

m-Learning in the Education of Multimedia Technologists and Designers at the University Level: A User Requirements Study

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Abstract—An extensive user requirements study was carried out to define the scope of functionality for the applications of m-learning with the potential to enhance the student performance and experience within the BSc Multimedia Technology and Design (MMTD) course at the School of Engineering and Design, Brunel University, United Kingdom. Based on participatory action research and user-centered design, the study involved 58 students attending the course at Level 2. All students participated in three sequential study sessions. The first session included a presentation of the concept of m-learning and a selection of related applications and underlying technologies. The second session consisted of 13 moderated semistructured focus groups. The groups were steered to specify their ideas as to how m-learning could best contribute to the MMTD course. In the third session, working in the same groups as in the second, the students were briefed to refine the ideas arising from the focus group discussions and “translate” them into the concept of the single m-learning application (one per group) that was seen as being potentially the most beneficial for the course. The 13 smart-phone-based m-learning applications that were thus generated were subsequently analyzed and their individual functions broken down and grouped into five main functionality themes. These themes, outlining the scope of functionality for m-learning in the context of education of multimedia technologists and designers at the university level, are: administration, presentation, feedback, motivation, and innovation.

Index Terms—m-Learning, multimedia information systems, mobile and personal devices, user requirements.

1 INTRODUCTION

THE term m-learning stands for mobile learning—a relatively new medium of education provision whereby the educational content delivery and uptake occur “on the move”—typically, outside the standard learning environments of classroom and home [1], [2]. Some authors consider m-learning as a progression of e-learning—with the added value of the mobility component [3], [4].

Functioning based on the paradigm of “anytime, anywhere,” m-learning is enabled by integrating various hardware and software technologies into multimedia applications facilitating the communication of educational content in a number of different formats (e.g., quizzes and games) and for a number of purposes [5]. m-Learning can be applied in a variety of subjects in primary, secondary, higher, lifelong, community, and professional education [2].

The end-user element of most m-learning applications involves a mobile phone (smart or older generation), a personal digital assistant (PDA), or a portable media player (a device such as Apple’s iPod). The applications are usually supported by the latest wireless telecommunication infrastructure (e.g., 3G and 3.5G telecommunication networks, mobile Internet, and Wi-Fi) and some also include a form of location-based services (LBS)—using a Geographic

Information Systems (GIS) software package in combination with the Global Positioning System (GPS) or another positioning technique [6].

The main characteristics of m-learning are [7]:

1. *Ubiquitous and On Demand*: Accessible regardless of time and location, capable of delivering the required content at any “point of need.”
2. *Bite-Sized*: The educational content of m-learning applications must be relatively short in duration as it is typically used in environments with a considerable amount of potential distractions to the user’s concentration. Examples of such environments are public parks and train stations.
3. *Blended*: m-Learning is very rarely used as the only or even as the primary platform to deliver educational content. Usually, it complements other more resourceful modes of the content delivery such as classical teaching and e-learning.
4. *Can be Collaborative*: m-Learning should take advantage of the mobile communication devices it uses as its basis (e.g., mobile phones and Wi-Fi-enabled PDAs) and promote collaborative learning as much as possible. The collaboration can be achieved through the use of SMS or e-mail.

m-Learning can facilitate different categories of learning activities, including behaviorist, constructivist, situated, collaborative, personalized, and informal learning [8], [9]. This flexibility offers the process of education a significant novelty at the level of method.

The use of m-learning is still not very widespread. However, with the end-user devices becoming more and

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more capable of managing high-end m-learning content and the supporting telecommunication services becoming increasingly affordable every day, the field is definitely gaining momentum, and thus, the potential to become mainstream in the foreseeable future.

The successful proliferation of m-learning requires a sustained activity to understand the needs, wants, preferences, and limitations of the potential users of m-learning applications—both in terms of interfacing and in terms of functionality and content. The work in this area has hitherto been somewhat limited and further efforts are needed to broaden and systemize the relevant body of knowledge.

For example, Kukulska-Hulme [10] has reported an interesting point related to the current state of the interface design for m-learning from the point of view of the used hardware. According to the author, the most of m-learning still takes place on devices (e.g., mobile phones and PDAs) that are not fit for the purpose. This mismatch often leads to various usability problems. The general issues include too much variation in the interfaces (e.g., keyboard size and arrangement) by different manufacturers, new models of devices being released too often (which imposes negative effects on the interface learnability), the need for frequent recharging, poor processing power of the devices (causing the applications to operate too slow), etc. Some discipline-specific issues—found to be a problem in, for example, accountancy (spreadsheets display and data entry) and music composition education—are too small and poorly lit displays and keyboards that are too compact.

Several authors have dealt with the topic of creating usable interfaces for m-learning software. There is a consensus that the main rule should be “Keep it Simple” [7], [11], [12]. The rule implies the need for a high degree of simplicity even if the application is based on the use of rich media. The main reasons for this need are related to the above-mentioned hardware issues—most devices are extremely portable and, as such, come with very small screens and keyboards that cannot manage complex interaction and navigation systems without causing a considerable degree of frustration to the user.

As suggested by Litchfield et al. [13], a possible way forward toward establishing a framework of wider understanding of m-learning users is conducting a range of practical participatory case studies across the educational spectrum. If shared extensively within the community of m-learning theoreticians and practitioners, the information to be thus obtained is likely to enable the development of m-learning applications that are not only user-friendly, but also novel in purpose and of innovative content.

Another approach to developing original m-learning applications is to directly engage the user in the development process. According to Kukulska-Hulme [14], the user-generated content stemming from learners’ own spontaneous requirements is a powerful motivator of innovation in m-learning.

2 THE STUDY

This paper reports an exploratory user requirements study that was conducted with the aim of defining the functionality scope for m-learning applications to enhance the

student performance and experience within the BSc Multimedia Technology and Design (MMTD) course—a full-time undergraduate course run by the Electronic and Computer Engineering subject area in the School of Engineering and Design, Brunel University, United Kingdom.

The paper contributes by presenting a number of m-learning application concepts that the MMTD course students recommended as potentially useful for their education. The concepts are organized under the themes of administration, presentation, feedback, motivation, and innovation—a novel categorization scheme for m-learning applications, which is an additional contribution of the paper.

Educating future multimedia technologists and designers, the MMTD course balances various areas of information technology with art, design, and business-related educational content [15]. The course can be studied as a 3-year or 4-year version. The 3-year version is academic only and the 4-year version includes a one-year industrial placement between Level 2 and Level 3. The principal graduate destinations are various technical and creative roles within the creative industry—in companies specializing in Web site development and design, 3D modeling, digital marketing and advertising, etc.

The course modules (2008/2009) at Level 1 are: Multimedia Design (with subjects such as graphic design and art and design history), Multimedia Studio, Systems and Computing, and Internet Technologies and Web site Design; at Level 2: Video and Sound, Imaging (Photography), Communication (marketing and human), Design Practice, and Web Applications and Interaction; and at Level 3: Multimedia Production Management, Digital Sound and Music Production, Databases for Multimedia Applications, 3D Graphics, Virtual Reality and Animation, e-Commerce and New Business Structures, Emergent Multimedia Technologies, Software Engineering and Technology, Image in Motion (film and video), and Final Year Project.

Most modules combine theory lectures with a considerable amount of practical lab work, thus enabling the students to acquire the feel for the industry while still at university. Currently, m-learning is still not being officially used within the course.

2.1 Method

The study design was based on the principles of participatory action research [16], [17], [18], [19] and user-centered design [20], [21], [22]. The study involved 58 undergraduate students, all of whom participated in three sequential study sessions. The first session included a detailed formal lecture that informed the entire participating student cohort about m-learning. In the second session, the cohort was divided and the students engaged in 13 separate focus group discussions. With three to six students per group, the focus groups were steered to discuss and specify a number of group ideas (i.e., requirements and preferences) on how m-learning could best benefit the course. The third session had the form of a design practicum whereby the students—working in the same groups as in the second session—refined and applied the ideas from the focus group discussions in designing the concept of a single m-learning application (one per group) that was jointly seen as bringing the most educational

benefits.¹ This activity generated 13 application concepts reflecting the critical user requirements and preferences. Subsequently, the preferential scope of m-learning functionality within the context of MMTD course was defined by analyzing the 13 concepts and organizing their individual functions into the main occurring themes. The full details of the study participants, procedure, and findings are provided as follows:

2.1.1 Participants

At the time of the study, the 58 undergraduate students who took part were all attending Level 2 of the MMTD course. Of these, 44 were male and 14 were female, with the age range between 19 and 24. Being both the potential users of m-learning (as students on the MMTD course) and—considering the nature of the course—possible future experts in the field, the students were very well suited to make an informed input regarding the study aim.

2.1.2 Procedure

The three study sessions are described as follows:

Session 1: Formal Lecture. The 2-hour formal lecture on m-learning that initiated the study was given in a lecture theater at Brunel University (by the paper author) and all 58 students participating in the study were in attendance. The content of the lecture was presented in two parts, with a 10 minute break in between. The first part introduced the study aim (i.e., to improve the MMTD course via m-learning), explained the methodologies of participatory action research and user-centered design, and provided an in-depth account of the concept of m-learning—by showcasing several examples of m-learning applications, some of which were aimed at higher education and some at different educational stages (e.g., primary and secondary education). The second part of the lecture explained various m-learning-related technologies. The lecture was highly interactive throughout; the students asked a number of questions, which were immediately clarified. The purpose of the lecture was to enable the study participants to develop a reasonably detailed understanding of m-learning, and thus, facilitate proactive participation in the remainder of the study.

Session 2: Focus Groups. The 13 focus group discussions took place on two consecutive days, in the week after the formal lecture (seven discussions on Day 1 and six

discussions on Day 2). The discussions were held in a multimedia lab at Brunel University and each lasted approximately 1 hour. With 15 minute breaks between the discussions, the total duration of the focus group exercise was about 15 hours and 45 minutes (8 hours and 30 minutes on Day 1 and 7 hours and 15 minutes on Day 2). The assignment of the 58 students to the 13 groups was random. As aforementioned, the groups involved between three and six students.

All the discussions were continuously moderated by the paper author and a graduate teaching assistant. At the beginning of the discussions, 5 minutes were allocated to remind the participants of the study aim and the content of the formal lecture from the week before (the concept of m-learning and the examples of m-learning applications and supporting technologies). The participants were then prompted to discuss and make notes of the following issues:

1. *What and how they study for the course:*
 - a. *Which modules and subjects* (e.g., Web applications, communication, imaging (photography, history of art and design, and programming languages).
 - b. *Where* (e.g., at home, in the university library, and when traveling to the university by the underground).
 - c. *When* (e.g., during the day, during the night, in the evening, and in the morning).
 - d. *For how long* (e.g., a number of short periods of time during a day and a few hours continuously).
2. *Which problems they face when studying* (e.g., not enough time, too much time spent on irrelevant tasks, and the study material being difficult to access or difficult to follow).
3. *How could their study performance and experience be enhanced by m-learning—in relation to that discussed under 1 and 2* (e.g., making the study process more efficient or more engaging).

The questions under 1 and 2 were meant to help the students develop a methodical insight into the modalities of their engagement with the course—an action that is seen as crucial in the process of design of new m-learning solutions [23], [24].

Toward the end of the discussions, the participants were asked to organize the discussion notes and summarize the specified group requirements and preferences as to how m-learning could improve the MMTD course.

Session 3: Design Practicum. As already reported above, the design practicum involved the identical 13 groups of students as the second session. The practicum was held during a single day—one week after the focus work discussions, in the same multimedia lab. It consisted of four subsessions, each lasting 2 hours and accommodating three to four student groups (13 groups overall—in three subsessions with three groups and one subsession with four groups, 8 hours in total).

In the briefing part of the practicum, the groups were instructed (by the paper author) to—thinking as users and designers at the same time—revisit the requirements list they produced in the second session and “filter” it into the

1. Action research can be defined as “*researching by doing*” [11], [12]. The methodology involves submitting research participants to certain tasks related to the research aim and drawing conclusions regarding the aim based on the analysis of the participants’ actions and the actions outcome. The analysis is typically carried out using the data collected by the direct observation of the actions (behavioral analysis) and posttask interviews (to capture the underlying process of thinking) and/or by studying, for example, the artifacts that the participants created in the process (the actions outcome). The engagement of the participants with the tasks tends to deliver a more accurate “picture” of the nature of the research problem and possible solutions in comparison to when the traditional research methods like questionnaires and interviews are used in isolation. Translated into the context of this study, “*researching by doing*” meant addressing the study aim of finding ways to enhance the MMTD course via m-learning (*researching*) by engaging the study participants in the task of m-learning applications design (*doing*). The responsibility given to the participants to apply the user-centered design methodology and deliver a series of concepts for m-learning applications (*outcome*) to improve the course is believed to have generated a more focused specification of the m-learning requirements and preferences than if the research included only, for example, classical focus groups and interviews.

specification of functionality for the m-learning application that would, according to the group's joint opinion, make the greatest impact to the course. The groups were also asked to subsequently draft a brief visual presentation of the application concept that was to be developed. The presentation had to include up to 10 slides explaining the concept through its purpose, the ways of use, interface design sketches, and the technologies behind the application. In the end, the practicum delivered 13 m-learning application concepts—one per each participating group.

2.2 Findings

After the third study session was completed, the 13 m-learning application concepts were carefully analyzed by reviewing the concept presentations. The review resulted in a detailed list of the individual application functions. The functions were subsequently organized and grouped into five main functionality themes: administration, presentation, feedback, motivation, and innovation. The five themes, outlining the preferential functionality scope for m-learning in the context of the MMTD course (and in the context of the education of multimedia technologists and designers at the university level in general), and the function descriptions of the m-learning application concepts falling under each of the themes are presented in Tables 1, 2, 3, 4, and 5. Taking into account the particulars of the study method and the manner by which the method directed the concepts generation ("filtering" the most important), the five themes can be considered as representative of the critical pool of the user requirements and preferences regarding the potential contribution of m-learning to the MMTD course. The 13 application concepts map to 11 application examples (Tables 1, 2, 3, 4, and 5) as there was some overlapping in the concepts functionality—particularly under the theme of administration.

3 DISCUSSION

The study provided a systematic insight into the ways how the MMTD course could be improved by the introduction of m-learning. The applications under the five identified m-learning themes offer a potential for enhancing the student performance and experience within this particular course, but also in a wider context of higher education on the whole.

The m-learning functions falling under the theme of administration (Table 1) represent the baseline of m-learning. Classifiable as *"Generic Academic Support"* [2], they are not course-specific and would most likely be found useful by any higher education student, regardless of the course and the university they are attending. Most of the functions (e.g., Table 1, Example 1: Automated SMS/e-mail notifications on timetable changes, Online coursework submission facility, Forum/Collaboration zone, Journey planner, and Campus navigation system) project the students' ambitions to improve the efficiency of the personal administration and organization behind the course attendance, and thus, allow for more time to focus on the study of the core course components. m-Learning is the ideal way to support these ambitions—as the ubiquity of m-learning solutions means that many administrative and organizational duties can be dealt with anytime, anywhere

(e.g., find out about the latest timetable changes while on the bus traveling to the university).

The forum and the chat functions (Table 1, Example 1) are "classical" examples of using m-learning to facilitate the education-related student-student and student-academic staff collaboration in the mobile virtual world. Similar to face-to-face interaction, the virtual collaboration contributes toward a greater understanding of the subject matter through shared exploration and discussion [2].

A number of the administration functions listed in Table 1 are already available on U-Link—the Web-based system currently in use by Brunel University. U-Link utilizes a Blackboard platform [25] to provide a university-wide e-learning support that includes an extensive range of functionality options. Nonetheless, the U-Link system has been criticized by several student groups participating in the study, with one of the groups being particularly harsh and stating that the system is being *"cluttered with unnecessary information,"* having *"too many options and irrelevant features,"* being *"unpersonalized"* (mixing the MMTD course-related information with the information aimed at other courses), having *"chat feature poorly implemented,"* being *"inconsistent and unstable,"* having *"unwelcoming interface,"* being *"slow and not streamlined,"* being *"uninteractive"* and not functioning entirely on mobile-phone platforms. The m-learning system that the group proposed as a U-Link substitute (named M-Link) is supposed to be *"a mobile version of U-Link addressing its many shortcomings"*—an *"application specifically designed for the MMTD course,"* with a *"simple, intuitive, more stable, and consistent interface based on the student feedback."* The input this group made to the study is particularly valuable as it demonstrates that the potential student users are very much concerned not only with the functionality, but also with the usability of m-learning applications. The features "requested" by the group in question are in line with the findings of other studies on the usability of m-learning [7], [11], [12], [26] and it is of paramount importance that they are considered at the stage of implementation of any m-learning application aimed at the MMTD course.

Considering the already established infrastructure of U-Link, the functions under the administration theme are relatively easily implementable—with modifying the system to ensure an increased usability and cross-platform operability likely to be the most demanding tasks in the process. As to the user-end, the Personal Information Management (PIM) systems [2] existing in the majority of portable devices supporting m-learning (e.g., smart phones and PDAs) are prone to facilitate a smooth transition from the e-learning to the mobile solutions.

As with the administration theme, the presentation theme applications and their functions (Table 2) are also applicable beyond the MMTD course and across a broad spectrum of university education programmes. Put into practice, most of these applications are very likely to have positive effects on student learning.

The usefulness of video podcasts (Table 2, Example 1) for teaching undergraduate students in higher education was explored in a study by Evans [27]. The study involved just under 200 students and concluded that—compared to the

TABLE 1
Theme 1: Administration

Applications to improve the efficiency of dealing with various administrative and organisational tasks related to the course

Example 1:

A smartphone-enabled application (or a set of applications) to include:

- 1) Up-to-date information on lecture and design workshop timetables;
 - 2) Information on coursework assignments submission deadlines;
 - 3) Information on the times when lecturers are available in their offices for individual student consultations;
 - 4) Automated notification system using SMS/e-mail to inform students about any relevant timetable changes and lecture and workshop cancellations/re-scheduling/lecturer changes;
 - 5) Document depository system containing assignment submission forms, assignment briefs, lecture and tutorial notes/slides/video recordings (viewable on a mobile phone);
 - 6) Calendar including week numbers and specific dates of terms start and end, holiday periods and significant events such as graduation ceremony;
 - 7) Forum/collaboration zone to enable students to post questions/comments regarding the course and specific modules (administration and taught content-related) and have them answered by colleagues, lectures and administration staff; the forum to include a SMS/e-mail notification system informing students when their question/comment is answered and a private messaging system linked to the register of students/staff who have signed up;
 - 8) Live chat (student-student and student-academic/administrative staff); the chat to enable students to communicate with lecturers at set times and discuss various taught content and coursework issues (including feedback); students to be notified by SMS/e-mail when a certain lecturer is on-line and available for chat;
 - 9) Facility to enable students to submit coursework and receive official feedback on-line;
 - 10) Webmail service linked to the university e-mail address;
 - 11) Links to useful web-sites - both within the university (e.g. student union, clubs and societies, university library, careers office, medical centre) and externally (e.g. various student jobs sites, design resources);
 - 12) A journey organiser linked to transport service information databases such as the London Underground web-site; the organiser to contain information on, for example, train times, delays and closures occurring on train routes and a route planner;
 - 13) Lecture and workshop timetables-linked navigation system to show the location and route/directions to the lecture theatres/labs where the lectures/workshops are held on the campus map; the system may also include real-time navigation using GPS/Wi-Fi.
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Example 2:

A smartphone-enabled, simple-to-use, interactive and intelligent application responding with a short answer to specific questions entered in the form of SMS messages; for example, Question: "Do we have the EE2160 lab today?", Answer: "Yes, the lab is held between 10:00 and 12:00 in TC208". To make it more fun to use, the application may include animated 3D avatars to impersonate the "respondent".

traditional revision tools such as textbooks and lecture notes—the podcasts are perceived as being highly advantageous in how much they contribute to learning and in terms of the time they take to revise the lectures. With the benefit of permitting the choice of when and where to study, video podcasts have a strong potential as m-learning tools. Judging by the outcome of this study, it is reasonable to expect that the use of video podcasts is to add to the MMTD course.

Besides the practicality of having such facility on hand anywhere and at all times, the idea to develop and regularly update an e-dictionary of terms, definitions, and references related to the taught content covered by the MMTD course (Table 2, Example 2) is interesting because of the collaboration this undertaking might entail. As proposed originally,

the dictionary is to be the result of an ongoing concerted effort involving both the course students and the academics. A possible indirect benefit of this effort is an increase in the level of interaction and cohesion within the course (both face-to-face and virtual)—which is to contribute to student development through the ensuing increased exchange of information and ideas.

The application to enable live video feeds of lectures (Table 2, Example 4) is most probably useful only in theory. Although it might help in cases when a student is unable to attend in person due to justifiable mitigating circumstance such as an illness, the possibility of the remote lecture attendance to be enabled by the application is likely to discourage the general student population from attending

TABLE 2
Theme 2: Presentation

Applications to enrich the modes of presentation and facilitate access to the course-related taught content

Example 1:

A multimedia library of past lectures and various module-specific tutorials. The lectures (recorded live in the lecture theatre) and tutorials (recorded in a more controlled studio environment) to be made available as podcasts in video format (sound and image) and usable both on-line (from a smartphone with direct Internet access) and off-line (when downloaded to a multimedia player such as iPod). The multimedia library should be made part of the standard university library catalogue.

Example 2:

A smartphone-enabled version of the standard university library catalogue. The catalogue should be made fully accessible from mobile phones with an Internet link.

Example 3:

A smartphone-enabled e-dictionary of terms, definitions and references related to various modules and subjects covered within the MMTD course ("information on all things multimedia"). The dictionary content to be regularly updated and edited both by the academic staff and the students on the course (similar to Wikipedia, but with the access enabled to the registered staff and students only).

Example 4:

An application to permit the live video feed of lectures to smartphones and thus enable students to "be present" in the lecture theatre from a remote location. The application would be useful in cases when a student cannot attend a lecture due to, for example, feeling unwell.

TABLE 3
Theme 3: Feedback

An application to augment the ways by which feedback can be obtained regarding various course-related assignments

Example:

A web-based application (to be fully accessible from smartphones) that would enable students to upload and showcase their coursework assignment artefacts (for different modules within the course) and receive informal feedback from colleagues at different stages during the process of creation. With the access enabled to the MMTD course students only ("The MMTD Channel") and involving private and public account areas, the site should be designed as a crossover between popular user-content web-sites such as Flickr, YouTube and Blogger. As such, the site would permit the simultaneous display of various content types - including photography, video, graphic design, web-design and essay-based coursework assignments.

lectures in person, and thus, deprive them from the benefits of face-to-face interaction with lecturers. This fact was also acknowledged by the students who proposed the application. An area where this type of application could be truly of use is distance learning.

The m-learning application belonging to the feedback theme (Table 3) is directly responsive to the needs of students attending the MMTD course (and similar courses). Asking peers to feed back on personal coursework projects at different stages of the project development is very common among the MMTD students—especially with

regard to creative coursework in the areas of photography, video, graphic design, and Web design. Feedback is typically sought for the purpose of reassurance or to inform improvements and receiving it informally from peers is seen as very useful. However, due to the lack of time incurred by heavy workload, tight deadlines, and similar, most students usually give and receive feedback only within the small pool of immediate friends. The proposed application is aimed at expanding this pool by providing an efficient online feedback exchange system.

The use of a smart phone as the application basis is to permit both the submission of projects for review and the

TABLE 4
Theme 4: Motivation

Applications to enhance the general motivation for learning and to add to the inspiration in creative coursework assignments (e.g. photography)

Example 1:

A smartphone-enabled interactive quiz application that automatically generates one (or a few) taught content-related multiple choice question/s to answer every day and thus prompts students to continuously revise the theory related to the course. The application to enable students to specify the subject/s in which to have their knowledge quizzed and to permit some form of progress tracking and advice (feedback) on how to improve.

Example 2:

A geographical context-aware smartphone application to permit the instant viewing of user-generated visual artefacts (e.g. photos and videos) related to a specific real-world location/place that are available on the Internet. Upon the user's request - using the mobile phone in-built GPS positioning and the associated keywording system - the application automatically converts the current location's geographical coordinates into the location keyword (name) and, based on the principles of semantic search, links to and draws the location-related visual content from the web-sites such as Flickr, Deviant Art, YouTube and Vimeo. The content is subsequently presented on the mobile phone screen and made available for the application user to view. A possible use scenario for such application is to facilitate photography coursework assignments. For example, a student is requested to deliver a series of photographs of Oxford Street in London. When on location, the student uses the application to view, highly efficiently and in real time, the photographs of Oxford Street that were taken by other photographers and published on the Internet. The viewing enables the student to get informed about the existing work and, in turn, potentially produce more inspired and creative photographs.

TABLE 5
Theme 5: Innovation

Applications to enable innovative methods of learning of different elements of the existing taught content

Example 1:

A smartphone-enabled application to facilitate the understanding of the effects of varying aperture (shallow/extended depth of field), shutter speed (more/less or no motion blur) and ISO value (more/less or no noise) on the quality of photographic images. To be used in photography studies, the application to permit the user to simulate the effects of the 3 settings on the images taken by the phone in-built camera and immediately see the results.

Example 2:

A smartphone-enabled application to support the studies of art and design history (and contemporary art and design practice). The application to contain a GIS database of, for example, all landmark public sculptures and buildings in a specific area. When physically in the area, the application to notify the user of the presence of the sculptures and buildings in the proximity (using the phone in-built GPS system) and provide the information on the relevant author/s, style/s, year/s of design/construction, etc. Thus, the application to help the user to experience the famous art and design works in real life (in addition to having been introduced to them in the lectures). Another possible use of such application is to alert the user whenever they approach any building designed in a specific architectural style, such as Art Deco - in order to facilitate the understanding of the concept of style in art and design.

feedback provision (in the form of textual comments) to be carried out in a mobile context. The "anytime, anywhere" practicability of such an approach is to make it much easier to engage in the process of feedback exchange and,

expectedly, result in the students receiving and giving feedback in much larger numbers.

An important technical feature of the application is the planned multitype content support. This support is aimed

at enabling the students to use the same application to submit coursework projects in various formats (e.g., photography, video, graphic design, Web-design (mock-ups), and essay-based) and thus, cover a range of different modules—in contrast to the popular Web sites such as Flickr and YouTube, which can be used to showcase creative work (and receive feedback), but only in a single content format.

Being continuously fed back on progress is a crucial formative element of student development [28], [29], [30]. Positive or negative, the provision of feedback is always followed by some form of self-reflection regarding the achieved, which, in turn, usually leads to improving academic performance. As such, it is feasible to expect that the feedback application is to make a significant contribution.

The interactive quiz application under the theme of motivation (Table 4, Example 1) is particularly well suited for the MMTD course. With the course being very much hands-on, students often focus on practical projects and “forget” to revise the theoretical content covered by the course lectures—which ends with poor results in the exams. The quiz application is to tackle this problem by acting as a continuous reminder to invest more effort into the theory, thus ensuring the permanence of revision and, consequently, better exam marks.

The application enabling the on-location viewing of photography and video artifacts created by other authors (Table 4, Example 2) could also prove to be very useful within the MMTD course context. When engaging in photography and video assignments outside the university environment (e.g., documentary photography in Central London), the course students often tend to underachieve in creative terms due to the pressure incurred by the typically very limited time frame of such undertakings. Feeling stressed knowing that the time is running out and the assignment must be delivered anyhow, the students panic and produce below-average results. Down to the lack of experience, the application in question might add to overturning this occurrence—by permitting the students to take a break, review the assignment-location-related photography or videowork by other students and professionals, and, subsequently, continue with their own assignment refreshed and inspired.

Both being conceptually highly original, the two innovation applications (Table 5) offer different approaches to the study of photography and history of art and design—the subjects that are extremely important in the context of educating multimedia technologists and designers. The first application (Table 5, Example 1) is to facilitate the understanding of the effects of camera aperture, shutter speed, and ISO sensitivity value on the quality of image. Enabling the user to instantly perceive the effects by simulating their impact on the images taken by the smart phone in which it is installed, the “camera settings” application is offering a very resourceful method to learn this often difficult-to-master technical aspect of photography. The second application (Table 5, Example 2) is to: 1) act as a live “reference book” of notable examples of public art, architecture, and design and 2) support the development of understanding of styles emerging throughout the history of art and design. Taking the subject of art and design history out of the lecture theater and enabling its study while out and about and engaged in

various daily activities, this application is m-learning in the truest meaning of the term.

The significance of the innovation applications is twofold. On the outset, they are meant to help students improve the efficiency of their study. The second—underlying and perhaps more important—purpose of the applications is to engage students with the course content in novel ways, and thus, enhance their study experience. Enhancing student experience by innovating the modes of taught content delivery is strongly supported by the contemporary literature on pedagogy [31]. Open to everything new in the world of multimedia, the MMTD students are always “on the hunt” for new gadgets. Therefore, they are certain to embrace the two proposed applications—as well as any other application potentially falling under the innovation theme.

An interesting point uncovered by the study is the strong preference for using smart phones as the technological platform to operate m-learning applications. Although the student groups were instructed to consider other platforms as well (e.g., mobile phones of older generations, PDAs, media players, and even portable laptops), the majority of the proposed m-learning applications were planned to be operable solely on a smart phone (Tables 1, 2, 3, 4, and 5). The most likely reason for this occurrence is the fact that contemporary smart mobile phones typically meet and, owing to the benefits of instant connectivity options, actually exceed the capabilities of devices such as PDAs—that were “traditionally” applied as m-learning platforms. Being very technology savvy, almost all MMTD students use a smart phone (Apple’s iPhone is the favorite). As such, with smart phones being highly capable per se, the students do not perceive having a PDA or a separate media player as beneficial—which was reflected in the choice of technology behind the m-learning application concepts. This choice could arguably be considered as a predictor of the future technological context for m-learning. Having already seen smart phones become more and more advanced and affordable almost on a daily basis, we may soon find m-learning linked exclusively with this type of operating platform.

Besides the potential benefits in terms of providing a conceptual framework for the incorporation of m-learning into the MMTD course, the study had a direct positive impact on education of the participating students. Carried out within Design Practice—a module being delivered at Level 2 of the MMTD course (Section 2) and led by the paper author—the main educational contributions were achieved with regards to the principal study area of m-learning and the two methodologies underpinning the study—participatory action research and user-centered design. Highly important for future multimedia technologist and designers, the topics of m-learning, participatory action research, and user-centered design have been part of the Design Practice module curriculum since its inception several years ago. Nevertheless, due to different priorities and related time constraints, the topics used to be covered only briefly within theory-based lectures. Including the study into the module meant that the generation of students who took part benefited from acquiring more in-depth knowledge of all three topics. As the student feedback regarding the participation in the study has been very positive, a similar exercise may be repeated in the years to come.

The future work should see the proposed m-learning applications implemented—with the MMTD course students continuing to take part in their development, both technology and design-wise. That way, the students are to benefit not only from the final outcome, i.e., being able to use the applications, but also from numerous learning opportunities to be set out by the development process itself.

Another imperative future activity is to expand the pool of user requirements established in this study by looking more closely into the specifics of applying m-learning to improve the delivery of the technology-based taught content within the MMTD course. As observable in the Findings section (Section 2.2), none of the functions listed under the five m-learning themes is directly linkable to the technology-related subjects such as programming. The absence of technology functions is explainable by the fact that the majority of the students on the course are more interested in the creative content (e.g., photography, video, and design) and often place technology behind creativity. Nevertheless, the technology-related subjects, such as Web Applications (Section 2, Page 2), are also very important and a future study should, therefore, focus on eliciting the user requirements and preferences as to how these subjects could be aided by m-learning.

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