

# Invoking Higher Orders of Thinking in Serious Educational Games

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## ABSTRACT

Serious Educational Games (SEG) are an increasing segment of K-18 instructional resources and have made headway into human resource and professional development training. The difficulty of creating complex adaptable learning activities can constrain SEG developers. Current SEGs tend to be narrow in content or limited in the types of learning assessed, i.e. rote practice and objective learning. SimSYS is a content agnostic game platform that addresses the need for an easily adaptable SEG that explicitly associates learning objectives with game play. In this paper, we describe the creation of a game challenge / assessment tool that encourages higher orders of thinking requiring analysis and judgment through an interactive sandbox.

## 1. INTRODUCTION

Diverse educational settings require some thought as to the contexts of the SEGs. An organization such as a school district or a multinational corporation could have one or more instances for teaching and training. For example, the Milwaukee Public School District in Milwaukee, WI, U.S.A. has a large number of K-12 schools, including Carson Academy, Centro Hispano High School and Sherman Multicultural Arts School. These schools have specific Wisconsin State mandated standards as well as locally specific curricula. Therein lies a challenge: how to create an adaptable SEG that allows for different curricula, in different grades, in different classrooms but draws upon a common learning standard and/or body of knowledge?

Through our on-going project, SimSYS, we are investigating how to effectively develop and maintain games. This large-scale project has been organized into a game development platform (GDP), which includes support for semi-automated [1] and automated [2] game generation. A semi-automated game design wizard in SimSYS assists instructor users with little or no game design experience to create SEGs. For example, a wizard can prompt the instructor to design a game through a series of leading questions that allow for user creativity, yet remain within the bounds of good game and instructional design (Figure 1). At the same time, challenges in the game remain tied to learning objectives.

In previous work, the SimSYS multiple choice/multiple answer challenges have been presented, which can be timed/untimed, non-competitive/competitive. They have been used in a variety of games and provide a valuable tool to assessing players' knowledge of, for example, facts about a topic in a quiz (Figure 2).

Here, we move beyond the multiple choice/multiple answer challenges and present our preliminary results for a sandbox challenge, which encourages higher orders of thinking. Through

the creation of a sandbox challenge, our SEG, SimSYS, requires players to manipulate provided 'generated objects of variability' with which they must not only be able to identify, understand and apply, they must also use creativity and reason to solve a more complex issue or problem.

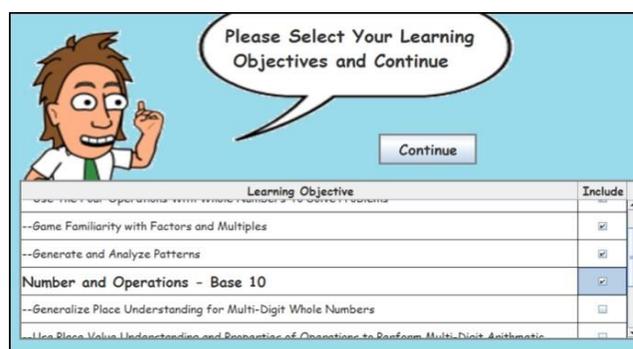


Figure 1. Prompting Designer to Select the Learning Objectives from WI State Standards 4th Grade Mathematics

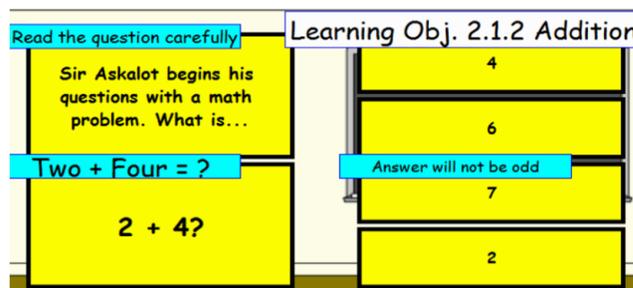


Figure 2. Generated Interactive Quiz with Learning Objective

## 2. GAMES AND LEARNING OBJECTIVES

One of the elements distinguishing SimSYS is that it employs a semi-automated game creation tool that then populates a game with learning objectives tied explicitly with goals and activities for student players within the game. Game challenges and player advancement rely on student players demonstrating competencies that are determined by the instructor [3].

### 2.1 Why Higher Order Thinking?

One of the more commonly known learning taxonomies in K-18 education is the Bloom taxonomy [4], which separates learning into types that are less complex (memorization and content awareness) to those that are more complex (towards application and judgment). Bloom's taxonomy is currently how assessments are expressed in SimSYS. Most serious educational games and

simulations, by their construction, emphasize lower orders of classifying learning: recall, understanding and application. We intend to facilitate learning at Bloom's higher orders of thinking wherein we emphasize analysis and judgment with different approaches to challenges and assessment. The higher orders of thinking draw upon a broad range of knowledge and critical thinking applications; these are more desirable skills, but more difficult to employ in a SEG.

### 3. THE SIMSYS SANDBOX

To create a dynamic assessment process, to go beyond recall and limited application, we have extended the challenges to include 'sandbox' activities that allow players to interact with onscreen objects as a means to resolve a stated requirement or query.

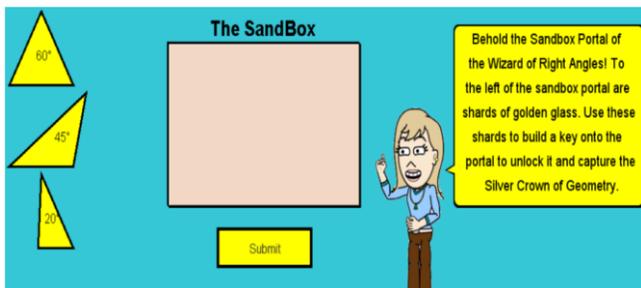
A grade four math game is used to illustrate the sandbox challenge. The learning objectives for the math game are in Table 1, drawn from the Wisconsin Common Core State Standards [5].

**Table 1. WI Common Core State Standards: Selected Learning Objectives for Mathematics Grade 4**

<p><b>Geometric measurement: understand concepts of angle and measure angles. Draw and identify lines and angles, and classify shapes by properties of their lines and angles.</b></p> <p>Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand concepts of angle measurement. ... Recognize right triangles as a category, and identify right triangles. ... Recognize angle measure as additive. When an angle is decomposed into non-overlapping parts, the angle measure of the whole is the sum of the angle measures of the parts. Solve addition and subtraction problems to find unknown angles on a diagram in real world and mathematical problems.</p>
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#### 3.1 Objects of Variability

In the sandbox challenge, the player faces a more difficult task. The player is confronted with a set of generated objects that are tied to solving a problem associated with a learning objective. In our case of 4<sup>th</sup> Grade Math, the players must infer that when they drag objects onto the sandbox, they need to create a 'key' that equates a right angle (Figure 3). This, then, is an application of several of the Grade 4 Geometry learning objectives in Table 1.

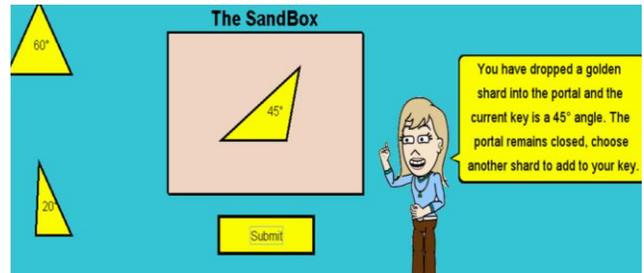


**Figure 3. Prompting Player to Solve a Geometric Problem**

#### 3.2 Input and Response

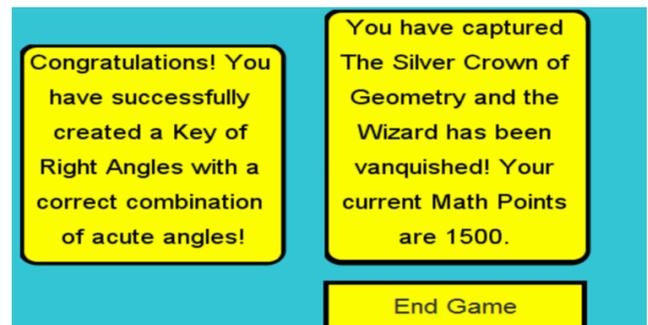
When a SEG requires student players to manipulate objects inside the sandbox, they are creating something new or different (Figure 4). As the player drags items into the sandbox area, the player receives feedback from the game. In the current example, the non-player character on the screen states the portal remains locked. Inferring that the addition of acute angles must add to the sum of

90 requires the use of higher orders of learning such as understanding and analysis.



**Figure 4. Feedback on Player Progress on Solving a Problem**

Once the player submits an input, the game responds by check to see if the parameters of the challenge has been met and provides feedback (Figure 5).



**Figure 5. Feedback for Player Upon Solving the Puzzle**

### 4. Conclusion and Further Work

In developing an assessment opportunity within a game that allows for both creativity and the manipulation of generated objects, SimSYS has developed a tool within the game that encourages analytical rather than rote applications of knowledge. Further work will include the incorporation of different knowledge bases from Software Engineering and the Milwaukee Police Code of Conduct. Likewise, introducing different learning taxonomies used by different fields like human resource training will also extend the SimSYS project. Finally, observing player abilities to practice topical higher order thinking outside of SimSYS can indicate the success of the project as a viable SEG.

### 5. REFERENCES

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