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VISUALIZING THE PAST: THE DESIGN OF A TEMPORALLY ENABLED MAP FOR PRESENTATION (TEMPO)

Nathan Prestopnik & Alan Foley, *Syracuse University*

We present a design case for a prototype visualization tool called the *Temporally Enabled Map for Presentation* (TEMPO). Designed for use in the lecture classroom, TEMPO is an interactive animated map that addressed a common problem in military history: the shortcomings of traditional static (non-interactive, non-animated) maps. Static maps show spatial elements well, but cannot do more than approximate temporal events using multiple views, movement arrows, and the like. TEMPO provides a more complete view of past historical events by showing them from start to finish. In our design case we describe our development process, which included consultation with military history domain experts, classroom observations, application of techniques derived from visualization and Human-Computer Interaction (HCI) literature and theory. Our design case shows how the design of an educational tool can motivate scholarly evaluation, and we describe how some theories were first embraced and then rejected as design circumstances required. Finally, we explore a future direction for TEMPO, tools to support creative interactions with visualizations where students or instructors can learn by visualizing historical events for themselves. A working version of the finished TEMPO artifact is included as an interactive element in this document.

Nathan Prestopnik is a doctoral candidate in Information Science and Human-Computer Interaction at Syracuse University's School of Information Studies. His research focuses on design science, which places technological artifacts at the center of study, using design and evaluation as tools for scientific inquiry into human cognitions, emotions, and behaviors.

Alan Foley is an Associate Professor of Instructional Design, Development, and Evaluation at Syracuse University's School of Education. His research focuses on implementing design research techniques to create innovative learning technologies that are accessible and usable for all learners.

INTRODUCTION: A DESIGN CHALLENGE

Maps purport to visualize many things in the military history context: movement on a battlefield or in a theater of war, the impact of combat on unit cohesion and readiness, and the role of luck, timing, and decision-making in battle. These elements of military-historical study are not just spatial in nature. They are spatiotemporal. They require the visualization of time as well as space.

Most military-historical maps do a poor job of this kind of visualization. This is because most maps in military history, especially those found in books or used in the classroom, are static: they are printed on paper or digitally represented as images in static media such as Microsoft PowerPoint. No matter how beautifully rendered or organized, static maps show only snapshots of individual moments, never the true temporal flow of a military-historical event. Arrows, unit and position marks, and multiple views are able to represent only a shadow of what really happened during past moments of great consequence.

Yet maps continue to have value for the student of military history. Maps abstract and simplify our understanding of terrain. Maps also clarify the physical battle space, with many techniques developed over the years to visualize terrain features, by either abstracting or emphasizing various details (Imhof, 1965, 1975; Kraak, Edsall, & MacEachren, 1997; Muehrcke, 1990).

In this paper, we describe the design and development of a spatiotemporal visualization tool for military history, the *Temporally Enabled Map for Presentation* (TEMPO). We designed TEMPO to address the problem of static maps in military history, specifically to seek ways that an interactive, map-like tool could enrich learners' perceptions of the past, including their understanding of abstract but important concepts such as luck, timing, and the nature of decision-making in war, as well as their understanding of terrain and the battle space. As a prototype, TEMPO addresses just one military-historical event (the Battle of Midway, 1942) but demonstrates the potential for temporally-enabled maps to address many different kinds of past events.

As an overarching goal of this project, we used TEMPO as a vehicle to explore the dynamics of embedding interactive visualization technologies into the military-history education context. In the following design case, we describe how our design decisions were impacted by a central research question: how do interactive visualization tools impact the instructor and student experience in military history education? We state this question not because we intend to answer it fully here, but because it underpinned the entire TEMPO project, from conceptualization through design to implementation and evaluation.

The pairing of scholarly inquiry and design activity is known as *design science* (Hevner, March, Park, & Ram, 2004; March & Smith, 1995; Simon, 1996; Zimmerman, Forlizzi, & Evenson, 2007), and we adopted this approach for the TEMPO project. Design science projects include a host of activities, such as theorization, design, and detailed evaluation (Prestopnik, 2010), tend to have too large a scope to compellingly report in just one paper. Accordingly, we concentrate here primarily on our design decisions and activities. Our scholarly findings on student and instructor experiences with TEMPO have been presented elsewhere (Prestopnik & Foley, 2011), and are of continuing interest.

In this paper, we explore TEMPO as a *design case*, adopting the perspective of Boling (2010) and Smith (2010) on this reporting methodology. According to Boling (2010) a design case is "a description of a real artifact or experience that has been intentionally designed." (p. 2). We present a detailed description of TEMPO and the many decisions—some supported by our prior design experience, others supported by research activity—that led to its successful implementation and evaluation.

BACKGROUND

We (the authors) are both researchers at Syracuse University, and we both have backgrounds as interactive designers. In addition, one of us (Nathan Prestopnik) also has a background in military history, holding an undergraduate degree in the subject. Recognition of the problem with static maps in military history was therefore an extension of our prior experiences, and we started the TEMPO project of our own volition for the sake of exploring this interesting and multi-faceted challenge. Our goal for TEMPO was to address an interesting and relatively unexplored design problem by building a system or tool. We also conducted Human-Computer Interaction (HCI), visualization, and education research around the system that we ultimately built. The TEMPO project was small and rapidly executed, with two researchers participating and a timeline of just one semester to conceptualize, design, implement, and preliminarily evaluate

SUBJECT SELECTION

Our design process for TEMPO began with a careful search for an appropriate military-historical subject to visualize. We eventually settled on the 1942 Battle of Midway, but considered other battles, including Gettysburg in 1863, Stonewall Jackson's spring 1862 campaign through the Shenandoah Valley, the Roman defeat in the Teutoburg Forest in 9 AD, and Nelson's victory at Trafalgar in 1805.

For practical reasons, we initially felt it was important to choose a relatively one-dimensional battle, featuring only ground or naval combat, avoiding the complexities of visualizing a multidimensional land, sea, and air campaign. We also recognized that it would be important to select a well-documented battle in order to make our visualization as accurate as possible. More importantly, we sought a conflict where luck and timing, often critical elements of conflict, had been important to the outcome. Our hope was that TEMPO could help dispel the false "Hollywood" view that historical battles are decided by heroic generals enacting brilliant feats of strategic and tactical legerdemain. Beach (1986) suggests a more realistic perspective in his discussion of the battle between the ironclads *Monitor* and *Virginia* during the American Civil War: "The professionals in both navies addressed themselves to what had gone right and what had gone wrong in the epic battle. . . . It was quickly apparent that the decision might have gone either way and that many incidental occurrences had had totally disproportionate effects" (p. 299).

To help select a historical moment to visualize, we engaged in an interview and discussion with a domain expert, a senior military history instructor at Syracuse University. Our domain expert suggested that the Battle of Midway might answer our needs better than some older battles. Even though Midway included both naval and aerial combat, the battle space was simple (open ocean with just two small islands of any consequence), and the battle itself featured several key moments of luck and timing that had a direct impact on its outcome. In addition, the main events at Midway were well documented and occurred over a time span of 15 hours, which seemed a substantial but still feasible amount of time to work with. Finally, Midway was an important and consequential battle, the visualization of which would be useful and interesting to a wide audience, including history educators, students, military professionals, political decision makers, and the general public. After reviewing several sources suggested by our domain expert (see Prange, Goldstein, & Dillon, 1982; Spector, 1985), we concluded that Midway would be an ideal engagement for us to visualize.

CONTEXT OF USE

Static maps are used in virtually all areas of the military history domain, from museums to libraries to books to classrooms. Their ubiquity required us to narrow our interest;

developing TEMPO for use in museums, libraries, or other venues would have been both possible and interesting, but we chose a more typical educational context: the classroom lecture. We were especially interested in lectures because in military history education these are a context where the use of advanced technologies is still relatively limited. Findings from our research question on the student and instructor experience could have potentially great impact.

Our domain expert invited us to attend an undergraduate lecture he was presenting specifically on the topic of Midway, as well as the larger Pacific theater of World War II. We attended, observed, and made detailed, ethnographic style notes (Emerson, Fretz, & Shaw, 1995) on the classroom space, the style and delivery of the instructor, the students, and the lecture itself. This exercise was very helpful, allowing us to gain a sense of how TEMPO might fit into existing lectures and work within the typical lecture space—large auditorium classrooms with digital projection screens and control consoles for the instructor.

We noted with interest that our domain expert used very few slides. He lectured for two hours from memory in a highly narrative approach, almost like storytelling, only occasionally quoting from news clippings or books. Projected media in his class were limited to photographic images of historical figures and a variety of different maps. Most of the maps only approximated what he was trying to demonstrate to the class, and he would frequently have to clarify details that were obscured, missing, or invisible to the students in the class. For example, one map of the Midway battlefield was too large, encompassing most of the Pacific Ocean. Our domain expert directed the class's attention to Midway Island itself with the accompanying apology, "well you can't see this very well, but Midway is down here...." Units and events from the battle were approximated with hand gestures and explanations.

During a later evaluative interview, our domain expert talked about the lecture as a pedagogical tool, saying that while many consider the lecture to be a "dead and destructive

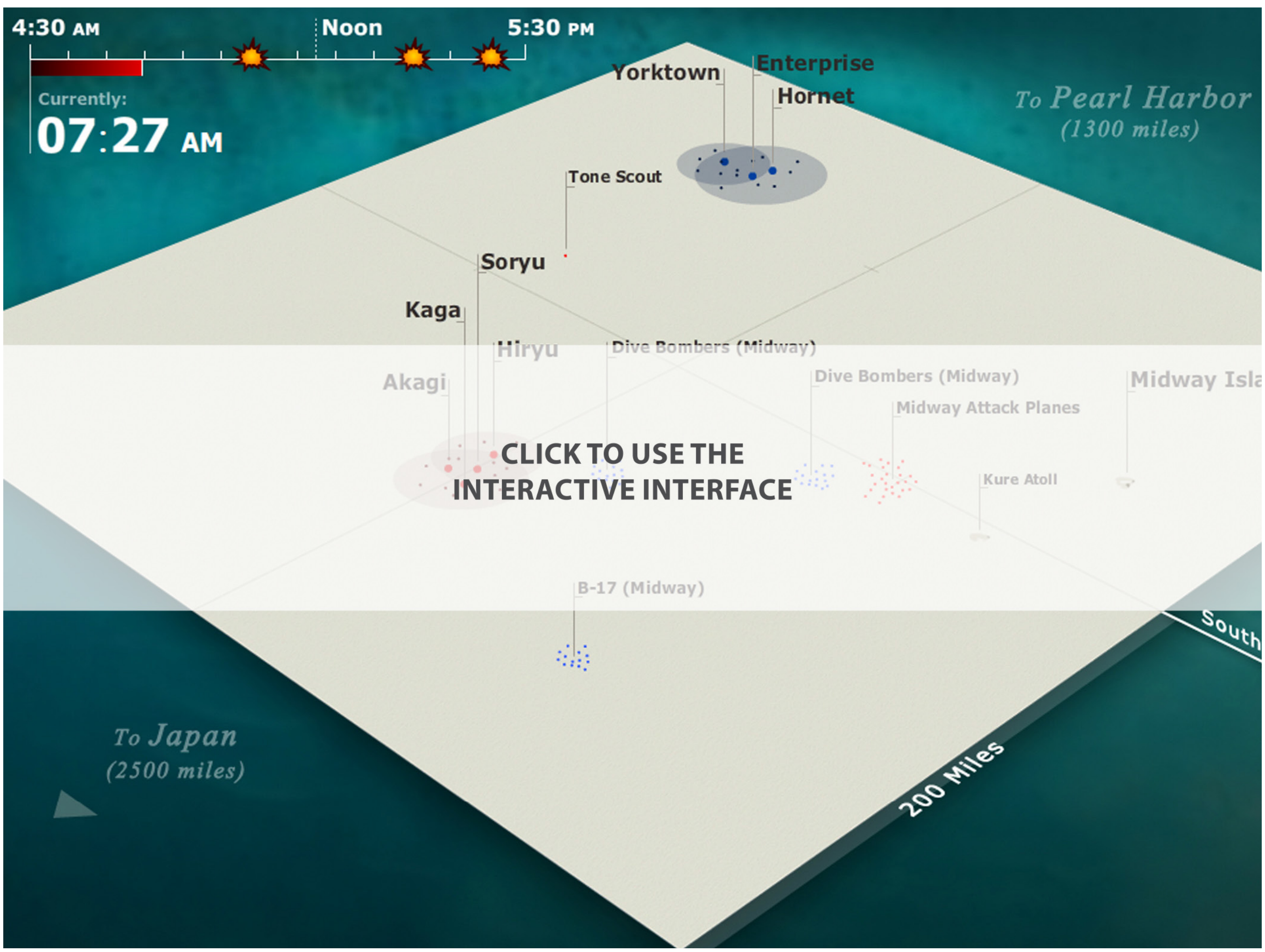

FIGURE 1. The final TEMPO interface—click the image to activate. This is a full embed of our finished TEMPO interface. The tool is fully interactive and all features are functional.

form of pedagogy," he views it as an "art form…a chemistry between lecturer and student." Despite his relative lack of media use during the lecture, our domain expert's presentation style made the talk itself fascinating, with most students paying careful attention and remaining involved despite the ubiquity of Facebook and YouTube applications on laptop screens prior to the start of class. Based upon our observations, we developed a key goal to develop TEMPO as a minimalist tool that could accompany and augment a well-delivered lecture, rather than replace it.

TOOLS AND TECHNOLOGY

Because TEMPO was to be a prototype system, we oriented our design process around speedy development and rapid iteration. We used Adobe Photoshop to produce visual layouts for several different design drafts which were evaluated in discussions between the authors and by presenting them to various potential users (colleagues, students, etc.) for feedback. Though informal, this process suggested many changes and improvements to the design of TEMPO.

Once we had a settled on a final design (see Figure 1), the visual mockups were rebuilt using Adobe Flash as our development framework. If we were to develop a commercial version of TEMPO, Flash would not be our first platform choice because it limits the use of certain technologies (particularly 3D virtual environments). Nonetheless, Flash is an excellent development environment for rapid prototyping because it is flexible, easy to work with, and finished Flash files (.swf files) can be easily embedded into web pages and played on most computing devices. An important limitation created by this choice is that .swf cannot be played on the Apple iOS mobile operating system. Our decision to use Flash was motivated by the standard lecture technology found in most classrooms (e.g., usually not mobile technology) as well as our deep knowledge of Flash compared to newer platforms that we were less familiar with. As the project evolved, however, the application of TEMPO (potentially) outgrew its envisioned but limited classroom use. Switching to a technology with better cross-platform support such as HTML5 would no doubt be preferable for future work on TEMPO.

THE FINISHED ARTIFACT

We produced several versions of TEMPO before settling on the final design of the prototype (though in acknowledging the iterative nature of design science, we understand there are still many future possible improvements to TEMPO). We describe several false starts and dead ends later in the paper, many of which were highly interesting and helpful to our design process. In this section we describe the finished artifact and the thinking that led to it. A working version of the finished TEMPO artifact is embedded in this document (see Figure 1).

The finished TEMPO visualization tool shows an animated overview of the Battle of Midway. Japanese forces appear in red and US forces appear in blue. Ship and aircraft icons in TEMPO were abstracted to single points for clarity and perceptibility due to the scale of the battle, which takes place over some 160,000 square miles.

Units are labeled clearly by ship name or aircraft type, as are the two islands involved in the battle (Midway and Kure Atoll). Photographic imagery of ships, aircraft, and location are readily available by clicking on their labels, allowing TEMPO to show both the time-based data of events as they unfold, plus more qualitative types of information ("how it was"). This feature was inspired by our domain expert, who indicated that helping students understand how the past looked and felt is an important aspect of his talks. Labels can be toggled on or off using controls at the bottom left of the TEMPO screen, a feature included to reduce visual clutter if desired by the lecturer. TEMPO generally follows the well-known visualization guideline of "overview, filter, and detail" (Shneiderman, 1996).

VISUALIZING TIME AND SPACE

TEMPO can be played at three speeds (including real-time), and can be paused and restarted at will. The temporal element redresses the problem of non-interactive maps, enabling the tool to visually convey the tempo of battle and illustrate abstract concepts that paper maps cannot—notably the elements of luck, timing, and friction that occur on the battlefield. We drew upon DiBiase, MacEachren, Krygier, and Reeves (1992), who describe three key variables in visualization animations: *duration* (the frame rate of an animation, or how long individual frames remain visible before the next frame is shown), *rate of change* (the magnitude of change which occurs between frames), and *order* (the sequencing of events within an animation). Manipulation of these three variables suggests three possibilities for a temporally enabled map: maps that "emphasize the existence of a phenomenon at a particular location," maps that, "emphasize an attribute of the phenomenon," and maps that, "represent change in a phenomenon's position or attributes," (DiBiase et al., 1992). Each of these types afford various forms of information. TEMPO most emphasizes the existence of a phenomenon (combat) at a particular location (various locales on the Midway battlefield).

We also drew upon Kraak et al. (1997), who describe two additional aspects of animated maps: *display time* (the timing of events as they unfold for the viewer of a map) and *world time* (the real time which passed as events unfolded). Display and world time may be equal (i.e., a "real time" map), but need not be. There are situations where a real time display of geographical data would not be useful, for example, a real time map of the Battle of the Somme, which took place over 4 ½ months (Marshall, 1964/1987). However, showing portions of a battle in real time to emphasize the actual speed at which events occurred and the nature of naval aerial warfare, which includes long periods of inactivity followed by intense periods of combat, could be extremely effective. We included a real-time play speed in TEMPO with this specific use case in mind.

DESIGN ITERATIONS

Placement of Controls

Our study of the lecture context led directly to the visual representation and placement of many TEMPO elements. For example, the play controls, in an early version of the design, were placed centrally in the screen. TEMPO was designed to have an expert lecturer in control at all times, and we realized that the play buttons could and should be made more unobtrusive so they wouldn't distract students from the main content of the visualization. Accordingly, we reduced the play controls in size and moved them to the bottom edge of the interface.

The timeline in the upper left also underwent changes as the classroom/lecture context became more familiar to us. In the same early version of TEMPO, the timeline extended across the entire screen and contained great detail, with several dozen key moments identified by time. After viewing this design projected in a classroom, we felt the timeline was too detailed to be easily viewed, and too restrictive to the lecturer, who might not weight the moments visualized with the same importance as we did. The timeline was changed to show only the most critical elements of battle, and to make it clear when aircraft carriers—generally understood by historians to be the most critical units of the battle—were destroyed.

Color and Imagery

Colors and icons were changed from early versions of TEMPO. Icons were simplified from tiny ship and airplane images (see Figure 2) to abstract colored dots. The ship and aircraft icons in early versions were far out of scale, making the battle appear much smaller geographically than it really was. At the same time, these icons were still too small to be perceived easily for what they were. In addition, because all were the same color, it was difficult to differentiate American from Japanese forces or make much sense of the battlefield events, particularly when projected and viewed from the back of a classroom. Simple colored dots overlaid on a neutral field (we did include some blue color in the margins of the final design to provide an impression of ocean water) addressed both issues. Our design process validated the basic notion that, "It is abstraction, not realism, that gives maps their power" (Muehrcke, 1990).

Tufte (1990, 1997, 2001) suggests visual simplicity in his discussion of 1 + 1 = 3 effects and chartjunk, where overlaid or unnecessary elements interact with each other to produce visual effects that seem to be more than the sum of their constituent parts. This effect is sometimes positive, as when visual elements, labels, and motion combine to tell a more compelling story than any individual layer could alone. The 1 + 1 = 3 effect can also be negative, as when overlaid elements with too much visual weight result in clutter and confusion instead of clarity. The use of bright, contrasting colors to draw attention is also well noted in the design, visualization, and cartographic literature (Imhof, 1965). For TEMPO, we applied this design advice in myriad ways, seeking a balance between content detail and interface simplicity.

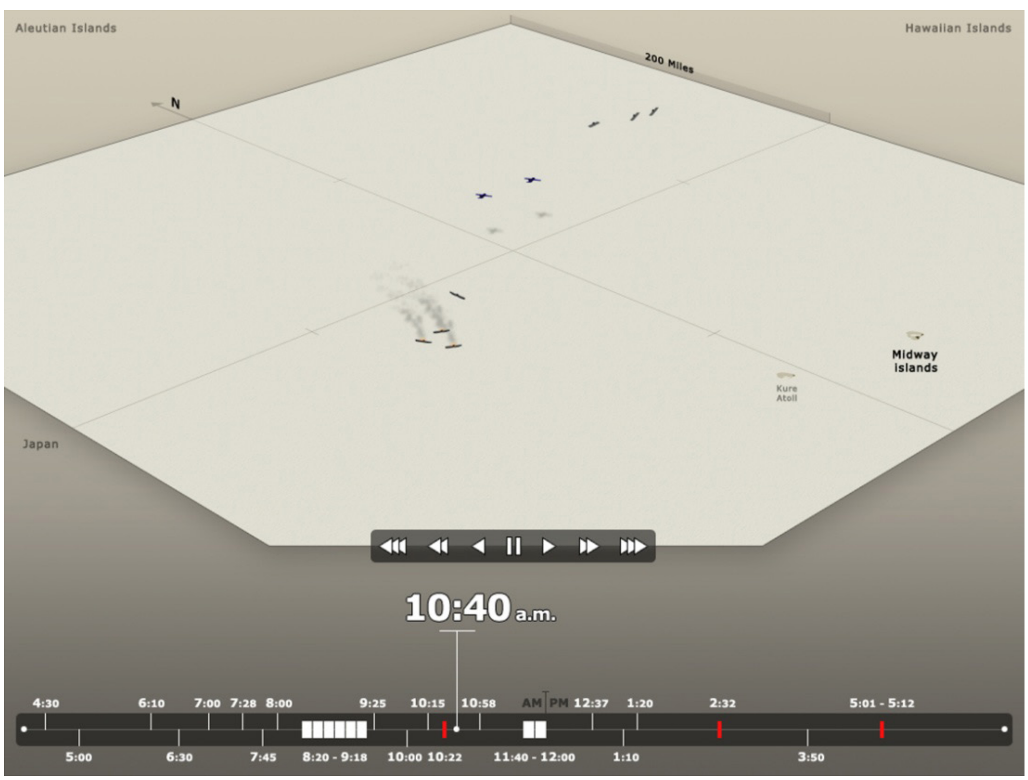

FIGURE 2. The first design iteration: an early version of the TEMPO interface.

TEMPO AND THE REJECTION OF THEORY

We have previously described a number of visualization theories that helped to inform the design of TEMPO. It was also our intention to draw heavily upon time geography theory (Hägerstrand, 1970, 1975, 1982; Miller, 2005; Raubal, Miller, & Bridwell, 2004; Thrift, 1977): a way of examining events which occur in both space and time. We initially felt that a stronger theoretical grounding and a unique departure from basic animation would benefit TEMPO and its end users.

Time geography, according to Thrift (1977), is "a respect for the conditions which space, time and the environment impose on what the individual can do." (p. 4). Individuals and social systems will be constrained by time and physical space: mutually dependent resources which may be spent but which are limited within any given context (Thrift, 1977). There are three basic dictates of time geography that describe these limitations (Hägerstrand, 1970; Miller, 2005): 1) capability (the ability of an individual to trade time for space for movement); 2) coupling (the need for individuals to meet at specific times and locations in order to accomplish tasks); and 3) authority (the ability for authorities to limit physical access to certain places at certain times).

Though time geography theory was conceptualized with civil society in mind, calculations of space vs. time, capability, coupling, and authority also seem highly applicable to representations of military historical events. The battle of Midway, for example, took place over vast distances, and the destruction of the Japanese carrier fleet on June 4, 1942 happened because of a remarkably fortunate (from the American perspective) confluence of events as planes and ships came together in time at space at exactly the right moment for victory to be achieved. Of course, the battle was also about authority, as American and Japanese forces sought to deny Midway Island to their opponent while claiming it for themselves.

We conceptualized an early version of TEMPO which drew heavily upon time geography theory, especially in adopting Hägerstrand's (1970, 1975, 1982) notion of the space-time prism, a visualization technique for showing connections in time and space using intersecting lines in a 3D space (see Figure 3). In a space-time prism, lines represent individual people (or ships, aircraft, and other units in our Midway context). Interconnections between lines represent moments where these individuals cohabit the same geographical spaces (e.g. the same room, building, street, island, etc.). Sloped line segments represent the time it takes to move in physical space; lines can never merge perfectly horizontally, since that would imply a travel time of zero. Slope serves as an indication of how long it takes individuals to traverse physical space in order to reach a given destination.

Our intention was to embed the TEMPO animated map into a space-time prism. We planned to place the map and animated unit movements on the "floor" of the prism, and allow the intersecting lines to move vertically downward as time unfolded, showing how different units would move

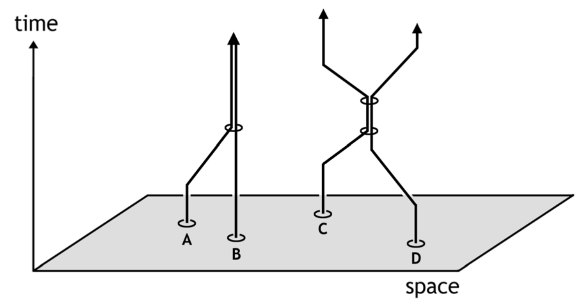

FIGURE 3. The space-time prism. In the 3D space shown, three individuals interact across space and time, coming into geographical contact with each other at various points, remaining in contact for defineable periods of time, and then parting ways. (Adapted from Hägerstrand, 1970)

and eventually intersect in physical space. This suggested itself as a unique way to emphasize and visualize elements of luck and timing in the battle. The lines of intersection would draw student attention to key moments of the battle (e.g., the ultimately successful American attack on the Japanese carriers) when many of them converged simultaneously.

Over the course of developing TEMPO, we realized that an important aspect of design science is to question theory under specific circumstances of design and use. The TEMPO design process gave us a powerful opportunity to apply theory to a real design situation and to question its value to our specific use context. While the space-time prism visualization technique initially seemed highly suitable for TEMPO, we eventually dropped our interest in it. An early design for TEMPO which favored the space-time prism technique was confusing to potential users and required too much explanation to make sense of; this version had turned TEMPO into a tool for teaching time geography theory, rather than for teaching military history (see Figure 4). Furthermore, it soon became apparent that a successful implementation of this technique would require a more advanced development platform than Adobe Flash. A 3-D implementation of TEMPO would be more likely to make successful use of time geography theory. We ultimately excised time geography theory and space-time prisms from the repertoire of visualization techniques that we deployed in TEMPO. However, the theory remained valuable to us as a framework for thinking about the various events that occurred during the battle of Midway.

Despite our rejection of the time-geography version of TEMPO, however, it is worth noting that a variety of positive improvements were developed in our time-geography motivated design. We began working on repositioning the timeline, using a left-oriented "waterfall" view with fewer events and larger text. We eventually transformed this into the even simpler timeline found in the final TEMPO instantiation (see Figure 1). We also developed the simpler red and blue dot system for identifying units in this version of TEMPO, though we had not yet settled on a unit labeling convention.

VISUALIZING THE PAST: CHALLENGES AND OPPORTUNITIES

Even though Midway is a well-documented and extensively written-about battle, there was no readily-accessible database of ship and aircraft positions to work with when creating TEMPO. Rather, we had to build our animation by hand, drawing upon paper history books and static maps as resources. We embedded a detailed map of the battle of Midway into the TEMPO application, positioning, sizing, and distorting it to fit our perspective view. Using published material on Midway and our embedded map as a guide, we began to establish animation key frames (stored in a dynamically parsed text file) so that each ship and flight of aircraft would accurately follow its correct path of travel in the correct amount of time while also displaying important events.

Ship by ship, plane by plane, we built the battle up over many days of flipping through history books, consulting published battle logs, and examining the static maps we had at our disposal for key event times: the time that Japanese aircraft were launched toward Midway, the time of the Midway attack itself, attack times for each separate US aircraft flight, individual times for each carrier that was destroyed, etc. No single book or resource contained every one of these pieces of information, and no resource organized them in a fashion that was ideal for our visualization project. Most resources that we used presented the battle of Midway as a story; important technical and time details were intermingled with a variety of other kinds of information across hundreds of pages of text and on dozens of maps. Finding, deciphering, connecting, and visualizing this material was a tremendously difficult, labor intensive, complex process. Despite this—or rather, because of it—our design activities ultimately suggested an interesting new research question: what do people gain by visualizing information for themselves?

CREATIVE INTERACTIONS WITH VISUALIZATIONS

Visualizations are frequently claimed to have cognitive or learning benefits for students in various fields, but results from studies empirically attempting to establish this connection are mixed (Geelan & Mukherjee, 2011; Lowe, 2004; Piburn et al., 2005; Winn, 1982). Visualizations have also been explored as a means of engaging students (Grissom, McNally, & Naps, 2003; Naps et al., 2003; Naps et al., 2002; Schweitzer & Brown, 2007) with similarly mixed results. Visualizations appear not to be adopted into the learning experience often enough or deeply enough to have the expected impact on student engagement or learning.

Our own experience was that the process of visualizing the Battle of Midway for ourselves made us vastly more knowledgeable than when we began, not just on the comparatively small amount of detail that went into the TEMPO visualization itself, but on the larger scope, meaning, and context of the battle. TEMPO shows just one day of the battle (the main and most eventful day), but there

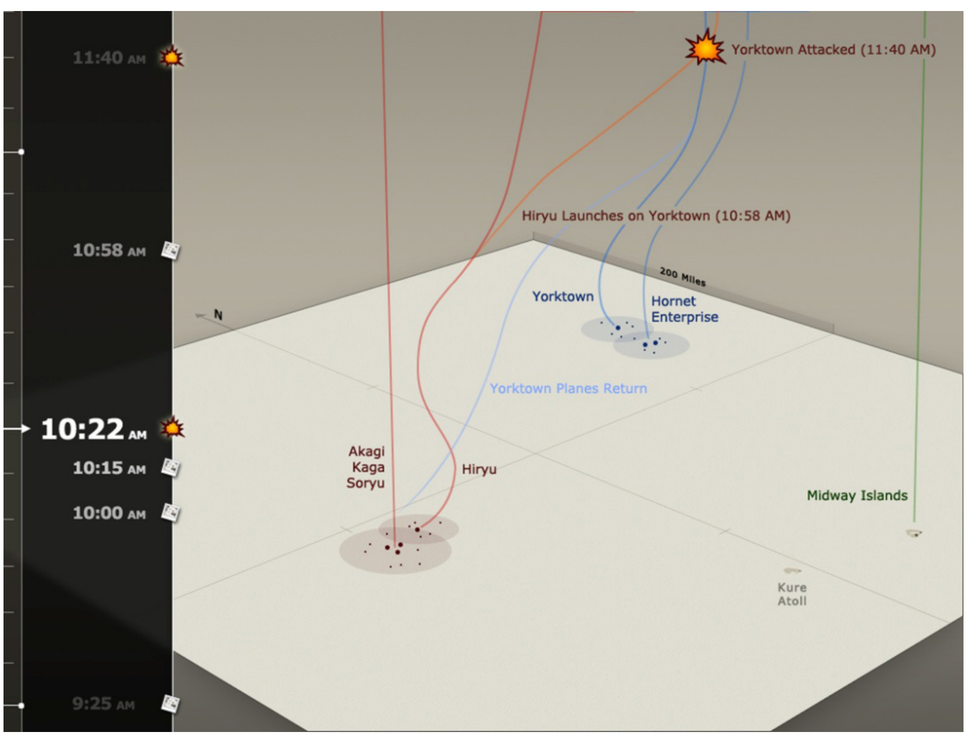

FIGURE 4. Early version of TEMPO, incorporating time geography theory and space-time prisms. We ultimately rejected this version for being too confusing and requiring too much background knowledge of the theories upon which it was built.

were related naval actions resulting in destroyed ships and killed men on the days preceding and following the sinking of the *Akagi*, *Kaga*, *Soryu*, *Hiryu*, and *Yorktown*. Understanding the entire course of the battle, including these other events and their larger tactical and strategic purpose, was necessary in order for us to meaningfully visualize what happened on June 4, 1942. We learned more about World War II history from the act of developing TEMPO than we ever would have from its use alone.

We also noted during our design activities that visualization scholars tend to focus on *representation* (techniques for visualizing specific kinds of data) rather than *interaction* (the ways that people interact with and use visualizations) (Chen & Czerwinski, 2000; Ellis & Dix, 2006; Thomas & Cook, 2005; Tory & Möller, 2004; Yi, Kang, Stasko, & Jacko, 2007). In particular, there is virtually no literature on how the act of building visualizations can impact the person who creates them, nor much scholarly writing on the differences in this act of creation between quantitative and qualitative forms of data. Yet it seemed from our design experience that creating visualizations for oneself could have a potentially huge impact on learning and engagement with historical material.

From this we envision a next step for TEMPO called the *TEMPO Creator*. *TEMPO Creator* would be a tool with affordances (map and animation functions, unit creation and placement tools, annotation features, timelines, etc.) for instructors and students to develop their own visualizations of past historical events, military or otherwise. *TEMPO Creator* might also contain features to streamline the process of finding information and "pinning" it to the main map and timeline, easing the work of an instructor who wishes to prepare such visualizations for ready use in class. These are important affordances to include, since adding content to TEMPO was, at times, tedious. Advances in information retrieval and natural language processing make it theoretically possible to analyze some historical resources automatically, extracting relevant bits of information and prepping them for use in *TEMPO Creator*. At the same time, students may find more educational value in seeking such material manually during a classroom or homework exercise. The notion that history students could complete assignments in a format other than the written word is somewhat radical, but is well in line with arguments made by historians such as Moss (2004, 2008) and Staley (2003) that written historical material can be effectively augmented with visual material. As designers (and one of us a former history student) ourselves, we are comfortable acknowledging the value of both written and non-written work in many different subjects. We think a tool like *TEMPO Creator* could add a great deal of value to historical study, without distracting too much from more traditional modes of learning and scholarship.

Following the design science tradition (Hevner et al., 2004; March & Smith, 1995; Simon, 1996; Zimmerman et al., 2007), we see an important future direction for our work with TEMPO: developing a prototype of *TEMPO Creator* with the intention of exploring its use in an educational context. The opportunities for scholarly study around a tool of this nature include: 1) exploring ways that creating visualizations for oneself can impact learning and engagement; 2) exploring creative visualization interactions from an HCI standpoint; 3) exploring innovative uses of computer technology for parsing and understanding historical materials; and 4) exploring the interplay of quantitative and qualitative data in historical visualization.

CONCLUSION

We presented a design case for the *Temporally Enabled Map for Presentation* (TEMPO) a prototype visualization tool designed for use in the military history classroom. Coupling our design activities with theoretical and evaluative research efforts, we explored how visualization tools can impact the instructor and student experience, and how different visualization techniques can shape the design and use of a tool like TEMPO. Ultimately, our design efforts led us to an even more exciting possibility: a tool to allow students and instructors to learn as they create visualizations for themselves. This tool, called TEMPO Creator, is our next step in studying the confluence of design, military history, human-computer interaction, and visualization.

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