StoryGrid: A Tangible Interface for Student Expression

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ABSTRACT
StoryGrid is a classroom-based design and presentation system for interactive multimedia posters. Employing the technology base first used in Eden's PitABoard, StoryGrid allows groups of learners to manipulate projected multimedia objects on a horizontal board using a small collection of shared physical tokens. In this paper, we present the ongoing design history of StoryGrid in the context of its introduction within an urban high school literature class. Interface modifications based on student and teacher feedback led on changes in token semantics and media importing methods. We describe how StoryGrid features enriched students' interpretations of literature, with particular emphasis in two areas: (1) attention to audience, and (2) reflection of multiple perspectives.

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INTRODUCTION

Less than half of adults in the United States read literature: novels, short stories, and poetry. While educators continue to place a premium on the active interpretation of narrative [10], they appear to be fighting a losing battle; the rate of decline in reading is at an historical maximum and is increasing. In certain subpopulations, the situation is particularly dire. In a survey conducted in 2002, for example, fewer than one in five U.S. Latino males age 18-24 indicated that they read literature [6].

While printed text is not perceived as a high-value medium among students, electronic artifacts have gained ever-greater currency among youth. In recent years, as tools for creating such artifacts have become more accessible, teachers have begun to use audio and video as expressive media in the interpretation of literature (e.g., [4,9]).

StoryGrid* (Figure 1) is a classroom-based design and presentation system for students' interpretation of narrative. StoryGrid differs from other student multimedia efforts both in the nature of the resultant work products, and in the way that those products are produced. Instead of single linearized audio or video pieces, StoryGrid adopts a composite framework in which individual media elements (from commercial audio and video sources, the Internet, and student-captured media) are combined to create interactive posters. The "consumers" of StoryGrid products (peers, teachers, parents, etc.) retain the freedom to activate poster elements as they see fit using the same interface as their designers, blurring the distinction between author and audience. By using a tangible, semi-public, multi-user interface, StoryGrid supports collaboration and encourages formative critique of student work products.
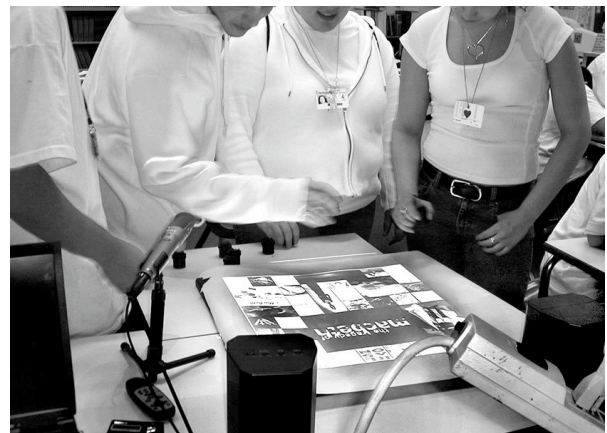

Figure 1. Students using StoryGrid to construct interpretation of Shakespeare's *Macbeth*.

In this paper, we briefly describe the design history of StoryGrid within the context of its usage in an urban high school literature class. Feedback from teachers and students informed design evolution, and shed preliminary light on how the affordances of StoryGrid could deepen students' engagement with literature.

TECHNOLOGY OVERVIEW

StoryGrid uses the same technology base introduced in Eden's PitABoard [1]. An overhead video projector displays

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*StoryGrid was originally named StorySpace [9]. The name was changed to avoid confusion with the commercial Storyspace multimedia product available from the Eastgate Systems, Inc.

the output of a laptop computer on a horizontal working surface. Underlying that surface is a plastic sheet containing an RFID (radio frequency identification) antenna grid connected to the laptop. Users place custom-built tokens with distinctive "caps" containing RFID *tags* on the working surface; their location and identity is sensed by the antenna and transmitted to the laptop application. Spatial sensing resolution is limited to 8x8 (the antenna grid was designed for a DGT electronic chessboard). A pair of inexpensive speakers is placed in proximity to the board.

The StoryGrid software divides the image space into an 8x8 grid of square *cells*, matching the antenna grid, and projects a collection of rectangular multimedia objects onto this grid. Each object is aligned with cell boundaries, and may be scaled in size from a single cell up to the entire board surface. Multimedia objects may overlap one another; the more recently positioned or scaled object is automatically brought to the front, occluding other objects. The tokens are used to change the organization of objects on the board, and to invoke audio and video activity.
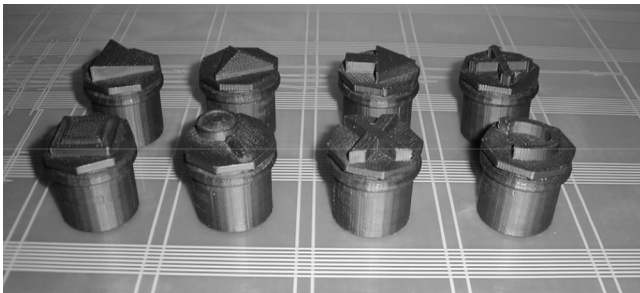

Figure 2. StoryGrid tokens resting on RFID antenna cells.

Each StoryGrid object contains an image component that represents the object in the board's "steady state." While the simplest objects have only this image component, interactive objects have at least one, and sometimes two, additional audio or video components. A configuration application running on the laptop allows users to bind the multimedia components together as a single object, and to specify an initial layout of objects on the board.

RELATED WORK

Tabletop tangible interfaces like that used in StoryGrid have a surprisingly long history. In the early 1980s, architect John Frazer was frustrated with the inapproachability of the design process and developed the Segal Model [3], a digital device that allowed architectural clients to prototype their own designs. Users arranged physical panels corresponding to building elements, and output the results on blueprints. Over a decade later, Fitzmaurice, Ishii and Buxton began revisiting these ideas. Their first system, Bricks [2], allowed users to shape curves and define simple drawings by manipulating physical tokens corresponding to drawing actions. Since then Ishii and his colleagues have created several tabletop interfaces [8] addressing educational applications in optical design, urban planning and chemistry. Rogers & Lindley [7]

recently found that such horizontal, tabletop surfaces offer advantages over vertical surfaces for collaborative design.

In addition to PitABoard [1], StoryGrid shares a surface similarity to Tangible Viewpoints [5], which uses a tabletop tangible interface to explore character perspectives within narrative. StoryGrid differs from Tangible Viewpoints in its use of a single surface for interaction and viewing of multimedia objects, and in its emphasis on interpretation rather than generation of narrative.

DESIGN HISTORY

Physical design

Portability was a central design goal for the system, precluding the use of a ceiling-mounted projector. We used a simple direct projection configuration with the projector mounted on a commercial light standard using a custom-built cantilever. The standard's legs fold in and the cantilever is removable, allowing the system to be collapsed to a small size for storage. Since a long cantilever would have required a much longer base, the standard had to be positioned in close proximity to one of the four sides of the board, reducing the number of usable positions. We also constructed a custom board to hold the RFID antenna and associated circuitry and connectors. White butcher paper was taped on top of the board for the projection surface.

In use, the system proved portable, but setup and breakdown time remain problematic for classroom environments, requiring at least 10-15 minutes each. Since the system was being used only for some class periods and not others, it had to be assembled and disassembled daily, seriously impacting usable time.

Most of the imagery that students captured or developed had a clearly preferred viewing orientation. (In this way, StoryGrid differed from the reported PitABoard applications, which typically adopt an overhead view that is orientation-neutral.) As a result, group usage rarely involved the canonical "one user on each side," but instead tended to cluster around the edge reflecting the "proper" orientation. In future versions of StoryGrid, we intend to introduce a *Rotate* token, although it remains an open issue whether rotation should apply to the entire board or to individual media objects.

Application software

The StoryGrid software was developed first by creating an isomorphic screen-based version so that the full functionality of the system was available for testing in the absence of the hardware; the same application later became the basis of the board configuration interface. The software interface to the RFID antenna required the development of a custom device driver, which, like the application, was written in Java. The application runs in the Windows XP environment and utilizes the Windows Media Framework.

A tension between usability and pedagogical goals became evident during usage of StoryGrid. Since the configuration

tools gave students full control over object placement and scaling, students tended to design on the laptop rather than on the board, frustrating the goal of engendering collaborative tangible design. The latest version of the configuration tool supports the assembly of objects from component parts, but no longer their board layout.

Tokens

Much of the initial design discussion revolved around the syntax and semantics of the control tokens. In chess, there are a dozen unique tokens. Rather than using all of the tags at the outset, we adopted the strategy of initially defining a minimal set of tokens (*Move*, *Grow*, *Shrink*, *Play*, and *Erase*) and employing user feedback to guide revision of the token set. That strategy resulted in significant transformations of the token set over a six-month period.

The basic operations we wished to support were moving, scaling, playing, and deleting media objects. Operations like playing and deleting have a single operand: the media object itself. Thus, a simple syntax—placing an operator on the media object—is sufficient to fully specify the operation. The move operation necessitated a more complex syntax, requiring a pair of gestures to indicate the initial and target locations of a media object. (The technology does not support the equivalent of a "drag" gesture). We chose a pair of simple, single-operand scaling operators: one to uniformly increase the size of the media object (by one cell in each dimension), and one to uniformly decrease its size.

Pilot tests led to the identification of several usability problems, leading to a number of design revisions. Moving multi-cell objects was confusing for users because of ambiguity in the "anchor" point of translation. We constrained the source and destination points to occupy the same relative positions of the object's image. The limitations of scaling proved difficult for students, forcing an early decision on object aspect ratio during configuration. We considered two solutions: (a) using four tokens for resizing: grow horizontal, grow vertical, shrink horizontal, and shrink vertical, or (b) using only one *Resizer* token, interpreting initial selections along object borders as signaling scaling in the respective dimension and direction. We chose the second solution. Although it has a complex multi-operand syntax, the solution uses a smaller operator set and allows the user to designate the *direction* of scaling. Other usability driven modifications included the addition of a *Stopper* token to interrupt playback of audio and video files and the introduction of an *Undo* token (for *Move*, *Resize*, and *Delete* operations).

Classroom teachers suggested two additional design modifications. First, they noted that students frequently resized objects to the full size of the board, played associated video, and then restored objects to their original size. This usage pattern was captured in a new token, the *Zoomer*. Applying the Zoomer to an object scaled it to the full size of the board; the next application to that object restored its original state. Second, teachers suggested that two distinct interpretations of a media object might be supported by linking it to two distinct files. These were originally couched as "student" and "teacher" perspectives, but could be any two points of view. For example, an image of Juliet's paralyzed body could serve as a trigger for both Romeo's tortured soliloquy and Juliet's hopeful anticipation of recovery from the temporary effects of her poison. To effect this we replaced the single *Player* with two separate players labeled simply *Player 1* and *2*.

In group use, students tended to share tokens rather than specializing their roles around retention of an individual token. For one extended design session involving three students, we instrumented the application to create a log of token usage. Design activity was concentrated; the students performed 314 token operations in 82 minutes; excluding two 10-minute breaks, a token operation was performed every 11.8 seconds. The distribution of token usage by type is given in Table 1. All of the tokens were used during design, with translation and scaling the most common. The nearly identical usage of the two Player tokens provides evidence of students' attention to multiple perspectives.

Token	Relative Usage Frequency	Token	Relative Usage Frequency
Eraser	6%	Resizer	19%
Mover	32%	Stopper	6%
Player 1	12%	Undoer	2%
Player 2	12%	Zoomer	11%

Table 1. Frequency of StoryGrid token use by a three-student group over an 82-minute session.

Student perception of StoryGrid

Anecdotal evidence supports students' affinity for the StoryGrid interface. Students comments centered on the tangible interface ("I liked it all, especially like moving the stuff around, using the pieces and [seeing] how it actually worked, the playing it and moving around"), the perceived directness of interaction relative to pointer-mediated input ("with [StoryGrid] it's like hands on, so it's like you're basically doing the same thing a computer does except you're doing it more direct yourself. Your focus is more on it than just sitting there and clicking the mouse"), and support for collaboration ("We… took turns on… where we're going to do things… It was better because we could switch off and everything; it would be more easier").

Other aspects of StoryGrid were less well received. Aligning the projected image with the RFID antenna required regular projector adjustments. The antenna's sensor grid has "dead spots" between cells, which were problematic for infrequent users; Eden reported similar reactions [1]. Inconsistencies between the Macintosh capture and editing platform and StoryGrid's Windows platform frequently crashed the system in early use.

EFFECTIVENESS FOR LEARNING

Motivating engagement with course content is a significant challenge for teachers. Student comments provided tentative support for StoryGrid's value in that effort. One student studying Macbeth told us "If it wasn't for the project I wouldn't know anything about Macbeth, because when I first read the play, I didn't really get it." Another student's candid admission, that "I learned a lot from Macbeth and I didn't even read the story," suggests the potential of such environments to stimulate transformative behavior.

Figure 3. StoryGrid poster reflecting students' interpretation of *Macbeth*. The poster contains 23 multimedia objects.

StoryGrid effectively engaged students with their peer audience and encouraged them to accommodate multiple perspectives. Students knew that their StoryGrid poster would be interacted with by fellow students, and with this awareness demonstrated an increased sensitivity to both tone and mood. One student reworked the music in his movie because he wanted to convey the "feeling" of the poem more effectively to his peers. Students reciting or commenting on the poem on video often made multiple takes in an effort to convey a consistent point of view. StoryGrid's interactive tabletop interface allowed students to observe the effect of changes, and make revisions in response to peer response. There was evidence that students actively discussed their designs with their peers, utilizing those peers as fellow designers as well as potential audience. Students used feedback from peers and examination of peer designs to review and revise their own posters to reflect multiple perspectives.

IMPLICATIONS FOR TANGIBLE USER INTERFACES

Though still preliminary, this research shows the promise of tangible user interfaces in education. Students found StoryGrid both exciting and accessible. Its tabletop, interactive format encouraged students to collaborate and consider their peers when forming their work, both as an audience and as partners with different perspectives. Yet our experience also revealed some shortcomings of the technology. Tangible user interfaces must become much more robust before they will see widespread use in the classroom. A more fundament challenge grows from the observation that collaborative use was negatively impacted by the viewing limitations introduced by the preferred orientation in most everyday media. A solution to this problem would be valuable in the educational setting.

ACKNOWLEDGMENTS

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