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WHAT HAPPENS? WHEN COMPUTER GAMES ENTER SCIENCE CLASSROOM: BOOSTING SCIENCE TEACHING AND LEARNING WITH COMPUTER GAME TECHNOLOGIES

Abstract

Teaching and learning science in classroom is not simply bringing contents and concepts to students but also provide them with authentic experiences that can lead them to deeper understandings, both conceptual and procedural. A computer game and its association is the latest technology that has received attention from educators. Many learning scientists are also now increasingly turning to computer and video games as tools for learning. It is suggested that computer and video games are good for learning because they present players with simulated worlds: worlds which, if well constructed, are not just about facts or isolated skills, but embody particular social practices. As such, it is worth noting that the idea of using educationally potential forms of computer games to design science learning activities used in classroom is a powerful strategy to motivate and engage students into encouraging learning environments, especially in science teaching and learning which is emphasizing on the process of learning, and also especially in the fast growing age of science and technology. This article is put the focus on investigating the use of a computer game in science teaching and learning.

Keywords: science teaching and learning, computer games,

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Introduction

Central to science education is the notion of its purposes. There are four arguments its purposes for science education (Layton. 1973; Millar. 1996; Milner. 1986; Thomas; & Durant. 1987). These are called the utilitarian argument, the economic argument, the democratic argument and the cultural argument. One out of the four is the economic argument which is accepted that science education is an important contributor to establishing economic development (Drori. 2000: 28). From this perspective, school science provides a pre-professional training and acts essentially as a sieve for selecting the chosen few who will enter academic science, or follow courses of vocational training. Coles's analysis (1998) of scientists and their work, their job specifications and other research summarizes the important components of scientific knowledge and skills needed for employment as: general skills knowledge of explanatory concepts, specific skills, application of explanatory concepts, concepts of evidence, manipulation of equipment, habits of mind, e.g. analytical thinking, and, knowledge of the context of scientific work. Coles' findings suggest that the skills developed by opportunities to conduct investigative practical work, such as that mentioned in national science curriculum– the ability to interpret, present and evaluate evidence, the ability to manipulate equipment, and an awareness of the scientific approach to problems – are outcomes which are to be valued as much as any factual knowledge of science. These skills can be developed through the iterative cyclic process namely called "scientific inquiry".

Practices in Science Teaching and Learning

In science classroom practices, science learning involves problem-solving activities, or called scientific inquiry process, which require students to: 1) engage in asking question, 2) make prediction, 3) build hypotheses, 4) make observation and measurement, 5) manipulate variables to inform those hypotheses, 6) evaluate and interpret the results they have gained from those measurements and observation, and 7) feed those observation back into their original hypotheses to refine and modify their ideas. As such, this scientific inquiry is considered as sitting in the heart of science teaching and learning.

Currently, science curriculum at all level is still driven by the agenda of the professional scientific community with a well-established pedagogy which is primarily based upon transmission of predefined, value-free content knowledge. (Osborne J.; & Hennessy S. 2003: Online). Thus, active roles in this kind of learning setting are placed on teachers who function as a giving machine while students play a role as a receiving one. However, the demands for change embodied in new curricula such as 21st Century Science require teachers to adapt and adopt a different set of pedagogic practices. Its goal of fostering 'scientific literacy' involves developing a knowledge not only of the broad explanatory themes of science but also of some of the discourse and practices of scientists, including the processes of theory construction, decision making and communication, and the social factors that influence scientists' work, albeit highly simplified. This implies that students have to play active roles in knowledge acquisition. Unfortunately, there are still some problems in affording to do so. School shortage of resources, such as laboratory instruments, is one of the main problems across the globe including Thailand (TIMSS. 1999). Moreover, many teachers are struggling with implementing bunches of science content in limited science class time. These result in some shortages in science education. One of the key forces for pedagogic change in science education is the new mode of inquiry afforded by computer-based tools and resources, now known collectively as Information and Communication Technologies (ICT).

A new mode of ICT use in learning, commonly called digital game-based learning, is emerging as alternative vision for digital age of learning. It is believed that computer/video game pedagogies bear considerable potential for science education in particular and the larger field of education more generally. It is also believed that digital game technology can provide students with the real world experiences in authentic situations where they are motivated and engaged to learn in meaningful learning environment. In digital game based learning, learners, or namely players, are required to play an active role to complete various kinds of puzzle and task to accomplish the goal of that game and their own goal of gameplay. Given puzzles and tasks in gameplay, particularly in project creation or management games, players are required to use higher order thinking skills (Bell; Davis; & Linn. 1996; Schlechy. 1990) and develop various strategies to reach the goal.

A Digital Game and Its Associated Technologies

When looking at digital game in social and cultural aspects, it is clear that digital games have been growing as a part of our culture; the global market is worth billions of dollars, related activities range from published magazines to spontaneous internet communities, and the impact of games play on young people has attracted significant interest from the popular media. Three quarters of children play regularly – is this harmful or beneficial, are they learning as they play, and if so what? These questions are worth studying. In this research study, the researcher tries to investigate the potential aspects of digital game-like learning environment designed by combining strategies used by commercial games and current lessons from research on gaming and learning.

What do we mean by the word “game”? For some, games are activities to be undertaken for pleasure and are explicitly designed to not to be real. According to Salen and Zimmerman (2004: 80),“ a game is a system in which players engage in artificial conflict, defined by rules, that results in a quantifiable outcome.” By this definition, there are four main features that constitute a game: system, rules, artificial conflict, and quantifiable outcome. Gee (2004: 2) suggests that a game is a complex system which is an emergent property of the rules that the designer has built into the game and the interactions of the players with this rule system. In this study, the researchers try to define the word "game" by looking at the current form of popular games, namely digital games, played by several thousands people across the world. There is a wide variety of definitions of digital games across the range of academic, the Internet, and media writing. The terminology also varies between authors and over time, and is often interchangeable. For example, the phrases *video game* and *computer game* are often used interchangeably. Typically, there is a screen (television, monitor, LCD display) through which the game is viewed. Input devices vary depending on the game and hardware, but usually involve a controller, joystick, keyboard or keypad.

According to John Kirriemuir (2002) Such a game is:

- playable using a television set. The game software is accessed via a games console, to which input devices such as joysticks or controllers are attached; or
- playable using a television set, with the game being accessible or downloadable through a satellite or digital subscription-based system; or
- playable on a PC or Macintosh; or
- housed inside a cabinet with a built-in screen and input device such as a joystick. These are typically found in arcades; or
- found on small, portable games machines, of which the most well-known is the Game Boy; or
- increasingly found in consumer electronic devices, such as mobile phones and handheld PCs.

Essentially, most video games can be viewed as simulations of some forms. Realism-based simulations include contemporary car racing games, business simulations, sports, combat and civilization development games. More abstract simulations involve adventure, fantasy, and space battle games, although realistic graphics and physics-based effects are used in many of these games. Other simulations include puzzle games such as Tetris, and conversions of traditional games such as Scrabble, Monopoly and crosswords. Digital games are not restricted to the entertainment sector. The business sector has long used games and simulations to train staff in developing fiscal, economic and trading skills. The military sector uses simulation-based games (due partially to advances in graphical and A.I. realism) in combat training, while the health/medical sectors are increasingly using similar realism techniques and technologies to those used in games. Aircraft pilots, and "drivers" of other vehicles, often use simulations in the early stages of training and equipment familiarization.

Digital games and its association are the latest technology that has received attention from educators (Gilbert. 2004: 9). Accordingly, many learning scientists are also now increasingly turning to computer and video games as tools for learning (Squire K. 2003: Online).

In order to answer the question “Why Games ?”, Shaffer and his colleagues argue that for a particular view of games—and of learning—as activities that are most powerful when they are personally meaningful, experiential, social, and epistemological all at the same time (Shaffer; et al. 2004: abstract; Gee. 2003; 2005). They further point out that video games are good for learning because they present players with simulated worlds: worlds which, if well constructed, are not just about facts or isolated skills, but embody particular social practices (Shaffer; et al, 2004: abstract). In the view of social activities, video games thus make it possible for players to participate in valued communities of practice and as a result develop the ways of thinking that organize those practices. In addition, Gee (2005) argues that games are good for learning because, they have the following features: 1) they can create an embodied empathy for a complex system, 2) they are action-and-goal-directed preparations for, and simulations of embodied experience, 3) they involve distributed intelligence via the creation of smart tools, 4) they create opportunities for cross-functional affiliation, 5) they allow meaning to be situated, 6) they can be open-ended, allowing for goals and projects that meld the personal and the social.

In learning perspective, when looking at particular elements of game for learning, we found that the most interesting games are those in which what unifies the different aspects is some overriding narrative through which the various components, rules, and interactions take on meaning. Salen and Zimmerman (2004: 35) suggest that meaningful play occurs when the relationships between actions and outcomes in a game are both discernable and integrated into the larger context of the game. Gee (2003) suggested that the real power of digital games is bound up in their potential to establish the third identity through which one can develop embodies empathy for the complex system. A well-designed game immerse players in a rich network of interactions and unfolding storylines through which she solves problems and reflects on the workings of design of the game world, as well as the design of both real and imagined social relationships and identities in the game and non-game world. As thus, in the view of learning experience, science teachers may see that helping students develop a personal empathy for the entirety of complex system is one of the educational potentials of games that hold much promise for science education.

Current Research on Gaming in Science Education

Over the past few years, several research projects, organizations centers, grants, books, and studies have emerged exploring new visions for game-based technologies in learning (Game-To-Teach Team. 2003). Educational research on academic learning through computer games has uncovered a few successful implementations which employ commercial games in classroom (e.g., Squire. 2004, on Civilizations) and some interesting examples of games explicitly designed to support learning (e.g., Jenkins; Squire; & Tan. 2004, on *Supercharged*), and has discussed contexts that situate game play as part of a larger educational agenda, such as the Fifth Dimension project (e.g., Nicopoloulou; & Cole. 1993). However, many games and their forms of use have relatively little impact on school curriculum, especially when contrasted with the prevalence of commercial videogames outside the school setting (Gee. 2003; Squire. 2005). The reason why is that most commercial video games are produced for entertainment purpose only and many of them lack of integrating learning principles and theories into its design. In this study, the researcher tries to review and discuss the use of game in education in general and in science education in particular. Some research findings show positive results of using game in learning. Cordova and Lepper (1996:Abstract) found that students learning with instructional games in mathematics classrooms outperformed students in more traditional settings and that context, challenge, control, and curiosity increased motivation. McFarlane, Sparrowhawk, and Heald (2002: Abstract), as part of a teacher evaluation research experiment found that computer games provided a forum in which learning arises as a result of tasks stimulated by the content of the games, knowledge is developed through the content of the game, and skills are developed as a result of playing the game. Moreover, survey studies suggest that game experiences are changing a generation's attitude toward work and learning (Beck, J.; & Wade. 2004: Abstract). Dede and Ketlehut, for example, (2003) have been developing and researching River City, which uses a Multiuser Virtual Environment Experiential Simulator (MUVEES) to introduce an engaging multi-user virtual environment that teaches science concepts in a way that draws on curiosity and play (http://www.virtual.gmu.edu/muvees). Similarly, Quest Atlantis (QA) is a learning and teaching project that uses a 3D multi-user environment to immerse children, ages 9-12, in educational tasks (http://questatlantis.org). This project is built on strategies from online role-playing games, QA combines strategies used in the commercial gaming environment with lessons from educational research on learning and motivation (Barab; et al. 2003). The series of research investigating the effects of these kinds of learning environment are still being undertaken. Some released show positive results of engagement and meaningful learning. By taking a closer look at this project study, it is found that this project integrates principles underlying the development of entertaining games (play, challenge, curiosity, and control) into the design of a learning environment, a practice frequently absent from textbooks and school-based activities. The project also entails a rich meta-game context through which children perceive their participation as meaningful and engaging.

Another example of research on gaming in science education is the work by Kurt Squire and his colleagues (Squire; Barnett; Grant; & Higginbotham. 2004; see also Jenkins; Squire; & Tan. in press; Squire. 2003) who have worked on a computer game called "*Supercharged!*" to help students learn physics. *Supercharged!* is an electromagnetism simulation game developed in consultation with MIT physicist John Belcher by the Games-to-Teach project at MIT (run by Henry Jenkins, see www.educationarcade.org). In this gameplay context, players use the game to explore electromagnetic mazes, placing charged particles and controlling a ship which navigates by altering its charge. The game play consists of two phases: planning and playing. Each time players encounter a new level, they are given a limited set of charges that they can place throughout the environment, enabling them to shape the trajectory of their ship. The goal of the game is to help learners build stronger *intuitions* for electromagnetic concepts based on perceptual and embodied experiences in a virtual world where these concepts are instantiated in a fairly concrete way. Squire, Barnett, Grant, and Higginbotham (2004) report some results that are part of a larger design experiment examining the pedagogical potential of *Supercharged* in three urban middle school science classrooms with a good deal of cultural diversity. The results show that the experimental group outperformed the control group on conceptual exam questions. Post-interviews revealed that both experimental and control students had improved their understanding of basic electrostatics. However, there were some qualitative differences between the two groups. The most striking differences were in students' descriptions of electric fields and the influence of distance on the forces that charges experience. In the report, they concluded that these initial findings suggest that the primary affordances of games as instructional tools may be their power for eliciting students' alternative misconceptions and then providing a context for thinking through problems. An adept game players appropriate game representations as tools for thinking, which were later taken up in solving other physics problems (p. 510).

These exemplary findings show positive result of developing educational games. However, in the context of gameplay, it is vital that social interaction happening around gameplay need to be taken into consideration for creating an effective learning environment. From the findings of research into the use of Supercharged game in classroom implementation, it is very important for the use of game in education to have a well-integrated combination of embodied immersion in rich experience (the game wherein the learner virtually enters an electromagnetic field) and scaffolding and guidance, both through the design of the game itself as a learning resource and through teachers making the game part of a larger coherent learning activity system. Therefore, learning process in gameplay context is not for games in and of themselves, but as part and parcel of a well-designed learning activity system.

Conclusion

In conclusion, it is believed that use of constructivist multimedia, such as digital game technologies, to coach or facilitate science learning and learning in the game like learning environment will enable learners to integrate their knowledge and skills to perform various kinds of complex problem solving which results in successful learning. As thus computer games and their associated technologies are holding positive promise for science teaching and learning and for the larger field of education.

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