Developing an Epistemic Game: A preliminary Examination of the Muscle Mania© Mobile Game.

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Developing an Epistemic Game: A Preliminary Examination of the Muscle Mania© Mobile Game

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Abstract: Several game scholars contend that the traditional understanding of vocational education in terms of curriculum content only is insufficient. Instead, they propose that lecturers need to develop a system in which students learn to think and work as reflective practitioners through an epistemic frame that mimics the real-world to allow students to have rich experiences of their domain-specific subjects. The Framework for the Rational Analysis of Mobile Education (FRAME) model offers some insight into the development of an epistemic frame within a mobile device. In particular, it extensively links the hardware, software and connectivity options to meets with learner's cognitive, physical and psychological needs in the context of their learning environment. In this model, the mobile device is an active component and the mobile learning experiences are viewed as existing within the context of information that is mediated through technology. The aim of this paper is to explore the efficacy of using Muscle Mania© as a mobile platform.

Arguments for implementing mobile-learning within higher education have generated an increasing volume of research. The general focus of these studies, however, is based largely on empirically documented work with little theorisation on the design of mobile games. In the pursuit of using mobile technology to develop an epistemic or discipline-specific game that will facilitate the teaching and learning of the muscles of mastication and facial expression, this paper explores the FRAME model and how it can be used as a substantive theory for mobile-learning. A qualitative research design and a case study strategy were adopted. Data was collected by means of reflective reports on the mobile game prototype from the technical designer, lecturers and students. With its strong emphasis on educational software design, the Device Usability Aspect of the FRAME model guided the internal architecture needed to design the epistemic frame of a mobile game. Equally significant, the FRAME model foregrounds the concept of technoentrepreneurship as it demonstrates how lecturers use technology to move from delivery and supervision to the production of knowledge.

Keywords: Android SDK; Muscles; Epistemology; Debriefing; FRAME model

1. Introduction

The evolution of wireless technologies and game applications on mobile devices has facilitated mobile learning. Subsequently, this is diversifying the higher education teaching and learning milieu. In particular, and as Traxler (2009) asserts, mobile devices are "changing the nature of knowledge and discourse…whilst being themselves the products of various social and economic factors". He, along with several other game scholars (Ally, 2009, Rupp *et al.*, 2010, Caperton, 2010, Ferran-Ferrar *et al.*, 2014), posit that mobile learning supports authentic and context-specific learning that involves real-world problems by situating and connecting learners, particularly in distant learning programmes.

Shaffer (2005) also argued that lecturers need to develop a system in which students learn to think and work as reflective practitioners through an epistemic frame. According to Shaffer and Gee (2005) an epistemic frame is a mechanism that mimics the real-world in order to allow students to have rich experiences of their domain-specific subjects. A corollary to this is an epistemic game, which provides students access to a particular form of thinking by enabling them to connect knowledge-in-context to knowledge-in-action. Shaffer and Gee (2005) elaborate that epistemic games facilitate the emergence of disciplinary thinking and acting which can also be transferred to other contexts. Consequently, it can be inferred that students are more likely to develop domain-specific expertise under realistic conditions.

Equally important, and as Shaffer (2005) maintains, games "make it possible for students to learn through participation in authentic recreations of valued reflective practices – a new model of learning for an era of dramatic social and economic transformation brought about by new technology". While there are arguments to implement mobile games within higher education (Ally and Tsinakos, 2014, Gupta and Koo, 2010), there is limited research work on a structured and comprehensive approach used to develop mobile games aimed at enabling students' access to, and acquisition of, discipline-specific knowledge. This paper reports on the software architecture and the technical aspects of the Muscle Mania© mobile game, which builds on the previous version of the digital game. In particular, and for 95 students who played the digital game over a three-year period, statistical analyses showed that their performance in tests improved (Vahed, 2014). The most noteworthy feature in Table 1 is the direction of the differences in student performances, particularly the mean values of the pre- and post-test results. The 2-tailed t-tests revealed that students' performance improved significantly after playing the Muscle Mania© digital game ($p < 0.05$). Consequently, this provided the impetus to transform the digital game into a mobile game, especially in light of what is considered as the mobile age, or the mobile technical revolution (Traxler, 2009, Ferran-Ferrar *et al.*, 2014), of higher education. From an instructional design perspective, the task of re-designing discipline-specific content for the mobile phone was not required. It is, however, necessary to briefly describe the Muscle Mania© digital game in order to understand differences of software designing for mobile applications.

Table 1: Improvement of Student results

Muscle Mania©	2009	2010	2011
Mean: Pre-test	36.04	31.94	56.48
Mean: Post test	48.35	60.41	70.52
p-value	0.000	0.000	0.002

The computer application of the Muscle Mania© game used Macromedia® Flash™ technology (Figure 1) to provide high-quality animations and to deliver flash objects across different screen resolutions. Macromedia® Flash™ technology also provided realistic ways of delivering complex muscle concepts in one computer application. To facilitate game speed and the automatic allocation of marks, the game was designed around multiple-choice questions, which centred on the structural and functional anatomy of the muscles of mastication and facial expression. The student's progress in the game is measured in terms of achieving the highest score. If students score 100%, they enter the *HOT* zone (Figure 2). If they score 80% or more they enter the *TWILIGHT* zone, and if they score less than 80%, they enter the *ICE AGE* zone. The objective of the game is to enter the *HOT* Zone, where three different skull images are displayed. The student is required to move the various muscles to the rightful place on the skull. Consequently, this reinforces the anatomical knowledge learnt during game play. It is worth noting that the Twilight zone offers movement of the muscles in the frontal view of the skull only (Figure 2). The Ice Age zone offers no rewards to the student. There are two different action sounds in the game, namely one to inform the player when he/she correctly answers a question, and another when answered incorrectly. As described by Ruggill *et al.* (2005), including sound in the game enriches and vivifies the visual landscapes and action sequences they accompany.

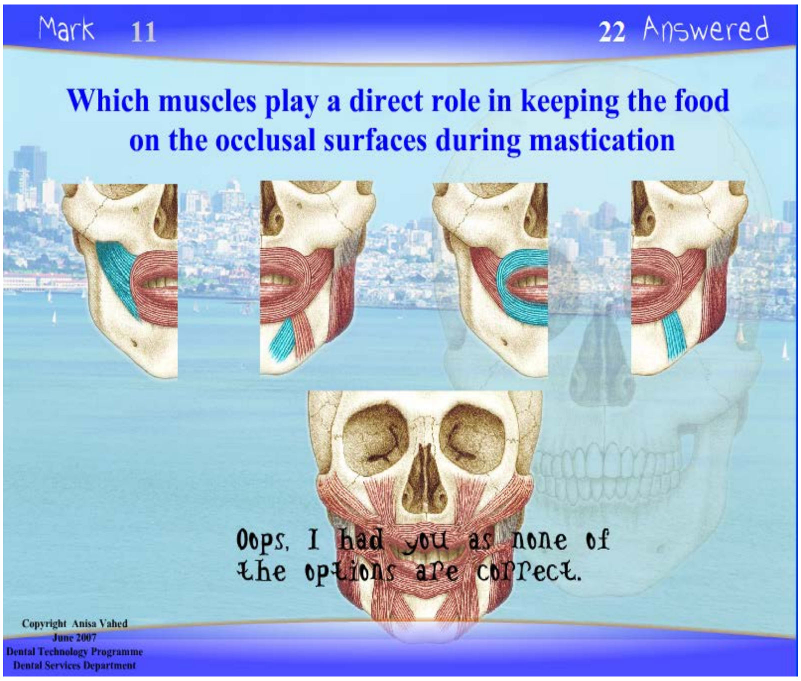

Figure 1: Macromedia® Flash™ technology

Significantly, the lessons learned from the technical design of the digital game compares with the literature on the software design of mobile technology. For example, and as outlined by Rekkedal and Dye (2009), mobile technology must be user-friendly and the graphics used must be compatible with the mobile software. This means the graphics must be of an acceptable quality and easy to navigate to enable the experience of learning through mobile technology. This paper therefore aims to explore the efficacy of using Muscle Mania© as a mobile platform.

Figure 2: Screen Snapshot of Hot Zone-Muscle Mania©

2. The Software Architecture of the Muscle Mania© mobile platform

Android provides a rich application framework to build innovative apps and games for mobile devices in a Java language environment. Essentially, using a Java programming language means that the programme can operate on multiple platforms through the Java Virtual Machine (JVM). From a software design perspective, Android platforms provide easy data sharing between apps and supports interoperability between apps. Such frameworks and technologies can integrate to enable access to hardware and software features on the device and to some user-specific information like the location of the device (Müller and Dikke, 2012, Ring, 2013). Hence, the Android software development kit (SDK) was used to develop the Muscle Mania© mobile game (March – June 2014). Android SDK is part of the open source community, enabling anyone to develop their own applications and market them through Google play. In particular, Android SDK also allows developers to modify and customise the operating system (OS) for each phone, especially as different Android-based phones may have different graphical user interfaces (GUIs) even though they use the same OS. A deployment view of Muscle Mania is shown in Figure 3. More desirable colours were used and icons were added to provide easy access to game features. In contrast with the digital game, in the mobile game the player scores ten points for every correct answer. If the player chooses to scratch the image for a clue to answer the question, two points will be deducted per scratch made. Scores are automatically recorded and are displayed for the player to track their own progress during game play. The action sounds for answering correctly and incorrectly were also changed. Similar to the digital game, success in the mobile game is measured by linking scores to performance zones (HOT, TWILIGHT and ICE AGE).

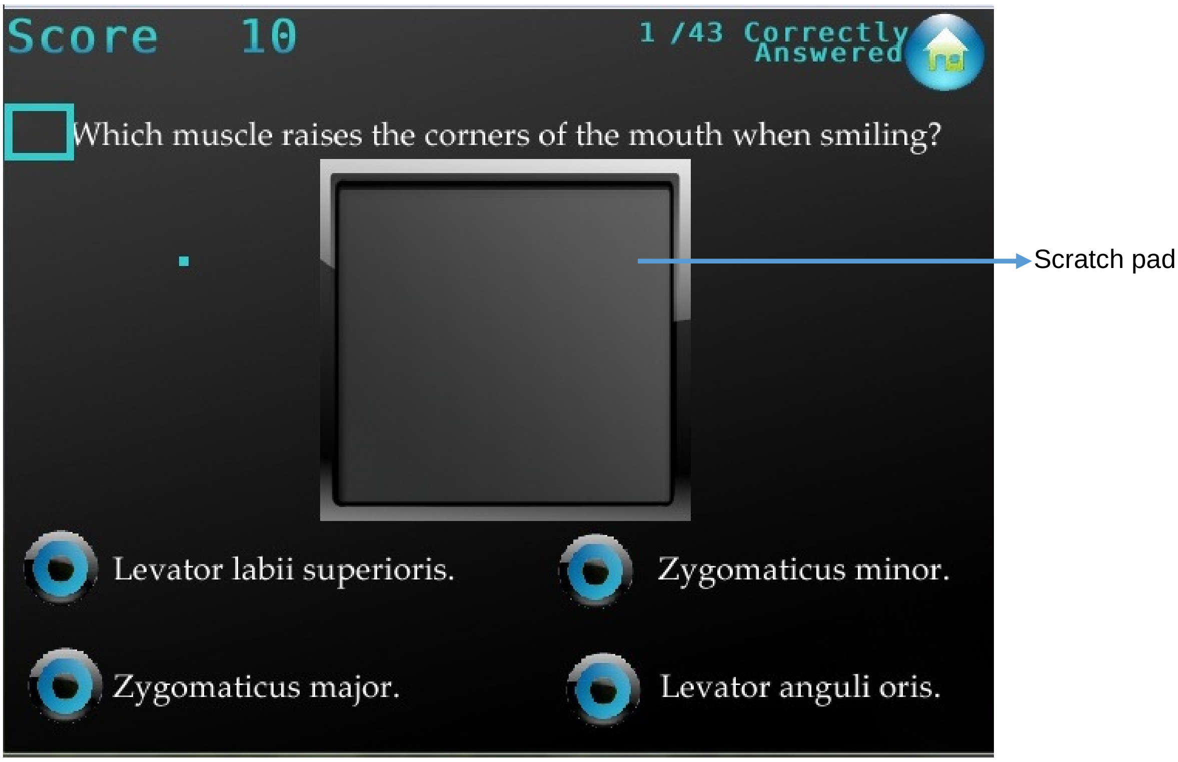

Figure 3: A print screen shot of the Muscle Mania© mobile game

3. Methodology

Several studies (Ally, 2009, Ally and Tsinakos, 2014, Hodgekinson-Williams and Ng'ambi, 2009, Wang *et al.*, 2007) indicate the potentialities of using mobile phone technologies to promote higher levels of student engagement in learning; support the transmission and delivery of rich multimedia, and interactive content; support meaningful, context-specific and immediate learning (situated learning); and provide authentic learning experiences where learning involves real-world problems. There is, however, a need for more rigorous reporting on the educational software design of discipline-specific mobile games. This research therefore sought to use a case study research strategy (Remenyi, 2013) to aid an in-depth exploration into educational software design of the Muscle Mania© mobile game. This approach is strongly associated with qualitative research as it aims to holistically "understand the case in depth, and in its natural setting, recognising the complexity and its context" (Punch, 2014).

Using their own mobile android-based devices, the 2014 B Tech: Dental Technology students and Dental Technology lecturers volunteered to play the game prototype. The participants were provided with the software, which was loaded onto their devices prior to playing the game. Data was collected by means of reflective reports from the technical designer, the 2014 Degree of Bachelor of Technology

(B Tech) Dental Technology students (n=5) and dental technology lecturers (n=4) who played the mobile prototype on the 5 August 2014 using their own android-supported cell phones. In turn, they provided feedback reports on their experiences of playing the mobile game. A week later another test session was conducted (12 August 2014) with the same test users, in order to determine whether the changes had improved the mobile prototype overall. A two-stage data analyses followed.

The first stage involved analysing the feedback from the reports in relation to Koole's (2009) Framework for the Rational Analysis of Mobile Education (FRAME) model. As illustrated in Figure 4, this model consists of a three-circle Venn diagram comprising the intersection of three fundamental aspects, namely: device, learner, and social. The device aspect focuses on the physical, technical and functional characteristics of a mobile device. The learner aspect describes how learners use their knowledge and how they encode, store, and transfer information. The social aspect of FRAME considers the processes of social interaction and co-operation. These aspects intersect to form sub-aspects in device usability, social technology, and interaction learning. The Device Usability (DL) intersection connects characteristics of mobile devices to cognitive tasks related to manipulation and storage of information. The Social Technology (DS) intersection focuses on how mobile devices enable communication and collaboration amongst multiple individuals and systems. The Interaction Learning (LS) aspect describes how learning is collaborative with meaning negotiated from multiple aspects. The mobile learning intersection (DLS) is the culmination of all the characteristics of the aspects and intersections.

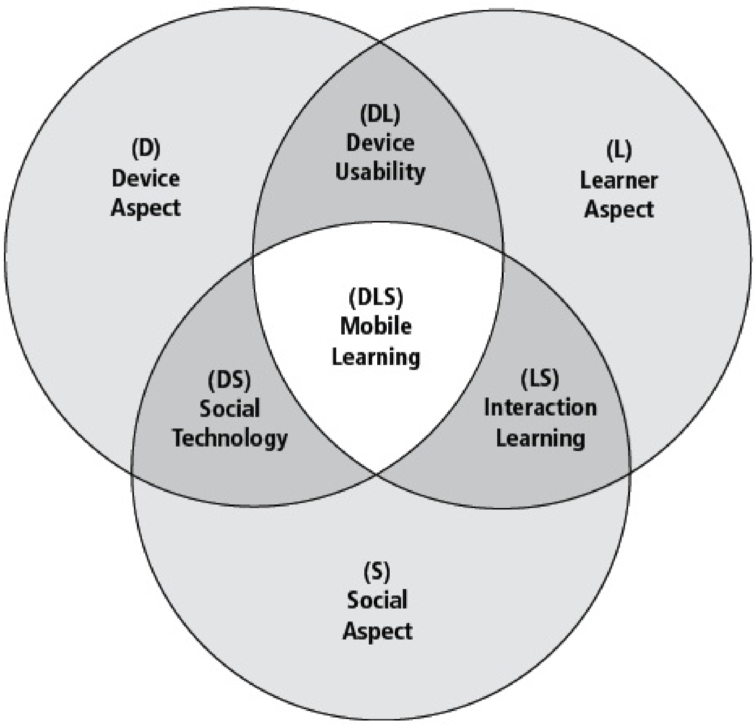

Figure 4: FRAME model (Koole, 2009)

This paper centres on the device usability (DL) aspect, only. As described by Koole (2009), DL "bridges the needs and activities of the learners to the hardware and software characteristics of their mobile devices". Potentially, this interface significantly impacts on the physical and psychological comfort levels of the user.

In the second stage of the analysis, the findings of stage one were assessed in terms of being compliant with the principles of the technical design frame of the Knowledge/Instructional, Technical and Educational (KITE) framework (Vahed, 2014). The criteria of this frame relates to:

- Synthesis of the game mechanisms (graphics and other multimedia materials) with the device software.
- Debriefing: this is a platform to share ideas (Crookall, 2010), which in turn legitimately enriches learning throughout the software developmental stages. This is significant when discipline-specific lecturers are part of the design team in evaluating the different stages of the software development process.
- Intellectual property: From a legal perspective, this knowledge guides the protection of the game design. This is an integral component of the frame particularly from the perspectives of introducing the game in mobile platform, or in legal terms the intellectual property, to the business world. This is significant in moving educational mobile games to quality levels of pedagogical validation beyond perceptions that they are purely for entertainment. It is worth noting that the design and artistic work of the Muscle Mania© game is copyrighted and a trade mark application has been filed through the Intellectual Property office of the Durban University of Technology (DUT).

The KITE framework critically foregrounds that careful consideration of the aforementioned elements is fundamental to the design of quality educational games, that is, they must be valid for the full range of purposes for which they are intended. Trustworthiness of the data was achieved using peer debriefing (Crookall, 2010), methodological and data triangulation (Somekh and Lewin, 2011).

4. Findings and Discussion

Feedback from lecturers and students was replete with positive comments on the user interface and execution of Muscle Mania© as a mobile platform. They uniformly claimed that the software design provided "…clear sounds and graphics." thereby making Muscle Mania© "…easy to read and understand." This finding is consistent with Gee's (2007) concept of situated learning as the mobile platform enabled lecturers and students to situate meanings related to the muscles of mastication and facial expression in an active and critical way. No mention was made to the size of their mobile screens, so we assume that no-one had concerns with it. Significantly, and through debriefing sessions after playing the Muscle Mania© mobile game, lecturers and students generally agreed that the game was clear and sufficiently bright on their mobile screens. As illustrated in Figure 5, they also pointed out that the colour, text type and text size displayed made Muscle Mania© legible. In relation to the DL aspect of the FRAME model (Koole, 2009), the positive comments received from the lecturers and students indicated that they were comfortable in playing Muscle Mania© as a mobile platform. This ease of use enabled them to focus on cognitive tasks rather than the device itself. The aforementioned findings are also compliant with the principles of the technical design frame of the KITE framework.

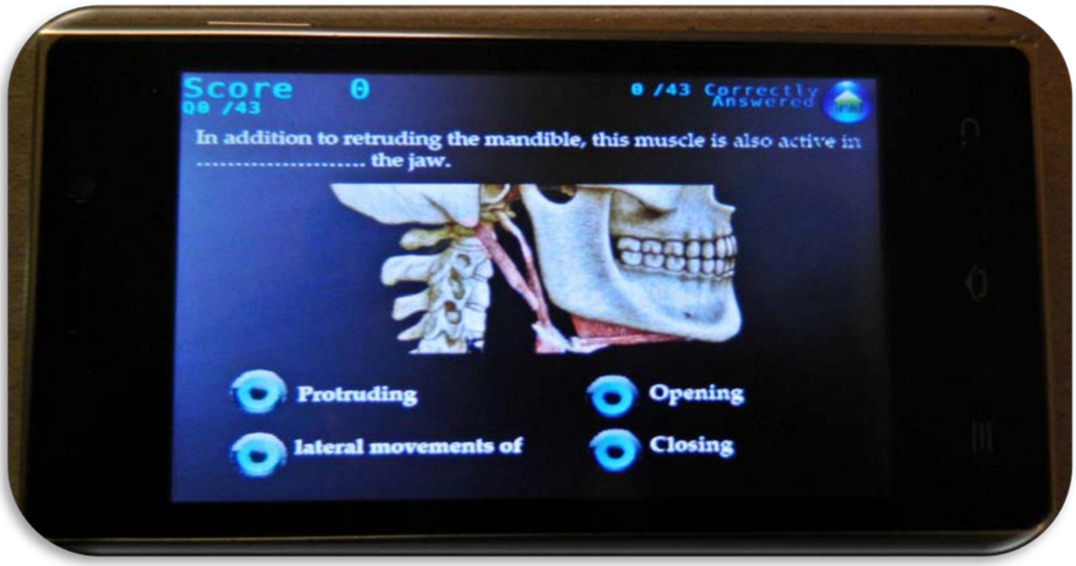

Figure 5: Mobile screen shot of Muscle Mania©

Regardless of the positive comments, weaknesses in the software design were identified in terms of contextual cues. The negative comments are given verbatim: "Think questions should be numbered."; "For revision purpose, I think the game should pop-out the right answer if the student got it wrong."; Need an option button to go back to the previous question".; "I think there needs to be an indication of which question is being answered correctly".; and "Number the question you are on." In relation to the last two comments above, this was corrected and is illustrated in Figures 3 and 5. In debriefing sessions, lecturers critically pointed out that the muscles in the HOT zone "goes back to the original position if placed incorrectly" or "… it will let the game place if for you." As advised by one lecturer, this can be corrected by introducing a "…double click to attach muscles". This will be considered when improving the software design of the game in the future.

In the early phases of developing the mobile game, debriefing sessions between the discipline-specific lecturer and computer programmer helped to identify connections between the visual and contextual cues. For example, compatibility of the multiple-choice questions with the software design was analysed in terms of appropriateness and clarity. This is evident from the verbatim comment below:

> *"…In the early phas*es she *(discipline-specific lecturer)* and I *(computer programmer)* had a fair amount of meetings in regards with discussing which questions to reuse *and how to rephrase the old questions to keep the user/player to challenging themselves and what new questions to create and include."*

Essentially, the interaction between the discipline-specific lecturer and computer programmer complies with the principles of the technical design frame of the KITE framework.

While educational game design is a form of what Squire and Jenkins (2003) call "social engineering", educational software design can arguably be recognised as 'techno-social engineering' as it enables the interweaving of different software mechanisms (game and mobile) intended to support learning through social interactions. The findings of this paper revealed that educational software design which is guided by the principles of the FRAME model potentially enabled discipline-specific lecturers to improve what they are actually doing as opposed to imposing changes to what they do. Equally important, having achieved a refined working prototype could promote Muscle Mania© through Google Play store. This is area for further research.

Conclusions and Recommendations

Overall, the salient features of this paper show that educational software design can leverage meaningful mobile design by providing richer and more supportive guidelines in making discipline-specific content accessible through mobile devices. This is particularly significant in a climate where mobile connected technology is becoming increasingly ubiquitous, and is being heralded as important in helping students to understand the relevance of work-based learning and the need to acquire specific skills of immediate value for professional practice. Herein lies an area for further research, particularly in terms of sharing and disseminating information on teacher-led innovations that use mobile technologies in higher education.

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