GameScapes and SimApps: New Techniques for Integrating Rich Narratives With Game Mechanics

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Abstract: A GameScape is a novel mixed-method platform that combines visual storytelling with game-based learning elements to challenge the student to critically evaluate cause-and-effect scenarios. In this paper, we discuss the design and implementation details of a GameScape developed for teaching five introductory environmental science modules in an introductory environmental science course. A SimApp (simulation application) is a game-based assessment technique that students complete at the end of each module. We present the design and integration of SimApps within GameScapes. Our approach is aimed at providing a novel method of integrating rich narrative based storytelling with short repetitive game play mechanics to promote improved student learning and retention. It is specifically designed to avoid trial and error gameplay and help provide proper remediation by making the player critically evaluate the choice of their decisions.

Keywords: game narrative, game mechanics, interaction design, assessment

1. Introduction

Experiential learning has been established as a model for improving higher education engagement (Kolb 1984) and an effective tool in a learning space (Kolb & Kolb 2005). It has also been proven that experiential learning is well suited to be a game-based learning model (Kiili 2005). Online and distance education platforms have often been challenged with providing an opportunity for students to demonstrate acquired knowledge in more active progressive development modes as opposed to the more passive traditional forms such as tests and essays. Games provide an engaging mechanism for tailoring the instruction and assessment toward a more experiential platform that suits and adapts to students' interests (Prensky 2001). In this paper we present the design of GameScapes and SimApps, two novel techniques that provide experiential learning opportunities via a game-based design methodology. A GameScape is a novel mixed-method platform that combines visual storytelling with game-based learning elements to challenges the student to critically evaluate cause-and-effect relationships presented in the game using immersive real-world scenarios. GameScapes are designed to specifically avoid the problem of trial-and-error, which many games face, by integrating remediation strategies into the design and by providing real-time visual and audio feedback based on the student's choices. In the final stages of the GameScape, the students enter a simulated world call the SimApp to critically think about the scenario and then configure a series of inputs to achieve set goals, all the while under time pressure to reach a decision. The SimApps are designed to be short and repetitive and provide immediate feedback to the student. The system is designed to track progress and to provide rewards via a badging system that encourages repetition without encouraging mere trial and error.

1.1 Game narrative

There has long been a disconnect between the development of story and the design of interaction in the overall creation of games. Traditionally, game designers focus first on interactive game elements with attention paid to creative storytelling coming much later. Half-Life (Isbister 2006) was among the first games to showcase the importance of story and to demonstrate why story requires equal consideration with interaction design. Since then there have been several attempts to apply a story-first approach to games, educational games in particular (Jenkins 2004; Dickey 2006). Recent work by (Dickey 2011) discusses the design of adventure based games with strong narrative components and explains why story elements promote learning. However Adams et al. (2012) counter that adventure-based games with strong narrative, played only for a short period of time, do not contribute to learning. Further, many designers assert that the limited success of narrative-based games in fostering learning is that the story can interfere with providing feedback to the player about the consequences of decisions made. Without this feedback, there can be no remediation. The questions that need addressing are: 1) how can feedback and remediation become a part of the narrative? and 2) where should they be included to become a natural part of the game play and story development? Aarseth (2012) describes a four-dimensional model for educational game design comprising of the world, objects, agents and events where the emphasis is on the design of agents and characters and immerse the player into series of story elements. This approach is similar to the popular and widely accepted notion of the Hero's Journey (Campbell 2008); see Figure 1, where the player needs to master a series of progressively difficult challenges by role-playing as an immersive agent of change by gaining a strong understanding of the underlying narrative. In both models, ample opportunities exist to include feedback and remediation, in the form of pertinent advice from a mentor, for example, that would allow the player to learn, grow, and improve in a logical and natural manner. However it has been a hard design problem to build educational games that can keep the player involved via narrative and at the same time provide proper remediation. In our approach presented in the next section, we remove the narrative from the design of the game and present it as rich interactive video sessions, where live actors role-play the narrative as real-world scenarios.

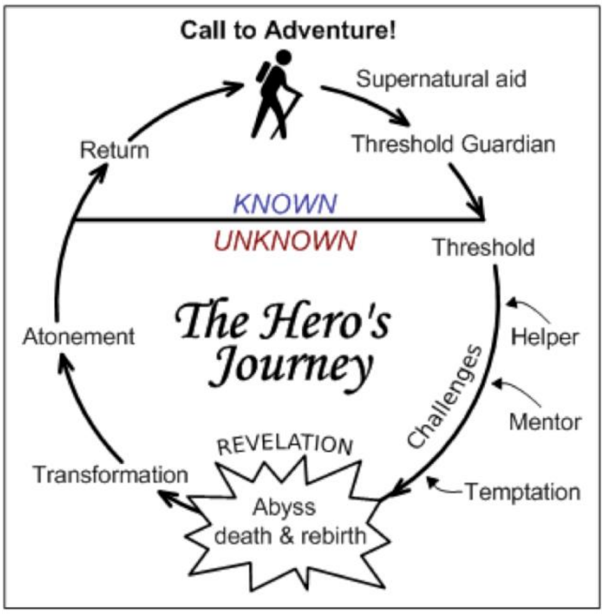

Figure 1: The Stages of the discovery according to (Campbell, 2008)

1.2 The environmental science GameScape narrative

The GameScape discussed in this paper focuses on teaching introductory environmental science concepts to undergraduate students. Similar to the narrative progression found in the journey of the mythic hero, GameScapes are designed to provide character development and level progression by engaging the student in a series of well-connected narrative elements. Over the course of five episodes, the student takes on several leadership roles with increasing responsibility to help a community address challenging environmental and sustainability issues. The student interacts with characters filmed on-location in highly realistic and authentic workplace settings to reach decisions that impact the course of the storyline. The GameScape contains a variety of interactive features that allow the student to download informational "Digital Learning Objects," to take notes, and to respond to reflection questions using "day-in-the-life" tools such as mobile phones, emails, progress reports, and governmental blogs to create their responses. Because many of these interactions involve branching dialogues with colleagues and employers, the student is in the position to receive ample immediate feedback and remediation (if needed) from the characters with whom they interact.

The GameScape is set in the fictitious city of Sparksville, a beautiful foothill community rich in natural resources and a citizenry focused on ecological balance in the region. As the game begins, the student plays the role of a local resident and biology teacher who, frustrated by the Sparksville City Council's mismanagement of the area's natural resources, has recently run and been elected to the council promising to bring a fresh new focus on environmental issues. The GameScape covers a period of 25 years with each of the five episodes taking place 5 to 7 years apart. Episode 5 provides a capstone scenario in which the student must propose a long-term sustainability plan for Sparksville. In each of the five episodes, game elements are embedded in a rich visual narrative, in which the student interacts with several different characters in each module. The critical decisions made and actions taken by the student are recorded on a consequential parameter graph (CPG) used to depict the impact of the student's choices on the community's environment, economy and political landscape. The scoring elements are automatically handled by the corresponding built-in variables that track public opinion, environment sustainability and economy. The decision making process is now a three dimensional balancing problem that progressively challenges the student to make optimal choices.

1.3. Repetitive games and SimApps

Returning to the overarching topic of games for educational purposes, repetitive games have been used predominantly in discreet settings, for example, to develop math- skills, where the interactions are short and the variables are numerous, and the solutions are dependent on the mastery of a particular skill. Chow et al. (2011) applied the concept of repetitive gaming to non-discreet problem sets in probability and statistics with effective results. The students played the game "Deal or No Deal," repeatedly, to learn and understand the concept of expected value in statistics. The real value of repetitive gaming is in the analysis of student behavior indicating that they have recognized patterns that lead to improved learning outcomes. Every module in the environmental science GameScape ends with a repetitive simulation game, the SimApp mentioned above. In each SimApp, the student makes choices about Sparksville's future and then experiences the consequences of those decisions. The SimApps are short (less than one minute of gameplay) with very simple interaction mechanic. The student chooses a set of inputs, assigns value, and hits play. The simulation compiles the result and enacts the consequences of the student's choices visually in the form of rich agents and characters as well as the CPG elements representing public opinion, environment sustainability and economy. Key to these SimApps is the option to replay them as many times as the student wishes and thereby experimenting with different variables. In short, the student makes choices, experiences consequence, and learns from the results, repeatedly.

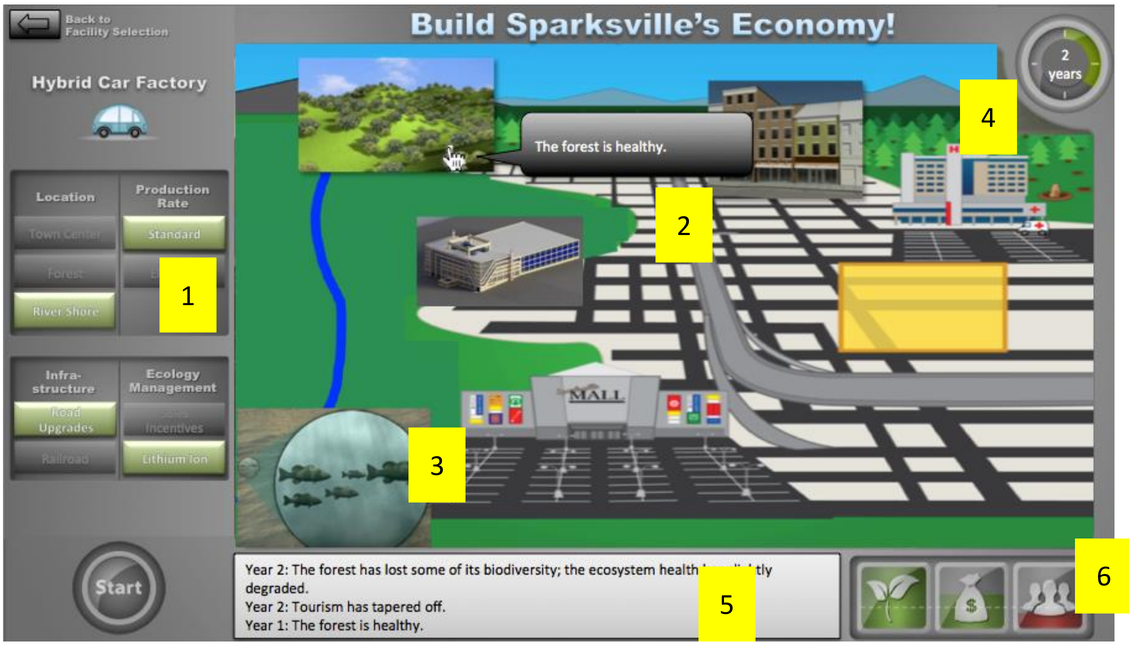

Figure 2: The Interface elements of a SimApp

Figure 2 shows the layout of a SimApp developed for third module of the GameScape aimed at managing and maintaining terrestrial and atmospheric resources. There are six main elements to any SimApp, which are briefly described in the Table 1 below. The first thing the student sees in the SimApp is the overview screen, which explains the game, provides an overview of the decisions the student will make, and describes how those decisions may impact the game. The Overview Screen is interactive to a degree – the student can point the cursor at components in the visualization area to get more background on them. The next step is to select the inputs, where a detailed description for each input choice is provided. Inputs can have dependent-child nodes, and the student must select all valid input slots before pressing the start button. After the student clicks the start button, the SimApp visualization plays out over six stages. During this phase, the student watches animations of the various agents and characters to see the effect of their selected inputs. Specified agents contain "Easter eggs" in the animations to emphasize certain successes and failures.
The Consequential Parameter Graph (CPG) (#6) displays the impact of the inputs on the environment,

economy, and public opinion. The Year Indicator shows the “real time” elapsed in the visualization measured in years. As the circular line animation in the year Indicator passes each “tick” mark, the year increments up by one. At the beginning of each stage, the state changes for each agent are handled and the corresponding ticker report is generated. The student can also hover over the individual agent to get feedback on its status.

Table 1: SimApp elements and their properties

SimApp Element	Description
1. Input Controls	Allows students to select and submit the desired inputs for the simulation
2. Hover Tags	Displays information of the agents and characters to the student
3. Visualization Animations	Displays the various states that the agents and components can be transformed into based on the inputs selected by the student
4. Year Indicator	Displays the elapsed time in years of the simulation
5. Ticker Report	Displays status updates that explain changes to animated elements in the visualization. Same component is also used to display feedback in the Feedback Box at conclusion of visualization
6. CPG values	Displays effectiveness of student’s decisions in three areas: environment, economy, and public opinion

2 Design methodology

GameScape design is accomplished by starting with the learning goals for the module. These goals are then mapped to story and narrative elements. Cause-and-effect scenarios are developed based on these storylines, and multiple remediation paths are constructed to respond to various types of student performance. The SimApp input elements are developed and scoring parameters are constructed along with the CPG elements. Table 2 shows the design progression for the third module developed as part of the environment science GameScape.

Table 2: GameScape design flow

Design stage	Description
1.Learning Objectives	• Summarize the causes and effects of human impact on an atmospheric issue. • Discuss a key challenge to controlling air pollution. • Identify the impact of human activities on a water resource, and formulate a sustainable plan to manage a water resource. • List challenges associated with managing terrestrial resources
2. Story development	• As Mayor, the student must balance the economic well-being of the area with the energy demands for industrial growth. • A political scenario unfolds when the student must analyze relevant factors necessary to decide whether to build an oil refinery, a hybrid car factory or a distribution center and where to locate it.

3. Choice and remediation paths	The student will explore and determine the benefits/drawbacks of three separate human activities and identify causes of environmental issues; further, the student will examine methods to manage these environmental issues and will formulate sustainability plans for each industry.
	
	• **Oil refinery**
	    ○ Rig is threat to water
	    ○ Pipeline is a threat to the land and water
	    ○ Refinery is a threat to the air, land and water
	    ○ High cancer risks
	    ○ Trucks are a threat to the air
	    ○ Well-paying jobs across range of skills
	• **Hybrid Car Factory**
	    ○ Toxic pollution issues with car batteries
	    ○ Air pollution
	    ○ Electricity source for the factory an issue (coal power?)
	    ○ Water pollution not an issue in terms of dumping/point source, but could be an issue with urban runoff concerns (parking area, etc.)
	    ○ Creates good amount of jobs, but not as much as refinery due to automated manufacturing processes
	• **Distribution center for consumer goods corporation**
	    ○ Trucks are a threat to air
	    ○ Non-point source water pollution from parking lot runoff
	    ○ Job creation is low

4. SimApp design	• The SimApp will test how the student's choices for each activity will impact Sparksville. • A total of 5 inputs with 3 choices per input are designed. • Student plays the SimApp by completing two challenges where the second challenge is made available with additional inputs and new set of goals upon completing the first.

2.1 Cause and effect engine

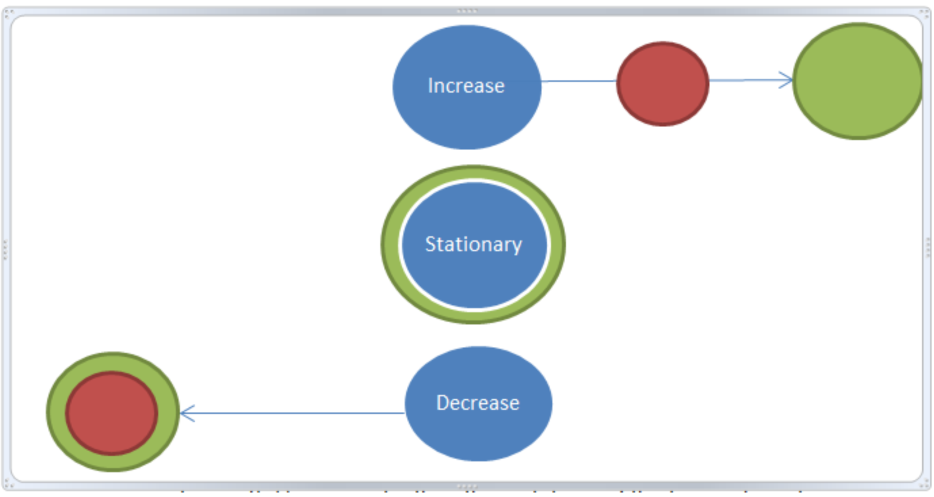

Figure 3: Components, states and terminal points

Each SimApp is designed to have a defined set of components that are the agents affected by the choices made by the student. Before the start of the game, each component will have an initial state that is determined based on the GameScape narrative. Upon the input selection and start of the game, each component will move from its initial state to the following states: stationary (the component was not affected by the inputs), increase (the component had an increase in its behavior or function), decrease (the component had a decrease in its behavior or function).

A speed parameter determines how fast the increase or decrease happens when moving from one stage to another. Also defined for each component (independent of the choices) is a terminal point. A terminal point is defined as a value for the component that causes the game to end when that value is reached in any of the states. A component sometimes may not have a terminal point defined or a component can have two terminal points defined. This is again left to the designer of the SimApp working in conjunction with the subject matter expert. Figure 3 shows an example of the component and terminal points. The blue circle represents the start value for all the three states. The green circle represents the end value for the three states. The red circle represents the terminal values for the components. In this case, there are two terminal values one reached midway between start and end values for the increase state and one that coincides with the end value.

Figure 4 illustrates an example in which there are three components that are affected by the student's decisions, A, B and C. There are six stages of visualization and in general each stage lasts no longer than 20 seconds. For each component corresponding stage values are calculated based on chosen inputs. A winning condition is reached when no component hits its terminal state in any of the six stages. Based on the inputs chosen by the student, Figure 4 shows the three corresponding causality waves represented in red, green and orange. The chosen inputs did not have a drastic effect on components B and A. In other words, they stayed closed to their desirable values across the six stages of visualization and their net effect was a success for the student. However, component C's values rapidly decreased, hit the terminal value in stage 4, and made the SimApp end. For a student to reach a winning condition, none of the components should reach their terminal value. This would lead the student to replaying with a different set of inputs. It needs to be noted that a rapid decrease or increase in a component's value doesn't necessarily mean that a terminal value will be reached. Depending on the SimApp and the narrative, the terminal values are estimated by the designer. In some situations a component being stationary might be a reason to trigger a terminal value.

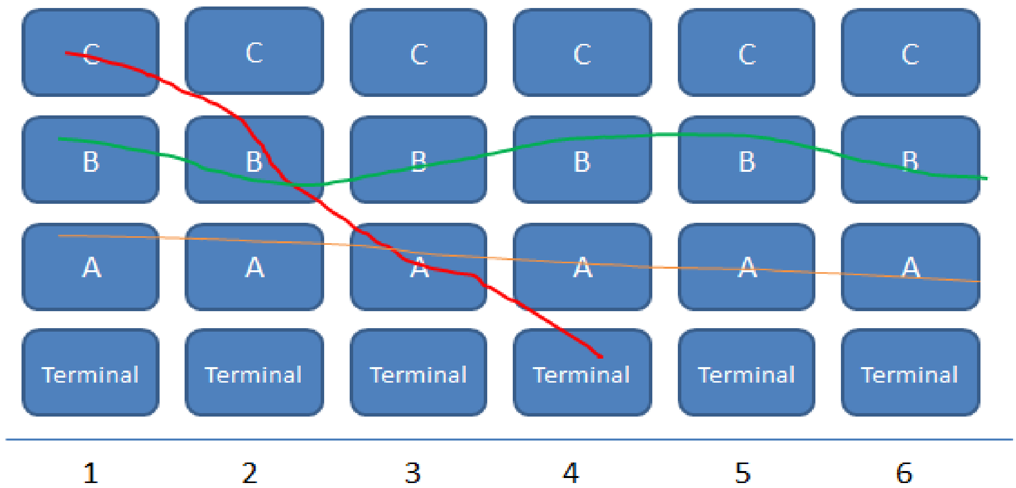

Figure 4: Visualization stages and the component representation

2.2 Game assessment and reward schema

Every attempt by the student, whether leading to success or failure, will result in a feedback message displayed along with the reasons for the resulting effect, including how it affected the three CPG items. Feedback screens are developed for each input set of choices, so in the example with three inputs and three choices per input there would be 27 feedback screens. It is also important to note that the sum total of all the terminal nodes and winning situations does not need to be equal to 27. It will always be a number much lower than 27 as many input choice sets would trigger the same terminal value for the same component. Figure 5 shows an example of a feedback screen where the student's choices have resulted in success. A remediation message (#1) is presented to the student, it this case all the components stayed in their desirable states and no terminal values were hit. The message explains the resulting scenario and gives the student the option to either retry, unlock the next challenge (only available when winning conditions are reached) or save and exit the game (#4). The player earns a badge (#2) and also coins that help unlock new challenges (#3). It is important to note that not all challenges require that the CPG parameters be balanced, in this example it was not important that public opinion be maintained.

Figure 5: Feedback screen displayed at the end of every input selection

At the conclusion of the SimApp visualization animation (whether the student was successful or not), the animations loop at their end state and the final update is added to the top of the ticker textbox. A final feedback message is displayed in a feedback box at the center of the screen. To visually reinforce the student's performance in the SimApp, a ranking badge is also displayed (see Table 3 below). Rank is determined by adding up the total CPG score for the key success factors in the SimApp (environment score + economy score + public opinion score).

Table 3: Ranking schema for badges

Rank Title	Graphic	Score Range
Eco-Hero		CPG Total = 251-300
Eco-Expert		CPG Total = 180-250
Eco-Citizen		CPG Total = 130-179 (All Eco-Citizen scenarios are terminal)
Eco-Newb		CPG Total = 0-129 (All Eco-Newb scenarios are terminal)

2.3. Technology

The GameScape and SimApps are built using two major tools, the Run Time Engine (RTE) and

ChatMapper (CM). The RTE is proprietary Adobe-Flash based software developed for this research and is loaded by the browser. It processes all of the content – animation files, videos, text responders and virtual locations. It is entirely content agnostic, meaning that the RTE does not know or care what the content is that is being loaded. In addition, the RTE is smart and adaptive: it is able to preload assets to minimize student load time; it is capable of hopping around and saving the student state when they return; and it manages the complex task of scoring. CM is a third party tool that creates the logic behind the RTE. It functions as the bridge between the content designer and the run time engine. CM is used as a technical driver that organizes content for the RTE, and it can also be used for scripting and storyboarding the narrative and storytelling elements. CM generates an XML file that represents the flow of the GameScape and is loaded by the RTE at runtime.

3. Conclusion

We believe that narrative-driven games in higher education, if properly designed, can provide an immersive and engaging experience that fosters positive learning results and enhance student learning experiences. Critics have claimed that narrative games lack the immediate feedback and remediation necessary for learning, and further, that they do not encourage repetitive play necessary for effective learning. In this paper, we provide a contrasting point of view and design examples that point to an opposite conclusion: narrative-driven games in higher education are academically sound and technologically feasible. We have presented and explained the design and implementation of two new techniques that provide experiential learning via a rich narrative-driven game based environment. In the future we will present evaluations of the impact of these new techniques on student learning outcomes, recall rates, student retention and skill development in online as well as hybrid course offerings. Our design methodology follows well established learning theories and is combined effort between instruction designers, content experts and game software developers. We would also be furthering this research by applying this methodology to different learning contexts and not just science based courses.

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