Physics and Playstation too: Learning physics with computer games

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2 authors:

Andrew J. Stapleton
University of Technology Sydney

Peter Charles Sinclair Taylor
Murdoch University

PHYSICS AND PLAYSTATION TOO: LEARNING PHYSICS WITH COMPUTER GAMES

Andrew J. STAPLETON and Peter C. TAYLOR
Science & Mathematics Education Centre
Curtin University of Technology
GPO Box U1987, Perth, W.A. 6845
Phone: (+61) (08) 9266-7501 Fax (+61) (08) 9266-2503
Email: pstapletona@curtin.edu.au and p.taylor@curtin.edu.au

Abstract

Computer games seem to captivate the imagination and attention of contemporary teenagers. If only the energy, motivation, fun and exhilaration they enjoy from playing games on their PC, or on consoles such as PlayStation 2, GameCube, XBOX, and Dreamcast, could be captured in learning physics! Andrew Stapleton, a doctoral student under Dr. Peter Taylor's supervision at Curtin University's Science and Mathematics Education Centre, believes it can and explores how in this paper.

The paper discusses both the *use* of games and simulations in physics classrooms and their *design* as legitimate means for learning physics. Based on theoretical and methodological insights Andrew gained from his doctoral research into the design of multimedia for conceptual learning of physics, the paper considers the role of design in the physics curriculum. Physics, education and design are brought together in dialogue in an endeavour to provide physics educators with new perspective and opportunities for their students to learn physics.

To illustrate the possibility of *learning physics with computer games*, the presentation will include examples from *SR Voyager*, a multimedia prototype Andrew developed for his research, which aims to promote conceptual learning of the physics of special relativity.

Rationale behind the SR Voyager Game Prototype

SR Voyager is a game prototype designed to promote conceptual understanding of relativistic phenomena. It was designed with a spirit of co-participation between the researcher (Andrew) and a university physics course lecturer, resulting in pedagogical strategies (e.g., two reference frames simultaneously on-screen) and concepts (e.g., time dilation) that were deemed particularly important to the lecturer's program of instruction. In this way, the lecturer became a co-designer and maintained input into the project's emergent design. Thus, the game supplements existing content (i.e., lectures/tutorials) and traditional approaches to learning special relativity (i.e., mathematical formalisms), and provides students with innovative ways of experiencing and understanding special relativity.

The narrative gameplay leads students on a voyage into deep space on spacestation *SR Voyager* as a consequence of a malfunctioning navicomputer. By taking the role of spacestation captain, the student can "manually" override the navicomputer by playing simulations and solving puzzles, eventually gaining access to the control centre and returning the station to Earth orbit. Students are encouraged to record events and experiences in the *Captain's Log*, which also provides a narrative commentary and written explanations of the simulations and puzzles, as well as "quick start" guides to their operation.

The design of the artefact was broadly guided by a *constructionist* perspective. Constructionism promotes a metaphor of learners being active constructors of knowledge, which "happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity" (Harel, I. & Papert, S. 1991)(p. 1). This contrasts markedly with a didactic, learner-passive, teacher-centred view of physics education, yet allows an *epistemological pluralism* that validates multiple ways of knowing and thinking (Harel, I. & Papert, S. 1991)(p. 161). Consequently, traditional approaches to teaching and learning, such as lectures and problem classes, are commensurate with a constructionist viewpoint. The aim of implementing the game in the physics laboratory is to complement traditional approaches and provide students with new ways of thinking about and understanding scientific theory.

"Embedded" in the game design is a view of learning physics as a process of *conceptual change* (Hewson, P.W. 1982). This is particularly relevant to *special relativity* (Einstein, A. 1961), the development of which is often recognized as a prototypical example of conceptual change for which "a complete emancipation from the mechanistic worldview was the essential prerequisite" (Hewson, P.W. 1982)(p. 75). Consequently, aspects of gameplay focus on representing a range of single concepts, such as time dilation, and allow learners to "play with concepts" through interaction.

The design presents learners with a highly visual (Epstein, L.C. 1997) and narrative (Stannard, R. 1989) game, aimed at developing a broader awareness of relativity beyond mathematical description. Consequently, learners are provided with a (fun) experience of playing with relativistic phenomena to promote conceptual understanding, an approach that supplements the mathematical formalisms provided by the associated lecture series[i].

Game Playing as a Context for Learning Physics

The notion of game playing as a legitimate context for learning (Norman, D.A. 1993, Papert, S. 1998, Prensky, M. 2001), is increasingly emerging in science laboratories and classrooms (Morris, B.M. 2002).

Computer and video games can be understood as *cognitive artefacts* requiring both *experiential* and *reflective cognition* (Norman, D.A. 1993) (p. 16). Experiential cognition is a mode of expert behaviour in which the player reacts effortlessly and efficiently to gameplay events, a form of "knowing-in-action" (Schön, D. 1983) (p. 49). Reflective cognition, requires active reflection, comparison and contrast, and decision-making (Norman, D.A. 1993) (p. 16). Although a simplification, these modes provide a way of understanding human cognition and motivation evidenced in computer games:

> *An interesting example of how one can combine experiential cognition as a motivator with tools for reflective learning is provided by video arcade games. …Once interacting with the game itself, the player has to use both experiential and reflective cognition to be effective: reflective mode to learn the secrets and develop the best strategy, experiential mode to enjoy the situation and also to be at the most appropriate skill level of responding. (Norman, D.A. 1993)(p. 22)*

Traditionally, the experiential mode has been the realm of gamemakers and the world of entertainment, whereas educationalists understand the requirements for reflective thinking. As Norman (1993) explains, "[t]he trick is to marry the entertainment world's skill of presentation and of capturing the users' engagement with the educator's skill of reflective, in-depth analysis" (p. 39).

Game Design as a Context for Learning Physics

Along with game playing, game design can also provide opportunities for learning sciences, including physics (Kafai, Y. 1995). The design process, which is part of a constructionist approach, is as much about "problem setting" (Schön, D. 1983)(p. 40) or "problem finding" (Harel, I. & Papert, S. 1991)(p. 68) as it is about (traditional) problem solving, and can provide students with opportunities for *hard fun*[ii].

Game design may be particularly relevant to physics education as it requires learners to construct representations - understood as a means for improving understanding and building a personal relationship with knowledge (Kafai, Y. 1995)(pp. 302-303). Further, representation lies at the heart of the evolution of physics itself as Eddington (1929) explains, "[t]he frank realization that physical science is concerned with a world of shadows [representations] is one of the most significant of recent advances" (p. 282).

Thus, providing students, as game designers, with opportunities to construct and manipulate their own representations of physical phenomena allows them to contextualize their physics knowledge and understanding, engage in problem-solving and problem-setting activities, and creatively represent their concepts, or ideas. In this way they begin to become researchers, part of a community of physicists, as they share and modify their representations and ideas with others.

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[i] A quantitative approach is not completely absent from the game. For example, the *Light Clock Machine* in the *Time Laboratory* requires students to derive the time dilation formula.

[ii] Kafai (1995) describes hard fun as "intense concentration coupled with passion" (p. 291).