Kong, S.C., Ogata, H., Arnseth, H.C., Chan, C.K.K., Hirashima, T., Klett, F., Lee, J.H.M., Liu, C.C., Looi, C.K., Milrad, M., Mitrovic, A., Nakabayashi, K., Wong, S.L., Yang, S.J.H. (eds.) (2009). *Proceedings of the 17th International Conference on Computers in Education [CDROM]*. Hong Kong: Asia-Pacific Society for Computers in Education.

Creating Educational Game by Authoring Simulations

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Abstract: The high level of engagement students have with games has motivated many researches to study various aspect of games-based learning. The approach taken in most of the studies is bringing instruction element implicitly in games. Adapting instructional content for creating games is a viable alternative approach to create interactive virtual learning environment development. Pedagogical support in the form of simulation exercises have been shown to be more effective in learning context. In this paper we argue the simulation exercises can be combined to produce games using an authoring tool. We illustrate our idea with an exemplar in the form of a 3D virtual physics game authoring tool. The results of evaluation of our exemplar indicate that use of subject-related terminology can help participants relate virtual game context with theoretical and real world phenomenon; however, games by themselves may not serve to be an effective way to learn new concepts.

Keywords: Authoring tool, design, simulation, educational games, graphics

Introduction

Games are interactive environments where users analyze a situation, make decisions and are rewarded or penalized for those decisions [1][2][3]. The competitive nature of games, which we call the game factor, appeals to users. Games demand users to be analytic and this potential motivates the educators to use games as an instructional methodology. This leads to the paradigm of educational games. Though it is an attractive alternative, the effectiveness of game based instruction still remains to be proven [4][2]. The major pitfall with game based instruction is that it is entirely left to the student to make the connection between the imaginary world of the game and the real concepts that the game intends to teach. This leads to the situation where it is uncertain if the learning process has happened at all.

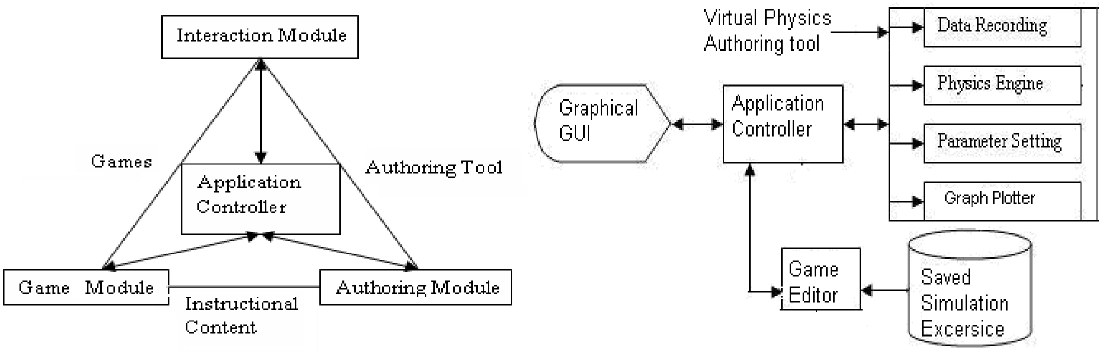
The traditional approach to ensure learning has been to add sufficient instructional content to games so that students can relate the concepts [5][6][7]. So educational games have so far remained primarily games to which instructional content is added. An alternative approach is to place the emphasis on the instructional content and add the game factor to it. Authoring tools are commonly used to create instructional content [8][9] but providing an authoring tool that enables end users to author educational games would be attractive.

In this paper, we propose a framework where one could construct instructional material pertaining to a concept *and* arrange them as multiple levels of a game. We present an exemplar system based on the proposed framework that lets the instructor create physics simulations/experiments and organize these individual simulations into different levels of a game. We believe that such an approach would let the instructor to specify the learning objective clearly and give the students a better learning experience.

1. Proposed A-G-I Framework

The framework consists of three modules. These are the authoring, game and interaction modules. The interaction module is the interface between the educational game and the developer/player of the game. The game module adds the game factor to the instructional content. It controls how to reward/penalize the user's decision, how to proceed to the next level and so on. The authoring module is responsible for the creation and control of actual instructional content. We explain this framework with a case study.

The case study is physics based game development tool. The authoring tool enables creation/control of 3D Physics experiments (simulations). The game editor helps designing games around these simulations and the interface module provides an adaptive GUI to the user. We describe the details of this system and its evaluation in the rest of the paper. The architecture of the system is shown in Figure 1 (b). The application controller handles the integration of all three modules.



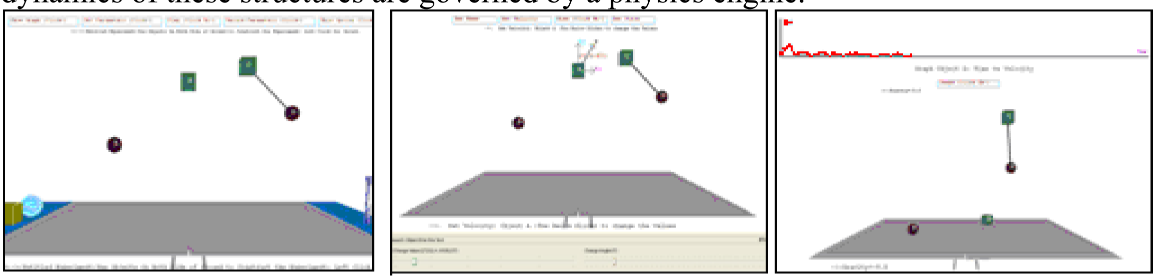
(a) (b)

Figure 1: (a) A-G-I Framework (b) Architecture of physics simulations-based game tool

2. A physics game development tool

2.1 Authoring module

The authoring module consists of an authoring tool that allows users to create simulations in a virtual environment by combining physical objects and connectors. The dynamics of these structures are governed by a physics engine.



(a) (b) (c)

Figure 2: (a) Virtual Experiment (b) Manipulating of parameters (c) Simulation of experiment.

These structures are saved to create simulations. Every simulation has a set of user-defined and computed parameters. In the pendulum example in Figure (2), the length of string and mass of the bob are user-defined parameters while the period of oscillation is a computed parameter. Users can visualize these computed parameters as tables or graphs. In our current implementation, the tool supports building simulations in a 3D environment.

2.2 Game module

The game editor adds the game factor to the simulations created by the authoring tool. In games, users are posed challenges and if they succeed they move on to a more challenging next level. While simulations also demand user to complete a task, a tight feedback loop like games is not present here. So, the input to the game layer from a game-designer should include a) specifications of tasks, b) definition of when a task has been successfully completed and c) the ordering among the tasks. All of these can be viewed as sets of conditions or constraints imposed on the simulations. For example, to throw a ball in a basket using a projectile-based simulation, collision between the ball and basket is a condition that indicates successful completion of the task. Another key input is on how points will be awarded as it not only completes introducing the game element into simulations but also helps to gauge how learners are participating in the given environment.

Our current implementation allows a game-designer to add two types of constraints - pre conditions and post conditions. Pre conditions will be validated before the start of simulation and post conditions will be evaluated at the end of simulations. The students scan the game environment looking for parameters which can be manipulated to achieve their goals. They need to, not only see their own roles or situations but also develop an intuitive, qualitative understanding of how the system itself operates. Pre-conditions are required to ensure that the initial structure of simulation experiment remains unchanged and only required object and their parameters are changed. Post conditions are basically the constraints to verify if the goal has been achieved. Users can proceed to the next stage when all pre-conditions and post conditions are satisfied. Users are awarded points based on the number of interactions they took to achieve a goal, with the base points increasing over the levels, as a reward.

2.3 Interaction module

The graphical user interface (GUI) has to adapt dynamically depending on whether a user chooses to play games or develop games. Hence, we have designed and developed the UI as a virtual environment composed of graphical objects where each object can be active. These active objects can play different role (navigation menu, input controls, simulation body) in virtual environment. The real time rendering of graphical object provides flexibility to configure the interface model with different needs. The visual designer can specify objects, their positional constraint with respect to each other, navigational components/controls and response associated with these controls.

3. Evaluation

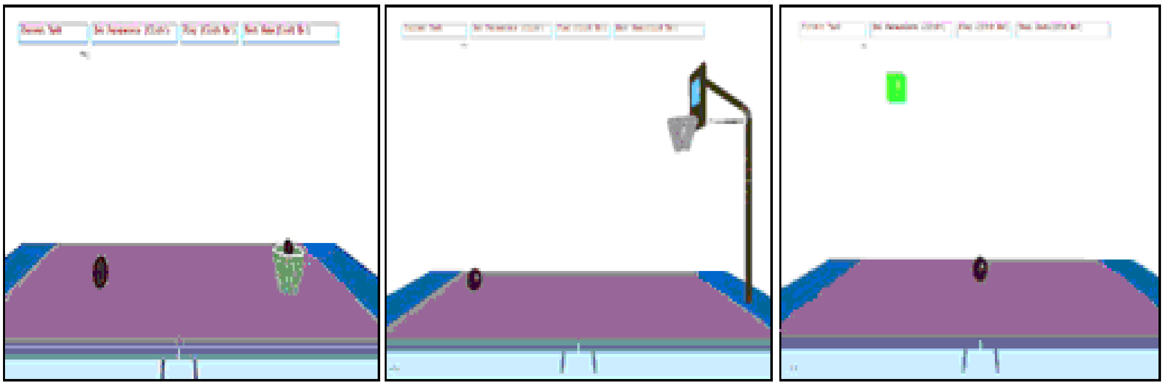
The assessment of a game based learning environment could explore multiple factors like rules, roles, criteria, goals, level of interactivity etc. In our evaluation we were interested in studying two factors.

- How well students learn new concepts from game based environments
- Effect of using simulations as levels of a game

3.1 Experiment 1

In our first study, ten students of grade seven participated. These students had an idea about the concepts of velocity and force but had not been formally introduced to projectiles.

A set of three simulation exercises were constructed using the 3D VPL authoring tool. They were linked together to form 3 levels of a game with increasing difficulty. The theme behind the game was the concept of projectile. Accordingly, the user could vary the angle and initial velocity of the ball. At the first level, students had to throw a ball into a bucket. In the second level, they had to throw the ball into a basket and finally, in the third level, they had to hit a moving object (target) with the ball.



(a) (b) (c)

Figure 3: Three levels in the game played by participants: (a) Bucket ball (b) Basket ball and (c) Hit a moving target

The participants were initially given a pre test on projectiles. The questions were related to the game they were given to play shown in Figure (3). One out of ten students got all the answers right. Then the students played the games which were authored with our tool. All students were able to complete the first two levels. Three students completed all three levels. After this a post test was administered on same set of questionnaires. In this, only 3 out of 10 students answered all the questions correctly. The study was done to understand what participants think is the best approach to achieve the task. In the games, they had to score the basket or hit the moving ball. Pre-test and post-test was done to evaluate the impact of playing games in teaching an altogether new concept (incidental learning Vs intentional learning). Our assumption was that participant will re-evaluate their answer after playing the games.

3.1.1 Result

We found that though students were able to progress in the games, they were not able to reason how varying a parameter like velocity or angle would affect the projectile. Even students, who completed the games successfully, followed a trial and error approach than any systematic reasoning based on physics concepts. Clearly, the notion of games which is reserved for fun-related activities in students' mind discourages them to associate problem solving and with theory. Games aid in experiential learning. But this argument holds only when the students have understood the concepts behind the games. Just completing the games doesn't translate to the fact that the students have understood the concepts.

3.2 Experiment 2

Here, a group of 20 students from the 9th grade constructed the bouncing ball (hitting a falling body) and pendulum experiments using the authoring tool first. Later they were asked to play the game as in experiment 1. These students had been taught projectiles and exposed to a real physics lab as part of their curriculum. At the end of the exercise we took written feedback on a fixed set of open-ended questions.

3.2.1 Result

Most students found that the games they played conveyed the same concepts as the experiments they constructed. They felt that the use of terms like velocity, angle etc. in a given task enabled better visualization of problem, formulating solution, results evaluation and concept development. They also were able to relate the game they played to their subjects better. Interestingly, 14 out of 20 participants said that they prefer to do experiment like activities than playing computer games in lab.

4. Conclusion

In this paper we proposed a framework for creating educational games and a case study based on it. We also argued that adding game factor to instructional content is a more effective way to create educational games. Our evaluation shows that mere usage of educational games cannot ensure learning. Games act supplementary to class room instruction and provide an environment to apply the knowledge they have acquired in classroom. For educational games to be effectively integrated into curriculum, researchers and developers should concentrate on developing simple and small games and make explicit the relation the game has to the lessons. This is better than creating very complex games where the student is left to figure out the relation. The game factor gives the student an immersive experience and fosters healthy competition among peers.

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