Video Game Genre Affordances for Physics Education

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ABSTRACT

In this work, the authors analyze the video game genres’ features and investigate potential mappings to specific didactic approaches in the context of Physics education. To guide the analysis, the authors briefly review the main didactic approaches for Physics and identify qualities that can be projected into game features. Based on the characteristics of the didactic approaches each video game genre’s potential for narration and simulation and affordances for reflection and assessment are evaluated, providing examples of specific games that adhere to those requirements and ways they can be utilized in educational contexts. The paper concludes by discussing the implications on serious game design and integration of games for Physics education in school environments and suggests topics for future research.

Keywords: Assessment, Conceptual Learning, Learning by Inquiry, Qualitative Physics, Reflection, Simulations, Video Game Genres

INTRODUCTION

Students’ interest in science topics is gradually declining in most countries. Physics is one of the subjects that is considerably suffering (Sandford et al., 2006; Smithers & Robinson, 2005; Kes-sels & Hannover, 2007). As expected, this has an impact on the number of people studying Physics-related subjects and doing research in Physics, which is gradually reducing. This can partly be attributed to the pedagogical approach used to teach Physics in educational environments, which is mostly based on simple transfer of facts and mathematical formulas that represent the laws of Physics (Sandford et al., 2006). Students have fewer opportunities to augment traditional narrative teaching with hands on experience in laboratories. As a result scientific reasoning skills remain underdeveloped.

Researchers investigate methods as well as tools which could enhance physics education. Some have turned to the medium of video games. Indeed, there is an extensive body of research work that advocates video games’ great potential to enhance the learning process (Chen et al., 2005a; Gee, 2007; Prensky, 2007; Klopfer et al., 2009). Video games offer a complex, interactive and visual environment with clear goals, rules and feedback that can stimulate and engage students. In games students formulate theories on how to approach a problem, work to overcome it and, in case of failure, adjust the
theory and try again. Physics is just one of the subjects that can potentially benefit from such learning environments.

Although there is a large volume of research that supports video games efficiency and potential as learning tools, the number of games actually used in educational environments is disproportionally small. This is partly due to a lack of widely accepted and systematic methods of integrating educational, and Physics, content into gameplay without undermining the video game’s engagement value.

Making a small step into this direction, in this work we analyze the video game genres’ features and investigate potential mappings to specific didactic approaches in the context of Physics education. To guide our analysis, we briefly review the main didactic approaches for Physics and identify qualities that can be projected into game features. Based on the characteristics of those didactic approaches we evaluate each video game genre’s potential for narration and simulation as well as the affordances reflection and assessment they provide. We conclude by discussing the implications on serious game design and integration of games for Physics education in school environments and suggest topics for future research.

DIDACTIC APPROACHES FOR PHYSICS TEACHING

Teaching Science is considered by the majority of school children as a difficult subject. According to a report by UK’s NESTA (Sandford et al., 2006), pupils in the UK are losing interest in science because too often the subject is being taught as just facts and formulas on a blackboard. Similar results in the USA were documented in the Smithers and Robinson (2005) report.

In an investigation assessing the underlying reasons why students do not engage with science in schools, Lyons (2006) conducted a meta-analysis of the findings of three studies which explored the issue. The studies were conducted in the UK (Osborne & Collins, 2001), Australia (Lyons, 2003), Sweden (Lindahl, 2003). Lyons grouped his findings into three major themes: the one-way transmissive approach of science teaching, the decontextualised content that fails to engage students, and the unnecessary difficulty of science.

Indeed, it appears that the prevalent approach in delivering physics knowledge across all levels of education (primary, secondary and university level) is by instruction in a lecture-based format. Occasionally, this approach is supplemented by the addition of laboratory work and ICT elements. However the main idea firmly remains learning through instruction and textbook.

In addition, instruction aims to present physics concepts quantitatively through mathematical formulae and definitions, with the conceptual element of physics teaching being suppressed. Students practice their understanding and test their knowledge primarily through solving end-of-chapter problems. However research suggests that, even after successfully solving physics problems, students lack conceptual understanding (Kim & Pak, 2002; Twigger et al., 1994). This indicates that mastery of the quantitative component of physics does not necessarily lead to (or even implies) a sound understanding of physics concepts.

Although it appears that the quantitative approach to physics teaching is prevalent, it is the conceptual understanding that lays the foundations for a concrete understanding of physics. Research suggests that students should deeply understand qualitatively the physics principles, before embarking in quantitative problems (Forbus, 1997; White & Frederiksen, 1998). Conceptual teaching does not suppress the quantitative elements of physics. Students taught physics focusing on conceptual understanding perform equally well on quantitative problems which require the use of equations (Thacker et al., 1994; Hoellwarth et al., 2005).

It should be noted, that while physics education in schools and universities is largely dominated by traditional teaching methods, there are efforts all over the world either to enhance traditional teaching with new techniques and media or to replace them by alternative
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