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INTEGRATING SIMULATION-BASED PEDAGOGIES TO ENHANCE LEARNING OUTCOMES

*Dr. Ram Mehar
**Neelu Arora

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Corresponding Author: Neelu Arora; Email: neeluarora_25@yahoo.com; doi:10.46360/cosmos.ahe.520212007

Abstract

Scientific discovery learning is a highly self-directed and constructivistic form of learning. A computer simulation is a type of computer-based environment that is well suited for discovery learning, the main task of the learner being to infer, through experimentation. Computer simulations have become a major tool of doing science and engaging with the world, not least in an effort to predict and intervene in a future to come. The focus is on two questions: how use of computer simulations can enhance traditional education, and how computer simulations are best used in order to improve learning processes and outcomes. We report on studies that investigated computer simulations as a replacement of or enhancement to traditional instruction. The reviewed literature provides robust evidence that computer simulations can enhance student learning outcomes, especially as far as laboratory activities are concerned.

Keywords: Simulation, Pedagogies and Learning Outcomes.

Introduction

Emerging learning technologies have created new opportunities for educators to create student-centered learning environments that foster the development of capabilities. The evolving use of Information and Communication Technologies (ICTs) in teaching and learning "raises a whole series of questions ranging from the appropriateness of the 'chalk and talk' paradigm, through the role of assessment, to the need to cater for different learning styles" (Holmes, Tangney, Fitz Gibbon, Savage &Meehan, 2001). Online simulations provide experiential learning environments that replicate workplace tasks or processes to allow students to practice and master work relevant knowledge and skills. They allow learners to apply critical thinking and decision making skills in a non-linear environment in which decisions and actions often lead to complex and unexpected outcomes (Bowness, 2004). Simulations are especially useful as a learning tool because they model aspects of reality in a safe environment, allowing learners to make errors that do not have real repercussions (Adobor & Daneshfar, 2006). In larger classes simulations offer a number of advantages over other experiential learning approaches because they provide automated and simultaneous feedback, enhance learner engagement and encourage productive team work (Edelheim & Ueda, 2007; Feinstein, Mann & Corsun, 2002; Fripp, 1997). Raines (2003) contends that teachers should ''create a lesson plan that maximizes student learning, encourages critical thinking, aids information retention, and allows students to apply key concepts and knowledge gained through readings and lecture to real (or realistic) problems.''

We agree and so we designed an active learning simulation to create such a lesson plan. Simulations allow students to relate their book knowledge to the real world (Brock & Cameron 1999, 252); they essentially provide laboratories, which soft sciences often lack, to recreate complex processes (Woodworth & Gump, 1994). Simulating these processes allows students to experience and apply the concepts and theories from the course to actual scenarios and events and ultimately to understand the concepts and theories more deeply (Asal, 2005). In short, it facilitates the development of critical and analytical thinking and problem-solving skills.

According to De-Jong and Van-Joolingen (1998) a computer simulation is "a program that contains a model of a system (natural or artificial; e.g., equipment) or a process". Their use in the science classroom has the potential to generate higher learning outcomes in ways not previously possible (Akpan, 2001). In comparison with textbooks and lectures, a learning environment with a computer simulation has the advantages that students can systematically explore hypothetical situations, interact with a simplified version of a process or system, change the time-scale of events, and practice tasks and solve problems in a realistic environment without stress (Van-Berkum & De-Jong, 1991).

Importance of Simulations

A simulation-based teaching environment enables students to acquire experience and consider their previous results (Nahvi, 1996). In particular, the gaming approach utilizing interactive media and/or simulation has been shown to be effective in improving teaching and learning of various subjects

**Professor, Department of Education, USOL, Panjab University, Chandigarh, Punjab, India.*
***Research Scholar, Department of Education, Panjab University, Chandigarh, Punjab, India.*

(Hsieh & Hsieh, 2004). By reducing practical learning time for students, and for schools and programs, simulation reduces costs for practice oriented educational methodology. The simulation-based training reduces the gap between learning environment and “real" environment, and making available training of “real world” situations that are difficult to simulate in a hands-on lab environment. Simulations promote active learning. As experiential learning, simulations generate student interest beyond that of traditional classroom lectures (Veenman, Elshout, & Busato, 1994) and thereby provide insight. Additionally, simulations develop critical and strategic thinking skills. The skills of strategic planning and thinking are not easy to develop, and the advantage of simulation is that they provide a strong tool for dealing with this problem (McKeachie, Pintrich, Lin, & Smith, 1986). In particular, computer simulation exercises based on the guided discovery learning theory can be designed to provide motivation, integrate information, and enhance transfer of learning (Faryniarz & Lockwood, 1992). By implementing properly designed simulation activities, the role of a teacher changes from a mere transmitter of information to a facilitator of higher-order thinking skills (Mayes, 1992). According to Magnusson and Palincsar, simulations are seen as a powerful tool to teach not only the content, but also thinking or reasoning skills that are necessary to solve problems in the real world (Woolf & Hall, 1995; Magnusson & Palincsar, 1995).

Why there is need of introducing Simulation based Pedagogies?

(i) A simulation model, in terms of its potential to promote higher-level thinking as demonstrated in this study with WILSIM-GC, can and should be leveraged in teaching students the difficult-to-master concepts and processes of landform evolution. We believe the benefits of using simulations are worth investing the time and effort to develop the associated curricular materials. This is also supported by the literature (Smetana &Bell, 2012).

(ii) Traditional paper-based approaches should not be discarded because they are similarly effective (albeit with a small to medium effect size) for teaching geoscience concepts, information, and terminology. In fact, as suggested in previous studies, scaffolding using traditional teaching approaches is necessary to help students develop enough background knowledge so that they are ready to explore within simulations (e.g., Khan, 2011; Schneps et al., 2014). We agree with this suggestion and recommend that traditional approaches be used in curricular materials that provide the basic concepts and foundation for more-advanced exploration and problem solving with computer simulations.

(iii) Such integration (of traditional approaches and simulations) may be critical to designing better curricular materials, especially for online courses in which direct interaction with an instructor is not readily available. An online simulation model, such as WILSIM-GC, also lends itself naturally to the increasingly common practice of the ‘‘flipped classroom’’ approach, where traditional lecturing is replaced with interactive activities in the classroom, and online learning is conducted outside of the classroom.

(iv) The effect of replacing traditional teaching methods by using computer-based simulations have been published (Trona & Klar, 2003) and shown that, the students who learn Physics instruction using simulated programs perform conceptual mastery than their counter parts who were trained by the traditional method of teaching.

(v) According to the report presented (Zollman and Fuller (1994) when a traditional teacher-centered method is used in teaching Physics at high school level, students expect everything from the teacher where he/she is the source of every concept and they are a mere receivers of knowledge. After the lesson is covered by one-way teaching method, that is, from the teacher to the students, students are fighting to solve problems and miscellaneous exercises, which are found at the end of each chapter in the textbook without understanding the concepts of the lessons.

(vi) Sherin, diSessa and Hammer (1993) reported that, activity-based environments combined with interactive discussions are superior to that of the traditional method of teaching to enhance conceptual understandings, experimental techniques and scientific literacy.

(vii) Several authors (Beerman, 1996) refer the use of simulations as a powerful means to smooth the approach to scientific concepts. From simple schemes to the color pictures that illustrate modern textbooks, there are several forms to transmit scientific content in a visual way. With adequate images, students may visualize some abstract concepts, allowing for a more direct contact with the subject being studied (Laws, 1991).

(viii) Dupin and Jashua (1987) showed, the challenge is: that students aren’t informed how these results are related conceptually to a model that tells what is happening in that situation.

(ix) Lakin Hein and Zollman (2000) showed that, traditional instructions supported by technology improve achievement of students. Computers help the teacher to prepare animation and to show a model of abstract concepts.

(x) Donelly (1997) explained that, complicated concepts can be presented and understood easily, with the help of simulations.

(xi) Johnston and Millar (2007) and Beerman (1996) also showed that, different traditional methods of presentations that are supported by computer demonstration give a chance to the teacher to manage the way of presenting information.

Reviewed Literature with Respect to Simulation Based Pedagogies

The available review of literature reveals that the simulation-based pedagogies enhance student learning outcomes. The studies of Rieber (1990) suggested that animated presentations can promote learning under certain conditions and were superior to static graphics. Marcoulides (1990) indicated that computer-based programs can help students learn and improve their performance. Mistler and Songer (2000) found that high level of motivation as well as achievement gained by using authentic images and online communication. Kadhiravan and Suresh (2003) found that computer assisted instruction to be most effective instructional strategy in enhancing the achievement as well as retention of learners. Akinsola and Animasahun (2007) concluded that teachers' use of stimulating teaching methods would go a long way in sustaining and motivating students' interest in learning mathematics. Kara and Kahraman (2008) found the positive effect of computer assisted instruction on the achievement of students. Erdogan, Bayram and Deniz (2008) revealed that web-based education has positive effects on the improvement of academic achievement and on motivation for learning when compared with traditional learning approaches. Schmid et al., (2009) explored the achievement effects of computer-based technology use in higher education classrooms with the variable degree of technology use was found to be significant. Brekke and Hogstad (2010) concluded that integration of computer-based work in classroom teaching helped the students to perform better.Serin (2011) investigated that there is a statistically significant increase in the achievements and problem solving skills of the students in the experimental group that received the computer based science and technology instruction. Bayturan and Kesan (2012) demonstrated that teaching mathematics with a computer assisted instruction method increased student success significantly in mathematics lesson. Koseoglu and Efendioglu (2015) proved that the multimedia-based biology approach was more effective than the teacher-centered biology approach with regard to supporting meaningful learning, academic achievement, enjoyment and motivation. Abdullahi, Yusuf and Mohammed (2018) concluded that the use of computer assisted instructional packages significantly improved the performance of students in chemistry. Caday (2004), Paul, Moses and Brandford (2013), Valencia (2016), Kumar and Kumar (2017), Lai (2019) studied effectiveness of computer-simulated experiments as one of an effective tool to improve achievement levels in the subject as compared to traditional method of instruction.

Conclusion

Computer -based learning (CBL) is a method, which use computer in learning media, strengthening students' motivation and education process. It gives opportunities to both students and teachers to learn by their speed and combine active learning with computer technology. The findings presented in this paper reveal that simulation by itself is not very effective in promoting student learning. However, simulation becomes effective in promoting student learning when used in conjunction with hands-on approach i.e. hybrid or combinational instructional strategy.

Conflict of Interest

There is no conflict of interest between the authors in this manuscript.

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