A Framework for Assessing the Quality of Mobile Learning

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Abstract

Quality in a mobile learning system can be assessed both in terms of product quality and in terms of the quality of the learning experience. Though these do overlap in some respects, it is also the case that current quality metrics such as ISO/IEC 9126 do not address what might be regarded as the 'softer' aspects of quality. Research indicates that the quality of a learning experience is not solely based on the quality of the software but also on the conceptual basis upon which the learning experience is constructed. In this paper we explore the quality related aspects of a conceptual framework for mobile learning and propose some metrics that might be adopted to assess the quality of a mobile learning application.

1 Introduction

Mobile learning (M-learning) is an approach to electronic learning (E-learning) that utilises mobile devices. Although in some cases M-learning is seen as simply an extension of E-learning, just another channel for delivering the same content, in fact quality M-learning can only be delivered with an awareness of the special limitations and benefits of mobile devices. This is not to say that awareness of known quality issues in E-learning is not relevant to the mobile context. Rather, it is important to consider features unique to M-learning when considering how to deliver a quality education experience.

Unlike desktop E-learning, M-learning has the benefits of mobility and its supporting platform, which can be summarised as being ubiquity, convenience, localisation and personalisation [1]. Ubiquity means that the learning content can be accessed anywhere, regardless of location. With ever increasing coverage by mobile network providers, M-learning services can have an increasingly ubiquitous presence. Availability via mobile devices at any time provides for convenience. The facility for wireless connectivity is integrated into the mobile device, whereas alternative ways of connecting to the Internet while travelling, such as accessing wireless or fixed networks, or using publicly available computers, can be difficult and /or expensive to access in many locations. Localisation is a specific strength of mobile devices, since they can use location awareness to provide services that are targeted to the user's current locality. Location awareness can be supported by a number of technologies, including triangulation from a mobile phone network or the global positioning system (GPS). Finally, personalisation is a key component of M-learning for two reasons. First, the difficulty of navigation and small screen size of mobile devices means that it is important to target learning material as much as possible. Second, such targeting is easier for enrolment based services like education, where the provider is likely to be able to gather considerable information about learners and construct accurate profiles

of their activities and requirements.

Most of the above-stated benefits of mobility can be regarded as being based on technical quality, either of hardware, software or the carrier network. However, perceptions of quality go beyond the merely technical to encompass the learner's own interactions with an M-learning system. These perceptions will of course vary between different types of user, but there are certain emerging patterns and requirements that can be applied as generic best practice. Traditional assumptions about learning quality being determined by the reputation of the provider institution and the status of the qualification are being replaced by demands for relevance, flexibility and richness of experience, and learners will only embrace M-Learning if it meets their requirements. Wilson et al, building on the work of Rogers, list seven features of technology that help determine its acceptance, which can usefully be interpreted as quality measures. [2]. These features are; simplicity, trialability, observability, relative advantage, compatibility and support. In contrast, Latham (1988) lists a number of features common to failed innovation, which we might regard as indicators of poor quality. These features are; disenchantment of practitioners due to unforeseen difficulties, loss of supporters, lack of training or funding, lack of management support, lack of accountability and a "take-it-or-leave-it" attitude on behalf of program promoters. Few of these factors, either positive or negative, can be addressed by purely technical or product quality measures. For example, the ISO/IEC 9126 Technical Reports [3] provide sets of metrics for measuring software product quality but these are primarily technical. Although there is some coverage of usability metrics, related to understandability, learnability, operability, attractiveness and usability compliance, but these do not extend to cover the 'softer' aspects of user experience in a mobile learning context.

In this paper we begin by acknowledging the importance of technical quality issues by detailing some of their key features. We then move on to consider research that indicates the importance of quality factors that go beyond the technical to evaluate the learner's experience. With these 'softer' quality issues in mind, we explore a conceptual framework for M-learning design that bridges the boundary between product quality metrics and softer quality issues. With the framework as a guide we propose three quality metrics that might be considered as important additions to a quality assessment based on the ISO/IEC 9162 metrics. We conclude with some discussion on further work required to validate these metrics.

2 Technical Quality Aspects

There are a number of aspects of M-learning quality that can be assessed from a technical perspective. For example, a significant aspect of mobility is quality of service in terms of the reliability and speed of wireless connections. Although some learning content can be downloaded to a mobile device and used locally, the limitations on storage mean that network connectivity is an essential component of most mobile learning environments. The reliability and speed of such connections can influence which media types can be used in an M-learning system, for example video streaming is only feasible over a high speed connection. Another technical aspect of M-learning quality is the limitation of screen size and resolution on many mobile devices, with certain mobile device operating systems and software platforms supporting different types of display. The system software also dictates what media types can be managed, for example not all devices are able to download mobile Java applications (MIDlets) and even those that can will vary in their capabilities in terms of which version of the Java 2 Micro Edition (J2ME) platform they will support. Similarly Microsoft Windows based devices have access to services that are not available on other operating systems.

Despite the difficulties of providing software that will work across a range of mobile platforms, this capability is an essential component of a successful M-learning system. A 2002 survey found that the most important aspect of quality in E-learning was that it should be free of technical problems across all users [4]. This is even more of an issue in M-learning because mobile devices are more varied in performance and capability than machines on the desktop. The Extensible Markup Language (XML) can assist in providing the same content across different platforms by encapsulating generic content that can be dynamically transformed for different client devices [5]. A further role of XML is to support the development of standard tools and metadata, to manage and describe content. This encourages reusability and integration of learning content from multiple sources. There are a number of approaches to quality through standardisation, one of the most ambitious being the Quality Initiative E-Learning in Germany (Q.E.D.) [6] The goal of this organisation is the promotion of internationally recognised, open quality standards for E-learning aided further education, aiming to provide a harmonised quality model and tools for practical deployment. Other efforts toward standardisation include the Shareable Content Object Reference Model (SCORM) [7] and the IEEE Learning Object Metadata (LOM) [8], which underlies much of SCORM. These standards are based on the use of XML as an interoperability format.

3 Beyond Technical Quality

The purely technical aspects of quality in M-learning are important, but are coupled with equally important aspects of quality that are content related. M-learning technologies that are easily customisable, technically flexible and contain relevant content are those that are most likely to be successful . Thus we see that a quality assessment for M-learning must encompass both technical and non technical aspects.

There are some positive indications that M-learning is able to deliver quality even in limited technical environments. A study by Ericsson in 2002 showed that even with a simple Wireless Access Protocol (WAP) browser interface, users felt that M-learning could be a quality experience [9]. In the study, 77% of participants felt that M-learning actually increased the quality of E-learning, and all felt that one of its key qualities was its ability to increase access to education and training. Although a majority felt that the learning experience would be improved by the use of graphics and illustrations, 33% of participants did not feel that this was of paramount importance. Another study using SMS as an interactivity mechanism also suggested that the lack of sophistication of the platform need not be a major stumbling block to the quality of the learning experience. This study indicated that M-learning applications can have depth and complexity, and encourage wider scale participation, even where it might be expected that technical limitations would discourage the learner [10]. It seems therefore that technological sophistication is not necessarily a measure of usefulness, since even simple technologies like classroom response systems have proved effective, engendering rich social practice around basic systems [11].

4 The Mobile Learning Context

The mobile learning context is not the same as that of more traditional E-learning. M-learning is often highly dynamic, targeted to the user's current context and learning needs. The terms *just in time learning* or *fast learning* have been used to refer to content provided for the user’s current context [12], [13]. Alternatively, M-learning can be regarded as a ‘down time’ activity. In either case one of the commonly stated characteristics of M-learning content is that it should be delivered in short ‘nuggets’ rather than large units of information. Successful mobile applications are goal directed, and are not effective if they expect too much reading from a small screen or

distract with unnecessarily rich media objects [14]. Therefore content format has to be chosen with care, from options including audio transmission [15], freestyle drawing tools [16], video streaming, simulation tools [17] and interactive scenarios [18], [19], among others,

A number of studies have identified requirements for quality M-learning. It should have clearly explicit pedagogical design principles appropriate to learner type, needs and context, to be up to date in terms of content and be highly interactive, enabling mutual feedback between education providers and learners and assisting in the identification of knowledge gaps [4], [20]. It should also enable the learner to construct and explore knowledge, converse and collaborate with peers, and control their own learning [21]. Collaboration and interaction can take many forms. It may in fact take place in a classroom, with the mobile device used as a classroom tool [11] or be a remote connection to 'live' tutor [16]. Participatory simulations can assist the understanding of emergent behaviour, and collaborative data gathering with mobile devices can encourage more cooperative work. Both of these are highly social activities. Interaction can be instigated by the M-learning system itself [12] or by learning peers or a facilitator [22]. Central repositories of shared content are also an important collaboration mechanism [23], [24], while the ability to share problems enables learners to compare their solutions with others [25].

5 Quality in a Conceptual M-learning Design Framework

Based on the quality themes of M-learning research outlined in the previous section, we have developed a conceptual design framework for M-learning based on a combination of design issues, dimensions of learning context, structural factors and their instantiation, and objectives (Figure 1). This framework has been described elsewhere [26] but in this context it is used to analyse quality aspects that go beyond the technical. A key aspect of the framework is the game metaphor, and this is based on previous work by Schwabe and Göth [27], using Prensky's [28] six structural elements of games, which we might briefly summarise as; rules, goals, outcome, competition, interaction and representation. Our framework also integrates Wang's [29] six dimensions of learning context: identity, spatio-temporal, facility (device, including adaptivity), activity, learner and community. We identify five design issues that are critical in M-learning; user roles and profiles, learning on the move, different media types, interface design and collaboration support. We map these to Wang's six contexts and then to Prensky's structural elements. From these we address the learning objectives of the system: improved skills, new knowledge, social skills and team building. The framework is shown in Figure 1. The links that are identified are those that we see as most important, though most of the components will relate in some way or other. Key features of the framework are that it identifies the importance of the user's roles and the learning community in meeting learning objectives. We also identify those issues, dimensions and factors that have a user focus, contrasted with those that have a platform focus.

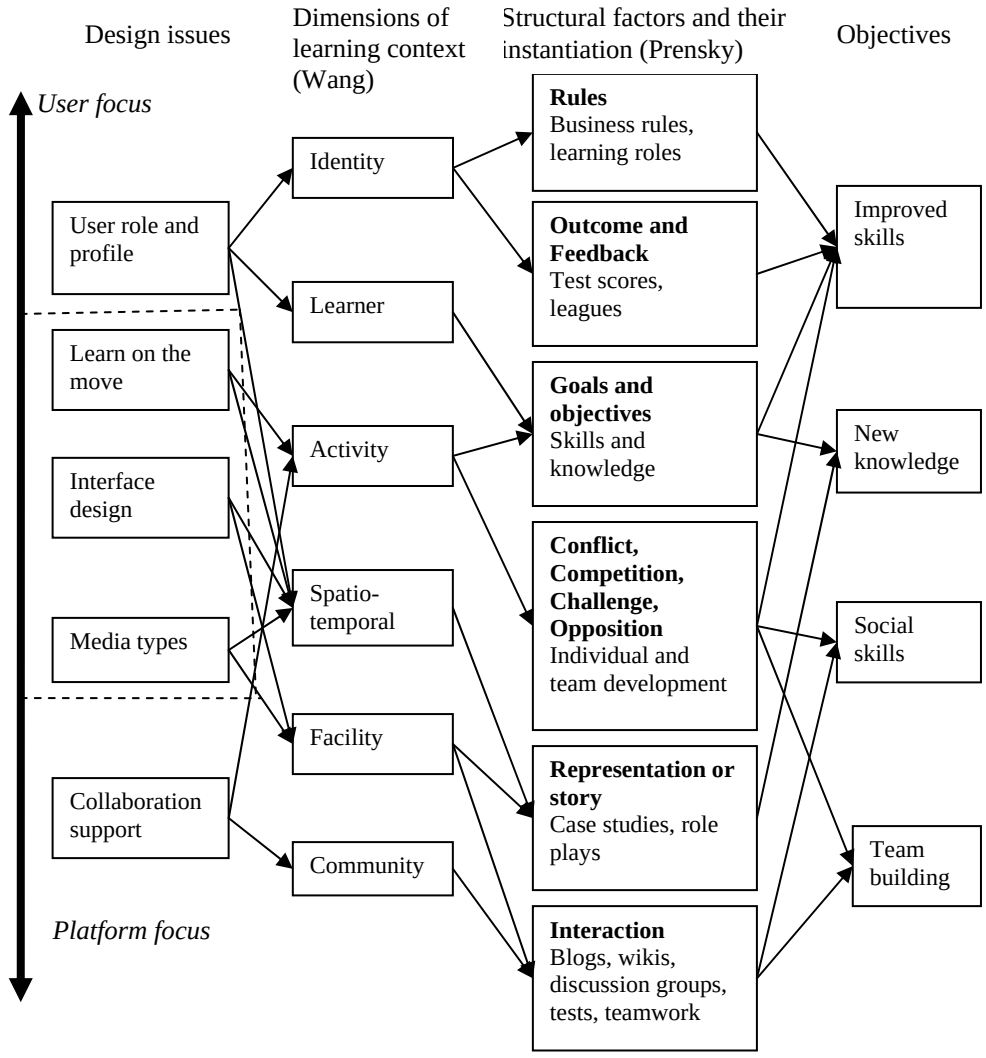

Figure 1: A conceptual design framework for M-learning

6 Current Work: Extending ISO/IEC 9162

The International Standards Organisation/International Electrotechnical Commission (ISO/IEC) Technical Report 9162 [3] provides a set of metrics for measuring software quality in process, product and use. Analysis of our framework from a quality perspective led us to consider the boundary between quality metrics that are product related, from the ISO/IEC 9162, and those that are quality in use focused. Figure 2 shows the relationships between internal quality, external quality and quality in use metrics as defined by the ISO/IEC. Our analysis suggested that it would be helpful to provide some extensions to ISO/IEC 9162 that would complement the 'contexts of use' dimensions of the 'quality in use' metrics, effectively extending the reach of these metrics. We have mapped these metrics onto our framework (as indicated by the dotted line in figure 1) and suggest that the design issues of *learn on the move*, *interface design* and *media types* can be assessed using existing metrics. However we also suggest that further metrics are required in order to assess all the areas of the framework. In this section, we use some case study data to illustrate this analysis

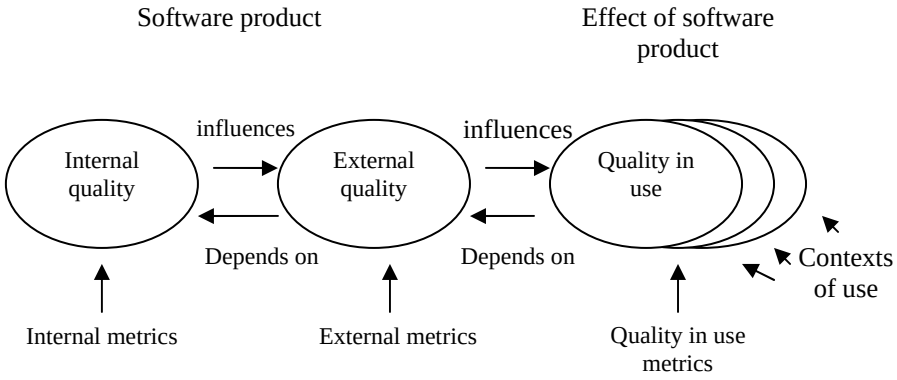

Figure 2: The relationship between types of metrics (from ISO 9162-2)

Extending the current metrics beyond the existing quality is use metrics is important because mobile learning contexts are normally grounded in learning experiences taking place in the contexts of use [30], [31]. By considering a case study we can identify both where current metrics can be applied and where additional metrics can be of benefit. A suitable example for this analysis is the Ambient Wood Project [32], [31]. This was designed to enable mobile learners to link their learning experiences on a field trip with the classroom context, with the support of mobile devices and visualisation tools. In this project, information from the field trip could be displayed on learners' PDAs or presented via loudspeakers in a field (re. the existing quality metrics of *media types*). Information could also be requested or obtained when a mobile learner was detected in a particular vicinity (re. the quality metrics of *learn on the move*). This project was also careful to avoid overloading the participants with digital information that might distract from their interactions and explorations of the physical world (re. the quality metrics of *interface design*). Using these examples, we can therefore directly employ some relevant ISO/IEC metrics (e.g., quality of reception, integration of input/output devices, functionality, service quality, reliability, scalability and so on) for measuring the quality of the mobile learning system. However, the Ambient Wood project also showed that mobile learning enabled novel forms of collaborative problem solving to occur in real time over distance, passing relevant information between the students in terms of their role in the group activity [31]. This means that two additional design issues, i.e., *user role* and *collaboration support*, are also central to the quality of the mobile learning environment, issues that have little or no coverage in the standard metrics. Of course, these additional two concerns have effects on the subsequent learning context and learning objectives in our framework, through the dependencies indicated by the arrows in Figure 1. We propose to adopt these five design issues, alongside the current standard metrics of software quality, in order to reappraise each of them for the mobile learning environment.

6.1 Three Additional Metrics

Given that current metrics do not cover all five of our design issues for mobile learning, we propose some additional metrics to those described in ISO/IEC 9162 that acknowledge further quality aspects of the learning experience, based on our framework. The three additional metrics are *metaphor*, *interactivity* and *learning content*. While these metrics are partially included in ISO/IEC 9162, it is worthwhile to re-emphasise them for the M-learning environment. The concept of metaphor is probably the most important part of the design process in the specification of M-learning systems. It has the function of bridging from an abstract and elusive vision to a concrete and complex situation. A defining quality of the metaphor is that it is

operational. This means it will have an explicit form that enables manipulation, simulation, and visualisation. Further, most importantly, a metaphor enables communication, so it may be measured. Table 1 (in the Appendix) suggests an approach to the measurement of metaphor, along with the other two metrics described in this section. We adopt a similar format for presenting these metrics to the ISO/IEC 9126 technical report. The metaphor metric highlights whether an M-learning system can provide an overall vision of the proposed learning processes.

Once an adequate metaphor has been established, a further quality metric relates to functions that support interactivity. One of the important features of mobile learning is its novel interactivity, that learners are able to interact with other learners and tutors across physical distance, regardless of location, making a collaborative learning experience. As demonstrated by the Ambient Wood Project, a mobile learner was able to integrate information obtained from the mobile device with their own observations of the physical environment and communicate with other mobile learners. It illustrated how mobile learners could use different devices and new types of interactive mechanism to further their exploration of the course objectives, which are the ultimate goals of an M-learning environment. The interactivity metric highlights whether an M-learning system can provide an adequate level of interactivity between the learner and the M-learning system.

Finally, we suggest that learning content, which has not been considered by traditional software quality measures, should be assessed from a quality perspective. This metric assesses what content could be effectively delivered by M-learning environments, and why it should be delivered in this context. For instance, participatory simulations e.g. [33], which encourage learner engagement in a playful social space, use a mobile device for each student to support simple data exchanges. These combinations of mobile and classroom learning enable students to act as agents in simulations. This can help them learn, for example, about scientific phenomena relevant to the learning context, and build up collaborative understanding of subjects such as the way that diseases spread. The appropriateness of the learning content for M-Learning should be rigorously analysed to ensure the learners feel that the learning components are of high quality within the M-learning context. The learning content metric highlights whether an M-learning system can provide content that is both optimised for mobile delivery and justifies delivery through the mobile channel.

7 Conclusions and Further Work

This paper aimed to consider how quality could be assessed in the context of a conceptual framework for mobile learning design. We considered which areas of our framework could be assessed using established quality metrics. Subsequently, we discussed what additional design issues should be considered in the M-learning system development process, i.e., user role and collaborative support, which have previously been less extensively covered than the technological aspects of the M-learning context. In addition, we proposed three metrics for assessing M-learning environments that could supplement the current ISO/IEC 9162 metrics, namely metaphor, interactivity, and learning content. Although this is not the final result of our research, our aim here is to foster further discussions about quality assessment for M-learning. Currently, we are investigating this approach to the evaluation of M-learning systems as part of the development of a prototype M-learning system.

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Appendix

Metric name	Purpose of the metric	Method of application	Measurement, formal and data element computations	Interpretation of measured value	Metric scale type	Measure type	Input to measurement	Target audience
Metaphor	Does the learner have an overall vision of the learning process?	Conduct user test and interview user with questionnaires Count the number of metaphorical components identified by the user	X = A / B A = Number of metaphorical components identified by the user B= total number of metaphorical components intended by the designer	0 < X < 1 The closer to 1.0 is the better	Absolute	A=Count B=Count X=Count/Count	User manual operation (test) report	User Maintainer
Interactivity	Is the learner able to interact with other users and/or tutors?	Conduct user test and observe user behaviour Count the number of interaction opportunities identified and used by the learner	X = A / B A = Number of interaction opportunities identified and used by the learner B = total number of interaction opportunities available	0 < X < 1 The closer to 1.0 is the better	Absolute	A=Count B=Count X=Count/Count	User manual operation (test) report	User Maintainer
Learning content	Does the learner feel that the learning component is of high quality	Conduct user test and get users to fill in a scaled evaluation form Measure the responses of the user to their learning experience	X = A - B A = Maximum score possible on evaluation B= Actual score	0 < X <=MAX The closer to MAX is the better	Absolute	A=Count B=Count X=Count-Count	User manual operation (test) report	User Maintainer

Table 1: Mobile learning quality metrics