers, offline design of questions and pretesting of the assessment (Singh & De Villiers, 2015).

Scalability

Scalability is one of the challenges commonly associated with e-assessment (Ristov, Gusev, Armenski, Bozinoski, & Velkoski, 2013). It is important that an assessment system has the scalability to support an institution-wide implementation (Leach, 2011). Scalability is also an important feature to account for higher number of students (Hillier & Fluck, 2013) and a mounting number of assessments (Gusev, Ristov, Arminski, Velkoski, & Bozinoski, 2013).

A system's scalability can derive from a certain degree of automation (Daly, Pachler, Mor, & Mellar, 2010). Scalability can also be obtained by resorting to cloud computing solutions for the development of e-assessment systems. The use of cloud computing represents a cost effective alternative to improving the systems' performance and scalability (Gusev et al., 2013).

Security

Security is a major concern in e-assessment (James, 2016). In general, it is necessary to enable the identification of unauthorised behaviour by the students; to ensure that the students can only access the e-test content at the designated time of the assessment; and to provide safe storage for the students' responses and personal information (QCA, 2007). The security of assessment systems can also be assured by restricting the access to grading data to those with authorisation and limiting the access to the test to certain IP addresses (Singh & De Villiers, 2015).

According to Miguel et al. (2014) the security of e-assessment is dependent on a multiplicity of factors, namely the student's integrity when completing the assessment and student identification and authentication. Resorting to question ordering and different versions of the same question (JISC Info Net, 2006) and to restrict or interdict access to the internet or the network (Hillier & Fluck, 2013) are some of the possible approaches for enhancing fairness. Moreover, for high stakes examinations remote monitoring can be used via video and biometrics for authentication, as well as the use of IP restrictions and the assignment of individual credentials (Crisp, 2011).

Access and Usability

The decision of adopting an assessment system is influenced by its ease of use (Oakleaf et al., 2013). The system's interface must be intuitive and offer help options (Singh & De Villiers, 2015). E-assessment systems should include features to promote access and usability, such as font size and colour edition tools, subtitled videos and transcription for audio resources (Hillier & Fluck,

2013). According to Mackenzie (2003) the ideal e-assessment system for e-learning should offer the learner pre-test and pre-question training resources if necessary.

E-assessment systems' software should have the capacity to run in the great majority of the operating systems (Hillier & Fluck, 2013) and devices (James, 2016). It is equally important that the system offers some type of support services. These services can vary from training assistance, to online help manuals, to telephone support (Oakleaf et al., 2013) and should have the ability to support a large number of users concurrently (Singh & De Villiers, 2015).

Feedback features

An assessment system must provide the student with detailed and instructive feedback and it should deliver information about the performance of the learner to the teacher in order to adjust tutorial help (Mackenzie, 2003). E-assessment systems should provide the students with access to the results of previous assessments and offer them the possibility to compare their grades with the average of their peers (Singh & De Villiers, 2015). Many assessment systems provide functionalities to manage assessment data, such as statistical analysis and offer the documentation of the students' assessments (Oakleaf et al., 2013).

The use of automatic grading is essential as it reduces the workload of the teacher (Ras et al., 2015). Certain aspects of marking need to be considered, namely misspelling and case sensitivity and there needs to be some flexibility in terms of the acceptance of answers (Walker, Topping, & Rodrigues, 2008). It is important to clarify this specific aspect of the feedback process, since in certain systems it could lead correct answers to be marked as incorrect based on errors related to misspelling (JISC, 2007).

Personalisation

E-assessment systems need to be adaptable (Armenski & Gusev, 2009). An adaptive e-assessment system uses the information it has about students' cognitive level to suggest their next assessment. Generally, these systems are constituted by an evidential module that works continuously throughout the learning process, processes the data that is collected from the students and decides what is pertinent to add to their profiles; and an adaptive module that adapts the assessment to the student and is solely employed at the time of the assessment tasks' creation (Baneres, Baró, Guerrero-Roldán, & Rodriguez, 2016). The capacity to deliver adaptive assessment activities is a central part of the system's capacity to offer personalisation features that the teacher can use to make the assessment more suitable to each individual student. Adaptive testing allows students to be presented with questions that are consonant with their knowledge level (Gusev & Armenski, 2014). Also, assessment systems should allow personalised configurations, so that the institutions can adapt the system to meet their needs (Hillier & Fluck, 2013).

Cost

E-assessment systems are required to be financially effective. When selecting which system to use for e-assessment one of the core concerns is the cost (Oakleaf et al., 2013). One of the aspects to consider when comparing systems is their availability as open source (Amelung, Krieger, & Rösner, 2011). When deciding what systems to use, institutions have to opt between a commercial solution, a system that they will develop themselves or a combination of both. Entities with more financial resources can recruit programmers and other personnel to design their own system, while entities with less financial resources often decide to use a commercial alternative (Sivakumaran, Holland, Wishart, Heynig, & Flowers-Gibson, 2010). From a financial perspective the provision of systems for e-assessment constitutes a substantial burden. Although some institutions have considerably invested in Virtual Learning Environments (VLE) and they do offer assessment functionalities, these are usually simple and insufficient to attain the institutions' assessment goals (Whitelock & Brasher, 2006). Similarly, many Learning Management Systems (LMS) do not offer a complete range of e-assessment features (Gusev & Armenski, 2014).

Interoperability

Accounting for interoperability adds credibility to the development of assessment tools (Sclater, 2007). Thus, the progress of e-assessment would benefit from the achievement of system interoperability (JISC, 2007; Whitelock & Brasher, 2006). One strategy for promoting it among systems is to develop common standards (JISC, 2007). The development of interoperability standards has the potential to foment the interinstitutional exchange of data (JISC, 2010). Moreover, e-assessment systems should have the capacity to use and share material and components with other similar systems and they should be effortlessly integrated into other educational applications (Armenski & Gusev, 2009). It is important not only that a system can be integrated with other institutional systems, but also that it has the capacity of assimilating active sources of data (Oakleaf et al., 2013). An important aspect of assessment systems is their capacity of integration with other systems (Amelung et al., 2011).

Methodology

This study is based on a quantitative descriptive research design that explores the viewpoints of educational experts about the fundamental characteristics of e-assessment systems. The sample was selected via a method of convenience and was composed of both higher education teachers and researchers working in education

technology and e-assessment. Their opinions were collected via an online questionnaire, which as a data collection instrument has the advantage of reaching participants that are geographically scattered and allowing a swifter collection of data (Wright, 2005). The questionnaire was composed of two parts: the first intended to collect demographic data and determine the respondents' familiarity with e-assessment systems; and the second section aimed to identify the participants' opinions about the proposed framework for the analysis and comparison of e-assessment systems, using an adapted Likert scale ranging from totally disagree to totally agree (1-5).

Presentation and discussion of the findings

The online questionnaire received a total of 342 responses, from which 231 were deemed complete and valid. The male participants correspond to 55% of the sample, while the female respondents correspond to 45%. Their ages ranged from under 30 years old (3%) to over 70 (3%), being that the majority of the participants (63%) are between 41 and 60 years old. The questionnaire received responses from 37 countries, namely Australia, Brazil, Canada, Colombia, France, Germany, Japan, Mexico, Russia, Spain, Switzerland, UK and USA.

In terms of their current positions, over 74% of the respondents hold a teaching position, 14% are engaged in research and 11% have other academic positions. Before presenting the respondents with the several items concerning the framework, it was important to assess their level of familiarity with e-assessment systems. For the purpose of this questionnaire only people who had at least read about this type of systems were considered. This basic knowledge of the systems was reported by 24% of the participants who claimed to have read about them and 21% stated they have conducted research about them. In terms of the participants who currently use the system or have used them in the past they correspond to 28% and 22% respectively. The majority of those who currently use them have been doing so for over 5 years (69%). A smaller percentage has been using them from 2 to 5 years (26%) and only 3% for 1 year and 2% for 1 semester. The majority the participants who have used them in the past did so from 2 to 5 years (61%) and a more reduced percentage used them for over 5 years (24%), 1 year (4%) and 1 semester (10%). In brief, the sample can be characterised as being experienced with e-assessment systems, which can positively impact on their evaluation of the framework and validates their suitability to answer the questionnaire.

The eight criteria that constitute the framework were all validated by the respondents, but with varying levels of agreement and disagreement. To establish a comparison between the different criteria, the average of the ratings for each of their items was calculated. The agree and totally agree ratings were grouped to determine total agreement and the disagree and totally disagree ratings were joined to calculate total disagreement (Figure 2).

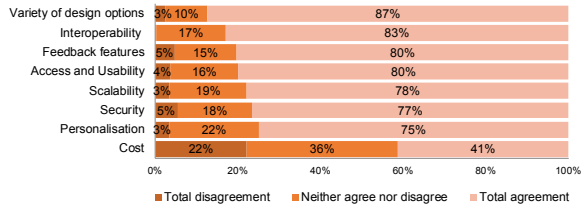

Figure 2: Levels of total agreement and disagreement for all the criteria

According to the participants, and in order of importance, e-assessment systems should have a variety of design options, interoperability, feedback features and they should account for access and usability, scalability, security, personalisation and cost. The criteria that gathered more agreement were a variety of design options (87%) and interoperability (83%). The remaining items also had high ratings of 75% or above, with the exception of cost that only 41% of the participants agreed with. In order to have a deeper understanding of the results, each of the criteria were individually analysed.

Diversity in design

The first element of the framework to be presented to the respondents was the variety of design options, with 5 essential items (Figure 3).

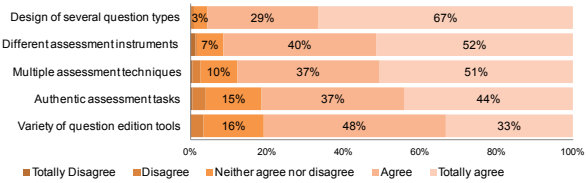

Figure 3: Agreement and disagreement levels for the variety of design options criterion

Overall the respondents reiterated the importance of all the items of this criterion. In particular the participants were in consonance with the literature (Buzzetto-More & Alade, 2006; Gaytan & McEwen, 2007; Hillier & Fluck, 2013; Mackenzie, 2003; Usener et al., 2011) and highlighted the importance of allowing the design of several question types (66.7 totally agreed and 29% agreed), different assessment instruments (51.5% totally agreed and 39.8% agreed) and multiple assessment techniques (50.6% totally agreed and 37.2% agreed). Despite a general acceptance there was a higher percentage of participants that were neutral to the inclusion of question edition tools (15.6%) and the incorporation of authentic assessment tasks (14.7%), when comparing with the other items. These aspects also had a small percentage (3.5 and 7.5 respectively) of

respondents who disagreed or totally disagreed with their importance.

Interoperability for e-assessment

Interoperability was the element of the framework whose items scored the lowest disagreement levels among the participants (Figure 4).

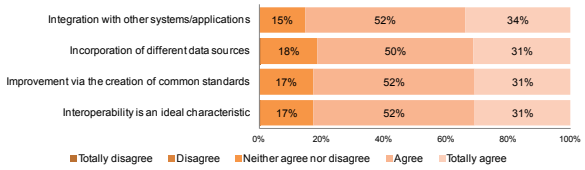

Figure 4: Interoperability's agreement and disagreement ratings

The percentage of viewpoints that disagreed or totally disagreed with the entirety of the items ranged from 0 to 0.4. The highest score for neutral opinions was 18.2 for the item related to the incorporation of different data sources, which also had the lowest score of responses stating they agreed and totally agreed (81.4%). These results corroborate the importance of interoperability to e-assessment systems as was concluded by previous research (JISC, 2007; Sclater, 2007; Whitelock & Brasher, 2006).

Provision of feedback

All the items related to feedback features proposed in the framework were validated by the respondents. The items concerning the delivery of feedback information to both students and teachers (59.7% totally agreed; 35.9% agreed) and the inclusion of options for the management of assessment data (57.1% totally agreed; 35.1% agreed) were selected by the respondents as the main feedback features that an e-assessment system should have and were also defended by previous studies (Mackenzie, 2003; Oakleaf et al., 2013). Despite Singh and De Villiers (2015) argument and the fact that a shy majority of the participants (58.4%) agreed or totally agreed that students should be provided with an overall depiction of their peers' results, 30% of the respondents were neutral to this item and 10.8% disagreed with it.

Accessible and usable systems

With regards to access and usability, most of the participants were in agreement with its importance for e-assessment systems (Figure 5).

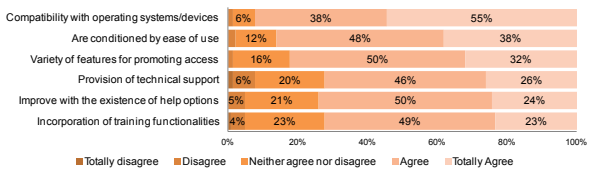

Figure 5: Agreement and disagreement levels for the access and usability criterion

The compatibility with most operating systems and devices, argued by previous studies (Fluck, 2013; Hillier & Fluck, 2013; James, 2016) was the item that gathered more consensus, with 92.2% of the participants stating that they agree or totally agree. Its score was even superior to the score received by the ease of use (86.1%), which has a solid support of existing literature (Oakleaf et al., 2013; Singh & De Villiers, 2015). On the other hand, the provision of technical support, the existence of help options and the incorporation of training functionalities had significant scores in terms of neutral viewpoints (19.9%, 21.2% and 22.9% respectively).

Scalable assessment

In terms of scalability the majority of the respondents agreed or totally agreed with the totality of the items (Figure 6).

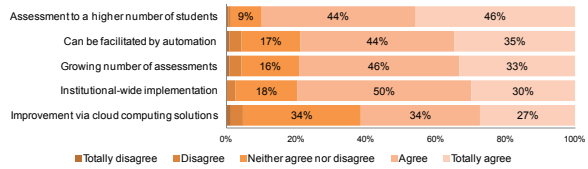

Figure 6: Scalability's levels of agreement and disagreement

The highest score was achieved by the capacity to deliver assessment to a higher number of students (45.9% totally agreed and 44.2% agreed), reiterating previous research (Hillier & Fluck, 2013). The contribution of scalability to a higher number of assessments and an institutional-wide implementation was still largely supported by the participants, but it was deemed only slightly less relevant than a higher number. The fact that a system's scalability can be improved by cloud computing solutions as argued by Gusev et al. (2013) was the item that generated more neutral responses 33.8%, which demands further scrutiny in the future research, to assess if the neutral responses can be explained by a lack of knowledge about this technology and its value for e-assessment.

Security options

The security criterion was also validated by the participants, but its items had differing levels of acceptance as is illustrated in Figure 7.

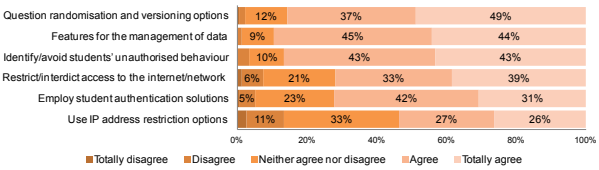

Figure 7: Levels of agreement and disagreement for the security criterion

A solid majority of the participants (86% and over of agreement) clearly believed that having features for

question randomisation and versioning, the existence of features for data management and having options to identify and avoid students' unauthorised behaviour increase the security of e-assessment systems, which is in line with previous research (JISC Info Net, 2006; QCA, 2007). Although restricting/interdicting access to the internet/network during assessment activities, using student authentication solutions and IP address restriction options were also deemed as solutions for increasing security, by the majority of the participants and the literature (Crisp, 2011; Hillier & Fluck, 2013; Miguel et al., 2014; Singh & De Villiers, 2015), these items had a considerable number of neutral responses with 20.8%, 22.5% and 32.9% respectively. Also, 13.4% of the participants disagreed or totally disagreed with the restriction of IP addresses.

Personalised assessment

Personalisation was composed of 4 items, which were supported by the viewpoints of the participants. In accordance to the literature (Armenski & Gusev, 2009; Baneres et al., 2016; Gusev & Armenski, 2014), the majority of the participants (84.8%) agreed or totally agreed with the fact an e-assessment systems' capacity for personalisation can assist teachers to develop more suitable assessment activities via the incorporation of adaptive testing, making this the item with the highest score in the personalisation criterion. These systems' capacity for personalisation was deemed a fundamental requirement by 67.1% of the participants, but had 28.6% neutral responses.

Cost effectiveness

The financial cost of e-assessment systems was the element of the framework that created more disagreement among the participants as can be seen in Figure 8.

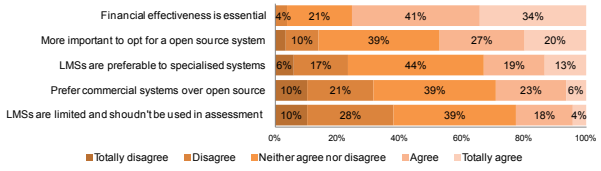

Figure 8: Agreement and disagreement ratings for cost

The only item that the majority of the participants (75.3%) agreed or totally agreed with referred to the fact that it is essential that e-assessment systems are financially effective, which is in line with previous research (Amelung et al., 2011; Oakleaf et al., 2013). The two items that referred to the use of LMSs for assessment generated high percentages of neutral opinions (39% and 44%), but in both items the respondents stated that LMS should be used for e-assessment (38%) and that LMSs rather than specialised e-assessment systems should be used for assessment (33%), even though the literature states that they have limited assessment functionalities (Gusev & Armenski, 2014).The biggest issue with this criterion of the framework concerns its items' high levels of neutral responses, ranging from 39% to 44%, which hinder their interpretation.

Conclusion

The growing importance of technology in the development of effective assessment activities has emphasised the importance of using high quality e-assessment systems. These systems assist teachers in the creation, delivery and evaluation of assessment tasks and can be determinant for the quality of assessment.

There are numerous factors involved in the successful implementation of e-assessment systems, namely human, technical and institutional, but the characteristics of the systems themselves are vital for their adoption. With a growing offer of systems in the market it is progressively more difficult to select a system that suits particular assessment needs. This paper proposed a framework of criteria to guide the selection of e-assessment systems and tested it via an online questionnaire with educational experts.

The sample of participants that completed the questionnaire reiterated the eight criteria that composed the framework that was proposed: variety of design options, scalability, security, access and usability, feedback features, personalisation, cost and interoperability. The criterion with the highest levels of agreement was variety of design features and the one with the highest levels of disagreement was cost. The five items with the highest scores in terms of agreement belong, in this order, to the criteria of variety of design features (enable different assessment instruments; several question types); feedback features (include options for the management of assessment data; deliver feedback information to both students and teachers); and interoperability (compatibility with most operating systems and devices). On the opposite side of the spectrum, the five items with the lowest scores in terms of agreement belong, in this order, to the criteria of cost (LMSs should not be used for e-assessment activities because the features they offer are limited; a commercial system is preferable to an open source alternative, if the assessment design options are more advanced; it is better to resort to LMSs for e-assessment than to use specialised e-assessment systems; it is more important to select a system that is open source) and security (use IP address restriction options).

Future research should further examine the aspects that caused a great percentage of neutral opinions and disagreement to identify the reasons behind the participants' responses. Also, it is important to include the

other stakeholders in this discussion, namely the students and the educational institutions.

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Contact author: Pedro Isaias, pedro.isaias@uq.edu.au.
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