Interactive Learning Resources and Linked Data for Online Scientific Experimentation

Alexander Mikroyannidis, John Domingue
Knowledge Media Institute, The Open University
Milton Keynes MK7 6AA, United Kingdom
{Alexander.Mikroyannidis, John.Domingue}@open.ac.uk

ABSTRACT
There is currently a huge potential for eLearning in several new online learning initiatives like Massive Open Online Courses (MOOCs) and Open Educational Resources (OERs). These initiatives enable learners to self-regulate their learning by providing them with an abundant amount of free learning materials of high quality. This paper presents FORGE, a new European initiative for online learning using Future Internet Research and Experimentation (FIRE) facilities. FORGE is a step towards turning FIRE into a pan-European educational platform for Future Internet through Linked Data. This will benefit learners and educators by giving them both access to world class facilities in order to carry out experiments on e.g. new internet protocols. In turn, this supports constructivist and self-regulated learning approaches, through the use of interactive learning resources, such as eBooks.

Categories & Subject Descriptors
J.m: Miscellaneous

Keywords
Interactive eBooks, widgets, Linked Data, Open Educational Resources, Massive Open Online Courses, Self-Regulated Learning

1. INTRODUCTION
Higher education is currently undergoing major changes, largely driven by the availability of high quality online materials, also known as Open Educational Resources (OERs). OERs can be described as "teaching, learning and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use or repurposing by others depending on which Creative Commons license is used" [1]. The emergence of OERs has greatly facilitated online education (eLearning) through the use and sharing of open and reusable learning resources on the Web. Learners and educators can now access, download, remix, and republish a wide variety of quality learning materials available through open services provided in the cloud.

The OER initiative has recently culminated in MOOCs (Massive Open Online Courses) delivered via providers such as Udacity[1], Coursera[2] and edX[3]. MOOCs have very quickly attracted large numbers of learners; for example over 400,000 students have registered within four months in edX[4]. Also, in the four years since the Open University started making course materials freely available in Apple's iTunes U, nearly 60 million downloads have been recorded worldwide[5]. More recently, the Open University established FutureLearn[6, 7] as the UK response to the emergence of MOOCs, in collaboration with premier British institutions such as the University of Cambridge.

These initiatives have led to widespread publicity and also strategic dialogue in the education sector. The consensus within education is that after the Internet-induced revolutions in communication, business, entertainment, media, amongst others, it is now the turn of universities. Exactly where this revolution will lead is not yet known but some radical predictions have been made including the end of the need for university campuses[4], while milder future outlooks are discussing 'blended learning' (combination of traditional lectures with new digital interactive activities). The consensus is however that the way higher education students learn is about to change radically.

The Future Internet Research and Experimentation (FIRE)[8] initiative has been established to ensure that the European Internet Industry evolves towards a Future Internet containing European technology, services and values. Through FIRE, a variety of facilities have been developed, including cloud computing services, Wi-Fi and sensor network test-beds, infrastructures for High Performance Computing, and more. However, the corresponding costs both for the establishment and operation of these facilities is not to be neglected. Therefore, optimal usage of the FIRE facilities is desired by its owners, a goal which has not been yet achieved.

WWW 2013 Companion, May 13–17, 2013, Rio de Janeiro, Brazil.
ACM 978-1-4503-2038-2/13/05.

[1] http://www.udacity.com/
[2] https://www.coursera.org/
[3] https://www.edx.org/
[4] http://www.guardian.co.uk/education/2012/nov/11/online-free-learning-end-of-university
[5] http://projects.kmi.open.ac.uk/itunesu/impact/
[6] http://www.futurelearn.com/
[7] http://www.bbc.co.uk/news/education-20697392
[8] http://cordis.europa.eu/fp7/ict/fire/

Forging Online Education through FIRE (FORGE) is a new European initiative bringing together the worlds of online education and FIRE. FORGE will align FIRE with the ongoing education revolution for mutual benefit. In particular, this project is concerned with specifying development methodologies and best practices for offering FIRE experimentation facilities to learners, related both to communications and IT but also to other science, technology, engineering and mathematics (STEM) disciplines and possibly even social sciences, leading to a strong connection between the learning community and existing FIRE platforms and supporting tools.

2. LINKED DATA AND INTERACTIVE LEARNING RESOURCES

Linked Data [2, 4] is the simplest form of the Semantic Web [3], where data representing any entity (e.g. person, place or organization) is identified by a URI and can be linked to any other data item forming a gigantic Web of Data graph. In general, Linked Data is now being used by companies such as Google, Microsoft and Yahoo to enhance web search[9], by Facebook to support the linking of social media resources[10] and by the BBC to support the delivery of online news content[11].

Building on the Linked Universities initiative[12] [5] and EU projects such as LinkedUp[13] (Linking Web Data for Education), we see the following uses of Linked Data in FORGE:

1. Delivery and navigation of learning materials – the rich structure provided by Linked Data-based descriptions supports the creation of easy-to-use navigation schemes. Additionally, semantic links and a uniform data format enable heterogeneous resources to be easily combined into a single space or page. Linked Data will enable us to combine data and services from multiple FIRE facilities into a single easy-to-navigate place.
2. Discovery and recommendation of learning materials – using semantic links we can highlight related resources. For example, the DiscOU tool[14] automatically displays Open University courses that are related to the content of web pages as they are browsed. Linked Data will provide support for discovering FIRE facilities related to course materials and vice-versa.

One of the main goals of FORGE is to enable educators and learners to access and actively use FIRE facilities in order to conduct scientific experiments. We will thus follow a constructivist approach to education where learning takes place by students creating artefacts rather than assuming the passive role of a listener or reader. Our approach is based on a wide range of studies that have shown that with the right scaffolding competent learners benefit greatly from **constructivist** or **learning-by-doing** approaches [6-8, 12]. The experiment-driven approach of FORGE will contribute to fostering constructivist learning by turning learners into active scientific investigators, equipped with world-class experiment facilities.

From a learning technology perspective, FORGE will be building upon new trends in online education. More specifically, in online educational platforms such as iTunes U, as well as in MOOCs (Massive Open Online Courses), such as Udacity, Coursera and edX, we see the large-scale take-up and use of rich media content. These include video in a variety of formats including webcasts and podcasts and eBooks, which can contain multimedia and interactive segments. In particular, eBooks provide a new level of interactivity since specific learning text, images and video can be closely integrated to interactive exercises[15]. In the context of the European project Euclid[16] (EdUcational Curriculum for the usage of LInked Data), we have been producing such interactive learning resources about Linked Data and delivering them in a variety of formats, in order to be accessed from a variety of devices, both mobile (tablets and smartphones), as well as desktop computers. Building on this work, FORGE will produce interactive learning resources targeting a wide range of mediums and devices in order to maximise its impact on the eLearning community.

FORGE will enable students to setup and run FIRE experiments from within rich related learning content embedded as widgets inside interactive eBooks and Learning Management Systems (LMS). The portability of widgets as bespoke apps that can be embedded into a variety of online environments will ensure that the FORGE learning solutions implemented as widgets will have a high reusability factor across multiple learning domains and online learning technologies. Figure 1 shows an example of such a widget used for finding open educational resources. The widget in question has been embedded into online courses offered by the Open University via two different environments: the Moodle LMS and an Apple iBook.

Additionally, an Educational Widget Store using Linked Data will be developed to host the FORGE learning widgets. Learners and educators who are looking for interactive tools for scientific experimentation will be able to find suitable FORGE learning widgets in this store, as well as contribute their own tools and share them with the eLearning community. A FORGE vocabulary will be developed for describing FIRE learning resources and FIRE facilities from a learning perspective. This vocabulary will build upon existing ontologies such as MLO, XCRI-CAP, and TEACH[17].

[9] http://schema.org/

[10] http://ogp.me/

[11] http://www.bbc.co.uk/blogs/bbcinternet/2010/07/bbc_world_cup_2010_dynamic_sem.html

[12] http://linkeduniversities.org/lu/

[13] http://linkedup-project.eu/

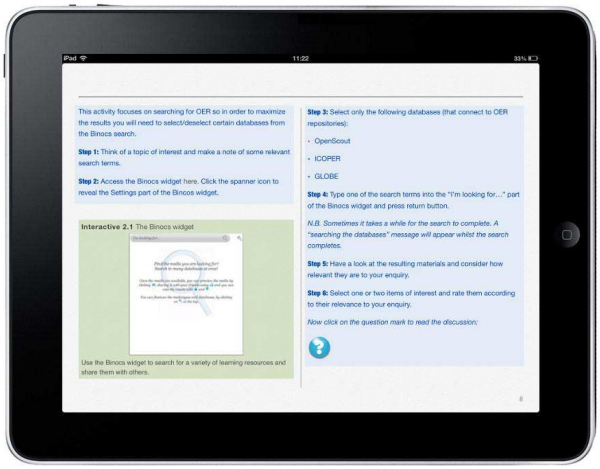
[14] http://discou.info/

[15] http://www.youtube.com/watch?v=KXCHKYsi1q8

[16] http://www.euclid-project.eu

[17] http://linkeduniversities.org/lu/index.php/vocabularies/

a)



b)

Figure 1. Integration of a learning widget inside (a) the Moodle LMS and (b) an Apple iBook

3. SUPPORTING SELF-REGULATED LEARNING

FORGE will promote the notion of **Self-Regulated Learning (SRL)** through the use and propagation of FIRE learning solutions in online education. SRL is a term that describes an individual's ability to learn how to learn. In some university settings the term SRL is more commonly described as **independent learning** or **auto-didactic learning**. From a cognitive perspective, SRL enables learners to become "metacognitively, motivationally, and behaviourally active participants in their own learning process" [15].

SRL has become increasingly important in educational and psychological research. The tenor is to give the learner greater responsibility and control over all aspects of technology-enhanced learning, which is beneficial for their actual learning outcomes [14]. Lately, as we have learned from the European project ROLE[18] (Responsive Open Learning Environments), the advance of lifelong and informal learning has made SRL quite important in non-academic learning environments, where instead of instructor- and teacher-orientation, more learner-orientation is necessary [9-11, 13].

SRL research within the ROLE project has produced the psycho-pedagogical integration model (PPIM) shown in Figure 2 [3]. The ROLE PPIM divides the learning process in 4 learner-centred phases:

1. The learner profile information is defined or revised.
2. The learner finds and selects learning resources.
3. The learner works on selected learning resources.
4. The learner reflects and reacts on strategies, achievements and usefulness.

It is assumed that the learner will implicitly or explicitly perform these phases during learning, with support from widgets and interactive learning resources.

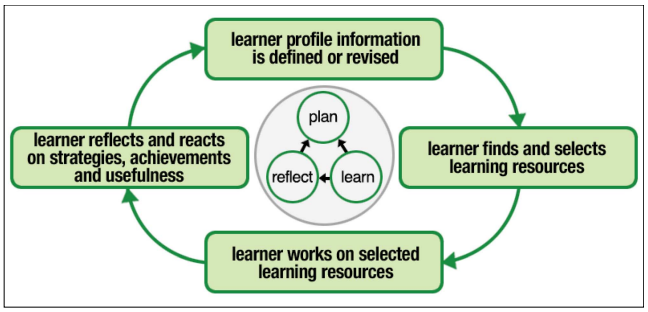


Figure 2. The ROLE Psycho-Pedagogical Integration Model (PPIM).

In order to showcase the application of the PPIM in FORGE, let us consider a scenario involving an informal learner. Jane is 42 years old and has chosen to study a Computer Networks course from the Open University (OU), UK. She is a mature student who has worked for many years and would like to broaden her horizons. She likes to learn but because she is working full time needs to be disciplined in her approach to her new studies.

Before the course commences, Jane decides to prepare herself for it, by updating her educational technology-related skills keeping in mind that it is sometime since she has taken any academic courses or used technology directly to aid her learning. Thus she starts her study preparation by trying to find an online course that focuses on the new learning technologies because her OU Computer Networks course is going to be delivered primarily in an online environment.

In essence, Jane is going to approach her Computer Networks course as follows:

1. Setting her goals
2. Looking for appropriate and recommended learning tools
3. Using those learning tools to enhance her skill set
4. Reflecting on the learning process

In this process, Jane is aided by a number of widgets available for various learning purposes: She uses a 'goal-setting' widget to record a list of her goals; she then uses the Linked Data-enabled Educational Widget Store to discover suitable FIRE facilities available as widgets inside interactive learning resources; she uses

[18] http://www.role-project.eu

the resources she finds in order to learn about the construction and operation of Computer Networks; finally she reflects on her experiences by providing feedback as comments and ratings in the Educational Widget Store. By using the FORGE widgets, Jane gets acquainted with a variety of FIRE facilities, such as PlanetLab[19], or an OFELIA[20] test-bed with Software Defined Networking capabilities, which allow her to explore networking implications under real conditions.

At the end of this process, Jane realises that she has acquired a lot of new learning resources, learning techniques and she has experienced a whole set of new learning tools in the form of widgets. She is now prepared to start the OU course in the upcoming semester and she also plans to keep on using these widgets throughout the course.

4. CONCLUSION

FORGE aims at complementing online learning initiatives with laboratory courses for an in-depth and hands-on educational experience. Within FORGE, our constructivist approach will be based upon the notion of the experiment. FORGE will allow students to create and conduct experiments using interactive learning resources within a comprehensive learning context. This approach will enable learners to take the active role of an explorer or scientist, as they will be engaged into solving issues they come across when setting up and executing their experiments, thus tapping into their personal feelings of curiosity. Learners will learn to investigate, be creative, and use their personal characteristics and identity in order to self-regulate their learning. Additionally, FORGE will advance research in Linked Data by targeting the application of Linked Data in the delivery and discovery of online learning resources.

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