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Wai Yin, Paco Tang

*Hong Kong Institute of Vocational Education (Sha Tin), Vocational Training Council, wytang@vtc.edu.hk*

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GAME-BASED LEARNING IN BUILDING SERVICES ENGINEERING VOCATIONAL AND PROFESSIONAL EDUCATION

W. Y. Tang

Department of Engineering, Hong Kong Institute of Vocational Education (Sha Tin), Hong Kong, China

wytang@vtc.edu.hk

Abstract

The application of digital games and gamification mechanics to non-gaming contexts have emerged as one of the prime subject interest in different sectors, such as education, marketing, health, technology design, etc. in recent years. Game-Based Learning approach in higher education has drawn teaching academics increased attention. Many believe that the game play approach could offer many benefits including, socialization, engagement, and problem solving to the millennial students.

In engineering education at undergraduate level, new methodologies and tools are being developed using game dynamics to present scientific evidence in many different engineering disciplines, e.g. mechanical engineering, civil engineering, manufacturing etc.

In this paper, a literature review relevant to gamification and game-based learning approach in higher education for engineering is conducted. A discussion on some of the examples regarding engineering education is given. Game techniques, gamification practices applying to building services engineering training are critically evaluated.

Keywords: building services engineering, game-based learning, gamification, vocational/professional education and training, BIM.

Introduction

For those who were born between 1981 and 1999 are typically referred to as the Millennial Generation. This is a generation which is the first to grow up with the new digital technology, i.e. personal computers, videogames, digital music players, video cameras, cell phones, and all the other gadgets of the digital age. Their daily lives are totally integrated with computer games, cell phone, instant messaging, blogs, etc. As a result of constant exposure and intense interaction with this modern environment, the millennial generation thinks and processes information in a fundamental way very differently in comparison with their previous generations. This new generation can be referred to as “digital natives” in whom they are all “native speakers” of the digital language of computers, videogames and Internet (Prensky, 2001).

As the technology evolved, the teaching environment in a traditional classroom has also been changed significantly over the years, we have moved from chalk board to white board; transformed from transparencies pairing with incandescent overhead projector to computerised slide presentation with colour overhead projector. Education practitioners have been continuously trying to make use of latest technology for enhancing the teaching quality and learning experience in a traditional classroom setting for students. In the above mentioned changes, we focused onto improving the visual aids in traditional classrooms with an intention to make the delivery of information more attractive and interesting and therefore, helped to engage students. The enhancement was not solely on visual aids but various teaching methods were also being introduced over the years.

Price (2009) suggested that active learning methods, as opposed to a more traditional lecture-only format, would be more acceptable by Millennials. She pointed out that Millennials have grown up in an era in which they were constantly engaged (with the Internet). When they are not interested, their attention quickly shifts elsewhere (with the Internet).

There are many suggested forms of active learning. Bonwell (1991) “states that in active learning, students participate in the process and students participate when they are doing something besides passively listening”. In vocational education context of building services engineering education at Higher Diploma level, we have adopted various active learning sessions in the curriculum, e.g. laboratories, design projects, work place attachment and work place projects, etc. These are formed as an integral part of the holistic learning experience for our students. This curriculum design has been proved to be appropriate to match with the requirements of relevant professional institutions, e.g. the Hong Kong Institution of Engineers, the Chartered Institution of Building Services Engineers, UK, etc. However, when facing with the Millenial Generation, we considered it is the right time and the right moment to inject something new to suit our students.

As a form of active learning method, game-based learning approach is believed by many to be highly
beneficial to millennial students. Gamifying in education is well known for its obvious benefit of increasing students’ engagement and for some cases of improving students’ short term learning retention. This is a very attractive active learning approach which has been explored by various education professionals at different levels.

However, as workplace practices and workplace environment have been simulated in vocational training context, we have to be very cautious when applying games-based learning approach to the curriculum or to individual modules that the industry working standard can be preserved. We definitely do not want to train students to play in the workplace. Game-based learning approach is intended to make the learning more interesting such that they have a better learning retention in a long run. In vocational education context, how far we could utilise game based approach to enhance teaching quality to students? How far would our employers tolerate their staff members playing games when performing assigned duties in a workplace? Clearly, a balance between students and employers, we have to find a balance very carefully.

On the other hand, gamification, defined as the use of game mechanics, dynamics, and frameworks to promote desired behaviours, has found its way into domains like marketing, politics, health and fitness, and very recently to education. Game players voluntarily spend hours in developing their problem-solving skills within the context of games (Gee, 2008). They recognise the value of continual practice, and develop personal qualities such as persistence, creativity, and resilience through extended play (McGonigal, 2011). Gamification applying to education attempts to harness the motivational power of games and apply it to real-world problems.

With the determination to continuously improve and enhance the teaching quality and learning experience for our students, we are committed to investigate on the game based approach to our present Higher Diploma in Building Services Engineering curriculum. This paper looks at relevant works relating to gamification in engineering education and explores the ways on gamifying the Higher Diploma of Building Services Engineering programme in Hong Kong so that our millennial students could be benefited from this game-based learning approach.

Summary of Literature Review

There are numerous definitions regarding gamification and game-based learning (GBL). Gamification can be taken as when game design elements, e.g. points, leader boards, and badges, are used in non-game contexts to promote user engagement (Attali & Arieli-Attali, 2015).

In education, game design principles can be used to change non game-like classrooms into fun and engaging game-like environments, for the purpose of motivating and changing learner behaviours.

Jones (2013) suggested gamifying class can have the following benefits:

- Make classrooms more fun and engaging
- Motivate students to complete activities
- Help students focus and be more attentive to what they are learning
- Allow students engage in friendly competitions with peers

From the above definitions, gamification is focused on fun and engaging students rather than learner’s knowledge retention. In this respect, gamifying classrooms could be regarded as using game-like elements to design activities that help to enhance the motivation of learner to complete certain activities.

While game-based learning (GBL), according to Wikipedia, is a type of play that has defined learning outcomes. Generally, GBL is designed to balance subject matter with gameplay and the ability of the player to retain and apply said subject matter to the real world.

It is the use of, predominately, video games for teaching a subject matter. The idea is to get students to play with games either ready-made or bespoke to fulfil a learning objective.

Deshpande and Huang (2011) provided a very comprehensive review on previous works relating to simulation games applied to engineering education. They concluded that simulation games would change the learner’s role from passive to more active than in traditional learning. Simulation games also encouraged the learners to invest more time on the analysis of the topic learned. They surveyed 50 previous works between 1969 – 2006 on topic-based simulation games relating to civil engineering, electrical engineering, computer engineering, chemical engineering, mechanical engineering, industrial engineering and environmental engineering, 7 major engineering disciplines.

Of these 50 previous works, 16 related to industrial engineering. That makes industrial engineering is the most popular area of engineering in terms of applying simulation games in education. Civil engineering applied simulation games in education can be traced back to 1969 and 1976, according to Deshpande and Huang (2011).

Mechanical engineering and electrical engineering are both relating to a single subject or topic only. No simulation games for the whole systems can be found.

Building Services Engineering Vocational and Professional Education and Training (VPET)

Building services engineering is a very unique engineering discipline which integrating mechanical engineering and electrical engineering into the building relating environment. It is a well-developed engineering profession originated from the UK and then dispersed to some other former Commonwealth members.

Building services engineering covers all mechanical and electrical services in buildings and these can be typically categorised into four main systems which can be commonly found in buildings, i.e. heating, ventilating and air conditioning systems, fire services
systems, plumbing and drainage systems and electrical installation systems. In North America, building services engineering sometimes refers to as mechanical, electrical package (MEP) or architectural engineering.

In Hong Kong, building services engineering education includes programmes designed for training craftsmen, technicians and engineers. From diploma to higher diploma to degree level of awards, students could study progressively to gain knowledge and experience in building services engineering through different awards. This discussion in this paper would be concentrated at the higher diploma level in which it is intended to train students to fit the rank of technicians or assistant engineers to help engineers to perform drafting, design calculations, documentations, etc.

A higher diploma (HD) programme which has at least 60% of the curriculum consists of specialised content in specific disciplines, professions or vocational skills. An associate degree (AD) programme, which is also pegged at the same Qualification Framework level in Hong Kong, has at least 60% of curriculum consists of generic contents (e.g. language, information technology, general education, etc.).

A higher diploma, by the above definition, should be a trade orientated programme in which the graduates of the programme should be able to work in the relevant industry without much difficulty on the required skills, attitudes and knowledge.

Computer-aided design (CAD) software is a vital tool for every building services engineering students in their normal working life. Currently, we use mostly 2D drafting to present the design of building services systems in buildings. However, the practice has changed very recently from 2D to 3D. This latest development is called Building Information Modelling (BIM).

In Hong Kong construction industry, Building Information Modelling (BIM) is a new tool which could probably revolutionise the current practice. With the lead from the Department of Housing, Hong Kong Government SAR, BIM is now a compulsory submission requirement for the design phase of all the Department’s new projects. This new tool allows drawings produced from various design and construction teams to be shared in 3D, instead of 2D in the past. During the design phase, this standard 3D drawing presentation format can be an efficient way to allow various design parties to communicate in this common platform, such as, clashes can be checked and detail information about the building elements can be stored in the tool, etc.

To provide proper vocational training to our students, despite the use of BIM in Hong Kong is yet to be a mainstream, we have included an elective module to introduce BIM focusing on building services design in our HD curriculum. Further integration of BIM with other existing design related modules could be expected in the near future once the construction industry in Hong Kong has becoming more receptive with BIM as a common tool for design, construction and facilities management for buildings replacing the traditional 2D CAD drawings.

From all the information gathered above, BIM would be an appropriate tool to implement gaming to relevant design project modules in the existing HD in Building Services Engineering curriculum. It is obvious that the industry is in the path to utilise BIM as a tool to enhance communication effectiveness among different design, construction and facilities management parties. However, as this is a new tool, training for teaching staff is also very important for sustaining the development of this new tool and potentially for implementing gaming for some modules in the curriculum. Apart from training of teaching staff, applied research on the use of BIM for enhancing industry efficiency has to be encouraged, so that the new tool could be a training media for both students of pre-employment and practitioners of the industry.

**Discussion**

Alanne (2016) gives a very detailed study on applying game-based learning to building services engineering education. The following is a discussion based on Alanne (2016) work taking into account the situations of Hong Kong’s vocational and professional education and training (VPET) in particular on building services engineering industry.

With the advance of mobile technology, we are constantly connected with the Internet by Wi-Fi or other connecting devices. It is therefore normal to deduce that the motivation of study could be increased when learning can be taken place everywhere according to one’s will. The future of game-based learning environment could be so called ubiquitous learning (U-learning) or mobile learning (M-learning). That means a ubiquitous learning environment is that learning processes are present everywhere, and the learners are totally enclosed by the environment or even without being aware of learning.

To create an ubiquitous game-based learning environment, the use of augmented reality (AR) could provide a possible solution for building services engineering education. AR can blend the real world and digital information, e.g. overlaying images, audio, video or haptic sensations over a real-time environment. Wang et al. (2012) propose a conceptual framework to integrate BIM with an AR application to make construction activities or tasks to be visualised in real time. Johansson et al. (2014) provide a tested prototype on immersive visualizations in the building design process integrating BIM with AR. Their model is aimed to help the design team members with different design culture and background, e.g. Architect, Structural Engineer, and Building Services Engineer, with an improved communication platform. This would reduce significantly the problems of insufficient collaboration and information sharing during the process. They argue that the ability to allow design team members to navigate freely through 3D scenes from a first-person perspective, it is possible to alleviate problems described above. BIM is therefore a good candidate for giving the handy 3D data from the architect's own design environment for this application.
The use of CAVE (CAVE Automatic Virtual Environment) and Powerwall are considered to be expensive and a large physical space is required for these systems to be installed and to be used as a fully immersive AR system. For CAVE, three walls and a floor are required for one person to operate the system. For a class of 30 students, the number of CAVE required to be built to reduce student's idling time during the class would become a huge and risky investment. Powerwall is simply a high revolution large screen which required a big conference room to allow its functionality fully explored. A group of people can be gathered in the conference room to collaborate at the same time using the big screen. These two systems have to be installed in a fixed location which makes the collaboration of various design team members have to be met physically. The most problematic of these systems to be used in building design process is the limited BIM-support.

A portable system for immersive BIM visualization is then developed using three main components: (1) the Oculus Rift Head Mounted Display (HMD), (2) an efficient real-time rendering engine supporting large 3D datasets that is (3) implemented as a plug-in in a BIM authoring software. This is a low cost system as comparison with CAVE and Powerwall. No dedicated facility is need for this portable system. The specially developed rendering engine is capable of managing large and complex 3D datasets and be able to be implemented as a plug-in to a authoring BIM software.

However, from their test results, the time required to complete the rendering and to make iterations for every input, time delay is still very noticeable. This suggests future work is required for shortening the time delay for rendering and iterations between design inputs.

Nonetheless, Jonansson's proposed portable system is still an attractive system for implementing game-based learning for design project modules of the HD in Building Services Engineering curriculum. The system is low cost and is affordable to be setup in numbers for a class. The use of the Oculus Rift HMD makes it a game-like system in which the HMD is very often being used as a game-play essential equipment. The Oculus Rift is not being used by the gaming industry but it is also can be used in the actual building design process. That piece of equipment if being used by students would make them feel like in a game rather than in a classroom. Students could be benefited from collaborating with others in a design team for different mechanical and electrical services in a 3D building during the design project modules using the above proposed portable system in a traditional classroom.

Conclusions and Future Work

Traditional classroom education already has several game-like elements. Students get points for completing assignments correctly. These translate to “badges,” more commonly known as grades. Students are rewarded for desired behaviours and punished for undesirable behaviours using this common currency as a reward system. If they perform well, students “level up” at the end of every academic year.

Given these features, it would seem that school should already be the ultimate gamified experience. However, something about this environment fails to engage students. In contrast, video games and virtual worlds excel at engagement (McGonigal, 2011).

Gamifying individual modules or the programme curriculum seems to have a brighter future for our new millennial students with increased engagement and problem solving skills.

BIM would become a new industry standard after CAD for building services engineering in the near future. Using BIM coupled with AR to enhance the learning experience of students and to implement the game-based learning approach is an ideal platform. Training to be provided at VPET on BIM and AR with gamification would provide a seamless transformation from education to employment.

We have reviewed some previous works relating to game-based learning for building services engineering. Our next work would take a step to gamify some of our modules based on some of the ideas given here and to focus on students’ performance and learning retention.

References


