



# eLearning Papers 39

July 2014

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Learning in cyber-physical worlds

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# Exploring the cyber-physical continuum in education

What lies in the space where the cyber world and physical world converge? A spectrum of blended augmented experiences and a fount of new opportunities for educational practice.

The success of this projected convergence depends on the availability of affordable virtual reality hardware, such as wearable haptic and movement tracking devices, and the use of engaging instructional approaches such as experiential learning, gamification and problem-based learning.

This issue of eLearning Papers features a collection of articles that highlight these approaches and their potential for the development of better learning experiences.

In the realm of 3D virtual worlds, we see in the first paper an example of how a Multiuser Virtual Environment (MUVE) or 3D virtual world can be used to enhance how science is taught in classrooms by replicating physical spaces and incorporating the 3D virtual world with the existing learning management system. Moving along the cyber physical continuum, researchers from Greece suggest the use of augmented reality to provide realistic visualizations of physical phenomena so as to combat common misconceptions and promote scientific knowledge.

Bringing innovative technology to the classroom, however, requires an investment of time, energy, and resources that can be prohibitive. Moreover, the constant emergence of new hardware, interfaces and applications highlights the importance of the Maker Movement. The Do-It-Yourself mentality has a high pedagogical potential in conjunction with the collaborative spirit in communities of practice.

A practical manifestation of this mentality can be found in another paper; the potential of distributed networks for collaborative teaching becomes even more apparent in the Bring Your Own Device for Learning (BYOD4L) open learning initiative. Even when high-end technology tools are not available, games and gamification can be effective instructional methods to transform learning into an enhanced practice-oriented experience. In a project management e-learning course in Finland, business students collaborated with entrepreneurs and competed in solving authentic entrepreneurial challenges. Playing games led to the effective acquisition of management skills.

Finally, a case study from UK provides insights on how web-based tools can be used to foster arts students' online creativity. The use of virtual worlds for learning today is richer and more diverse than what we anticipated only a few years ago.

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## Challenges from implementing Blended Learning in a 3D Multiuser Virtual Environment

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### Tags

[web-based LMS](#), [moodle](#), [sloodle](#), [MUVE for learning](#)

With their ability to simulate real life and allow users to interact with the virtual environment, Multiuser Virtual Environments (MUVES) are very useful platforms for education and training. A survey of the related literature shows that MUVES in education are mainly used only as a supplement of the traditional lesson in the classroom, which is mainly the idea of blended learning. In this work, we go one step beyond and examine whether this blended learning model can be fully implemented online, with MUVES replacing the face to face interaction. This is ideal for open learning communities, whose members are able to meet only online, and can hardly meet in the same classroom. For an open learning community, we investigate whether the existence of a MUVE can be combined smoothly and productively with the already established tools for online learning communities support and the first user experiences are positive: users prefer to use LMS because of its simplicity and are attracted from the 3D virtual environment and the interactivity it offers.

### 1. Introduction

Although online MUVES were not primarily designed for educational use, they have attracted the interest of educators and institutes and are used in parallel with the in-classroom courses (Miller et al, 2010; Sturgeon et al, 2009; Thomas and Mead, 2008). This use assumes that the educator spends a few teaching hours to introduce students to the new environment and explain the activities to them. During the activity, which is usually held in a computer lab, the educator is physically present in order to facilitate students on the use of the MUVE (Konstantinou et al, 2009). The result from the use of MUVES is a blended course, which mixes face-to-face in-classroom interaction with computer mediated activities (Bonk & Graham, 2006), (Trapp, 2006)

In a MUVE, participants are represented by graphical characters called avatars and acquire the feeling of coexistence in the same virtual space. We consider that this feature may under certain circumstances substitute the presence of the participants in the same physical space. According to the analysis of Biocca (2003) the sense of presence is divided into: a) the physical presence which is defined as the simulation in a virtual world in a way that is perceived as the physical world, b) the social presence, which is defined as the individual's interaction with the other participants and c) the self-presence which is the mental sense of the individual's representation in the virtual world. Therefore, we transfer the blended learning model completely online, with the MUVE being the substitute of the classroom and the Learning Management System (LMS) being the online learning platform.

The aim of this study is to examine whether this transfer is feasible, what implications may arise and how educators and members of the learning community in general can resolve them. In order to test our idea, we designed a series of courses on different disciplines, such as chemistry, physics and astronomy, which can be significantly favored by 3D visualizations and the use of multimedia. The various learning objects and the asynchronous learning activities of our community were served from a popular e-learning platform (Moodle) and the MUVE (Second Life) was mainly employed in order to create the sense of being in a classroom to our community members. For this reason, we created a 3D virtual classroom representation and arranged weekly meetings for the community members. In this virtual classroom, members meet face to face, or at least avatar to avatar. Teachers give lectures that simulate lectures in the classroom, answer to students' questions and motivate students to use the educational material and additional web resources.

The main contributions of this work can be summarized in the following:

- An implementation of the blended learning model completely inside the MUVE. The implementation combines the merits of an open source e-learning platform (Moodle) and a multiuser virtual environment (SecondLife - SL)
- The smooth integration of a traditional e-learning platform, which focuses on the asynchronous activities of the community members, such as the distribution of any digital content and the scheduling of learning activities and the MUVE, which is the ground for all the synchronous activities of the learning community.

Section 2 performs an overview of the related research works that introduce MUVE in the learning process. They either use Second Life or other competitive MUVES. In section 3, we provide details on the design of our first course. Section 4 highlights the most important implementation issues and section 5, illustrates the students' impressions from an educational, psychosociological and technological aspect. In this section we examine the interestingness and usefulness of the virtual blended learning approach, and the students' impressions from the simulation of the traditional learning model in the virtual environment. Finally, section 6 presents our first conclusions and summarizes our next steps.

## 2. Related work

The aim of virtual learning communities is to collaboratively improve knowledge in the field of expertise of the community. MUVES such as Second Life allow individuals to interact, communicate, collaborate and learn. They can offer an enhanced learning experience if used properly in group-and collaborative project-based assignments (Lambropoulos & Mystakidis 2012). This makes them the ideal platform for taking the blended learning paradigm (Varlamis & Apostolakis 2010) completely online: face-to-face activities can be replaced by avatar-to-avatar interactions and computer mediated-activities can be more interactive and realistic in the 3D environment.

Online MUVES, such as Second Life, OpenSim, Wonderland and Croquet offer better simulation of the interaction in classroom (Wang and Burton, 2012; Leidl & Rößling, 2007) since they support the use of 3D-avatars, voice chat, lips and other body part movements which can help address the lack of awareness and attract students' and teachers' interest (Konstantinou et al, 2009). The use of avatars lowers inhibitions and increases social interactivity (Yalcinalp et al, 2012). Most 3D virtual environments offer full customization of an avatar's appearance and gestures, allowing users to strongly identify with the chosen representation for their avatar and easily distinguish the other participants. This customization strengthens the perceived sensation of presence and awareness (De Lucia et al., 2009).

Most research works in the literature use learning activities in Second Life as a complement to the traditional learning activities (Beltrán Sierra et al, 2012; Honey et al, 2012; Baker and Brusco, 2011; Miller et al, 2010) and consider Second Life as a means for engaging learners (Iqbal et al, 2010), or as a game activity that will help students to overcome their technophobic barriers (Chow et al, 2011). In most works, the role of the teacher ends in facilitating students to familiarize themselves with the new environment. In our study, Second Life is the main platform for delivering knowledge, and the teacher is primarily educator and secondary a facilitator for the students.

According to social constructionism, a virtual world has two essential capabilities: a) tele-presence (via avatars) and b) immersion in the virtual world (Girvan et al, 2012). These capabilities are less prominent in traditional LMS' than in immersive MUVES (Lambropoulos & Mystakidis 2012). On the other side, most of the virtual worlds are not designed for managing learning content. Although one can include

streaming media (audio and video), storing and managing documents “in-game” is still cumbersome. The import and export facilities for common file formats – e.g., Word, PDF, or PowerPoint – are currently only rudimentary. Applications like Sloodle (Livingstone & Kemp 2008) integrate web-based Course Management Systems (in this case Moodle) into virtual environments (Second Life) and try to benefit from both sides. They combine the improved social interaction capabilities of Virtual Worlds and the content-management qualities of LMS, which are more suitable for asynchronous communication, simple tests and persistent storage of related documents

As stated by Perera et al (2011), the management of the learning environment is a challenging task for teachers, since the 3D system functionalities are less cohesive for their educational processes and students might focus more on environment features over the Intended Learning Outcomes (ILO). As a result, the transfer of e-Learning and traditional learning activities to the MUVE must consider the benefits and limitations of the new environment and must be supported by traditional learning or e-learning methods. For example, when the lectures are performed in a virtual environment, it is harder for the teacher to monitor the students’ attendance. So the lecture must be redesigned to be more interactive and to require students’ feedback. Similarly, when designing students’ assessment activities, the teacher must have in mind that students can have access to the web and other resources during the assessment.

### 3. Technological solution

The working example in our study was the design of a platform for learning Physical Sciences. For this reason, we developed “Physical Sciences Virtual Classroom” which is a hybrid electronic environment that combines Moodle and Second Life. We designed 3 courses, entitled “Brewing”, “Health and Nutrition”, “Coulomb’s Law” and “Solar System” for the science of Chemistry, Physics and Astronomy respectively. The courses have been designed in order to allow students of different of ages and without prior knowledge to attend them.

The pillars of our platform were Moodle and Second Life. The bridge between the two was Sloodle, an open source module, designed for this purpose.

**Moodle** (Modular Object - Oriented Dynamic – or Developmental - Learning Environment) is a Course Management System which has been designed to support virtual communities that capitalize

on social constructive learning. Its main characteristics are: a) Modularity, which based on a large collection of independent pieces of code (modules) which support the learning process, b) Object Orientation, by capitalizing on the use and re-usability of learning objects, c) Dynamic, since Moodle is a continuously evolving platform. The most important advantage of Moodle, is that it can be accessed through a web browser and needs no additional software to be installed in the students’ or teachers’ computers. In its current deployment, our “Physical Sciences Virtual Classroom” runs over Moodle 1.9.7, which has been installed over a LAMP web server installation (active URL: <http://www.medialab.edu.gr/dk/vclass/>). The default set of Moodle plugins has been extended with a calendar and an online text chat.

**Second Life** (Lybeck et al., 2011) is a 3D virtual environment, which is based on the typical client-server architecture, it provides a model of the real world, with accurate simulation of physics including a meteorological and gravitational system; as such, anything can be modeled and simulated. The virtual classroom of our community has been created from scratch. A slide projector and a multimedia screen have been added, as well as sitting desks for every student. A virtual brewery and a planetarium that have been employed in our virtual visits have been created by members of the Second Life community.

**Sloodle** (Simulation Linked Object Oriented Dynamic Learning Environment) is a Moodle add-on which facilitates data transfer between Moodle and Second Life platforms. Sloodle aims to bring improved learning support to 3D multi-user virtual environments through integration with web-based virtual learning environments (Livingstone & Bloomfield, 2010). It provides a variety of tools for supporting learning contexts in immersive virtual environments. The administrator of the community can simply activate or deactivate a tool in the options of Sloodle Controller. From this same controller, the administrator is able to add the virtual objects in the Second Life classroom. All the necessary configurations for linking objects between the two platforms are automatically adjusted.

Our platform comprises several synchronous and asynchronous e-learning tools and combines the merits of the 3D virtual environment of Second Life, which offers visualization of objects, synchronous voice and chat, virtual participation via avatars etc. with those of the popular e-learning community platform Moodle, which offers several synchronous and asynchronous tools for teacher and student communication

and facilitation, presentation, apprehension and assessment of acquired knowledge. Sloodle allowed us to seemingly integrate the virtual world and the e-learning platform in a homogeneous environment. The result of this platform merging, as shown in the analysis of a survey performed among the community members, is that attendants had most of the facilities that exist in a real-world classroom, whilst they stayed at home. Moreover, they had access to online resources and other facilities which are typically available only in asynchronous, web-based, e-learning environments.

## 4. Course management

Every student and teacher was able to connect to the LMS and apply for a login account. After approval, users are able to login to the platform, customize their profile, communicate with each other using private messages, and access the online text chat and the asynchronous forum. They can also download and study the educational material, answer quizzes or view their performance in courses. Depending on their roles (teacher, student, course creator, administrator and visitor) users have access to specific parts of the online content, activities and course administration tools.

The LMS was the main entrance point to the courses, the reading material and the online lectures performed in the MUVE. Participants joined the virtual learning community from their places by login to the LMS and from there they could either browse the reading material or teleport to the MUVE (see Figure 1). The two platforms (Second Life and Moodle) have been adjusted in order to exchange necessary data and provide links

between each other, thus creating a seemingly homogeneous learning environment for the attendants. Students were able to easily switch between the MUVE and the text based e-class environment and attend the various activities in their preferable platform.

## Online lectures

The lectures, were given only inside the MUVE, but all interactions were recorded and made available through the LMS afterwards. In a predefined meeting time and point in Second Life, the teacher and a technical assistant were waiting for students outside the virtual classroom. The students could either login to Second Life and teleport to the virtual classroom, or login to Moodle and then teleport to the meeting point by clicking the appropriate link. They used voice, text chat (which was common in SL and Moodle) and private messaging in order to welcome students and facilitate them in their first steps in the virtual world. Inside the virtual classroom, students sat at their virtual desks, from where they could see the virtual whiteboards and listen to their teacher (see Figure 2). The main whiteboard was used for projecting the presentation slides. A secondary whiteboard allowed the teacher to project videos and images or to display an interactive web browser. During the lecture, both teacher and students were able to communicate with voice (public) and text chat (public or private).



Figure 1. Moodle welcome screen



Figure 2. The virtual classroom in Second Life (from the technical assistant point of view)

## Educational visits

After each lecture, students were teleported to a different virtual room, related to the lecture topic. For example, the first visit was on a virtual brewery (see Figure 3), where students had the chance to view the different stages of beer production from malting to fermentation, examine 3D virtual replicas of all the devices, click on items, read or listen to recorded info and search for the next item in the process. The teacher and the technical assistant was there to assist them in every step, or to answer questions that relate to the course subject. A virtual beer was waiting the students who managed to pass through the whole brewing process. Depending on each student's decisions during the brewing process, a different type of beer was created.

## Students' evaluation

After the virtual excursion, students were able to return to the virtual classroom and answer an online test. The questions (multiple choice questions or correct/incorrect statements)



Figure 3. A visit to the virtual brewery

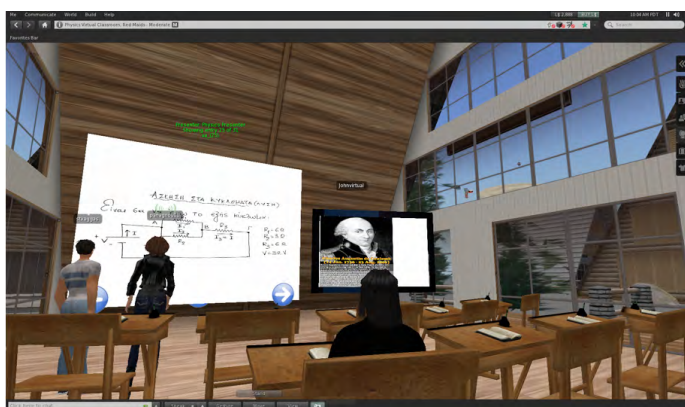


Figure 4. The student is solving problems on the class' virtual blackboard



Figure 5. The outside of the virtual classroom

covered both the online lecture and the information provided during the visit. The test was accessible both through Second Life or Moodle and was available for another 24 hours after the end of the course in order to facilitate students that needed to access the reading material. In some courses, the test was replaced by problem solving in the interactive virtual blackboard of the class (see Figure 4).

For the courses we employed the following tools (see Figure 2 and Figure 5):

- **RegEnrol Booth:** A virtual booth in Second Life, where users can link their SL avatar to their user profile in Moodle with a simple click. After this registration process, any actions in the virtual world are mapped to the respective Moodle tools (e.g. chat, answering a test, getting a grade in a course etc.).
- **Sloodle Presenter:** The virtual whiteboard where the course slides are projected. The presentation has been created by the teacher and uploaded in Moodle.
- **Web intercom:** This tool allowed the connection between Moodle's and Second Life text chat services, thus creating a common real-time chat room accessible from both platforms. Students can choose in which one to be or connect at both. Plus it saves the chat logs in Moodle database.
- **Quiz Chair:** At the end of each lecture, students sit in the Quiz Chair and answer the questions. A correct answer moves the virtual chair to a higher level, whereas wrong answers lower the chair. As a result, a series of successful answers will elevate the above his classmates.

## 5. Evaluation

At the end of the first course, all students were asked to evaluate various parameters of the course and the platforms by completing a questionnaire, which combined questions found in the bibliography in related projects that evaluate LMSs and MUVEs in education. The aim of the questionnaire was to examine the users' perception of the virtual course and the linked platforms. Questions aimed to evaluate the educational value of the virtual course and its psychosocial effects and to identify usability and technical problems.

### 5.1 Pedagogical evaluation

The results presented in Figure 7 showed that the majority of the students were excited by the idea to participate in a virtual online course in a MUVE. Almost all found the course very or extremely interesting and understandable. They also liked the idea of 3D simulation and found it very helpful in understanding the brewing process. In comparison to a course in real a class, the opinions were contradicting. According to the negative opinions: the virtual course was not able to replace the immediate contact with the teacher, it was difficult for the teacher to interact with students and make them more active, students' attention can be easily distracted since they are sitting in their own places and the tutor is unaware of it. The MUVE provides a good simulation of the real class environment, since it gives the ability to the teacher to use an avatar and his/her own voice during the presentation and the same holds for students. On the other side, the distraction of students' attention in modern classrooms or computer labs is a reality (Barkhuus 2005, Fried 2008) and virtual classrooms cannot avoid this fact. However, a shorter lecture and more interactive

activities that encourage student creativity can keep students' attention in a high level.

### 5.2 Psychosocial evaluation

The results of the evaluation of the psychosocial aspect (see Figure 8) show that most of the students had the feeling of presence inside the virtual space. Most of the students felt safe and confident inside the virtual place, although most of them have never met their classmates before in the real or virtual world.

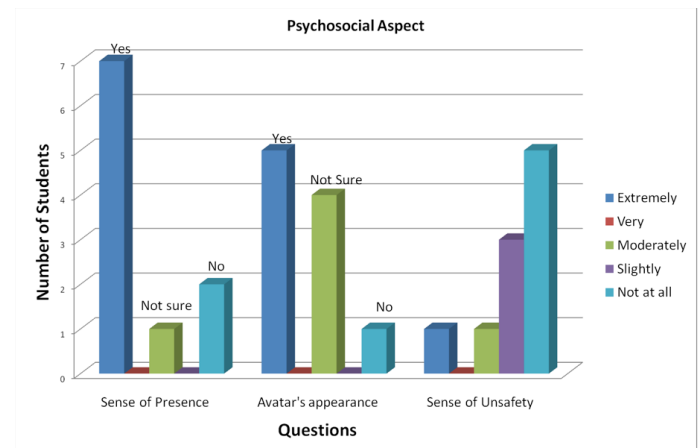


Figure 8. Results on the psychosocial aspect

Four out of ten students had never used Second Life before. Three of them felt a little unsafe from being together with people they had not met before in real life. Despite the fact that the remaining six students had used Second Life a few times, two of them felt a little unsafe in the virtual world. One student said that during his stay in the virtual space he felt he could easily lose touch with reality.

All students pointed out that they would like to use Second Life or another virtual world in the future. Half of them would do it for a learning process, three for gaming and two for meeting new people and socializing.

### 5.3 Technical – Functional Evaluation

Almost all students logged on easily to the virtual world and most of them were happy from their navigation in the virtual world (see Figure 9). The majority of the students feel comfortable to use the platform in the future without the aid of the teacher or a technical assistant. However, one student stated it would be too difficult for her.

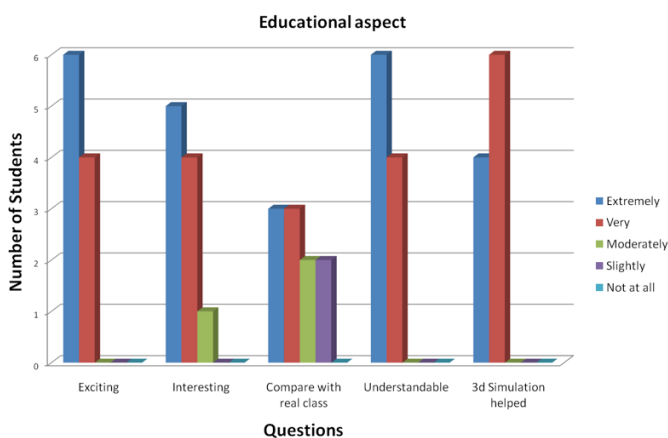


Figure 7. Results on the educational aspect



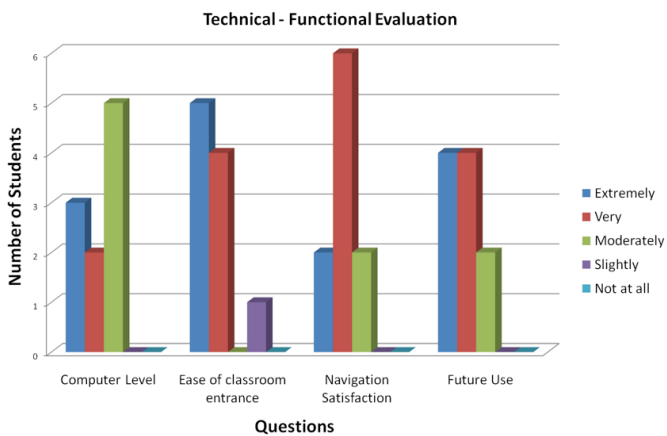


Figure 9. Results on the technical aspect

Despite the overall satisfaction, students faced several technical difficulties during the lesson, which were mainly due to their limited technical experience, and to insufficient equipments.

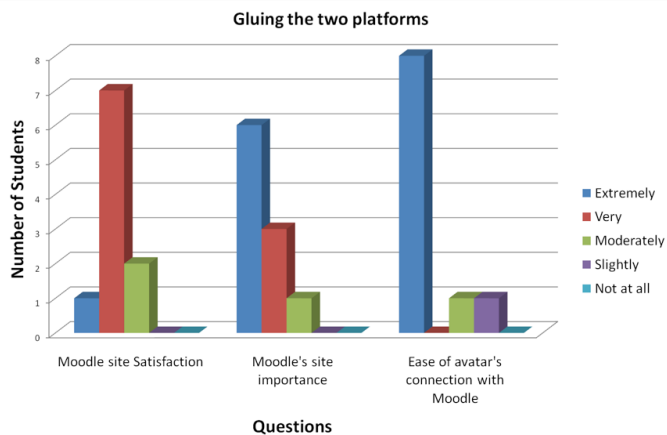


Figure 10. The evaluation of platform merging

Communicating with others in virtual worlds requires a certain skill in multi-tasking which is not necessary in the 'real world' (Edirisingha et al., 2009). A student should be simultaneously participating in public and private text discussions, using voice, observing what is happening on the screen and moving his/her avatar to indicate body language. They also should be able to switch within the two platforms, or to search the internet for context relevant to the course (as happened in the "Solar System" course). Dumitrica and Gaden (2009) note the importance of technical skill on determining the range of choices for identity. Highly customized avatars experience more interaction (Petraou, 2010), so students need to be technically skilled in customization in order to fully participate and have presence within the learning community. There is a steep learning curve and difficulty in virtual setting navigation by users

inexperienced in 3D computer games (Jarmon et al., 2009). In De Lucia et al. (2009) SL ranked lowest in terms of usefulness, ease-of-use, team attitude, and perceived team attitude, when compared with: email, forums, video conferencing, and MSN. In addition, SL requires a high level of technical infra-structure in terms of broadband access, network speed, graphics capability and processing speed on individual computers. In order to offer equitable access to the virtual learning community, technical support is necessary. Technological support staff should be available to facilitate applications, assist in development of virtual learning environments, and support teacher/learner needs (Meggs et al., 2011). Using the platform is easier for those who study computing-related careers, for the rest, if the difficulties not addressed in a correct way, can result in demotivation (Beltran et al., 2012). Along with the basic technical skills training to help learners customize avatars and navigate, learners also need to explore both the features of the 3D virtual environment and Moodle's features as well.

As far as it concerns the Moodle site, students were satisfied overall. The majority of them found it easy to connect their Moodle profiles to their Second Life avatars and stated the presence of the two-dimensional platform is important (see Figure 10). The tools and educational content were found necessary. Finally, they reported that a two-dimensional platform strengthens the sense of safety that weakens inside the virtual world. All students agreed the Moodle platform was integral in facilitating easy access to the subject matter, news, announcements, tests and grades. One person mentioned that the Moodle platform was necessary because it offers quick access to content and is closer to what most people are familiar with, while another stated it can provide a good introduction and acquaintance with the object of study, plus an easy transportation to the virtual classroom by means of a simple click.

## 6. Lessons learned

In order to improve the quality of the courses offered through our platform, we asked our attendants for feedback. Based on their comments on the first course, we tried to modify the educational strategy and adapt it to the specific features of the platform. An important comment in the first course was that the virtual environment allowed students to "hide" behind the virtual avatar, to move away from their computers without the teacher being aware of it. In order to improve interaction and keep student awareness high, the teacher of the second session

frequently checked the virtual presence of students, by asking questions or setting small quizzes.

We also shortened the length of the next lectures and tried to include more interactive activities. For example, in “Planets and the Solar System” course the students were asked to pick a planet or a moon in the virtual planetarium movement (See Figure 6) and instantly they transported to the planet’s Wikipedia page, where they could read information about that particular celestial object. The teacher asked the students to look for information regarding the temperature of the planet or moon each had chosen, while assisting them to convert the temperature from the Kelvin to the Celsius scale. Communication through voice chat was ongoing while the students searched for the information online. Upon their return to the classroom, each student reported the temperature of the celestial object he had chosen, along with other info that had made an impression on him. The teacher solved any questions the students had, regarding the lesson in particular or the universe in general.

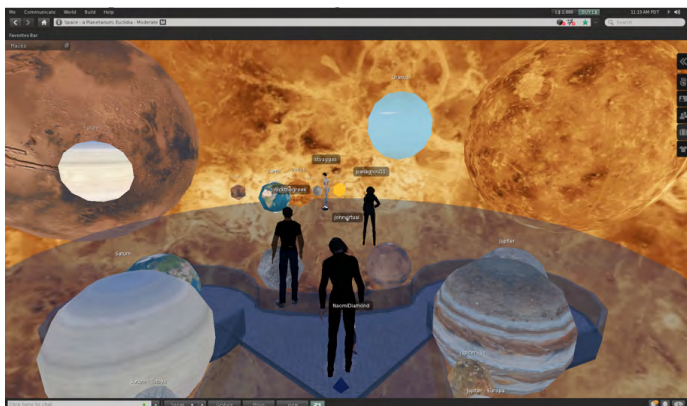


Figure 6. A visit to the virtual planetarium

Another interesting feature of our community is that members exchange roles from one course to the other. The teachers are not professional educators but rather community members that want to share their knowledge with other members. As a result, they learn to use the capabilities of the LMS and the MUVE both as teachers and students and in the same time they improve their teaching skills through collaboration with other community members. An analysis of the results from a survey that took place at Korea National University of Education (Cheong, 2010) concluded that the practice sessions influenced the participants (pre-service teachers) to improve their teaching efficacy. Teachers’ self-efficacy has been defined as a belief on their ability to influence students’ learning. The survey suggested

that pre-service teachers can gain valuable teaching practice in Second Life, and furthermore that collaborative practice teaching is more effective way than individual approaches to practicing teaching. Observing others’ successful teaching could strengthen the pre-service teachers’ own efficacy.

## 7. Conclusions

This paper examined the feasibility of transferring the blended learning model completely online by combining the strengths of a MUVE and an LMS. The platform we developed allows the community members to perform every learning activity, from virtual lectures to exams and assignments, online. The goal of this platform is to support both the rich sense of place and social community that exists in 3D virtual environments while continuing to provide access to learning activities and learning management tools that are provided by modern web-based VLEs. The 3D virtual environment, since is built by the users, can be adapted according with needs of a specific teacher, subject or group of students. Real-time collaboration and cooperation ally to the several connections that can be established from in-world with Moodle also gives several possibilities for learning contexts. Everything can be built, modeled, emulated and simulated – all education areas can be covered and any subject can be delivered with the help of a 3D immersive virtual environment (Loureiro & Bettencourt, 2011).

The first experiences of users from this unified platform are positive and show that users prefer to use LMS because of its simplicity and speed of access, but are also attracted from the virtual environment, the interactivity and 3D visualization it offers. The next step of our work is to evaluate the platform in more courses and learning communities’ cases and adapt this totally virtual experience to the needs of blended learning.

Since in our example students voluntarily join the community, we implicitly assume that they are positively positioned against technology. However, in the general case the technology acceptance model (TAM) is necessary to explore students’ intention to participate. Recently, Chow et al (2012) have introduced an extension of TAM for Second Life and is on our next plans to apply this extension to our students. Since our learning community fits well to the Community of Inquiry framework, it is on our plans to adopt a Col framework survey instrument (McKerlich and Anderson, 2008), in order to observe the existence of cognitive, social and teaching presence in our online blended learning model.

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## The Maker Movement. Implications of new digital gadgets, fabrication tools and spaces for creative learning and teaching

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The “Maker Movement” deals with innovative forms of production and do-it-yourself work. It is not only a way for new business models and developments, e.g. using 3D print or other new digital tools and gizmos, but also influencing education. This paper introduces several diverse terms (from FabLabs to Hackerspaces) and gives insights into background, practice and existing experiences from Maker Movement in educational settings amongst all age groups. As a conclusion, the authors present reasons why practitioners and researcher should consider its educational potential. Besides its creative and technological impacts, learning by making is an important component of problem-solving and relating educational content to the real world. Besides this, digital tools for making are not expensive, for example apps for mobile devices or rents for 3D printer (compared with desktops in 1:1 settings). The Maker Movement is seen as an inspiring and creative way to deal with our world, it is aware of ecological challenges and of course, and it is able to develop technological interest and competences casually. Finally, the authors give recommendation for reading for all who got interested in making.

### Tags

3D print, maker movement,  
hackerspaces, innovation,  
creativity

### 1. Exploring new trends in education: The Maker Movement

As innovative educators and researchers, it is important to be up-to-date on current trends and developments and how they might impact education. In higher education, a popular resource for e-learning trends and future developments is the New Media Consortium’s (NMC) Horizon report (e.g. Johnson et al., 2012) that is released yearly. Based on data collected from professionals in the field, the report focuses on the potential wide-range adoption of technologies currently used for learning within the next few years. Another popular resource, The Innovating Pedagogy report (Sharples et al., 2013) from the Open University in the UK views trends and future developments more broadly to include new trends and future (un-invented) technologies. Grounded in new educational terms, theories and practices, it proposes ten innovations that “have not yet had a profound influence on education,” but “have the potential to provoke major shifts in educational practice, particularly in post-school education” (Sharples, et al., 2013, p. 3). One of the innovations listed in the 2013 Innovative Pedagogy report is “maker culture” with the subtitle “learning by making” that “encourages novel applications of technologies, and the exploration of intersections between traditionally separate domains and ways of work” (Sharples et al., 2013, p. 33). The Maker Movement was already named a top ed-tech (educational technology) trend in 2012 by hackeducation.com (posting from November; see Watters, 2012). Its potential for education has been avidly discussed on several websites and discussion forums, where some see it as the next revolution in education, using statements such as “The next revolution in education

will be made, not televised.<sup>41</sup> This article attempts to answer the question: What is the “Maker Movement” and what are its influences and its (potential) impact on learning and education? Given the possible impact of this trend on education, the aim of this contribution is to provide a broad introduction to the issue and discuss its likely influence on education as a first step to initiate discussion of this (potential future) trend.

Within this article we will a) introduce the Maker Movement and its elements b) describe how it relates to other developments in the history of education c) provide examples of how it has been adapted and has influenced learning spaces or educational settings d) review existing literature on this new phenomenon, and e) discuss the implications for learning and teaching with respect to why educators, learning organisations as well as researchers should be aware of these new developments. A scientific in-depth analysis of the status quo is not possible in this article as we were not able to find any existing comprehensive work that brings together these related strands, stories and existing work within the new field. Due to the newness of this phenomenon, we also reviewed sources such as Wikipedia, other Web sources and reports on current developments, whose validity might be a point of contention. It is also possible that despite our efforts, we have missed some existing literature or part of the puzzle. Nevertheless, we hope this contribution is a helpful step forward to provide a robust overview of these new developments and their significance for educators.

## 2. The Maker Movement: Internet of Things, its adoption through makers and their key ideas

The idea behind the Maker Movement is to create and develop new things (concrete or digital) using new tools such as 3D printer in open spaces, work shops or labs (Anderson, 2012). It combines innovative forms of productions and do-it-yourself work. Even if not everything and every action amongst makers is digitally driven, making deeply builds on the development of the “Internet of Things” (IoT). Small computers or digital devices and tools, which are connected via the Internet, are built and used to create or produce new products. Some examples for this are: to sew fancy interactive clothes, to develop new user interactions with the Internet using RFID chips (for example to send an e-mail if a key is hung up at home), or to construct a robot which is able to clean one’s own flat. Making in this

<sup>41</sup> <http://www.techlearning.com/features/0039/meet-the-makers/54261#sthash.XT9Z5nj5.dpuf> (2014-04-04)

context does not just focus on IoT and uses a fusion of the digital and physical world as well as traditional tools.

In the “Maker Movement Manifesto”, Mark Hatch (2013) identifies the following nine principles for the Maker Movement:

- **“MAKE** – Making is fundamental to what it means to be a human. We must make, create, and express ourselves to feel whole. [...]
- **SHARE** – Sharing what you have made and what you know about making with others is the method by which a maker’s feeling of wholeness is achieved. [...]
- **GIVE** – There are a few things more selfless and satisfying than giving away something you have made.[...]
- **LEARN** – You must learn to make. You must always seek to learn about your making [...]
- **TOOL UP** – You must have access to the right tools for the project at hand. Invest in and develop local access to the tools you need to do the making you want to do.[...]
- **PLAY** – Be playful with what you are making, and you will be surprised, excited, and proud of what you discover.
- **PARTICIPATE** – Join the Maker Movement and reach out to those around you who are discovering the joy of making. [...]
- **SUPPORT** – This is a movement, and it requires emotional, intellectual, financial, political, and institutional support. The best hope for improving the world is us, and we are responsible for making a better future.
- **CHANGE** – Embrace the change that will naturally occur as you go through the maker journey. [...]” (pp. 1 ff).

According to Hatch (2013), his manifesto is only an initial sketch. He writes, “In the spirit of making, I strongly suggest that you take this manifesto, make changes to it, and make it your own. That is the point of making” (p. 2).

Social movements do not normally originate from one point or one man’s idea, but take place as multiple sub-developments in different ways. This is also true of the Maker Movement that has evolved in multiple forms such as public studios and laboratories where people are able to make something (sometimes for a small fee) and these forms have received different names. Specific terms and hubs for the Maker Movement such as the FabLab initiative in MIT, hackerspaces and makerspaces are explained later in this section. On the one hand, these terms are sometimes used synonymously with each other, and on the other, fundamental differences between their concepts (concerning business model; non-profit vs. commercial) and

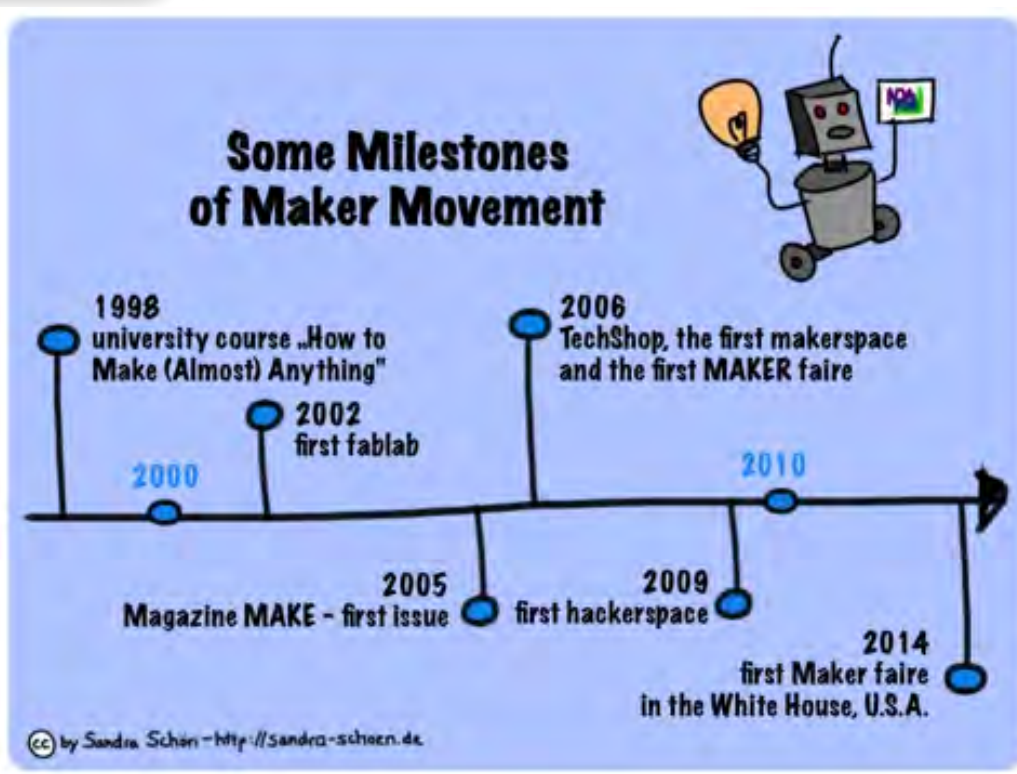


Figure 1: Some Milestones of Maker Movement

main activities (fabrication, programming, and the role of digital tools) have been highlighted. Some readers may hesitate to accept the term “Maker Movement” because they might consider it an exaggeration for a recent development to be equated to a social movement. Using existing definitions and theories, Walter-Herrmann (2013) confirmed that the FabLab movement is a social movement, and we consider the FabLab as a part of the Maker Movement. Although all the different terms and definitions that fall under the Maker Movement do not have a “corporate identity” and are not always viewed as belonging together, and some might not regard the Maker Movement as a social movement, it is used as a heuristic term in this paper. The following paragraphs describe some of the different terms, movements and hubs that make up the Maker Movement (Figure 1).

## The Fablab

The motto of the MIT Fab Lab (short for “fabrication laboratory”) project is “Give ordinary people the right tools, and they will design and build the most extraordinary things.”<sup>2</sup>. The project originated in 2001 at the Center for Bits and Atoms at the Media Center of the Massachusetts Institute of Technology under

<sup>2</sup> <http://www.fablabdc.org/about/history/> (2014-04-07)

Neil Gershenfeld, the author of the book “Fab, The Coming Revolution on Your Desktop - From Personal Computers to Personal Fabrication” (Gershenfeld, 2005). Fablabs “provide access to prototype tools for personal fabrication” such as a 3D printer or laser cutter<sup>3</sup>. Following the opening of the first FabLab in MIT in 2002<sup>4</sup>, Fablabs have spread across the world from Boston to Africa and Europe. They have found application in areas such as agriculture, health or housing, and are (normally) supported by non-profit organisations or funded by communal sponsors. Examples from Europe are the OTELO initiative (“Offenes Technologielaor”, in English open technology lab, Austria non-profit organisation, <http://www.otelo.or.at/otelo/idee/>), the HappyLab (Vienna, Austria, co-financed by the Ministry and others, <http://happylab.at>) or the FabLab Munich (Germany, non-profit organisation, <http://www.fablab-muenchen.de/>). The Fab Lab foundation describes four essential features of registered FabLabs: Public access (free, at least for some time), a common set of tools, participation in the FabLab network, and they have to sign the FabLab Charta<sup>56</sup>. Currently about 280 FabLabs can be found at the foundation’s Website<sup>7</sup>.

<sup>3</sup> <http://www.fablabdc.org/about/history/> (2014-04-07)

<sup>4</sup> As mentioned by Walter-Herrmann & Büching (2013, p. 12), there are several other sources and also similar development elsewhere.

<sup>5</sup> <http://www.fabfoundation.org/fab-labs/> (2014-04-07)

<sup>6</sup> <http://fab.cba.mit.edu/about/charter/> (2014-04-08)

<sup>7</sup> <http://www.fabfoundation.org/fab-labs/> (2014-04-07)



## Maker faires

In 2005, the same year of the publication of Gershenfeld's book, a new magazine called "MAKE" was published in the U.S. MAKE is issued every two weeks and focuses on do-it-yourself projects involving computers, robotics, electronics, and other product areas. The magazine established the first Maker faire in 2006, a public and now annual event, in San Mateo Fairgrounds with over 100 exhibiting makers. "Maker faire" is a trademark, thus all events are registered and supervised by the Maker magazine. The special nature of these events has been emphasized by Watters (2012), who states, "There were plenty of other science fairs this year — including ones at the White House and at Google — but Maker Faire is fairly unique, I'd argue, in its culture, creativity, and community." By now, several Maker faires have also been hosted in Europe, for example the "European Maker Faire 2013" in Rome<sup>8</sup> or the Maker Faire 2013 in Hannover (Germany)<sup>9</sup>. Last, but not least, the White House in the U.S. plans a "maker faire" in 2014<sup>10</sup>.

## Do-it-yourself (DIY)

The new technological possibilities, grassroot-driven activities and FabLabs comes include the do-it-yourself (DIY) as a new business model. In a book titled "Makers," Anderson (2012) termed the "Maker Movement" a business development that can be likened to a new industrial revolution. The possibility of fabrication using new tools such as 3D printers by nearly everyone is a foundational part of this development. It allows inventors not only to develop a smart idea, but also to produce it. Invention, design and business go hand-in-hand, providing a lot of options for enterprising people, such as the possibility of very small businesses and low risks. According to Anderson, makers are combining do-it-yourself and manufacturing with new digital tools that he terms "digital DIY". Additionally the sharing of ideas and plans amongst the community is a unique cultural dimension of the movement that, along with fabrication, is supported by the usage of uniform standards.

## Makerspaces

Another part of the Maker Movement is the development of "makerspaces". Makerspaces are (commercial) studios equipped with digital fabrications tools such as 3D printers or laser cutters, vinyl plotter and AutoCAD software that anyone

<sup>8</sup> <http://www.makerfairerome.eu/check-out-the-program/> (2014-04-04)

<sup>9</sup> <http://makerfairehannover.com/> (2014-04-04)

<sup>10</sup> <http://www.youtube.com/watch?v=e53UPIFDH0k> (2014-04-04)

can use for a relatively small fee. The mindset of people organising and visiting such makerspaces and its workshops is described as open, friendly, supporting and creative. The CEO of the first commercial makerspace, the "TechShop" founded in 2006 in Silicon Valley, Mark Hatch describes makerspaces as "a center or workspace where like-minded people get together to make things" (2013, p. 13). Success stories from the makerspace TechShop are contained in the Maker Manifesto (2013). Making is therefore an inspiring and creative way to use modern technologies and communication tools to support the potential development of innovation with a business impact (Anderson, 2012).

## Hackerspaces

Besides "FabLabs" and "makerspaces", there are also "hackerspaces" (or "hacklab", "hackspace"). Whereas the first two terms are tend to be used synonymously and are used for public areas with digital production tools, hackerspaces have a slightly different focus. The idea of "hackerspaces" originated in Germany as an idea of the Chaos Computer Club in 2009<sup>11</sup>: Physical public meeting rooms for hackers (software developers and experts) are seen as inspiring places for open software development – and other technical applications. The first "hackerspace" was at the "c-base space station" in Berlin, Germany "a culture carbonite and a hackerspace [that] is the focal point of Berlin's thriving tech scene"<sup>12</sup>. Other popular hackerspaces are the "NYC Resistor" in New York City, USA).

In summary, the term "Maker Movement" has probably been coined based on all the above terms such as "MAKE", the MAKER faires, Anderson's (2012) book "Makers", Hatch's "Maker Movement Manifesto" and several others. It is used in several references in the educational literature. However, the term "Maker Movement" is not widely used or used by all those who describe these activities and who might prefer to still use other terms with slight differences and meanings for the activities we heuristically describe as part of the "Maker Movement" in this article. Perhaps the current phase of the Maker Movement and its bunch of terms (and definitions) is comparable with the early years of the OER (Open Educational Resource) movement, where several terms such as free open educational content, open learning resources, were used to describe the similar resources. Before people in the field came together, shared terms and resources, and the phenomenon was

<sup>11</sup> See Wikipedia, [http://de.wikipedia.org/wiki/Hackerspace#cite\\_note-1](http://de.wikipedia.org/wiki/Hackerspace#cite_note-1) (2014-04-04)

<sup>12</sup> <http://bergie.iki.fi/blog/ingress-table/> (2014-04-14)

more widely acknowledged, several terms were used by people in different parts of the world or the field. This also means that a term other than “Maker Movement” could get more popular in the future, but understandably, we are unable to foresee it. Before we describe how the Maker Movement and its tools are influencing educational and learning environments, we would like to explore the history of this movement in education.

### 3. Roots and references of the development in education: Constructionism

The construction of knowledge using physical artefacts and the usage of technologies to invent or engineer is not new in education. In this section we trace the roots of the Maker Movement to other developments in the history of education (see figure 2). Reformist and progressive educators from the first half of the 20th century such as Maria Montessori, Friedrich Fröbel, Johann Heinrich Pestalozzi, Célestin Freinet and John Dewey promoted the usage of physical artefacts and tools in education. All of them viewed “the prospect of child development in the fact that he/she constructs knowledge by him/herself through physically manipulating his/her environment” (Schelhowe, 2013, p. 95). Montessori emphasized the use of all the senses in learning, while John Dewey was a strong proponent of learning

by doing, who emphasized two-way learning interactions between learners and their environments, stating that learning should entail “participation in something inherently worthwhile” and a perception of the “relation of means to consequences” (1926, in Archambault, 1964, p. 150).

Building on Jean Piaget’s view of learners constructing knowledge by interacting with their environment, Seymour Papert proposed constructionism or “learning-by-making” (Papert & Harel, 1991, p. 1) where learners would use tools to make things in order to construct knowledge. Providing the example of children creating soap sculptures in art class, that “allowed time to think, to dream, to gaze, to get a new idea and try it and drop it or persist, time to talk, to see other people’s work and their reaction,” (Papert & Harel, 1991, p. 1) Papert describes constructionism as a means to learn “in a context where the learner is consciously engaged in constructing a public entity, whether it’s a sand castle on the beach or a theory of the universe” (Papert & Harel, 1991, p. 1). According to Papert, Logo, a language he developed in 1960 enabled students to use “this high-tech and actively computational material as an expressive medium; the content came from their imaginations as freely as what the others expressed in soap” (Papert & Harel, p.2). Papert’s seminal work “Mindstorms” that describes

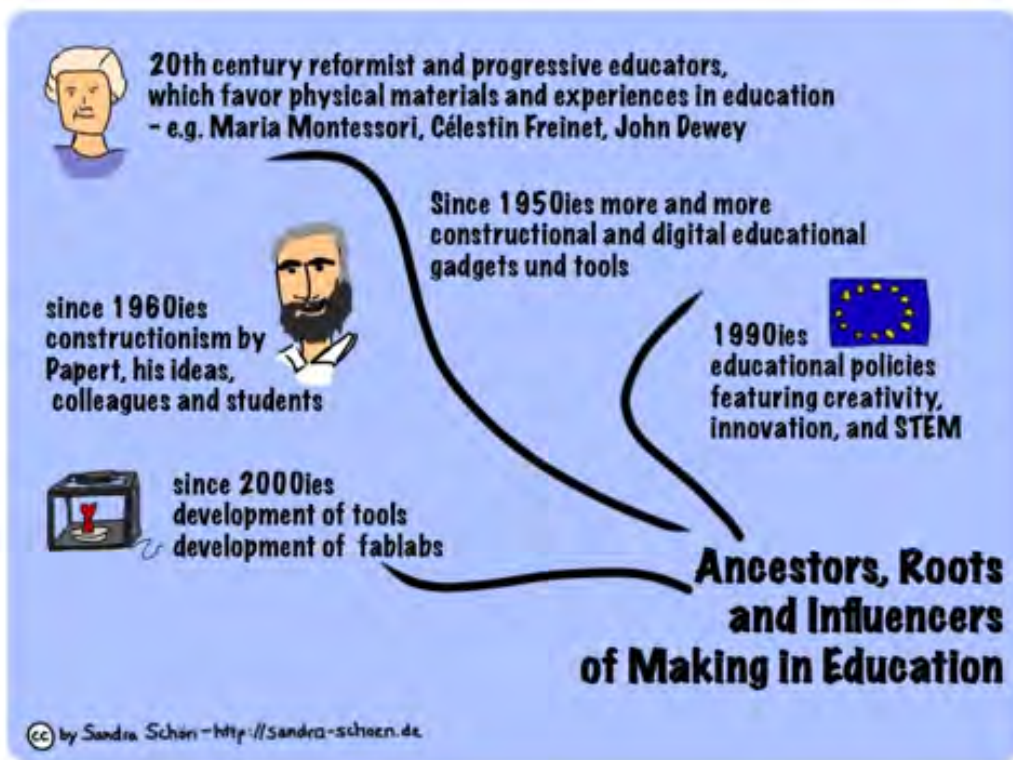


Figure 2: Ancestors, roots and influences of making in education

a microcosmos for children as a computer based learning environment (Papert, 1980) and innovative projects at MIT such as the Constructionist Learning Lab (Stager, 2006) have greatly influenced present learning environments for makers. Papert describes eight main ideas of his Constructionist Learning Lab as: “learning by doing”, “technology as building material”, “big idea is hard fun”, “learning to learn”, “taking time – the proper time for the job”, “you can’t get it right without getting it wrong”, “do not unto ourselves what we do unto our students”, and “we are entering a digital world where knowing about technologies is as important as reading and writing” (Martinez & Stager, 2013, p. 73f).

Interestingly, the idea of “engineering for children” was often focussed on boys in the 1940ies to 60ies, whereas the education focus of “making” for girls was on cooking, tinkering and household. Small wooden blocks are probably the first developed materials for children to build, construct and engineer a small new world. The development of small plastic blocks by the Swedish enterprise LEGO (1949/1958) are the modern popular plastic variant of such educational engineering materials. Probably the first construction kit for radio technology was offered in 1950 by KOSMOS. Other examples of development toys for children are the construction toy “Fischertechnik” available since 1965 that enables the building of small machines in children’s rooms or classrooms. Digital technologies have also played a role in educational toys for engineering since the introduction of the LEGO Mindstorms series at the end of the 1990ies. This construction kit allows children to built robots and machines with a programmable brick computer, sensors and motors. It is available since 1998 and builds on prototypes developed by the MIT Media Lab.

While several of educational tools were developed in conjunction with the educational theories discussed above, not all educational tools and learning spaces related to the Maker Movement might be directly derived from them. Besides the Maker Movement and constructionist traditions, technologies have been used as digital tools for creating or learning in several other settings that are influenced by other reasons, aims and theoretical backgrounds, which are too diverse to review in this article that is focused on the Maker Movement. For example, science fairs are similar to maker faires, but focus on fostering interest in science and sciences activities. Another example are science museums or universities that have labs or workshops for children to arouse interest and provide interactions in science. Other activities, such as programming sessions for kids,

aim to foster well-defined competences, for example software developing skills. Further reasons to use technologies and digital tools in learning are the development of media skills, communication skills, creativity and civic participation.

## 4. Exemplars of Educational Application from the Maker Movement

Within our paper we use the term “making” as related to new forms of relative simple ways to fabricate real or digital things with digital tools, including fabrication, physical computing and programming (see Martinez & Stager, 2013). Building on how “making” is a result of several developments and theories in the history of education, in this section we review some exemplary educational tools, learning spaces and educational settings that we consider representative of the Maker Movement. We start with short introductions to tools that are explicitly built



Figure 3: Digital Tools for Making in Education

to initiate and foster creative engineering and application in children and adults (see figure 3).

### Physical Computing

Physical computing<sup>13</sup> encompasses several digital tools such as sensors or micro controllers that are used to control systems, regulate motors and other hardware or to make analog signals available for computer software. In recent years, the “MakeyMakey kit”<sup>14</sup> developed by students of the Media Lab

<sup>13</sup> See [http://de.wikipedia.org/wiki/Physical\\_Computing](http://de.wikipedia.org/wiki/Physical_Computing) (2014-04-04)

<sup>14</sup> <http://www.makeymakey.com/> (2014-04-04)

at the MIT has gained a lot of attention. The kit was developed to create and invent new forms of inputs for a computer. The very simple usage makes it possible to use bananas as input keys of a laptop or putty as a joystick (at least as input device for the arrows). Additionally, Arduino<sup>15</sup> and Raspberry<sup>16</sup> Pi hardware kits are comparatively simple hardware devices that are programmable with relatively simple developer knowledge. “Lillypads” is a special hardware kit used for clothes, for example, it is now possible to design a dress that blinks according to the bass within a dance hall. Robotics kits such as Lego Mindstorms<sup>17</sup> that enable the creation of robots, which can perform different activities, also belong in this category.

### Programming Tools

Several educational programming tools are available that have been specially developed for children. Etoys, directly influenced by constructionism and Logo, enables the programming of virtual entities and their behaviours. It was followed by the development of programming language Scratch<sup>18</sup>, a multimedia authoring tool popular in educational settings for both children and adults, by the MIT Media Lab’s Lifelong Kindergarten group. Over 400,000 Scratch projects have been created in the last decade and are shared in a Web-based community platform using a Creative Commons license that allows users to re-mix parts of projects to new products. A further example of an educational Java-based programming tool that enables community sharing is GreenFoot, which older students can use to build interactive games and simulations. As hackerspaces focus on software development and open source software, an open movement for coding by children has emerged, called „Coder Dojo“ and driven by the idea „We want every child to have the opportunity to learn how to code which is why the movement is Open Source“<sup>19</sup>.

### Fabrication Tools

Although fabrication tools are used and adapted for educational settings, it appears that that special educational adaptations of these tools are not yet available. Special 3D printers for children as toys are currently a future vision that might be a possibility according to reports about a partnership of Hasbro

and 3D systems<sup>20</sup>. Although it seems to be possible to construct a 3D printer with Lego Mindstorms<sup>21</sup>, a special 3D printer for educational purposes is not yet available.

### North American experiences with making with kids

Martinez and Stager offer four possibilities of using materials for making in educational settings: “1. Specific concept. Use the materials to teach a specific concept, such as gears, friction, or multiplication of fractions. 2. Thematic project. Visit a local factory, amusement park, airport, construction site, etc. and construct a model of it. Design a set for our medieval carnival. 3. Curricular theme. Identify a problem in Sub-Saharan Africa and build a machine to solve this problem. 4. Freestyle. The materials become part of your toolbox and may be used when you see it. This choice of media or medium requires student to develop technological fluency (p. 65).”

In the USA, makerspaces for kids exist in various learning environments, namely, in-school, after school, home-based, homeschooling and museum-based (Young Makers, 2012). An example of a makerspace within schools is the MENTOR program in 2012 that piloted ten low-cost makerspaces in California high schools. By 2016, MENTOR aims to have more than thousand makerspaces installed in high schools (Watters, 2012). A special makerspace for kids located in Toronto (CA) that is described by Jennifer Turliuk, Co-executive and “Chief Happiness Officer” as follows:

“The first element is a dedicated space where kids know that they can be safe, be creative, and have autonomy, and we’ve seen that they really take ownership and do things like tell other kids to clean up after themselves or to act more safely with tools, which I haven’t seen elsewhere. Secondly, we have real tools — we give kids the ability to use soldering irons, saws, glue guns, things that are quite dangerous. If kids ask us if we can do something for them because they’re too scared or they’re not sure how, we generally say no and help them learn to do it safely and become more comfortable with it, or find another way to achieve their goals. Thirdly, process over product — we emphasize that it’s okay to fail, and we value experiential learning (learning by doing), so instead of telling them step-by-step instructions, we advise them to try and figure out how to do it themselves, ask other kids, or research it online.”<sup>22</sup>

<sup>15</sup> <http://scratch.mit.edu/> (2014-04-04)

<sup>16</sup> <http://www.raspberrypi.org/> (2014-04-04)

<sup>17</sup> <http://www.lego.com/en-us/mindstorms/?domainredir=mindstorms.lego.com> (2014-04-04)

<sup>18</sup> <http://www.lego.com/en-us/mindstorms/?domainredir=mindstorms.lego.com> (2014-04-04)

<sup>19</sup> from <http://coderdojo.com/#zoom=3&lat=48.9225&lon=-35.15625&layers=00B0T> (2014-04-04)

<sup>20</sup> <http://www.theguardian.com/technology/2014/feb/17/hasbro-3d-printing-children-kids> (2014-04-04)

<sup>21</sup> A tutorial: <http://www.instructables.com/id/LEGO-bot-3d-printer/> (2014-04-04)

<sup>22</sup> <http://makezine.com/magazine/how-to-remake-the-world-by-making-with-kids/> (2014-04-04)

## Developments specific to Europe

Two main forms of maker-like learning spaces and the usage of such tools in learning settings in Europe are workshops in and outside of schools. These workshops are driven by the need to foster STEM knowledge and skills at an early age. For several years now, workshops focusing on robotics, electronics or similar areas use technologies to increase interest and skills in technologies, development, and engineering. Typically, such workshops are offered as “research centers for pupils”. For example, such workshops for children were held in Bremen in 2008<sup>23</sup>: “Sports and technologies” (for children between 9 and 13 years), “mobile robots” (for children from 11 to 15 years) and “humanoid robots” (for children between 13 and 17 years). Workshops for children (and adults) within the FabLabs and makerspaces in different parts of Europe, mentioned earlier in this paper, also serve as excellent learning spaces that focus on showcasing certain techniques and encouraging the creation of creative and innovative products. For example the Austrian FabLab “happyfab” in Vienna offers special programs, workshops and times for children<sup>24</sup>.

## 5. The Maker Movement and education – considering its educational potential

As a conclusion of our introduction of Maker Movement and its educational adaptations, we want to summarize reasons for its educational potential. While we acknowledge that there are other forms of learning activities and educational strategies that also include relevance to the environment, creativity, and problem-solving, such as problem-based learning or project-based learning, there are several reasons why we consider the Maker Movement to be a trend relevant to educators. There are potentially diverse approaches to structure reasons for making in education. We choose the traditional didactic triangle of teacher, student and content, which is in our case a set of tools for our following description (see figure 4).

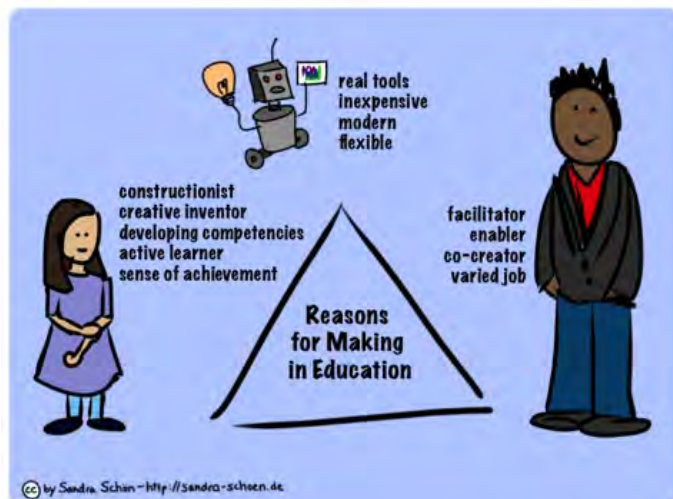


Figure 4: Reasons for Making in Education

### Maker students

We start our collection of reasons for making in education with a look at the student. Children today grow up with digital technologies (Ebner et al., 2013). Using modern digital tools is in general a way to meet their expectations and prior knowledge. Educators can exploit this familiarity with technology, students’ tendency to play with technology, and the easily availability of technology to help students create or construct products that relate to their environment. Especially maker tools and maker movement will challenge and develop their ability to construct something, and potentially to construct something new, creative and innovative. Making in education may address specific learning content, for example electronic circuits. Nevertheless, it can address a wide range of teaching goals for students. Besides STEM and technology interest, knowledge and competencies, this includes creative, innovation development, and problem solving. Maker students are active learners, with a high need to explore, to discuss and to share experiences and ideas. Also social and personal competences are to be included in our potential learning goals. In general, the skills of creating and innovating can have a broad impact on students’ lifelong learning and ultimately for education and society.

Besides this, making as constructionist activity of students is a theoretically and historically funded principle for successful learning, coined as “learning by making (doing)” (see above; Papert & Harel, 1991). With respect to learning, it helps young and old experiment with innovation, develop an open mind, be creative, compute, and problem-solve, while considering the impact of their creations on society, ecology, and the environment.

<sup>23</sup> <http://www.innovationscamp.de/workshops.php> (2014-04-05)

<sup>24</sup> <http://happyfab.at> (2014-04-05)

The construction within making leads to several products and concrete results: Students fabricate “real things” (such as a machine) or products (such as a stop motion animation). Compared with typical learning results for students in form of ranked test results and marks, this can be seen as valuable source for senses of achievement. This can be important, but is not restricted to, school underachievers. And sense of achievement might be the best, when making comes up to solve problems of the real world, and/or when teachers and parents are surprised by students’ ideas, solutions and constructions. Last, but not least, the openness of the maker movement and its Internet affinity additionally have the potential of idea sharing and co-operation in excess of classroom boarders.

### Maker teachers

Looking at the teacher in a maker setting, it is obvious that traditional teacher-centred teaching does not fit. Typically, teachers in maker settings change their role to facilitators and enablers. Making means that students themselves are active. This automatically shift teachers’ role from leading to support and tutoring. In contrast to problem solving and project tasks, where teachers are experts or at least the most experienced in the classroom, maker settings may also dangle such clear competence gaps. On the one side, students may be better or more experienced in one of diverse tools, for example the sewing machine or the mobile phone. But even more important, the openness of the setting and the creative results within this approach may lead to a situations, where the students may be better as the teachers. Co-creation, and also learning by teaching, than will not only be a (wished) mind-set, but teaching reality. This can be challenging as well as motivating and surprising for teachers. For students, it is the chance to see teachers as inspirational partners as well as models for their own learning, while watching their (better) learning and problem solving abilities.

### Maker tools and content

As a third strand we want to discuss the role of maker tools and “maker content” for education. As described, these are digital tools and facilities to fabricate and produce new products and also art work. Inherent, the do-it-yourself approach includes up-cycling and other environment friendly materials. What maker tools and materials make special from the perspective of learning and instruction is that they are real content, compared

with typical learning materials as textbooks, virtual learning environments, blackboard and so on. Maker tools are not only “theoretical” content as concrete, real action is needed to deal with them. Making deals also with theories and concepts, but more important is practice and transfer. As we mentioned in our paragraph about educational roots and ancestors, the character of maker tools and content and the related work with it has been seen as important for learning at least for several centuries of educational theorists and practice, if not for all human times. Making own experiences, making something concrete, dealing with concrete (but also “digital”) products can be seen as an elementary learning with the potential of deep learning adventures.

Although learning and education is seen as important in current times, financing issues plays a big role. Of course it might sound expensive to equip a maker space in a school for example with 3D printer, laser cutter or vinyl plotter, and several other tools and materials. Nevertheless, the making approach is neither a 1:1 setting for high-end tools, nor is it focusing only at very special disciplines and ages. Compared with other approaches for learning with technologies, especially the 1:1 desktop setting in computer classes or personal textbooks in every discipline, maker tools are inexpensive. Maker tools are of great flexibility, as they can be used for a diverse set of disciplines, learning settings, focus and learners’ ages. While making might involve the use of physical materials, it is increasingly also possible to produce virtual artefacts while “making”, as mentioned above (e.g. with Greenfoot). Digital software for making is also not very expensive, is increasingly available as open source, and can often be used on mobile devices that are becoming more usable and more popular lately. Similar to other maker tools, such maker apps on mobile devices enable children of any age to create and make and are not specialised for special ages, settings and disciplines.

Not necessarily, but an important driver to use and deal with maker tools is simple that they are modern and up-to-date. There are so many tools and application scenarios that it is simple to realise ideas that were not thinkable some years ago. This is attractive for students and makes it magic for educators: Maker tools bring the possibilities to use up-to-date technologies and innovative learning settings in classrooms. Compared with the effort to offer up-to-date learning software and hardware for computer and Internet based learning for a whole school, the usage of latest tools and developments now gets realistic.

From our perspective, these are several reasons why educators and policy makers should consider the Maker Movement and its potential in education. Of course, making in education has not only potentials, but also challenges. Inherently, several challenges might influence our sketched potentials negatively. Papert and Harel (1991) for example see a challenge in the prevalence of “instructionism” in mainstream education: The need of teachers to feel to be in control of learning environments and to lecture students, is opposed to students being able to experiment and create to learn. Besides such challenges, our list of reasons to consider making as a new form of learning and teaching for education hopefully inspires to take a deeper look into the field.

### 6. Learning from Experience: Further Resources about the Maker Movement

We would like to end this article with further resources for readers who might want to read more about the present state of the art of literature, research and further education with respect to the Maker Movement.

There are a lot of collections for maker educators that concentrate on new tools and gizmos as well as potential products or exemplary developments. Wilkinson and Petrich (2014)'s book “The Art of Tinkering” presents the products and projects of more than 150 makers “working at the intersection of art, science and technology” These include example recipes for conductive dough or how to fuse plastic for up-cycling. The book's cover itself is printed with a special ink that conducts electricity (“open up this book and discover how to hack it”).

The amount of research on selected maker issues, for example tinkering with computers, robotics in schools or programming with pupils is enormous. Selected books that make an initial contribution to the role played by “making” in education are:

- An open access book, “The Maker Club Playbook” is offered by Young Makers (2012). It is for everybody who wants to open a makerspace and includes several examples for education settings and approaches. Also for practitioners and free available is the “Makerspace Playbook” by Makerspace / Maker Media (2013). The PDF includes helpful lists from tools to funding ideas. A good help to design maker programs as activities for children, including also for example maker faires for kids, is offered with open access by New York Hall of Science (2013).

- Martinez and Stager (2013) 's “Invent to Learn” about “making, tinkering and engineering in the classroom” is meant for educators and gives insights into learning concepts, examples and the practice of making in schools. They describe the development of makerspaces in schools and also a didactical framework for its usage in the classroom.
- Honey and Kanter (2013)'s “Design. Make. Play. Growing the next generation of STEM innovators”. is meant for practitioners, policymakers, researchers and program developers and is a collection of several chapters on making, but only on games, which potentially influence and foster the STEM competences of children.
- Diverse digital tools for education are also topic of a chapter within the German speaking L3T textbook that is available as open educational resource (Zorn et al., 2013).

European educators had already started to adopt, to adapt and to share their experiences. From our point of view, especially community building and research above the diverse strands of maker activities – for example of FabLabs, hackerspaces, or coder dojos – should be brought together. As our research, especially in German speaking countries pointed out, terms and ideas of several shops and communities may have potential (and actual) maker activities for children. We would love to inspire you, besides reading and discussing, and to initiate you to be an active part of the maker movement for educational purposes. Just make it!

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## Using Augmented Reality for Science Education: Issues and Prospects

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This paper attempts to investigate potential contribution of augmented reality to the reformation of students' misconceptions regarding physical sciences. Based on its intrinsic feature of enabling ubiquitous interaction with digital information superimposed on physical objects, we argue the merit of exploiting AR technology for the development of learning experiences to facilitate visualization and thus, conceptual understanding of principles and processes of physical sciences. The study briefly introduces present research status of implementing AR for science and focuses on highlighting augmented reality features that render it particularly suitable for the development of experiences that will allow learners to envision physical processes, to give up their prior ideas and embrace scientific knowledge. Furthermore, it emphasizes on AR's affordances and limitations towards this perspective. Along these lines, learners shall be encouraged to conceptualize and interact with three-dimensional physical processes that are otherwise very difficult for them to perceive. This approach suggests the bridging of the "scientific" world with the "real" world, in a manner that learners' conceptions are likely to approach scientific knowledge.

### Tags

science misconceptions;  
science education;  
augmented reality; mobile  
learning; contextual learning;  
constructivism

### Learners' misconceptions relative to physical sciences

Children are being introduced to the world of physical sciences having already formed their own personal ideas of how the world is functioning around them, based on their own personal experiences and everyday interactions with the physical environment (Hestenes & Wells, 1992). These «alternative conceptions» or «misconceptions» about physical phenomena that people start forming since early childhood, often appear strongly inconsistent with scientific knowledge. In addition, these misconceptions are very resistant to change, at cases, even after many years of science education. This is due to the fact that learners are generally unaware that the knowledge they have is wrong whereas learning entails replacing or radically reorganizing this knowledge (Viennot, 1977; Halloun & Hestenes, 1984; Alimisis, 1994; Kokkotas, 2003).

Especially when it comes to the concepts of force and motion, both at the center of Newtonian mechanics, it has been a common belief for many years now (Halloun & Hestenes, 1985; Hestenes & Halloun, 1992) that relevant misconceptions are significantly incoordinate with scientific knowledge, while traditional teaching approaches appear inadequate to bring about significant conceptual change in student knowledge. Based on a plethora of related studies (Pope & Gilbert, 1983; Hestenes & Halloun, 1992; Hestenes & Wells, 1992) it has been confirmed that traditional teaching, having the teacher describing and interpreting physical phenomena while trying to explain related concepts and properties, does not seem adequate to produce such a change. The major difficulty appears to be the learners' reluctance to

let go of their already formed, intuitive knowledge rather than understanding and accepting the new one.

Generally, students do accept new knowledge but they tend to combine it with the old one in a way that both coexist. According to cognitive learning theories, the power of preconceptions is very significant to further learning activities, simply because the ways people observe and interpret physical events and processes, communicate or accept new information is related and built upon these, often erroneous, understandings (Viennot, 1977; Driver & Easley, 1978).

### Augmented reality (AR) research efforts for science education

As technology seeks and discovers new ways of exploiting ICT in educational programs, technology itself evolves at a fast pace. Current generation of mobile devices (smartphones, tablets) already provides users with advanced features like location awareness, internet connection anytime-anywhere, touchscreens, data recording and processing. High-tech wearable devices are currently becoming commercial, elegant, wearable gadgets, allowing for the visualization of one, or better yet, multiple digital “worlds” overlaid on top of the physical one. Furthermore, the capability of bringing a mobile device within any learning environment indicates its potential for teaching and learning objects within an authentic context.

At present, practices relevant to mobile learning are shifting towards hybrid and augmented reality systems. Several educational research groups and centers are already harnessing these technologies for learning purposes (Dunleavy & Simmons, 2014), whereas scientific research has already highlighted several strengths and privileges of AR being used in learning contexts (Dunleavy, Dede & Mitchell, 2009; Wu, Lee, Chang & Liang, 2013). It actually turns out that augmented reality possesses certain intrinsic features (Wu et al., 2013), that render it particularly appealing to be utilized in learning contexts.

As both a cognitive tool and a learning approach, augmented reality lines up well with the principles of contextual learning theory and constructivism (Dunleavy & Simmons, 2014). AR allows for the overlay of virtual, synthetic 3D objects onto the real world, in order to augment the visual perception of a system or environment. Relevant research indicates that AR is capable of positioning the learner within a physical, social, real-world context allowing for the guidance, facilitation and

building of participatory, post-cognitive learning processes like authentic research and active observation via a multi-dimensional, multiple way representation of scientific concepts and processes (Dunleavy et al., 2014). We believe that, by further exploiting these features, AR technology could potentially be used in proper approaches in order to provide three-dimensional learning contexts of collaborative learning that will allow for the conceptualization of both the visible and the invisible and will enhance the experience of the learner’s engagement and immersion, in an effort to encourage learners to give up their prior, intuitive ideas and eventually develop a scientific understanding of concepts, properties and processes relevant to physical sciences.

From a technical perspective, two types of AR experiences for learning purposes are currently being implemented: a) the location-aware type and b) the vision-based type. The former type utilizes GPS technology of the mobile device to overlay digital data on the physical environment while learners are going around a certain physical space and observe that space through the mobile device camera. Digital data (text, graphics, sound, image, 2D or 3D object models) augment the physical environment with narration, navigation and/or academic information related to the place. The latter type of AR is based on image recognition and provides the learners with augmented data only after they point their device onto a specific physical object (Dunleavy et al., 2014).

In 2006, Kerawalla, Luckin, Seljeflot και Woolard (Kerawalla et al., 2006) developed an augmented reality learning environment for teaching about earth, sun and moon in an effort to explore the potential of AR for teaching primary school science. An empirical study was conducted with 133 children aged 9 – 10 years and their teachers from five London schools, focusing on the AR learning outcomes compared to those of more traditional teaching methods. According to the project’s findings, teachers were positive about the potential benefits of AR for teaching subjects such as earth, sun and moon and indicated that such an approach is capable of “bringing to life” learning subjects of similar type (Kerawalla et al., 2006).

In addition, design considerations were formulated and proposed, to be taken into account while developing AR experiences for learning purposes within an inquiry based learning context: flexible content, adaptable to the learners’ needs, guided exploration so that learning opportunities can

be maximized, in a limited time, and attention to the needs of institutional and curricular requirements.

In much the same spirit, the «Learning Physics through Play» program, supported by a grant from the National Science Foundation, engaged 6–8 year old students in a series of scientific investigations of Newtonian force and motion including a set of augmented reality activities (Enyedy, Danish, Delacruz & Kumar, 2012). This project illustrated some of the strengths and benefits of using AR for scientific inquiry and suggested that using augmented reality to support learning through play in a small scale is of unique value. The project also suggested that future work will be needed to further unpack the depth of conceptual understanding that students develop through augmented reality environments and participatory modeling (Enyedy, Danish, Delacruz & Kumar, 2012).

Su, Feng-Kuang and Xu (Su, Feng-Kuang & Xu, 2013), also supported by grant (from Beijing Natural Science Foundation, the Fundamental Research Funds for the Central Universities and the State Key Lab laboratory of Virtual Reality Technology and Systems, Beihang University), conducted a case study based on a convex lens image forming experiment in two learning environments, one AR-based and another based on traditional teaching. The researchers developed a convex lens image forming AR tool and highlighted its effects compared with using current techniques. Two groups of eighth-graders took part in the experiment. Researchers observed that students not only preferred learning physics with AR tools but also were impressed by the instructional display and experiments using AR, because AR instructional applications were motivating, engaging and helped them memorize the results of conducted experiments (Su, Feng-Kuang and Xu, 2013). Among others, research findings indicated an interesting result that, although students are afraid to take physics courses, they are interested in some of the physical phenomena in their daily life, especially when performing physics experiments. Based on these results, the researchers reasoned that most students like to make inquiries and try new activities, including doing experiments by themselves. Therefore, the study underlines the need for teachers to experiment with innovative instructional methods and present students with more realistic questions that reflect everyday situations in physics courses.

The EcoMobile program (Kamarainen et al., 2013), funded by the National Science Foundation and Qualcomm's Wireless Reach initiative, in line with situated and inquiry based learning,

combined an augmented reality (AR) experience with use of environmental probeware during a field trip to a local pond environment, in order to fulfill specific educational goals relevant to environmental education. The intervention was conducted with five classes of sixth graders. Students were able to access and collect information and clues using a mobile device. They captured pictures, video, or voice recordings to serve as evidence in solving an environmental mystery. The mobile devices also allowed students to access special features through an augmented reality interface, which provided them with information that would not otherwise be apparent in the natural environment. The survey suggested that there are multiple benefits to using this suite of technologies for teaching and learning. Research findings confirmed the positive effects of AR on students' motivation and engagement. Teachers participating in the program reported high levels of student interaction with the pond and with classmates as well as deeper understanding of the relevant scientific principles than was typical on prior field trips without these technologies. Positive gains on students' responses to the affective survey also supported the above suggestion. Furthermore, teachers underlined that AR mobile technology encouraged independence and freed the teacher to act as a facilitator, thus suggesting that mobile AR can provide a powerful pedagogical tool that supports student-centered learning. Based on the results of the students' surveys and teacher feedback, researchers underlined, among others, the strength of AR technology in giving prominence to non-obvious causes for student's attention, as it has been observed that AR encouraged students to recognize non-obvious or unseen factors as significant factors in ecosystem dynamics. Moreover, the survey suggested that the AR experience propped up students to actively process the acquired knowledge, therefore helping them develop deeper understanding, discover gaps in the knowledge gained, and realize the potential for transfer of that knowledge in similar, real-world contexts.

### Capabilities of AR for reforming learners' misconceptions in science education

All aforementioned AR features highlighted by recent studies might be utilized to potentially depict the three-dimensional, real-time, space and time evolution of physical phenomena, as well as the concepts and properties involved, that are particularly difficult, if not impossible, to represent by other means and that evolve in either too small or too large scales to be observable. Under this perspective, students might exploit

AR technology in order to construct solid scientific knowledge based on 3D objects that enliven underlying information (Sotiriou & Bockner, 2008; Enyedy et al., 2012). Dynamic processes, objects too small or too large could be brought to the learners' environment, in a form and scale suitable for them to comprehend and manipulate, thus creating links between the received knowledge and everyday life phenomena.

Given the difficulties most students encounter while trying to perceive processes taking place in three dimensions as well as a certain weakness in visualizing physical phenomena of the microcosm and the macrocosm, one may assume that a properly designed AR learning experience could potentially represent a realistic "microworld" (Papert, 1980). This microworld could be explored by learners in a more experiential manner, compared to already existing technologically enhanced learning environments, by freely altering parameters and variables and having direct feedback of their actions, inside a realistic three-dimensional real-world space.

Based on constructivist learning theories, development in cognition and improvement in conceptualization depends on the process used to internalize the knowledge. Therefore learning is actually a process of discovery. Many researchers have indicated that, in order to teach scientific concepts in a meaningful way, the use of multi-dimensional simulation environments are far more powerful than traditional learning methods (Hewson, 1985; Novak, Gowin & Johansen, 1983; Thornton & Sokoloff, 1990, 1998). In accordance to the above thesis, several studies indicate that the use of multi-dimensional instructional environments contribute significantly to improving students' motivation, whereas visualizing physical and chemical processes, further encourages conceptual understanding (Trindade, Fiolhais & Almeida, 2002). In light of this, instead of being asked to "envisage" a certain physical concept or process, AR could potentially provide learners with a common, three-dimensional, tangible representation of that concept or process. Such an AR representation, being a common experience to all learners involved, would be observable and manipulable from different perspectives through the learners' personal ubiquitous interface of a mobile device or, in the near future, a wearable computer in the form of glasses or even contact lenses.

Under this prism, one may discern the potential of AR technology to support the deployment of experiences developed specifically to bridge scientific knowledge with the learners' intuitive perception of real world processes and to highlight and

reconstruct preconceptions relative to concepts and phenomena of science. In this line of thought, a carefully designed learning AR experience might serve as a more successful, nearly haptic experience with respect to a computer simulation resulting, therefore, in a more efficient reconstruction of preconceptions as well as to the smoother uptake of new knowledge.

Additionally, AR Technology intended primarily for tablets and smartphones, seems to introduce a new dynamic for on-the-spot inquiry and learning, with no need for dedicated equipment. This last feature does seem to consist one of the most appealing characteristics of this technology. Possibilities introduced by such experiences involve portability, social interaction, connectivity to any given environment (Squire & Jan 2007; Squire & Klopfer, 2007; Klopfer, 2008). We believe that this on-the-spot enrichment of real-world objects with digital, 3D visual information might potentially function as a bridge between scientific information and experiences of physical phenomena in everyday life.

Based on the above, it might be of authentic value to investigate the potential of utilizing AR features for teaching concepts, properties and phenomena of physical sciences, in particular, as well as for identifying and reforming learners' preconceptions about these phenomena. Consistence to the basic principles of inquiry-based learning approach should be the main guideline when it comes to designing such experiences. More specifically, such an environment should allow the learners to experiment with the elements provided (true and virtual), to formulate hypothesis and test their validity, to visualize and sense all related concepts, principles and quantities through multiple representations and eventually reform their prior conceptions.

### Considerations and limitations of applying AR for reforming learners' misconceptions in science education

A number of pedagogical, technological as well as learning issues emerge from the implementation of AR experiences and systems with the scope of addressing and eventually changing misconceptions relative to physical sciences.

From a technological viewpoint, perhaps the most significant issues that arise are relative to the proper selection of tools available for the implementation of a suitable experience, with respect to the learning educational goals to be addressed, the availability of the required equipment (requirements for mobile

devices with camera, GPS, QR reader) as well as the teachers' and learners' familiarization with these devices.

Currently, due to the absence of tools for the development of science-specific AR for learning, most AR experiences designed for teaching science are limited to QR code reading which, in turn, superimposes digital, relevant content on the image in focus. Obviously, such experiences offer the learner limited to none interactivity. At present, there are augmented reality platforms available for teachers to define their own triggers and overlays. Examples include Aurasma (<http://aurasma.com>), Layar (<http://layar.com>) as well as Junaio (<http://junaio.com>) and Qualcomm's Vuforia ([www.vuforia.com](http://www.vuforia.com)). This means that educators and students have already started to design, build and manage their own Augmented Reality experiences. Yet, advanced programming skills would still be required in order to develop a solid science-related, interactive learning experience that implements specific learning goals.

Therefore, at present, a major limitation of the technology investigated, particularly with regard to the points addressed in this paper, appears to be the lack of off-the-shelf programming tools. Such tools are necessary in order to allow the teacher herself/himself organize and configure a learning experience with respect to a particular learning subject and in order to implement specific educational goals, as well as to create realistic 3D phenomena representation models.

Furthermore, successful implementation of such an approach closely relates to the educator's ability to handle it and introduce it seamlessly into the school class (O'Shea, Dede & Cherian, 2009). The organization and setup of such experiences require, at present, the use of equipment that is rarely available to students in public schools. In addition, it might demand for advanced technological skills of both teachers and learners, thus necessitating the concurrent presence of two or three staff members, to successfully organize and support such experiences (Dunleavy et al., 2009; Dunleavy & Simmons, 2011).

Perhaps, the most evident pedagogical limitation of such attempts, relative to the exploitation of AR within formal educational settings, stems from the insufficiency of routine teaching methods in modern schools to align with AR, which appears to be most appropriate for supporting inquiry based learning activities (Dunleavy & Simmons, 2014). Towards this direction, we believe that further research is needed in order to identify and put forward the limitations entailed in the integration of such experiences in formal learning contexts

(Kerawalla et al., 2006; Mitchel, 2011). Especially with regard to the implementation of AR experiences targeting the promotion of prior ideas and misconceptions and the construction of new knowledge regarding science, further research is needed towards the organization and implementation of carefully designed learning scenarios and interventions based on appropriate AR experiences, in order to investigate the potential strength of achieving specific learning goals relative to the reconstruction of knowledge. In this line of thought, the adaptation of existing teaching approaches for the reconstruction of science misconceptions in AR learning contexts should also be considered, whereas learning outcomes from both learning approaches in various learning scenarios should be measured and compared.

Moreover, development of appropriate AR learning experiences might further indicate specific abilities and skills that could be enhanced within appropriate augmented reality environments, such as cognition of dynamic processes (Rosenbaum, Klopfer, & Perry, 2007) and the ability to conceptualize phenomena that are impossible to observe in real-world surroundings (Kerawalla et al., 2006). Similarly, it would also be of value to investigate and document if and how particular features of this technology affect and eventually reform the concepts of authenticity and engagement of a learning environment (Wu & Huang, 2007).

In that respect, we suggest that AR experiences need to be designed and developed with the purpose of representing concepts and processes encountered in everyday life. Emphasis should be given on enhancing these experiences with scientific knowledge in such ways that learners are actually convinced of their faulty preconceptions and are, therefore, willing to give up their prior ideas and embrace scientific knowledge. We believe that further research towards the above directions is needed to shed more light on the arguments introduced in this paper.

## Concluding remarks

The alignment of augmented reality with the principles of contextual learning theory and constructivism combined to the multiple-representation capabilities and the interactivity that it introduces appear to render it appropriate for the conceptualization of principles, physical properties and phenomena of science. Under this line of thinking, we believe that the importance of inventing ways to utilize these capabilities becomes evident. Science-related learning experiences should be designed and developed in manners that learners shall be

able to perceive and comprehend the scientific interpretation of AR-represented concepts and processes that take place inside the three-dimensional physical space. Apart from engaging learners in meaningful learning activities, these experiences may further encourage them to seek for and eventually identify gained scientific knowledge in real world contexts, for the benefit of further strengthening and consolidating that knowledge.

Such an approach introduces a new perspective in relation to overcoming science-related misconceptions and eventually, accepting scientific knowledge. Yet, it entails significant difficulties that relate to limitations regarding both the development of pertinent augmented realities as well as the organization of corresponding experiences within formal educational settings, with respect to overcoming specific, science-related misconceptions. To this end, educators should try to further exploit current AR tools towards the above directions, engage in inventing ways of organizing AR learning experiences in the classroom and evaluate both students' response to these experiences as well as learning outcomes. The possibility of experimenting with transferring traditional approaches of overcoming prior ideas to AR learning environments might also be worth considering. Such efforts could help researchers further identify and exploit curricular and learning potentials that can be offered by AR in science education, compared to other learning media. This might also shed further light on the ways students interact with the AR learning material within formal contexts and provide more evidence on how to best design and organize such learning activities. At the same time, the development of specialized software tools for implementing science-related AR is considered necessary. These tools should integrate physics engines as well as built-in 3D graphics libraries and should provide friendly interfaces to allow educators design and build their own AR experiences for science without the need for advanced programming skills.

Overall, we suggest that further research is needed, regarding the above matters, in order to face limitations and allow for the organization of systematic, science-related AR experiences inside the classroom, targeting to the understanding of science-related concepts and processes in more experiential manners.

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## E-learning meets game-based learning (GBL) – transfer of GBL research results in the e-learning project management course

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One of the objectives of the project GREAT, was to develop a vision for the role of GBL in training and education and to transfer innovative methodologies to correspond with the digital preparation of the European citizens. This paper documents the GREAT piloting phase i.e. concept and structure, along with the experiences and results, of an e-learning course that successfully utilised games to teach leadership, time and project management competencies, all within an e-Learning environment. The course was developed utilising GREAT learning resources and GBL research results.

### Tags

Game-Based Learning, Project Management, Learning Experience Design, Evaluation, e-competences

## 1. Introduction

The Project GREAT (Game-based Research in Education and Action Training) (2013) aimed to provide methodology and guidelines for using Game-Based Learning (GBL) in education and training. GREAT was an EU Leonardo da Vinci funded project, started in October 2011 and lasting for two years, and aimed to provide documented ways of using Game-Based Learning within teaching-learning processes by transferring innovative methodologies, corresponding with the ICT/digital preparation of European citizens in 2020.

The overall objectives of the GREAT research phase were to develop a common vision for the role for GBL in training and education, to identify the key policies and instruments that may be needed, and to develop a common view of the scenarios, contexts, content, environments for better use GBL.

Combining different approaches, i.e. desk research, expert interviews, online survey and expert focus group, the partnership gathered information from companies, training institutions, and stakeholders about the existence and the use of games for learning and training. There were 540 completed responses to the survey from 32 different countries, both inside and outside the European community. Over 20 stakeholder interviews in Austria, Hungary, Slovenia, Portugal, Romania and Turkey were carried out, and 16 international experts contributed to the focus group.

The research results were conclusive, that games and GBL can be used as an innovative teaching tool for training and up-skilling, and guarantee an efficient teaching method capable of offering trainees key skills and information regarding different subject matter, while incorporating collaborative learning and a learning by doing approach (The Future of Learning, 2013).

### 1.1. Designing the Learning Experience

For designing the effective learning experience utilising elements of eLearning and GBL, Kolb's experiential learning theory and problem based gaming model were considered.

Kolb (1984) experiential learning theory states that learning follows a cyclic pattern of four stages, and the reflection on experience is part of the learning cycle itself. As summarized in McLeod, S. A. (2010), based on Kolb model, effective learning is seen when a person progresses through a cycle of four stages: of (1) having a concrete experience (doing / having and experience) followed by (2) observation of and reflection on that experience which leads to (3) the formation of abstract concepts (analysis) and generalizations (conclusions) which are then (4) in the phase of active experimentation used to test hypothesis in future situations, resulting in new experiences.

The Figure 1 shows Kiili's suggested learning process while playing digital games, in both single and double loops. Kiili (2007) suggests that reflection may occur in isolation or during collaboration with others, but states that only the player themselves learn while reflecting on their own experiences. He also states that not only the reflective process is vital for learning, but also the feedback that the game provides is critical from the learning point of view.

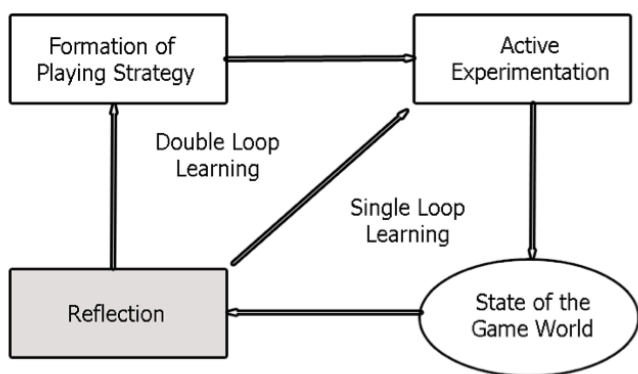


Figure1: Problem based Gaming Model (Kiili, 2007)

### 2. Development of a Mixed GBL and E-Learning Course

The GREAT partnership developed a course aimed at enhancing the level of GBL use in training and providing trainers and project managers with relatively new methodological and pedagogical tools, that support acquisition of necessary project management skills. The course was developed modularly, as to allow adaptation to different needs and learning environments.

The overall learning objectives of the GREAT Project Management for Entrepreneurs course for the participants are focused on increasing their project managements skills and related soft skills as well as their e-competences, especially to:

- Experience combination of e-learning and GBL
- Acquire various competences for project management
  - acquire professional competences in project management to define and structure a project (project leadership and time management)
  - gain methodological competences in project management (using communication platforms, transfer and link expertise to on-going projects of the own company, giving feedback to team members)
  - practice your on-line social skills (communication and interaction, reflection, self-initiative and taking your own responsibility)
  - enhance individual competence for pro-active behaviour (learning to learn, defining goals, assessing its achievements, developing customized solutions)
- Learn from and with each other
- Reflect upon efficacy of different online activities
- Develop strategies to transform learned competences to their problem area

In addition, the course has 3 basic learning perspectives, namely collaborative learning, learning through reflection and learning by doing. This means that the course work revolved around:

- Activities that encourage participants to reflect on their own learning experience, enabling them to set and pursue personal learning goals relevant to their specific situation.
- Group activities that allow participants to learn from and with each other.
- Activities that enable to transfer and apply different competences and learned techniques to their specific learning and virtual company team situation.

For the purpose of offering the course to the students of Information design as an additional offer of two subjects, we selected two PM competences – leadership and time management. We took GREAT learning materials and digital games from GREAT Games Catalogue (2013) related to selected competences, and developed E-Tivities (Salmon, 2002) to support defined learning objectives. The course is divided into two weeks, each week includes 5 tasks and provides a list of selected materials and tools to study, try out and reflect upon.

### 1. Leadership Module – Week 1

The overall purpose of the module is for the participants to access the course in the E-Learning platform, to become familiar with other participants, to explain their individual project management situation and expectations what they want to learn, to get familiar with the module resources, to acquire a set of leadership competences, to reflect upon their learning experience.

#### Teaching and learning activities

##### **E-Tivity 1.1. Present yourself and your project management situation**

**Purpose:** Write your first post and become visible for other participants.

**Task:** Describe the project management situation and outline your role within your virtual company. Share in your post what do you expect to learn in this course.

##### **E-Tivity 1.2. Course expectations**

**Purpose:** What are your expectations of this course.

**Task:** Share with others which project management experience you already have, and what do you expect to learn from this course.

##### **E-Tivity 1.3. Management competences**

**Purpose:** Study the leadership resources.

**Task:** Study provided resources and information on leadership. In your post share with others what you found interesting from the viewed resources and outline how you understand leadership competences.

##### **E-Tivity 1.4. Share your management experience**

**Purpose:** Check the list of games, select and play at least one. Report on your game play experience, and relate the game play to management competences.

**Task:** Play at least one game from the list. In your post outline experience you made while playing the game. Try to establish a relation of your experiences from the game play to (project) management competences in general.

#### **E-Tivity 1.5 Reflection on the first week**

**Purpose:** Reflect on your participation in the first week of the course.

**Task:** Write a short post outlining your thoughts at the end of the first week. Share with others what you found to be useful and helpful, and what was more difficult to accomplish than you expected.

#### **GBL learning activities**

In the Leadership Module – week 1, in conjunction with ppt presentations and 8 e-books on leadership, games were also offered as resources. Kiernan (2005) states that students “need to be provided with educational experiences that will enable them to deal successfully with current and future change with optimism and resilience” (p.7). However, surveys in both the UK (Futurelab, 2009) and the US show that students are critical of educational games as the expected quality of a commercial recreational game is often missing. Therefore, for this project we searched for fast paced and turn based games, that allow players make reasonable progress and achieve results in relatively short time, and where versions are available for free. From the GREAT Games Catalogue (2013) we selected Diner Dash, Tiny Tower and Sims free play. All these games are commercially available, and there are no-cost versions that can be played. A short game-play description and where the games can be downloaded was provided.

Diner Dash- the player has to manage customer orders in a restaurant within a short period of time, i.e. optimizing sequence of taking orders and providing food. This leads to stressful situations that need to be resolved in a way that customers stay happy. Targeted PM competences: resilience and stress management skills, time management.

Tiny Tower – in this open ended game, the player tries to build a tower in which people live and work. This includes building floors, providing stores for food and entertainment and keeping the inhabitants happy. Targeted PM competences: leadership, people management, cost management, planning.

Sims free play - game is an open ended simulation of a small town. The goal of the game is to increase the wealth of the

town and to keep the inhabitants happy. There are three virtual points systems in place: Simoleons, the virtual currency, is earned through the jobs the Sims do and the overall worth of the city, Experience points are gained through most interactions with the game like providing food for a Sim or building another home, and Lifestyle points are gained for reaching special goals. Targeted PM competences: planning, time management, cost management.

Two of the module E-Tivities were focused on games. Students were encouraged to study offered materials and information on games. All selected games are commercially available and a short description of game play and where the games can be downloaded was provided.

In the Task 4 (as outlined before) students were explicitly asked to report on their game play experience, and relate the game play to management competences. Students were also asked to read other posts and comment on at least two postings from other participants.

## 2. Time Management Module – Week 2

The overall purpose of the module is for the participants to reflect upon their own time management, to explain their individual project management / time management situation, to get familiar with the time management module resources – examples and different techniques, to select one and try it out, to make a plan on how to improve their TM in the future, and to reflect upon the course and the offered materials.

### Teaching and learning activities

#### E-Tivity 2.1 Learn different ways of time management

**Purpose:** Familiarize yourself with different time management techniques.

**Task:** Study provided resources and techniques on time management. In your post list several factors, that you find important for good time management (either personal or of a project team).

Please note: E-tivity 1 should be carried out on Monday, as to allow enough time for the e-tivity 2 (you should observe your time management behaviour for approximately 2 - 2,5 days).

#### E-Tivity 2.2 Analyse your time management behaviour

**Purpose:** Select one technique, try to keep and manage your time for the period of approximately 2 – 2,5 days. (Mo-We)

**Task:** Select one of the time management techniques, and apply it to analyse and improve your time management. In your post outline what observation you made (behavioural patterns, surprising findings, positive or negative aspects, or similar).

#### E-Tivity 2.3 Common time wasting methods

**Purpose:** Reflect upon situations that illustrate well personal or team time wasting (procrastinating) activities.

**Task:** Think about 1-2 specific situations where you observed / experienced time delay and minimum progress. In your post outline briefly these situations, and what were major time wasting activities.

Results of this e-Tivity is that the moderator collates a list of most commonly observed time wasters from all posts of participants.

#### E-Tivity 2.4 Plan further actions / Transfer

**Purpose:** Transfer the methods you learned to your project management context.

**Task:** Formulate your personal plan for application of acquired project management competences. Outline briefly your personal goals / personal plan how you want to include the acquired project management competences to improve efficiency of your study / work / work of your team. Which competences especially you plan to pursue and develop further?

#### E-Tivity 2.5 Reflection about the course and learning method

**Purpose:** Reflect on how your participation in this course, the knowledge you gained, and the experience you made so far, will help you to improve your project management skills and techniques in the future.

**Task:** Write a short post outlining your thoughts at the end of this course. Outline what are your overall impressions about the course, and offered material and methods. Share with others, which two project management competences you will add to your project management tool box.

## 3. The Pilote Phase

The course duration was scheduled from the 8th to the 21st of April 2013. Course was structure into two modules, each module in the duration of one week. Modules were delivered through the e-learning platform and were pursued by the individual participant in their own time (within one week). The course was officially opened couple of days earlier, on 6th of April 2013. Twelve students were enrolled in the course; ten of them were actively participating. Two certified moderators were supporting the course. The conversation in forums was very dynamic, with a lot of posts, majority of posts were very detailed and reflective. The discussion was open and of high quality, often providing also links to external resources or apps that participants found and shared with others.

### 3.1. Participation Overview

The Figure 2 shows all activities of this course, that means all log-ins and contributions by all roles, i.e. 10 participants, 2 moderators and guests. At the first day the activity level was relatively low, but it increased very fast. The first peak was reached on the fifth day of the course, on Friday. The highest activity in the entire course was measured on Wednesday in the second week of the course.

During the two week course period there were in total 447 posts in forums, average 44,7 posts per E-Tivity. As shown in the Table 1, seventy was the highest number of posts in the second week to the topic of E-Tivity 2.3 – Common procrastination methods.

E-Tivity	No. of posts
1.1. Present yourself and your PM situation	24
1.2. Management competences	50
1.3. Share your management experience	52
1.4. Share your play experience	48
1.5. Reflection on the first week	33
2.1. Learn different ways of Time Management	60
2.2. Analyze your TM behavior	51
2.3. Common procrastination methods	70
2.4. Plan further actions /Transfer	33
2.5. Reflection about the course and the learning method	26

Table 1: Overview on the posts per each E-Tivity

### 3.2. Reflections on eLearning

As shown in the previous chapter, students were very active and exploratory learners, and the participation was evenly distributed through the course. Very often we would observe bouncing ideas from each other, and elaborating in the group on the solution. Enclosed are some excerpts from our participants' posted reflections, where they express their thoughts on the course and (e)learning method.

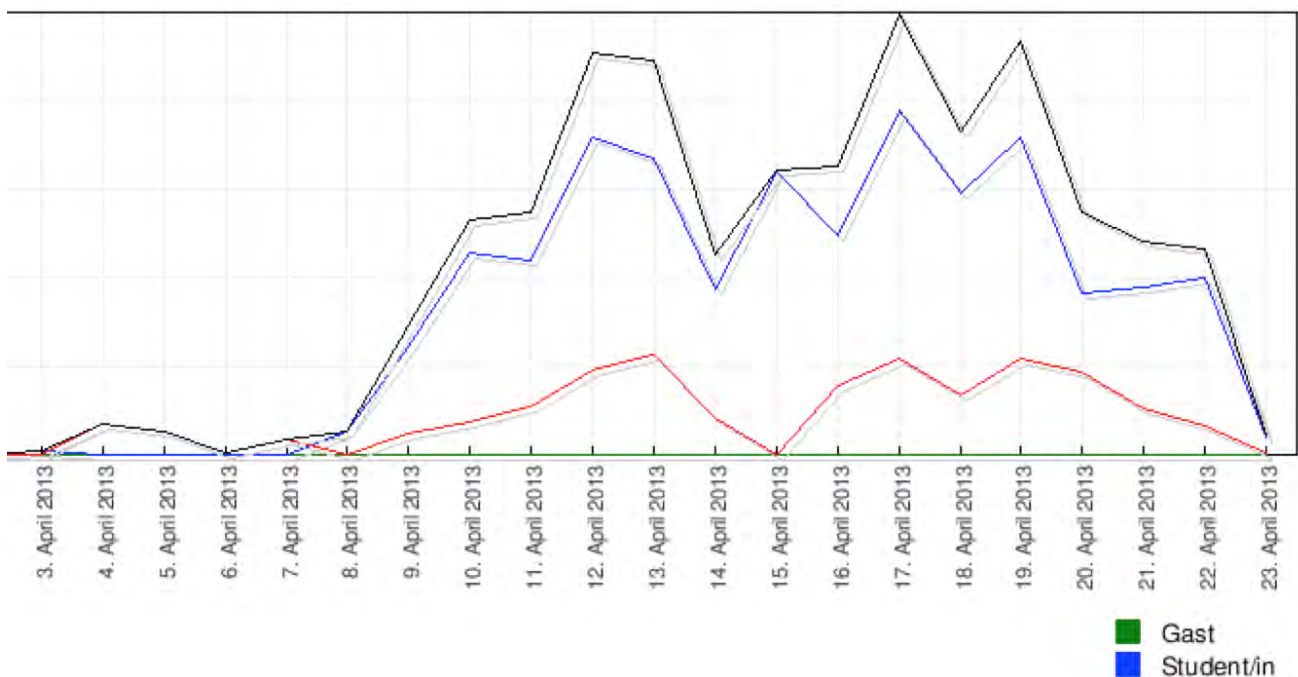


Figure 2: Dynamic of the Course Activities

*„I'm really impressed how many information we could exchange in this short period of time. ...was really a fantastic new experience!“*

*„I really love that concept of interacting in this way and I fear that in the last 5 days I gained much more personal feedback than in many other non-virtual courses.“*

*„The more you read about the others, the easier it is, to structure your own thoughts to reflect about it. I got a huge benefit from the other discussions, some of them changed my point of view slightly.“*

*„During this week there was a good dynamic in discussions and I liked reading the posts and comments, though, like others have already mentioned, unfortunately it was sometimes hard to follow really all of them. ... This course made me think a lot of different point of views of the same subject.“*

*„I had the feeling that some posts were really honest and that the participants had lots of engagement. The e-moderators gave good inputs and feedback. It was nice to work with all of you!“*

*„I think it's easier to write about what you think. So you have time to structure your thoughts. And of course there was this great atmosphere of interest and understanding.“*

*„Wow! Two weeks are over (like the wind). In this weeks I learned a lot – big outcome with a expenditure of time, but paid off. Every forum with its own topic and instructions was really helpful.“*

*„Reflecting the last two weeks simply two words pop up in my mind: Thank You. ...I guess that most things during the course, I did not only learn by reflecting on my own management behaviour, but even more by gaining insights into the ideas and feelings posted by others.“*

### 3.2. Reflections on GBL

Out of 10 active participants, 9 reported on their play experience and were active in discussions. Several students played two or three games and then reported on one. More than half of the students outlined that they played one game two times. First time they just intuitively played the game and tried to progress

the best they could. Often they would struggle and after several attempts they would figure out how best to progress.

Second attempt was either based on reading first the manual and in game instructions or elaborating a strategy in advance, that resulted in smoother play, students understood and were guided by the in-game feedback, achieved better results and learned better. This learning cycle as described by students is well presented in Problem based Gaming Model by (Kiili, 2007).

*„When I started the next game I thought about what I would do, if I wanted to start working at an agency. I took one office space, byed many plants and a wonderful painting, a coffee machine (a coffee machine has to be in every office where cretiveness should happen!) and after some days I really made benefits. My staff stayed happy (100 percent) and after some time I had enough money to enlarge my office. ... By doing the second system - starting step-by-step I had a better overview of all - over the staff and over the funds.*

*That's a thing I can keep in mind also for real projects. You can have a big vision - but you should start small and should think in a way where you always have the right overview. Because if you as the head loose this basic, your company only can go under.“*

*“The major difference between my game #1 and game #2 was this: At first, I treated my enterprise like a dinner party with friends: I hired three, four people - obviously a friendly atmosphere where no one must be strangers, right? - and got caught up in the details. I wanted plants and a coffee machine before I even built an elevator; I hired researchers before I had enough workers to even realize innovation.*

*At my second go, I followed the game's advised steps and suddenly things fell into place: there is a chronology to management. Certain infrastructure and investments are the start of every business - be it one of three people, or three hundred.“*

Students easily related games and game play experience to different PM areas in real life, e.g. resource management in general, how to grow business, pointed out importance to understand staff and motivate them, they thought about pros and cons of different distribution in offices, communication with customers, people with special needs, decision making, time management. Students reflected individually in their posts upon

their game experience and red and commented on reflections by other students. As there were two moderators in the course with wealth of experience in project management, they guided and provided additional information for the debriefing phase via forums.

*„I think you can connect Diner Dash with leading a big group. You have to observe your members which often do different tasks. As in the game you have to keep an eye on every person.“*

Even the two students with less affection towards games outlined some learning value of playing, and also pointed out the missing social component that is important in the real life.

*“You learn how to keep the balance between investing and earning. Maybe you get a feeling of how much work and time is necessary in relation to the growth of your office building and still having benefits.*

*Of course a game like this isn't able to simulate social aspects in a realistic way. Even if there is a scale for the happiness of the worker, there is no space for social interaction and communication between the employees.“*

#### 4. Lessons Learned and Conclusions

In addition to E-Tivities that supported weekly reflections on learning, the course structure and provided material, we also collected additional feed back with a questionnaire. We obtained 10 filled in feedback forms and below we list a summary of what contributed to the success of the course and where improvements are necessary.

##### 4.1. Success factors

- **Familiarity with the eLearning Platform**

All participants were familiar with the basic functionality of the Moodle eLearning platform, as it was used for information exchange and communication in other classes, therefore the technological barrier for participating at the eLearning part of this course was low to non existing.

- **Course and Content Structure**

The course was clearly divided into two separate modules, each containing consecutive activities. Students were instructed on how to progress throughout the course. Each module had a separate area with related resources, so it

was easy to connect activities and necessary resources. The timing of the posts as well as the high activity exactly within the course duration shows the importance of a clear structure and clear defined activities. All E-Tivities were carried out within the scheduled time.

- **Time frame**

The participants made two observations related to the time frame of the course:

First: Due to the short duration of the course the majority was happy with the time span of two weeks, some of them could also imagine an expansion of the course up to three weeks (especially for the time management module, as to allow more time for self assessment and trying out different tools and techniques). All participants more or less liked the short duration of the course which enabled them to “stay tuned and not to lose the plot”.

Second: Selected time of the course in the middle of the semester was perfect for everybody. At that point in time the demand for Leadership /TM competences is high because students had already made their first experiences and mistakes in their real world projects within their virtual companies. Therefore they could also reflect upon their own experience and current project needs.

- **Intensive Moderation**

For the successful course it was necessary to support the participants very actively throughout the course by providing hints and tips, answering on posts and linking different comments or external resources. This includes of course moderation also in the evening hours, were the activity always reached the daily peak, as well as on the weekends. As stated in their feedback the participants highly appreciated this intensive support.

##### 4.2. Possible Improvements

- **Technical Issues related to Games and Different Platforms**

The results of the questionnaire and the posts during the course have showed that some improvements could be made regarding the used games with regard to their technical viability for all platforms. In the course one needs to provide more detailed information considering all possible platform.



The importance of the technical problems should not be underestimated, because if problems caused by different devices or browser occur while playing the game, this disturbs the learning process and often causes frustration of the learner. So instead of focusing on learning, learner is more focused on technical issues. However, these problems can be only limited by providing more information.

- **eLearning platform**

The feedback on the platform showed potentials for improvements. Mentioned suggestions were to less use of the forum or to tunnel a discussion in one thread, because some participants perceived the fora as unstructured and confusing. Unfortunately there were no other suggestions on what other features students would prefer.

- **Transfer of the skills to a Real Life Project**

As much as students appreciated the discussions, exchange of practical experience in forums, and also reported on learned conclusions based on studying and discussing the material, they also expressed a wish of an individual “hands on” assignment, where they could apply their improved project management competences. In addition, students wished for more detailed feedback and tutoring related to this specific assignment.

### 4.3. Conclusions

The interdisciplinary learning opportunity and collaboration of two subjects offered in the form of the E-Learning course on Project Management Competences was well accepted and provided adequate input for learning and practical work of the students. The E-Learning form of a course was well chosen and allowed all students to participate in addition to their regular classes. GBL activities were well placed, supported active learning and for some students playing games opened new focus on learning. As one of our students outlined in her final reflection:

*“...Furthermore, the teacher as an “adviser” rather than an “instructor” is a wonderful and functional concept for academia. ... I hope it doesn't sound pathetic, but - e-learning made me feel re-transported to that child I used to be. And it certainly helped that one of my tasks was to play a game! ..”*

We repeated the adapted version of the course in the summer semester 2014, approximately at the same time, as to optimise the learning experience for students. Based on the feedback,

we successfully introduced some improvements of the course— e.g. extending the duration of the course up to 3 weeks, providing more technical information on games and related device requirements (for iOS and Android), extending the list of TM material also with interesting apps. We introduced a Google Hangout, a synchronous event e.g. question / answer session with a manager of local business incubator, to keep the momentum of learning and interaction in the longer course. In this second run we had 27 students participating, and 25 students finishing the course with a certificate. The student interest and positive feedback on the learning topic and method indicates that the course provides skills that students would wish to learn. In next edition of the course, addition to these 3 weeks, optional there will be a separate module of 10 days with a specific assignments and feedback loop, to foster transfer of learned competences into the real life environment.

To introduce new teaching and learning methods teachers and students need to be digitally literate and have a set of e-competences. For students it is important to have a basic skill set for navigating and using different on-line resources, and learning in the online environment. Teachers need to be able to integrate digital games into the classroom, familiarise themselves with the game-based methods and the games themselves, and have competences to structure and moderate eLearning activities. Institutions must invest time and resources to up-skill teachers and to allow for the time necessary to modify pedagogical approaches. At the same time, institutions have also to be aware that transversal competences such as digital literacy and development of e-competences of students are of crucial importance for later employment and lifelong learning; e.g. some of our students outline MOOCs as future choice for learning.

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## Facilitators as co-learners in a collaborative open course for teachers and students in higher education

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### Tags

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This paper describes Bring Your Own Device for Learning (BYOD4L), an open learning initiative exploring the use of smart devices for learning and teaching in higher education. BYOD4L was developed by educational developers in the UK using freely available social media able to run on personal smart devices. BYOD4L was offered by the Media-Enhanced Learning Special Interest Group (MELSIG) in collaboration with volunteer facilitators. The paper focuses on the open facilitator experience as lived during the first iteration of BYOD4 in January 2014. A phenomenological approach has been used and data has been collected via a qualitative survey instrument which was completed by all facilitators. Findings are shared and discussed that provide an insight into the facilitator experience that might be of value for other similar open collaborative learning events and other open educational interventions.

### Context

Interest in the professional development of teachers, evident opportunities for transforming teaching through the proliferation of digital and social media, forays into open and informal learning spaces all indicate it is time to learn about innovative personal teaching and learning spaces designed around the learner, wherever they may be.

The professionalisation of teaching is an important agenda in United Kingdom higher education (HE), especially since the revision of the UK Professional Standards Framework and a Code of Practice for Teaching by the Higher Education Academy (HEA, 2013). Initial and continuous teacher development in HE, together with teaching qualifications and professional recognition, have been shown to have a positive and lasting impact on practices (Parsons et al., 2012).

The European Commission (2013) calls for collaboration among institutions to explore more open approaches to education for the benefit of students and staff across the European Union. It also encourages institutions to model such practices in the professional development of their academic staff. Ryan & Tilbury (2013) concur and discuss the need for more flexible pedagogies.

The impact of new and emerging digital technologies on the way we live and, by extension, on the way we can teach and learn across formal and informal contexts, needs to be understood. Redecker (2014), for example, refers to the social and open nature of learning and the informalisation of learning that she believes will become a reality for higher

education. Boundaries between formal and informal learning are blurring (Conole, 2013) and interest is increasing in more open and lifewide curricula in which all learners can benefit (Jackson, 2014).

The Digital Age is typified by both staff and students being continuously connected through social media and, given the functionality of personal smart technology and its ease of use, by the ability of each of us to make and consume content. Due to the connectivity afforded us through smart technologies we are able to do this together (Gauntlett, 2011; Hatch, 2014).

Social media are increasingly used to complement or even replace institutional learning technologies being valued as offering more immediate, connected and collaborative learning opportunities irrespective of actual co-location, potentially mobilising learning and teaching on a massive scale and bringing educational conversations into the open (Johnson et al., 2014); that is, involving others living, learning and working beyond the formally understood boundaries of traditional modes of delivery who add richness to the experience of learning.

It seems education in the Digital Age may become distinguished by learning through rich communication, collaboration and creativity. As no permission is required to create something on the web individuals experiment with new ways of learning and teaching. Some of these include open educational practices (Zourou, 2013). BYOD4L, the intervention discussed within this paper, fits such a description well. Veletsianos (2013) notes that there is still limited research into the student experience in open online courses, insights into the open facilitator experience might be even more limited as stated in Ross et al (2014) linked to facilitation in Massive Open Online Courses (MOOCs). Within this paper the authors focus on the facilitation aspect of an open mobile development initiative for teachers and students. The authors aim to provide an insight into the facilitator experiences linked to an open educational offer that sits outside a MOOC typology. However, the findings shared might also be of relevance not only to other Do-It-Yourself (DIY) course designers but also MOOC initiatives.

## A bite-size open learning event for students and teachers in Higher Education

BYOD4L is a grass root open pedagogical intervention developed by two educational developers in the UK (authors of this paper) and offered under the MELSIG umbrella as an open course to teachers and students. It was developed using freely available social media technologies such as Wordpress, Google+ community, Facebook, Twitter and others. The pedagogical rationale had its foundations in Problem-Based Learning (PBL).

The concept of BYOD4L can be understood more usefully as a learning ecology than a course. Jackson (2013) defines a learning ecology as “a process(es) created in a particular context for a particular purpose that provides opportunities, relationships and resources for learning, development and achievement.” This reflects the organisers aspirations which was articulated before the start using the metaphor of “our magical open box” (Nerantzi & Beckingham, 2014).

BYOD4L was offered for the first time in January 2014 over five (5) days with 10 volunteer facilitators from different institutions at the end of January 2014. Nine (9) out of 10 facilitators participated fully and consistently during BYOD4L. Nine (9) facilitators were located in the United Kingdom while one (1) of them was located in Australia. BYOD4L aimed to help teachers and students to develop their understanding, confidence and competence around using their own smart devices for learning and teaching. It also aimed to inspire them to experiment and make new discoveries with others. The pedagogical design developed was loosely based on Problem-Based Learning (Barrows & Tamblyn, 1980). Short authentic video scenarios linked to specific themes were used to trigger individual or collaborative inquiry: connecting, communicating, curating, collaborating and creating. One set of thematic case studies provided the focus for each day, being used to trigger engagement with three activities for autonomous and collaborative learning through experimentation, reflection and sharing. The daily themes enabled learners to dip in and out as they wished with the pick ‘n’ mix themes and activities based on their needs and interests. Open badges for learners and facilitators were used as motivators to increase engagement, reward learning and effective facilitation (Glover & Latif, 2013).

Asynchronous conversations took place in BYOD4L community spaces (the course Wordpress site via comments, a Facebook group and Google+ community group) and were facilitated together with the daily tweetchats: live exchanges through Twitter. Further exchanges and learning conversations unfolded on Twitter, asynchronous and synchronously, as well as in personally defined learning spaces.

Building a team of facilitators with capability to support a diverse and unpredictable cohort of learners was a critical challenge to designing and running BYOD4L successfully; openness promotes inclusivity only if the course is able to reliably support each learner within parameters defined by their diverse expectations. The facilitators played a vital role in establishing a sense of community by creating, extending and modelling opportunities for conversation and exchange, showing interest and care through supporting learners as well as each other.

### Facilitators' team profile and working practice

The BYOD4L facilitators hold a variety of roles within higher education including academic developers, learning technologists, lecturers and educational researchers. Nine of the ten facilitators worked at institutions in the United Kingdom; the other in Australia. Facilitators were selected by the two organisers who knew the individuals through other professional activities and networks. Most facilitators had not worked with each other before on such a project. The majority of them came with experience of learning online before joining BYOD4L and were experienced and professional users of social media and networks. Only two facilitators had experience of online facilitation or open learning courses. Whilst each facilitator had an online presence and experience using a variety of social media, some of the tools and platforms used during BYOD4L were new to some of them. With this in mind, the facilitators' roles became multifaceted: they were learners, teachers and, of paramount importance, supporters of the learners, there to make a transformative difference to learners (Nerantzi, 2011; Nerantzi and Withnell, accepted). The expectations and responsibilities of the facilitator role were discussed and agreed from the outset. A buddy system was used to ensure support for facilitators and to help manage the facilitation load.

The facilitator group was initially established in early January 2014 and continued to be expanded during this period leading up to the course delivery at the end of January. As it grew, the facilitator role description became clearer through asynchronous

discussion and guidelines which were put together and agreed with facilitators.

Key to the formation of the group was providing opportunities for the facilitators to get to know each other prior to the start of the course; albeit at a distance. Several of the facilitators had previously met others in person or knew each other from social networks, but mostly BYOD4L brought people together for the first time.

The two course leaders felt it important to engage all participants, learners and facilitators, in a variety of spaces beyond the main course presence, which was a multi-functional Wordpress site. This principle reflects the close correlation between smart media, social media and open learning; a set of interests common to most BYOD4L participants.

The facilitators brought with them a wide range of skills and experience; however, not all were confident users of all of the spaces used to host the course, its activities and conversations. This in itself provided them with new and largely welcomed challenges as they experienced and tested new learning environments first-hand. Professionally, the facilitators were attracted by being engaged in a genuinely authentic learning inquiry.

Google Drive was used to optimise the transparency of the planning by sharing documents with the whole team. Google Hangouts, the synchronous video conferencing environment, presented an effective alternative to meeting face-to-face, although participation was limited to ten people at a time. The Hangouts enabled each of the facilitators to put names to faces. The Facilitators' Facebook group was established to provide a private group communication channel and the group quickly coalesced around this space which provided information, support and discussion during planning, but also helped to establish a social identity and being to the group. The Facebook group acted as a course virtual 'staff room' in which the two course leaders in the group were able to preempt and invite questions, and to encourage early dialogue. During the course they reminded facilitators to signpost new information and establish imminent activities, necessary to help the orientation of learners and ensure the delivery ran smoothly and the facilitators were able to support their peers, especially as experience and confidence grew throughout the week.

Facilitators took part in a variety of daily activities. These included asynchronous discussions and synchronous tweetchats.

Most of the facilitators captured their BYOD4L reflections in their blogs throughout the week and shared them with the wider community. This reflective and formative writing often encapsulated the blurred boundaries between their teacher and learner personae.

It should be noted that all of the facilitators were volunteers and involvement was something they took on in their own time. Participation in this new role was typically expressed as a personal and professional development opportunity in the area of open educational practice as well as mobile learning. The course leaders, aware that time would be the key barrier for facilitator engagement, organised the week's activities so that they worked together in pairs responsible for leading one of the daily synchronous sessions. In addition they could join and engage with a social learning space of their own choice as and when time permitted. The size of the facilitation team meant there was greater flexibility and choice regarding facilitation.

## Methodology

The study uses a qualitative phenomenological approach to identify qualities and methods leading to effective facilitation in open learning spaces.

A short survey was designed and created using Google Forms. The survey was composed of three main questions and addressed the experience, successes and challenges of the BYOD4L facilitation. Using open questions, respondents were invited to reflect on their overall experience and provide answers based on what they selected as being significant.

Two of the facilitators were also course organisers and all three authors of this paper were part of the BYOD4L facilitation team. All individuals who completed the survey provided their consent for fully anonymised data to be used for research purposes.

The data were generated from a qualitative survey completed by all ten facilitators and resulted in findings organised using five categories representing the key dimensions of the facilitators' experience which emerged during the analysis of the survey data.

## Findings

### 1. Enjoyment of facilitation

Without exception, the facilitators were positive about their experience and found the BYOD4L experience enjoyable and exciting. Some stated that they felt "on a high" and that they learnt a lot. For example one facilitator noted:

*"FANTASTIC experience learnt a lot of new things and 'met' some great people."*

They commented that, overall, they actively supported learners throughout. Some commented on how much they enjoyed the Tweetchats for example. One stated,

*I loved the Tweetchats and the sustained engagement in these throughout the week. [...] I would say that the engagement wasn't superficial and that we had some really good and useful conversations there.*

### 2. Professional development opportunities

Facilitators stated that they felt that BYOD4L was an opportunity for their own professional development. For example, one noted, "It has given me loads of good ideas for new things to try out in my own practice." Others commented on the opportunity, not just to facilitate, but also to learn from other facilitators and learners. It appears that they valued the opportunity to work together in a distributed team.

The course particularly provided the facilitators as an opportunity to learn new ways of using some of the social media to enhance their professional practice and how it worked really well giving them ideas to implement in their own practice. One said,

*In the Google + community [...] there was great interaction. This opened my eyes to the benefits of G+ communities which I have not previously used much - I will be using this in the future I am sure.*

Another facilitator commented on the freedom to experiment while learning and developing. They wrote,

*I had never done a Tweet chat before and was looking forward to doing it my way. I was pleased that my Tweetchat partner went with the idea. It was mad but in an exciting way.*

### 3. Community of facilitators

The professional relationships that developed during BYOD4L are highlighted in the survey responses by the facilitators as important indicators of what worked well. The facilitators expressed a strong affinity to feeling part of a team capable of supporting each other. One facilitator noted for example, "We worked really well together, the organisers and facilitators. We were honest and supported each other." The facilitators developed a collective identity and were proud to be associated with BYOD4L. For example, seven noted their intention to claim an open badge. The comments demonstrated how the facilitators perceived themselves to be more than a team defined by the timeframe of the course. Several expressed their desire to do more, outside of the initial objectives of delivering the course, indicating the group's evolutionary characteristic often found in a community of practice (Wenger et al., 2002). This was captured by one of the facilitators:

*"A fantastic experience. One that needs to be sustained. This need for sustaining the learning community is further evidence of BYOD4L not simply being understood as a course."*

Some facilitators expressed sadness when it was all over after Day 5:

*"There was a silence (possibly too dramatic to say emptiness) when the Twitter chat finished on the Friday. These connections, I think, will continue beyond the end of the course."*

One of the facilitators, who was the only one facilitator outside the UK, felt perhaps less part of the team. In their own words:

*"Being on the other part of the world, I felt disengaged with the live events and especially the Twitter, which I did not follow and where a great deal of interaction took place."*

This indicates that despite the affordances of asynchronous communication, the facilitator felt that not being present in real-time this could lead to a sense of detachment from the rest of the community.

### 4. The time factor

Responses showed that facilitators found the experience intense as all facilitators were in full-time employment and their normal day-to-day job was their first priority. The BYOD4L facilitation was taken on voluntarily and added further daily tasks to an

already busy work schedule. The majority of activities were asynchronously and engagement in these could continue beyond the normal work time. This added flexibility to facilitator engagement while also 'eating' into personal life and made it challenging for others, especially as the only synchronous activity was offered in the evening (UK time).

The survey results confirmed that the biggest challenge for facilitators was finding time to engage consistently during BYOD4L. One facilitator, reflecting a commonly articulated concern, commented:

*"...finding time within a busy week to look at all the sites and comment on blogs etc." While another facilitator noted that "Time!!! Being a family man time is very limited."*

### 5. Social media

Facilitators felt that the social space for their communication as a group was really valuable to them and helped them connect as individuals and as a team to support each other:

*"The team approach and the way we knitted together was wonderful. Having informal social spaces to communicate just for the team was important."*

The Facebook group set up for the facilitators was seen as an effective communication and socialisation tool. One commented:

*"The FB community, for the facilitators team, which was private, was a vibrant space and enabled a rich exchange, reminded each other of specific tasks and support each other." While another facilitator noted regarding Facebook: "It made us feel a bit more relaxed and share more personal stuff, which I think we wouldn't in other settings?"*

The suitability of the social media used as course spaces was questioned. One facilitator commented on the relatively low use and interaction with the learners' Facebook group:

*"Facebook is not the most appealing tool for such open courses mostly due to its private nature...you are using [it] with your 'real' friends and for particular reasons that are not directly relevant to connecting and creating!"*

This facilitator suggested LinkedIn as a potentially more effective space for professional conversations.

### Discussion

#### 1. Facilitators as co-learners

BYOD4L was seen as a great opportunity not only to support learning, but to engage as professional learners, both experiencing social media-enhanced open learning and developing understanding and skills in the course's focus area of learning with smart devices. This aligns with Debowski's (2014) thoughts about developers as co-learners and fits well with how the facilitators saw themselves, acted and experienced facilitation naturally. The facilitation model of co-learners was powerful and created a more 'horizontal' and diverse learning ecology (Jackson, 2013) which seemed to benefit everyone, bringing participants together in a wide and loosely united learning community. Support, communication and collaboration was fluid, quick and effective. This contributed to a strong sense of belonging: everybody who participated visibly mattered equally.

#### 2. The social glue creating a community of facilitators

The social aspect of the facilitator team and its role in creating a close, functional team, became evident. The bond created through the use of social media increased the facilitator commitment and motivation. Veletsianos (2014, online) talks about "social media as places where some academics express and experience care." This was something that was observed through facilitators' behaviour and comments.

Attending a Google Hangout as a team meeting was seen as a valued part of the initial bonding process and socialisation. One Facilitator who was unable to join the hangout due to a technical issue expressed a feeling of being left out.

Using Facebook as a professional space was new for many and for some felt to be 'foreign to their existing learning culture' (Tyree 2014, 6). The general familiarity of the space itself, however, minimised the technical challenges and also seemed to speed up the process of socialisation with individuals being more relaxed. In their study, Coughlan & Perryman (2013, 9) noted that the use of Facebook assists the development of community and provides a "low-cost way of nurturing groups." When putting a facilitators' team together special attention should be paid to ensuring it is inclusive and that it enables active participation in scheduled team and learning activities, taking into account geographical locations and timezones.

#### 3. TweetChats

Acosta (2014, 16) notes "Twitter can build community and engage people in conversations they may not have traditionally participated in." For many BYOD4L participants, especially the facilitators group, the course was synonymous with the TweetChats which were run each evening for an hour. These synchronous structured discussions were well attended and the facilitators' reflections highlighted them as being important opportunities for enabling rich communication, exchange of ideas and community building; something that is also observed by Satterfield (2014) who has discussed how well Twitter chats can support focused interaction. The same technique was used by the facilitators in planning the course and it was observed how this enabled them to contribute to the shape and style of BYOD4L; an approach that can be used to make any course team planning activity more inclusive.

The Facebook group helped to establish the facilitator buddy system which was used to organise the co-facilitated TweetChats. The use of a buddying system made use of the diverse and complementary strengths of the facilitator group. Learning from and with each other was valued and the open sharing of this gave confidence to those with less experience. Each brought different skills to the group and therefore created an opportunity to contribute to this social learning experience in a different way (Seely Brown and Adler 2008).

The early evening schedule for the TweetChats seemed to be convenient; at least for learners from the UK and similar time zones. They consistently attracted a good number of learners who looked forward to and who engaged in the discussions with a passion. Facilitators also noted how they enjoyed the TweetChats and how they brought learners and facilitators together. As an open learning event, potentially attracting learners from around the world, further cases are needed to learn more about effectively managing engagement across time zones. In BYOD4L one of the facilitators was based in Australia and he reported how the synchronous activity could not easily fit with his early morning commitments.

Solutions to this are dependent upon how sub-communities can be formed globally and the relation of these sub-groups to each other and the opportunities for designing in inter-group interactivity as they work through activities. Offering at least 2 tweetchats in a day is something that could be considered in the future.



4. Global open educational offer and the challenge of timezones: BYOD4L involved facilitators and learners from around the world. We found that it is not enough to invite participation in open education where it operates across time zones. Participants need to feel part of what is happening and must not feel excluded from events. Selecting facilitators from different geographical locations could promote inclusion. In BYOD4L the majority of the facilitator team was based in the UK and this might have made the challenge more acute. Sub-groups within the learning community could provide time-zoned conversations and materials, including additional problem-based scenarios, so as to reflect the diversity of participants.

5. Time to fully participate was a challenge for all facilitators. Facilitators engaged in BYOD4L in a voluntary capacity. This was a challenging additional commitment to the day job and caused some additional pressure to individuals. It is hoped that, building on the success of BYOD4L, future iterations of the course will garner more institutional support. This becomes more feasible as more learners from each institution take part in the open offering.

Facilitators have noted that the success of BYOD4L has reflected well on associated institutions and so more consideration should be given to the indirect benefits of being involved in such an open course including the development opportunity it offers facilitators as learners and the access it provides to knowledge and resources which can be used in other situations.

Galley et al. (2010) developed the Community indicators Framework (CiF) for observing and supporting community development which consists of four indicators: identity,

participation, cohesion and creative capacity. They suggested these indicators develop in sequence within a community and that the presence of specific indicators reveals the strength of a community (Figure 1). There are parallels between the CiF and Tuckman's (1965) forming, storming, norming, performing team-development model.

Using the CiF framework to reflect on the development of the BYOD4L facilitation team it becomes evident that a strong sense of identity was formed by using the online social media spaces selected by the group. This formation is likely to have been enhanced by the innovative nature of the approach and the need for all to work collectively and rapidly. The explicit flat hierarchy and overt distributed expertise across the group helped to clarify the nature of facilitator participation. Facilitators were reminded by each other in Facebook group conversations that they were members of the core group and this message was reinforced in the Google Hangout pre-course meeting. Because of BYOD4L's rapid development, this engagement was not an outcome of sustained interaction - the group became fully functional quickly. Our findings question the necessity of this attribute of CiF therefore. The group did demonstrate all of the attributes of cohesion, however, being supportive and tolerant, open to turn-taking, and operating within a convivial, playful and often humorous context. The creative capacity of the group was one of its strongest identities, with peers being very receptive to doing things 'differently'. Facilitators were aware, as innovators, that any assumption associated with the BYOD4L experiment was open to be challenged. This commitment to active innovation provided the group with the energy it needed.

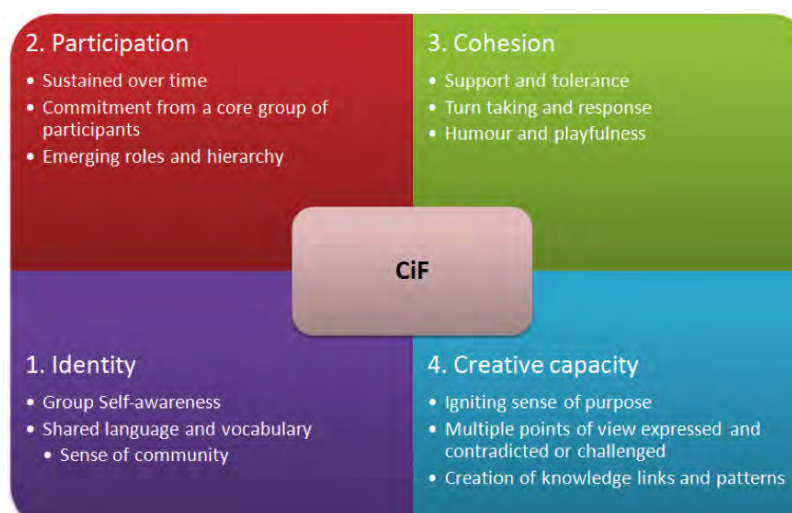


Figure 1. The Community indicator Framework (CiF) Galley et al (2010)

### Conclusions

The five day course was intense, even so it was considered manageable. Attending courses, workshops or conferences in person, with the benefits of working across institutions, requires an individual to take time away from their normal working space and this adversely affects engagement with professional development. For many this is compounded by cuts in funding. This provided a driver for BYOD4L to examine whether open CPD courses can remove the associated constraints of time and cost.

Grassroots open learning initiatives, such as BYOD4L, born out of the interests, curiosity, need and commitment of a small distributed group of professionals can alter the landscape and nature of professional development. It has the potential to bring learners and educators as co-learners closer together into a community, where openness, sharing and caring is practised and provides the social glue. This is what happened in BYOD4L when a group of distributed facilitators came together to learn about professional open practice through co-development, application and immersion.

Evidence from BYOD4L suggests that open learning facilitators, acting as member of a facilitation community, will be motivated to invest more in their role and see this as a valued professional development opportunity while supporting others in their learning; the notion of learning with the learners characterised the BYOD4L course facilitation role. Their positive relationships with each other also influenced the way they engaged with the learners and set the tone for how learners interacted with each other. One of the facilitator's noted, "We can achieve so much more when we work with others and this project is a testimony for this." Could this communal and caring approach to professional development provide a useful model for others?

*"There was a silence (possibly too dramatic to say emptiness) when the Twitter chat finished on the Friday. These connections, I think, will continue beyond the end of the course."* BYOD4L facilitator

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## Gamification and working life cooperation in an e-learning environment

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Despite the importance of cooperation between education and the working life, there are substantial difficulties on the road. Gamification refers to introducing game elements into another domain. While there is evidence on the usefulness gamification in education, its potential in bridging education and working life is still untapped. Our contribution is in investigating the possibility of facilitating knowledge sharing through a gamified platform. The case study describes the development and execution of a game-based platform for working-life cooperation, acting as a knowledge-sharing platform between schools, students, and participating entrepreneurs. In the case study, the hurdles identified in previous research were successfully overcome. Entrepreneurs evaluated the results of the game positively, expressed high motivation, and felt the produced knowledge was useful. Results suggest the potential of a gamified learning environment in increasing engagement, motivation and participation in a problem solving community of students and entrepreneurs. The nature of a game supports a shift towards learning in working life, the interviewees argue.

### Tags

gamification, working life  
cooperation, knowledge  
community, cooperative  
education, entrepreneurship  
education

## 1. Introduction

There is a high demand for partnerships between education and the working life. In Europe, the Council of the European Union calls for enhancing partnerships between vocational and higher education, employers and other parties. One purpose of better cooperation is to ensure that the competencies students learn match those needed in the labor market. Employers have an important role in identifying these competences and contributing to them. This is particularly important in terms of the competitiveness of Europe in a difficult global economic climate. There is also the perspective of knowledge sharing and knowledge dissemination. Educational institutions possess vast bodies of knowledge, which should be put into use in fostering innovation and ensuring its transfer into practice (The Council of the European Union 2009).

Working life cooperation is particularly necessary in entrepreneurial education. Entrepreneurial education has a positive connection to the propensity of becoming an entrepreneur (Kolvereid and Moen 1997), but it is necessary to employ learning by doing. Entrepreneurship is difficult to teach only based on theory – a link to actual practice is necessary (Fiet 2000). One way of ensuring authentic education is through cooperation with real-life entrepreneurs. However, the hurdles of cooperation may compound in the entrepreneurial context, where time is scarce and scarce resources considered critical (Mariotti & Glackin 2014, p. 14).

In this article, we approach cooperation between education and the working life from a new angle: through gamification. Deeper cooperation between education and the working life is essential and strategically important from the point of view of student competences as well as innovation transfer. However, research suggests that even though the importance of cooperation is accepted, it is difficult to achieve. Some of the hurdles in cooperation relate to motivational dispositions, while others relate to the lack of common working cultures between the parties. Gamification is a new development that addresses the issues. There is evidence that gamification can impact motivation as well as changing the working cultures – whether in education or in business use. We describe an example of a community of multiple educational institutions, businesses, and students working together through a gamified environment.

## 2. Cooperation between education and the working life

Educational systems are facing challenges. Today, the production of knowledge requires deeper cooperation with the working life, which raises multiple questions of interaction between the school, the workplace, and society. As Tynjälä et al. (2003) discuss, new demands change the way knowledge is produced and disseminated in education.

The new way of thinking about education ties closely together the topics of learning, innovation, and solving working life problems (Tynjälä et al. 2003, Van den Bergh et al. 2006). This type of thinking is based on a socio-constructivist view of learning, where issues such as learner activity, authenticity and problem solving become important (Blumenfeld et al. 1991). The idea of learning through experience is not new, dating back to Dewey's conceptions of learning by doing and having been extensively developed by Kolb in his experiential learning theory (1984).

Integrating all of these aspects is no simple feat. As Gibbons et al. (1994) have noted, the entire production of knowledge is shifting from a research focus towards more practical application. The shift takes place through what Gibbons et al. term "Mode 2" interaction. Similarly, Engeström (2001) has discussed the application of expansive knowledge creation in bridging learning and workplace development.

Rogers and Horrocks (2010, p. 142) discuss this shift in terms of two dimensions: the processes of learning and the settings where learning takes place. The structured, formalized processes

often associated with schools are a separate dimension, they argue. Of course, these are often related: we expect school learning (formal setting) to be structured (formal process), and workplace learning (informal setting) to be unstructured (informal process).

Historically, a gap has existed between the two worlds of formal and informal learning, theory and practice, and school and work. As Resnick (1987) has famously noted, traditional learning in schools has been formal, structured, intentionally planned, whereas learning at work has been and still is mostly informal at nature. The challenge is to break the barriers between these silos.

As Wenger (2011) argues, schools are in a transformation related to the management of knowledge. While education-working-life cooperation can take multiple forms (Ylikoski & Kortelainen 2012), there is a need for bringing together students, academics, teachers, and practitioners in new practice-oriented communities. These "knowledge communities", as defined by Earl (2001), "exchange and share knowledge interactively, often in nonroutine, personal, and unstructured ways, as an interdependent network". Such networks are often seen in businesses striving to create learning organizations, by connecting various bits of knowledge with the knowledge-enabled actors (Earl 2001).

According to Wenger (2011), the new type of cooperation borders on issues such as organizing educational experiences that ground learning in practice; connecting students' experiences to actual practice; and serving the lifelong learning needs of students by organizing communities of practice.

These knowledge-creating communities serve multiple purposes. They support developing the organization through improving skills, assisting learning by sharing best practices, help develop professional skills, help in recruiting talent, and even driving company strategy and identifying new business opportunities (Wenger & Snyder 2000). Moreover, as Wenger (2004) has noted, communities of practice are "social structures that focus on knowledge and explicitly enable the management of knowledge to be placed in the hands of practitioners." The idea here is that the people who use knowledge in day-to-day activities, are in fact in the best position to manage this knowledge. The difference from the conventional expertise-related emphasis is dramatic.

Even though the need for closer cooperation between schools and the working life is becoming accepted, it still appears difficult to achieve (e.g. Lee & Hung 2012). Studies (Henricksen 2012, Katajavuori et al. 2006) point that much more needs to be done before true collaboration is achieved. Gupta and Govindarajan (2000) have outlined the major difficulties in sharing knowledge in knowledge communities. Some of the main hurdles in knowledge flows relate to motivational dispositions of the parties. Other issues have an impact as well, such as the value of the information, the existence and richness of information channels, and the absorptive capacity of the receiving party.

The gap between schools and the working life stems at least partially from different cultures. Aside from different cultural backgrounds, Gomes et al. (2005) have found a gap in the nature of knowledge. According to their results, business people find that the knowledge produced by an educational institute is of little practical value to the company. Hence, the benefits of knowledge sharing may not always be perceived as worth the cost (Gupta & Govindarajan 2000). The phenomenon may be emphasized in small business contexts and entrepreneurial businesses, where time becomes crucial (Mariotti & Glackin 2014, p. 14). This links back to Resnick's (1987) address on what is perceived important in a learning setting.

All of the problems as listed by Gupta and Govindarajan (2000) can have an effect in the knowledge sharing community of a school and its surrounding working life. Both parties can be affected by motivational issues. Proper information channels may be absent as well. There may not be appropriate processes of collaboratively creating the knowledge, hence making new cooperation platforms necessary.

### 3. Gamification and overcoming hurdles in cooperation

Gamification, the introduction of game-like elements and logic into other domains, is one of the hottest topics today. While there appear to be numerous accounts of gamification's positive effects on learning and business (e.g. Corcoran 2010, Daniels 2010, Lee and Hammer 2011), there is very little evidence on its effect on bridging these fields. Interestingly, the effects of gamification parallel the problems related to education-working life cooperation. We argue gamification could be used as a tool to overcome the hurdles in a knowledge community.

Gamification can boost student motivation, focus and activity in the matter, particularly when combined with a student-

centric, active learning view (Thomas & Brown 2011, Shelton & Scoresby 2011). A game logic and game elements of a learning environment can increase engagement and sense of ownership. Muntean (2011) argues that these are essentially based on improved feedback. In a game, instant feedback is essential to create a sense of urgency and immediacy. Similarly, in a gamified environment, the user gains a feeling of being in control of the results (e.g. Pavlus 2010).

A relevant feature in a gamified environment is the sensation of total involvement, often termed "flow" (Csikszentmihalyi 1990). Sheldon (2012) argues that an immersive feeling of being in the flow is one of the most important benefits that gamification can offer. Feeling of being in the flow causes people to lose track of time, bordering the feeling of happiness (Csikszentmihalyi 1990).

The sensations of being in the flow, feeling engaged and immersed, assist learning by increasing participation and consequently, expended effort and focus. Typically a gamified context contains elements designed to improve felt immersion and flow (see e.g. Deterding et al. 2011). However, it is important to differentiate between different focuses of these elements. Extrinsic rewards (or motivators) refer to outcomes separate from the activity while intrinsic motivators relate to the inherent enjoyment of the activity (Bonus 2011, Shelton & Scoresby 2011). The traditional way of motivating students is related to extrinsic rewards, such as credits or grades, which is prone to causing difficulty as the learning and rewards become separate. In gamification, it is important to avoid choices increasing separation from the content.

It is important to keep in mind that gamification as such does not imply turning everything into a video game. For example, Bonus (2011) argues that a successful instructional game represents a simplified, simulated picture of reality. The authentic nature of a learning task and gamification are not opposing goals. According to Bonus (2011), gamified learning needs to offer constant feedback on activity with little concern for failure; needs to align game mechanics with instructional goals; needs to align the game narrative with instructional goals; and finally, needs to allow players to choose and customize their characters.

Based on the problems in education-working life cooperation and the potential benefits of gamification, we propose the following. As previous research has found, motivational issues can cause a major obstacle in creating a practice-oriented knowledge community (Gupta & Govindarajan 2000). We

propose that the motivational effects of gamification can be expanded from students to working life participants as well.

One reason for the shortfalls in knowledge community creation is related to how the created knowledge is perceived (Gupta & Govindarajan 2000). There is ample evidence of students having created world-class innovations and started successful corporations (e.g. Google and Yahoo! originated as student projects), suggesting students can have tremendous potential. The difference may be related to how students approach knowledge creation. Is it only a compulsory chore, or is it about really putting your mind to it? We propose gamification can have a positive effect on the outcomes.

Lack of common culture and platforms are problems, which might benefit from gamification. The flow and immersion of a game lowers the threshold to participate, while potentially increasing the propensity for risk taking. In knowledge communities, we propose that a gamified approach may facilitate entrepreneur as well as student participation. It may be easier to formulate the goals of the cooperation in a game, taking a different angle than in "real life", with less to lose if the project fails.

### 4. Methodology

The case study brings together entrepreneurs, students, and teachers in a knowledge-producing game. Our analysis focuses on participating entrepreneurs' perspective on work-based and game-based learning as well as co-operation with schools. As discussed by Gomes et al. (2005), business people are particularly critical in finding practical value in educational cooperation. The participating entrepreneurs represent small businesses, where the entrepreneur is actively involved in daily business operations, strengthening the research argument. All participating entrepreneurs had had some cooperation with an educational institution, although none had participated in a game. Hence, the entrepreneurs may have had a lower threshold for participation. Importantly, they also had experience of traditional educational cooperation.

We interviewed all six participating entrepreneurs on their experiences. We also sought input to our assumptions of game-based learning in education-working life cooperation. The theme interviews focused mostly on experiences with the game, while also covering other possible experiences in educational cooperation. Additionally, we collected student input to support the key criteria. While the focus of the research is on the entrepreneurs' perspective, students brought valuable

information about the cooperation. Students participated in a group discussion in class, which was videotaped and transcribed. Also, students' reflective thoughts in written reports were used. Interviews were conducted during the spring of 2013.

We adopted an emotionalist view on interviewees as experiencing subjects who actively construct their social worlds. We treated the data as means to an authentic insight into people's experiences, and tried to achieve this through semi-structured, in-depth and open-ended interviews (Silverman, 2001, p. 87). Following Holstein and Gubrium, 1997 (p. 116), our aim was to formulate questions and provide an atmosphere conducive to open and undistorted communication. This way, respondents were allowed to use their own ways of defining and describing the phenomenon of interest, and also to raise important, fresh issues not contained in a more structured interview schedule or data collection procedure (Denzin, 1970, p. 125; in Silverman 2001, 93).

Following the chosen approach, our concern was not with obtaining objective facts but with eliciting authentic accounts of subjective experience (Silverman, 2001, p. 90). The interviews were first videotaped, and then transcribed into written form. Following that, the textual data was analyzed through different categorization devices. We categorized the data firstly on the basis of the described forms of cooperation, and then focused on the descriptions of the drivers and modes of various actions. On the one hand, our aim was to find similarities between the narratives; on the other hand, we identified contradicting and absent experiences.

Additionally, we applied frame analysis to explore the relationships between interviewees' interpretations of the cooperation and the cultural context of the cooperation (see e.g. Alasuutari, 1995, p.111-115). In this case, the frame refers to sets of rules that constitute activities so that they are defined as activities of a certain type (Goffman 1974). When interviewees created a picture of "what is going on" within the cooperation, our aim was to locate a frame that makes the situation understandable.

In the project, a business perspective, an entrepreneurial perspective, a pedagogical perspective and social media perspective were present in a knowledge community. Because of the gamified nature, however, the community appeared as a game to the participants. As argued before, we introduced gamification into the community to lower the thresholds in cooperation.



## From the field

The “LOL<sup>1</sup>” game was an online community of entrepreneurs, students and teachers. It featured an online game board, designed to support learning on three educational levels. The purpose was to enable students to work on authentic business problems in teams. Entrepreneurs, on the other hand, offered their skills and knowledge for the community’s use.



The project was funded by the Uusimaa Regional Council (Finland), as part of the European Regional Development Fund Program. The coordinating party was InnoOmnia, the development unit of the Omnia Vocational School of Espoo, Finland. The Kasavuori Secondary School of Kauniainen (Finland) and Laurea University of Applied Sciences of Lohja (Finland) participated in designing the game and piloting the game in fall 2012. The game was played in three physically separate schools by piloting student groups.

The game took place on a virtual game board, running on a web server and accessed with a browser. The game board was designed for keeping track of all the sections within the game. The game board was programmed by a game designer agency, using the Google Education platform. A visual designer created the board’s visuals, aiming for “fun and accessibility” in the layout.

Using Google Apps for Education, the teams were given virtual workspaces for developing and sharing ideas. The game also featured a Facebook page, which was used for communication and collaboration. Game board updates, new tasks, and task

<sup>1</sup> LOL is a dual meaning acronym, representing both the well-known Internet meme and the words “Slightly Odd Business” in Finnish. The name was chosen to represent something easily approachable and non-intimidating. While it would be accurate, we will nevertheless refrain from calling the game S.O.B.

feedback appeared as notifications in Facebook. Finally, a YouTube channel was used for distributing related videos such as interviews and video reports. The main game application was connected to the applications in the workspaces as well as the game’s Facebook page. Virtual trophies appeared both on the game board and on Facebook.

The game tasks focused on entrepreneurial day-to-day issues. The educational purpose was to support students’ business studies by giving them the opportunity to solve real entrepreneurs’ authentic problems. For the entrepreneurs, the community offered new insights and solutions into their business problems. In practice, all of the problems were related to marketing issues such as product design, marketing communications, and distribution. This was the result of the entrepreneurs’ decisions and not a limitation of the game itself.

In the game, students formed teams and tackled the tasks as presented by the entrepreneurs in YouTube interviews. They sought to find creative solutions to the problems, while keeping in mind typical business constraints.

Two rounds were played in the game, with different entrepreneurs participating in each round. The rounds consisted of several sections to break up the workflow into meaningful segments. As an individual game round consisted of multiple tasks requiring planning, research and presentations, taking several weeks, only two rounds of the game were played within the semester. First, students formed teams and devised a strategy. The next phase consisted of a pitching contest, where teams made presentations on the tasks that they preferred. An educator served as game leader, giving feedback and assigning the tasks to teams based on these pitches. The game’s Facebook group was the main platform for discussion, feedback and commentary during the game rounds.

Next, students got to plan their final solution. They made a rough outline of the creative idea and implementation, on which the game leader gave feedback. Finally, students designed the final solution for the task and videoed it for YouTube.

Having reviewed the final propositions, entrepreneurs gave feedback, while teachers gave education-related feedback on the video reports. A jury of participating entrepreneurs chose the winners based on best match with business objectives. Virtual trophies and awards were distributed to the winner teams.

### 5. Findings

In the interviews, a recurring theme relates to the flow of information and knowledge sharing. Importantly, the knowledge flows exceeded the borders of the schools and businesses. We could observe knowledge sharing between student teams and entrepreneurs, as well as between different entrepreneurs. In this sense, the knowledge community created in the game represents Earl's (2001) description.

Moreover, the interviews suggest that the community met Wenger's and Snyder's (2000) call for multiple purposes. We could observe knowledge flows from the students to the entrepreneurs, helping in identifying new business opportunities. Students reported gaining new insight into their studies, reflecting Wenger's & Snyder's skill improvement. Finally, with entrepreneur collaboration, sharing of best practices could also be observed.

Transferring knowledge and ideas in multiple directions was perceived as the most substantial result. The ideas that students created brought "new approaches" and "useful input"; in the interviewees' own words. Many entrepreneurs commented that the ideas surpassed their expectations. Some of the students managed to go outside the box in their thinking, which was commended in the interviews. This was particularly apparent in the cooperation across educational levels.

The entrepreneurs brought their skills and experience into the table, offering this knowledge to the students. At its best, this resulted in cooperation, shared learning and transfer of knowledge to the end of creating new business opportunities (see Wenger & Snyder 2000). New business opportunity development is apparent in the following quote:

*"For me, the biggest thing is that we got to think about issues together. The kids brought up new ideas – like suggesting new youth target groups for my products – and I have expanded my marketing scope based on those ideas."* (Interviewee)

The entrepreneurs felt the students' ideas as particularly useful when the students brought in a youth perspective, whether in terms of marketing, service use or technological literacy, as this quote demonstrates:

*"Students have a lot to give for marketing and sales based on their own experiences in life, such as 'how I do this thing'. You can go to a corporate seminar to hear media gurus talk*

*about technology and social media, but they do not really live in that world. These young people do."* (Interviewee)

Entrepreneurs participated in jury sessions, where the winners for each round were decided. In terms of knowledge transfer, these sessions offered a lot particularly in terms of sharing best practices. As this quote suggests, the game succeeded in creating a network of knowledge where every participant had the opportunity to learn and share knowledge for others:

*"I was totally blown away by the closing session, where other entrepreneurs were present. I got a lot of ideas, like what you could do with this or that, and even commented another entrepreneur's business problem. The diversity was a very good thing."* (Interviewee)

Based on previous research, we expected difficulties in cooperation and knowledge sharing to focus on motivational dispositions, perceived value of information, and suitable platforms. Overall, we managed to overcome these hurdles. In general, entrepreneurs perceived the game highly positively. Cooperation across multiple educational levels, a fun approach to serious content, a creative implementation and fostering creation of new ideas were all perceived as worthwhile and valuable goals.

In the interviews, there are multiple mentions of the value of the information produced in the game, supporting our proposition of the usefulness of gamification. Entrepreneurs were surprised how well the game succeeded. Many felt they received something concrete from the ideas that students produced – perhaps for the first time ever. Another sign of success is that several entrepreneurs would have liked to see the ideas taken into practice: they felt the students' ideas had so much potential that they could have been developed further to a more detailed level. Within the schedule, this was not possible, however.

A recurring theme in the interviews concerns the level of involvement and motivation resulting from the game. Motivation was one of the potential problems identified in the literature review. Based on the results, all entrepreneurs experienced increased motivation to participate, and most students reported the same.

Genuine problems taken from an entrepreneur's life make for a more authentic learning experience. For the students, this had several benefits. The students reported a higher level of motivation because of the authenticity. Similarly, entrepreneurs felt the novel approach increased their interest in cooperation.



Photo: Teemu Ylikoski

It was easier to participate in cooperation with a limited scope and a fun aspect. Educators and entrepreneurs observed a sense of ownership taking place within the students. It was as if the students started feeling the tasks and ideas more as their own. This would imply a shift towards intrinsic motivation. This is an important observation from a learning standpoint.

Because of the nature of the game, the tasks could be constructed so as to resemble reality. This is at the core of the motivational aspect of the game. In the interviews, entrepreneurs praised the knowledge creation tasks on multiple occasions. Students were presented with genuine real world problems with no single solution. The entrepreneurs felt these open-ended tasks were a unique opportunity to learn the challenges of business life as well as cooperation skills. Students had an opportunity to learn in practice what it is like to solve business problems. There was no single predetermined correct outcome – just like in real life. This forced students to look for solutions creatively, not relying only on textbooks in their search for knowledge. This approach emphasized the practical nature of the required ideas, as the following quote demonstrates:

*“I feel it is important to be able to give the students the tools and a place to work, but not limit them with ready-made solutions. We should let them think it out and come up with a solution. During the game, I think it was important to note that for every group who had made their own decisions, each and every one of them stood behind those decisions in the end.”* (Interviewee)

The game appeared to facilitate cooperation and thus overcome the hurdles of missing common platforms (discussed by Gupta and Govindarajan 2000). Entrepreneurs were highly

in favor of development of games such as this. Students taking on the role of the entrepreneur, solving daily problems and cooperating through gamification were perceived as important future directions. Knowledge creation becomes more concrete through these directions. The game succeeded in transferring real knowledge and ideas, through which cooperation gained a genuine, concrete meaning, as discussed in this quote:

*“This is a good way of linking the school with businesses. Rather than the usual ‘pretending to cooperate’ way, here we have really done something concrete with real outcomes.”* (Interviewee)

Entrepreneurs were unanimous on the need for more informal, “real life” learning opportunities. In order to learn skills required in today’s workplace, students need an authentic, genuine learning environment. On-the-job learning came up in multiple instances as an example of a non-institutional learning setting. Entrepreneurs also felt that interviews, discussions and meetings were necessary in order to create better learning and interaction, as opposed to classroom learning. These observations suggest that potential differences in cultures and perceptions of knowledge between the participants could be overcome.

Finally, one purpose of the game was to advance entrepreneurial education. Students had the opportunity to assume the role of the entrepreneur and try a small-scale version of the entrepreneur’s daily life. Students described this as having been useful, e.g. in a potential future situation, where one would have the opportunity to create an innovation, as this quote suggests:

*“...we worked on this innovative product, and talked to the entrepreneur. I’m thinking entrepreneurship is not so far away anymore. If I had a good idea, I might think about commercializing it and becoming an entrepreneur.”* (Student)

Entrepreneurs felt similarly about entrepreneurial attitudes and education being transmitted. This final quote summarizes the benefits of the game:

*“In best cases, students get to see all aspects of an entrepreneur’s life. The students get to play in the entrepreneur’s role, coming out of the everyday school settings. For some, it can be exciting to work with a live entrepreneur, doing real things, seeing what the entrepreneur does for a living and what it takes to survive.”* (Interviewee)

### 6. Summary and conclusions

Education today requires a cooperative relationship with the working life. This cooperation can evolve into an authentic partnership, where knowledge is created and transferred interactively, in mutual collaboration. There is an increasing need for practice-oriented communities to support learning. However, it seems that the parties are often worlds apart. Differences in cultures, perceived benefits of the cooperation, and lack of appropriate platforms render true collaboration between education and the working life difficult. Deep collaboration requires letting go of the preconceptions of who is the learner and who is the information provider. In the new type of cooperation, all participants must be able to contribute equally.

We have experimented with an online gamified platform with the purpose of bringing the parties together, towards closer cooperation and knowledge sharing. The platform can be seen as a way of creating a more informal, realistic and authentic learning setting, where real-life problems can be tackled. In addition to bridging the education-working life gap, we experimented with bringing together schools in three educational levels.

The LOL game is an example of a practice-oriented community that is built on knowledge sharing. Gamification was used as a tool for improving collaboration, motivation, and perceived authenticity. Numerous statements from entrepreneurs as well as students emphasize the sensation of authenticity arising from the game. The ability to work on a “real” problem and produce “real” results recurs in the findings.

Previous research suggests that gamified environments can support active participation. In the LOL game, the learners became active participants on the hunt for new information. This was achieved by designing the game so that success relies on active studying, information search, problem solving, and risk taking. The fun, concrete approach resonated with the entrepreneurs as well.

An intensive learning game requires substantial effort from the learner, supporting active seeking, trial and participation (Thomas & Brown 2011, Cohen 2011). On the other hand, gamification also makes collaboration and peer support possible and even more rewarding. Several observations suggest that gamification facilitated in communicating the target problem. This seems to have impacted on pedagogical aspects as well as

collaboration with the working life. We found multiple examples of the entrepreneurs being highly motivated in the project. Could gamification support in making educational outcomes more concrete and valuable in the eyes of the practitioner? It would appear so. The entrepreneurs seemed delighted with the results obtained.

Overall, the results are highly promising. At its best, cooperation approached a true knowledge creating community, where all parties were involved in creating and transferring knowledge. The game acted as a bridge between the world of education and the working life. It seemed to motivate the participants in both ends, by creating a fun way of thinking about the curriculum and the day-to-day business problems. It also helped in creating a platform through which new ideas could be transferred in one direction and entrepreneurial skills in another direction. Finally, the ideas developed through the game were perceived as highly practical, addressing the third obstacle in cooperation.

Based on the results, a gamified approach shows potential in the light of entrepreneurial education. The game lowered the threshold of participation for students and entrepreneurs. Making entrepreneurship something that is fun and involving does not necessarily take away the seriousness of the message. On the contrary, student quotes suggest entrepreneurship may be closer than before the game. Nevertheless, more research is needed to measure gamification’s effects on students’ entrepreneurial attitudes.

A practice-oriented approach is in many ways the future of education. However, research suggests that often the cooperation remains rather superficial and lacking in depth. The entrepreneurs in this case study felt very strongly about the concrete results produced in the game. Also, by participating in the game, entrepreneurs were forced to take a new angle to their business problems. Many expressed that the new way of thinking opened up new horizons altogether.

In the future, we would welcome research into the effects of gamification in knowledge sharing. This project has touched some of the issues, but several topics are still uncovered. The small scale of the study imposes limitations; while the observations support our conclusions, more research in larger quantities is needed. Also, the role of the educators should be investigated. This project was in the fortunate situation of having a number of involved and motivated educators, but sometimes more effort may be needed to convince all participants.

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