Developing a Design Framework for UMI Educational Scenarios

O. Fragoul¹, A. D. Kameas¹,², I. D. Zaharakis¹,³

¹Computer Technology Institute and Press, Diophantus, Patras, Greece
²School of Science and Technology, Hellenic Open University, Patras, Greece
³Computer and Informatics Engineering Department, Technological Educational Institute of Western Greece, Greece

Abstract: Ubiquitous learning (u-learning) is a new paradigm which is based on ubiquitous computing technology. The most significant role of ubiquitous computing technology in u-learning is to construct a ubiquitous learning environment which enables anyone to learn at anytime anyplace. Nonetheless the characteristics of u-learning are still unclear and being debated by the research community. Designing instructional tools that actually promote u-learning experiences is a cumbersome task in the sense of taking into consideration and combining a variety of complex, technological tools and characteristics of u-learning. This study describes the characteristics and design methodology of a UMI-Sci-Ed Educational Scenario Template as a medium to organize and construct u-learning experiences based in a u-learning environment. It also presents a case study scenario, based on UMI Subject Matter Experts’ interaction with the predefined and designed Educational Scenario Components.

Keywords: “u-learning”, “instructional design tools”, “multidisciplinary educational scenarios”

1. Introduction

The evolution of ubiquitous computing has been accelerated by the improvement of wireless telecommunications capabilities, open networks, continued increases in computing power, improved battery technology and the emergence of software architectures [6]. Its emergence creates new conditions for all working as educational professionals and learning as students. However, the key factor is not the logic or technical specifications of the machines but the new ways in which meaning is created, stored delivered and accessed [2]. Just using state-of-the-art machines in learning, does not mean that new learning is taking place. The new paradigm of u-learning, emerging of these technology developments has to be based in an instructional paradigm and context which makes use of the advanced characteristics of the new technology affordances, towards shaping up a robust framework of u-pedagogy. Under this scope, this paper presents important characteristics of u-learning paradigm and technologies. Section 2 describes the basic characteristics of u-learning while Section 3 includes the proposed approach in developing a design framework for u-learning educational scenarios, highlighting design characteristics. Sections 4 and 5 detail the methodology of the design framework and present as a case study, preliminary data of a scenario design in UMI-Sci-Ed project, formed with the contribution of SMEs (Subject Matter Experts) in Internet of Things (IoT) technologies, in Higher Education. The conclusions are presented in the final part of the paper.

2. U-learning

Currently, u-learning is carried out in various educational settings and investigates in different directions such as ubiquitous pedagogy, classroom centered u-learning mode, specific curriculum centered u-learning mode, faculty education for the implementation of u-learning, development standards of u-learning resources and

¹ UMI stands for ubiquitous computing, mobile computing, Internet of Things.
development of u-learning instructional management system [9]. Just because the computing is ubiquitous, not all learning has to be machine mediated, and distanced from its natural and embodied sources: the machines need to be seen, not as ends in themselves but as documentation devices for off-screen learner activity. Even though u-learning has attracted the attention of researchers, the criteria or characteristics for the establishment of u-learning are still unclear [4]. U-learning seems to integrate best characteristics of former pedagogical paradigms as presented in the Figure 1.

![Figure 1: Evolution from e-learning to u-learning](image)

Six characteristics of m-learning have been adapted by various researchers as part of u-learning: urgency of learning need, initiative of knowledge acquisition, mobility of learning setting, interactivity of learning process, situating of instructional activity, and integration of instructional content [5]. Though the most prominent characteristics of u-learning are permanency, accessibility, immediacy, there is one another parameter for considering the learners’ mobility within the embedded computing environments concluding on more two characteristics: interactivity and situating of instructional activities [4]. Utilizing context-aware and ubiquitous computing technologies in learning environments encourages the motive and performance of learners [5]. Under this scope, as main characteristics of u-learning emerge: urgency of learning need, initiative of knowledge acquisition, interactivity of learning process, situation of instructional activity, context awareness, actively provide personalization services, self-regulated learning, seamless learning, adapt the subject contents, and learning community [1]. Thus, u-learning does not come without challenges, such as the need for context aware infrastructure, along with methods for development of specific tools that are based to a particular situation and the necessity to research, from a human computer interaction perspective, new paradigms of interaction with ubiquitous and contextualized media and learning experiences [5]. Thus, designing and developing a learning environment that supports u-learning is by default a complex and demanding process which has to take into consideration not just the technological parameters but also combine and rebuild in a creative way traditional modes of learning, adhering to new learning and evolutionary situations.

3. Developing a Design Framework for u–learning Educational Scenarios

3.1 Characteristics

An *educational scenario* is defined as an educational setting in predefined time frame: it describes an educational arrangement designed or set up to provide a rich
methodological educational unit. It aims at presenting all important and subsidiary functional aspects of learning (i.e. time, context of learning etc.). Its use in multiple educational settings and contexts – aided by the use of technologies – is important for orchestrating tools and processes in authentic education settings, in an effort to plan learning [7]. In the context of u-learning, the use of educational scenario seems to serve the following purposes:

- It complies with the interest for rich activity-based pedagogies that originate from various socio constructivist influences.
- It is tied up to the goal of creating deeper, better integrated and applicable knowledge.
- Its use, as structured schema, is required in creating effective “new pedagogies”, where the teacher has to fulfil a triple role as facilitator, manager and orchestrator.
- It shapes the learning space describing the social space that provides intellectual and emotional support.
- It provides a constantly evolving structure for the design transition to describing advanced learning situations (i.e. virtual learning activities).
- It means that both the structure and content of a scenario can be used for alternate presentation mode.

On designing u-learning educational scenarios there are certain moves which explore and exploit the potentials of u-learning, shaping affordances under a different spectrum. These moves comprise important actions on designing a u-learning experience such as (a) blurring the traditional institutional, spatial and temporal boundaries of education, (b) shifting the balance of agency from the teacher to the student, (c) recognising learner differences using them as a productive resource, (d) broadening the range and mix of representational modes, (e) developing conceptualising capacities, (f) connecting one’s thinking into the social mind of distributed cognition, (g) building collaborative learning cultures.

A u-learning environment relies on the constructivist learning theory; teachers just not deliver information but they also provide guidance as well as an explorative learning experience. It also relies on conversation and collaboration between students, who can learn by interacting with and even teaching other students. To capture basic components of the learning process, we initially designed a conceptual framework in the form of an educational template, comprised by several blocks (Figure 2).

Synopsis presents a brief educational scenario description. The Scenario orientation/Focus includes information describing the scenario on the basis of knowledge, skills and attitudes expected during the scenario implementation process. A brief content analysis on the basis of key terms presents basic information for scenario categorization. Shaping the temporal space of the educational scenario the block Time Distribution refers to the actual implementation time of the described educational scenario. Using the Bloom taxonomy, Expected Learning Outcomes block provides information on the basis of precise sentences describing what learners are expected to accomplish. Though u-learning scenarios are multidisciplinary, we thought it was important to place the scenarios’ design on specific curriculum areas, presented by the block Placement and Course. The Actors that actually influence the learning process are the Teacher and Students on a first basis: however, in this case, social schemata of
Communities of Practice are expected to function as moderators in knowledge creating and knowledge sharing. As far as the pedagogical design of the template is concerned subsidiary functional aspects of the learning process, Modes of Interaction, Delivery, Media and Products have been included as blocks. Modes of Interaction refer to the types of orchestration and organization, the desired modes of interaction between Actors. Media refer to the technological tools involved in the educational scenario implementation whereas Delivery includes on ways the students have access in the educational scenario. The block Products of the educational scenarios includes artefacts, source code and digital material produced during the learning process. The underpinning pedagogical theory is described in the Pedagogical Elements block, whereas learning prerequisites that are important to be fulfilled before implementing the educational scenario are included in this block. The Content block presents the actual content that students will see and explore during the educational scenario implementation. As Assessment is an important factor in the learning process effectiveness there has been a block introduced in the UMI-Sci-Ed Educational Scenario Template, whereas possible ways of scenario expansion, are introduced to the corresponding block. A separate block on describing ways of Reflection and Feedback has also been introduced in the UMI-Sci-Ed Educational Scenario Template.

![Figure 2: The UMI-Sci-Ed educational scenario template](image)

### 4. Methodology

#### 4.1 Scenario-based design

Scenarios follow systematic and recognizable steps. Though there are numerous techniques in scenario design, there are aspects quite similar: the designer has first to clarify the important decisions that (s)he has to take, challenging the mental maps that shape people’s perceptions and collecting information from various sources. The next steps are more analytical: identifying the driving forces, the predetermined elements and the critical uncertainties. The deeper structure and system behind the scenario narration and their underlying logics are elaborated to explain them and reveal their crucial differences. Finally, the key events or turning points that would channel the future towards one scenario version are identified ([4], [8]).

The scenario based design methodology has been adapted because (a) scenarios evoke reflection in design, (b) design situations are fluid, (c) design moves have many
Consequences, (d) any scenario has many views and (e) technical knowledge lags technical design. Technical professionals are experienced people performing complex tasks; they want to reflect on activities and they routinely do reflect on activities. To design the UMI-Sci-Ed Educational Scenario Template initial decisions had to be made based on content analysis so as to shape a generic content schema including important aspects of the learning process: actors, media, content, learning outcomes and assessment. On further developing the design blocks of the educational template we decided to add categories such as Key Terms, Delivery and Expansion to provide a more elaborated description in a meta-level. U-learning scenarios include activities such as (i) gathering and distribution of information, (ii) creation of collaborative learning documents, (iii) discussions and comments about the productions and (iv) project management related activities.

Constructing scenarios-of-use inescapably evokes reflection in the context of design: the scenario emphasises and explores goals that the user may adopt and pursue. When designs incorporate rapidly evolving technologies, requirements change even more rapidly. The more successful, the more widely adopted and the more impactful a design is, the less possible it will be to determine its correct design requirements. To manage an ambiguous and dynamic situation, the design has to be concrete but also flexible. It seems that effective reflection must be tightly coupled to action [8]: the analysis needs not be complete and consistent, it needs only to guide a restructuring of the current situation that can produce new design actions or new insights.

Powerful pedagogical designs that aim at the development of general problem skills, deeper conceptual understanding and more applicable knowledge include characteristics such as (a) the use of complex, realistic and challenging problems that elicit in learners active and constructive processes of knowledge and skill acquisition; (b) the inclusion of small group, collaborative work and ample opportunities for interaction, communication and co-operation; and (c) the encouragement of learners to set their own goals and provision of guidance for students in taking more responsibility for their own learning activities and processes [8].

4.2 What about STEM education?

As the education profession develops programs to address the evolving STEM teaching and learning needs, a central factor that must be understood is that STEM content and STEM education are not the same [7]. Further, expertise in one STEM discipline does not automatically translate to expertise in another discipline even if the process of scientific inquiry is well understood by the learner [3]. The multidisciplinary nature of STEM education presupposes conceptually generic pedagogical schemata, however open to elaboration so as to be applicable in a variety of learning situations covering an array of subject domains. Jobs go unfilled in STEM settings because there is a gap between what graduates in STEM can do and the skills STEM employers are seeking [7]. The problem is not about STEM graduates lacking of the technical skills needed for the job but actually the non technical, such as ability to network, time management, the so-called “soft skills”. In a research sample of 1,065 employers surveyed by the Deloitte Access Economics commissioned by the Office of the Chief Scientist, Australia, these emerged as important work skills required for STEM graduates to achieve success in their workplace (Table 1).

The importance placed on the skills and attributes varied by industry sector: for example 86% of employers in the Information, Media and Telecommunications sector
rated programming important or very important—much higher than other sectors. This sector also rated design thinking as high priority.

![Chart showing respondents' rating of each of 13 different skills and attributes]

*Table 1: Respondents’ rating of each of 13 different skills and attributes (Source, Deloitte Access Economics Report, Australia’s STEM Workforce: a survey of employers, [www.chiefscientist.gov.au](http://www.chiefscientist.gov.au))*

5. Towards developing UMI-Sci-Ed Educational Scenarios – SMEs Case Study I

In order to start using the UMI-Sci-Ed Educational Scenario Template, the design of educational scenarios for 14+ youngsters using UMI technologies for STEM education has been initiated. The following section presents a brief description of the scenario designed by SME in UMI targeting at educating students in cryptography principals and concepts. The rationale of designing the scenario covered 3 basic phases as presented as follows.

**Step I – Analyse the problem**

Safety issues in using wireless technology and smart devices are very important in the sense that users need to be serviced by the use of UMI technologies in their everyday lives, however they also have to learn to protect themselves from risks emerging from malicious use and possible intruders. Under this scope, being able to process data in order to i) make decisions regarding safety issues and in a sense privacy issues, and ii) critically examine parameters of data entry so as to select appropriate technique for data encryption, are the basic steps in this educational scenario. The educational scenario’s basic steps are presented as follows:

- Introduction of basic steps and principals of cryptography
- Selection of the application and the data that are going to be encoded
- Selection of appropriate algorithm, e.g. symmetric key algorithm
- Performing of encryption process according to selected algorithm
- Performing of reverse operation for decryption
- Outlook and knowledge feedback

**Step II – Identify strengths and weaknesses**
People wishing to engage in a secure exchange of information will swap public keys and use some method to ensure the existence of identical private keys. Creating an educational scenario based on concepts and processes of cryptography has proven a quite cumbersome task in the sense of pinpointing and elaborating material suitable for 14+ youngsters. However, the interest of young users in a topic like that (cryptography) and the challenge of making a subject like that feasible for learning with UMI technologies seemed to be the greatest challenge of all. The experts must explain how the security and consequently cryptography relates to privacy and how it facilitates the control of information flows (i.e., who gets to know what when?) and helps to ensure the correctness of data. Students have to be prepared for obstacles such as the proper exchange of private keys and complete transactions in a secure manner. They also have to face problems such as the compromise of a private key. By using this scenario students are expected to:

- Learn fundamental primitives of cryptography and its relation to privacy
- Familiarised with the encryption/decryption processes
- Summarise the basic issues of data encryption and decryption
- Summarise security issues of ubiquitous computing
- Identify the need of cryptography in ubiquitous computing applications as an integral part of any privacy solution

**Step III – Analysis of the external environment**

The time slot for applying the specific scenario is 4-5 hours in workshop settings, involving also a grouping mode (4-5 students). As hardware tools, UDOO NEO† can be used with the appropriate peripherals for data entry and I/O external devices. UDOO NEO is an open hardware, low-cost platform equipped with a powerful 1GHz ARM® Cortex-A9 and an Arduino UNO-compatible platform that clocks at 200 MHz, based on a Cortex-M4 I/O real-time co-processor, all wrapped into an i.MX 6SoloX processor by NXP. This is actually a tool for fast prototyping, which provides a boost to DIY (Do It Yourself) world, and a new vision to the educational framework: the idea of training up a new generation of engineers, designers and software developers skilled in digital technology: physical computing, multi-media arts, interactive arts and Internet of Things.

### 6. Conclusions

Design based methodology has been used to as to start developing an UMI-Sci-Ed Ubiquitous Science Learning Environment (USLE). Projects in STEM learning encompass the many foundations of STEM learning, including intellectual, behavioural and social factors, as well as emerging contexts and tools for STEM learning. Research on learning environments investigates new, high-impact learning opportunities in STEM, including in classroom, non-classroom and virtual settings. The UMI-Sci-Ed Educational Scenario Template has been presented in its initial design stage as well as preliminary findings covering the design of a ubiquitous computing educational scenario based on UDOO NEO hardware kit. The educational scenario template is currently evaluated and updated according to SME’s feedback. The next step is to start developing and orchestrating samples of activities based on

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† [http://www.udoo.org/udoo-neo/](http://www.udoo.org/udoo-neo/)
the actual educational scenario design so as to start expanding basic concepts and processes in a learning ecology using UMI technologies.

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8. References