Employing Interactive Multimedia as a Cartographic *Research* Tool

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Introduction

Interactive multimedia has been used successfully as a cartographic data display method for thirty years. Because the most basic definition of multimedia includes virtual presentations, this method arguably began with the first cartographic animations, which appeared beginning with Tobler in 1970. It took several decades for the method to find popular application and the increased use is reflected in the burgeoning number of papers devoted to subjects of animation as well as interactive multimedia during the last decade. Several authors document the development of interactive multimedia cartographic presentations, design issues, and the successful application of these products, either as spatial data displays, alone, or as educational tools (Andrews 1994, Campbell and Egbert 1990, DiBiase 1994, Dorling 1992, Gersmehl 1990, Moellering, 1980, Monmonier 1992, 1996, Peterson 1993, Slocum, Robeson, and Stephen Egbert 1990, Tilton 1994, von Wyss 1996,Weber and Buttenfield 1993). While interactive multimedia and animation are now accepted as effective cartographic tools under the appropriate circumstances, an additional application of these tools remains, with little exception, unexplored. This paper will introduce some potential applications of interactive multimedia as cartographic research tools and present some issues to consider before choosing to implement interactive multimedia testing instruments as part of a research methodology.

Dynamic Mapping Defined

Because this paper addresses the research applications of dynamic mapping, interactive multimedia, in particular, brief definitions are offered here. Dynamic mapping is an umbrella term encompassing three distinctly separate (but often used collectively) mapping methods: hypermedia (interactive mapping), multimedia, and animation. To begin, hypermedia, or interactive mapping, allows the map user to interact or control the map. Interactivity level may from a simple set of start/stop buttons to an entire map with “clickable countries”, which when clicked reveal more detailed information about each location. These types of maps have found wide-spread use on the World Wide Web. Multimedia maps include the use of more than one type of media, which may include: text, graphics, sound, video, and animation. An animated map is any map that shows movement and has been found to be a useful technique to explain dynamic events such as military campaigns, glaciation, and plate tectonics. Interactive maps must be created for viewing through an interactive video/sound system (such as a computer or video game system). Multimedia and animated maps may be created for view through any video/sound system; the system need not be interactive. One single method can be used to create a dynamic map, but more frequently, the methods are combined for creating a single presentation.

Research Applications of Interactive Multimedia

As a testing device, computers have long been used for test scoring; students or subjects record answers on a special answer sheet, which allows a computer to score the responses (potential benefits and problems are discusses in Anastasi and Urbina, 1997). But, psychologists are beginning to move beyond using computers only for scoring; research-based computer administered testing instruments are finding application as research tools in psychology. Researchers have utilized an interactive multimedia test to measure cognitive abilities and

conflict resolution skills (Olson-Buchanan, Drasgow, and Moberg 1998), compared the effectiveness of pencil and paper tests to computerized test versions (Donovan, Drasgow and Probst 2000), addressed the pros and cons of interactive multimedia test development (Drasgow, Olson-Buchanan, and Moberg 1999), conducted validation measures of a Computer Based Performance Measure (a test which serves as a criterion measure of job performance for air traffic controller selection) (Hanson, et al. 1999), and identified the areas of assessment best served by interactive multimedia tests (Burroughs, et al. 1999).

Cartographic research, too, may benefit from implementing interactive multimedia testing instruments. In cartography, interactive multimedia need not only be limited to displays; the method may also be used effectively as a tool in cartographic research. While this application has found limited use to data, more researchers may soon discover the flexibility and power of interactive multimedia as part of their research methodology.

Before incorporating interactive multimedia as a tool in a cartographic research project, five factors must be considered; those factors are: potential applications, technological considerations, research tool design, reliability and validity evaluation, and potential usefulness.

Potential Applications

Nearly any cartographic research project that involves the use of human subjects may benefit from utilizing an interactive multimedia testing device. Whether pencil/paper or computer administered tests are used, the testing device design will vary, depending on the project. But the decision to implement an interactive multimedia test will nearly always be dependent on the level of precision needed in test scoring. Computer administered tests offer the ability to record subject responses more precisely that can be done with a pencil/paper test. For example, a computer test can record (to the millisecond in some programs) the amount of time a subject spends on each answer. In addition, the computer can record the exact placement (to the pixel) of answer locations. As a result, interactive multimedia tests offer cartographic researchers the ability to determine more that whether an answer is correct or incorrect; the tests allow researchers to look at the relationships between test questions to a degree not possible with most traditional tests.

The following paragraphs will discuss specific areas of cartographic research that could benefit from the use of interactive multimedia testing devices. Examples are included with each discussion.

Psychophysical studies, which often involve asking subjects to evaluate map design elements such as text, color, symbols, pattern complexity, and map layout can, to an acceptable degree of effectiveness, evaluate responses through the use of pencil/paper tests. However, an interactive multimedia computer administered test could provide further useful information. For example, recall the well-known experiment designed and conducted by Flannery (1971). He designed an experiment that asked subjects to estimate magnitude of graduated circles. A similar experiment could be designed using a pencil/paper test as well as an interactive multimedia test. With the pencil/paper test, subjects could identify the most to least effective circle sizes for a given set of data by numbering (according to perceived effectiveness) each representative symbol/data combination. The results will reveal a ranking scheme of symbols, allowing the researcher to determine which set of symbols best represent the data. However, a computer administered testing device could be programmed not only to reveal a ranking scheme, but also to identify where ranking difficulty occurred. If a test is designed to allow subjects to “drag” a number (identifying rank) to each set of symbols, the computer can reveal which numbers were more problematic by recording the amount of time spent dragging each number as well as recording the various locations to which each number was dragged. In other words, if 5 symbols were included in the test, the best and the worst may be easiest to identify, meaning that number 1

and number 5 would be dragged first, quickly, and only to one location each. The middle-ranked symbols may be harder to identify, so subjects may spend more time ranking numbers 2,3, and 4.

A computer administered place-name experiment could also indicate areas of relative ease or difficulty. A pencil/paper place-name test may only include correct or incorrect answers. Experimenters can time the test and/or they can provide a blank test for each place (to increase difficulty by removing previously named neighboring areas). Beyond revealing right or wrong answers, researchers cannot determine the difficulty of each place. A computer test would be able to determine relative difficulty of every place that was named. For example, a researcher may want to determine subjects' United States place name geography ability. Using a pencil/paper test, researchers could present each subject with a series of blank 48 base maps of the 48 contiguous states; each map would have a different states' name at the top and the task would be to identify the correct location of the state. Only right and wrong answers can be recorded. A computer test, however, could identify not only correct/incorrect answers, but also the amount of time spent on each map, revealing the difficulty level of each state. Figure 1 illustrates the same test created as a pencil/paper test and as a computer-administered test. The computer test may be programmed to create text files indicating correctness and time (in milliseconds) for each state.

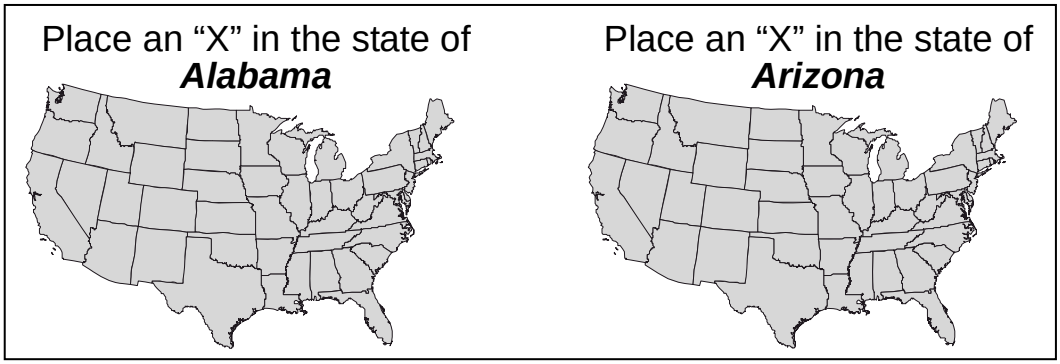

Figure 1a: pencil/paper test

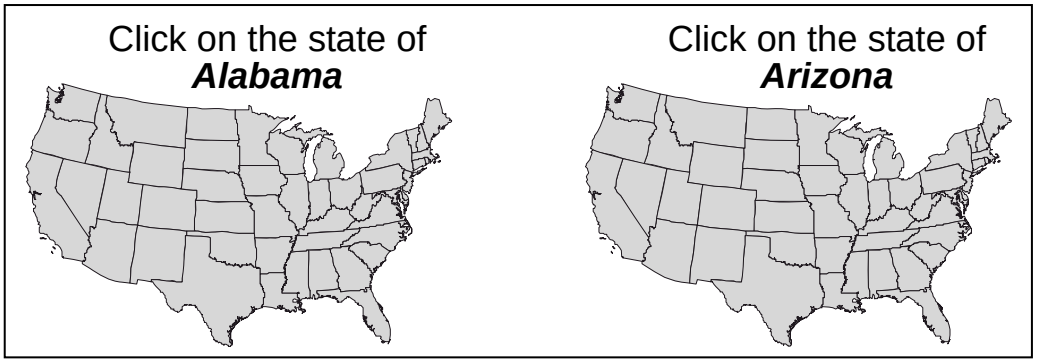

Figure 1b: interactive multimedia test

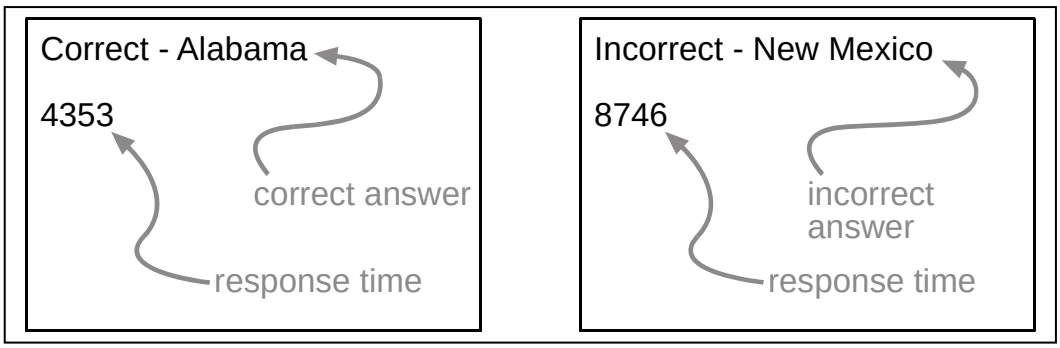

Figure 1c: response text files

Interactive multimedia testing devices also have application in cognitive cartographic research. The ability to time responses could be revealing for cognitive testing. For example, a researcher may want to test subjects' map rotation ability. In a series of printed, rotated, paired maps, subjects may be asked to determine which pairs include a "flipped" map. If designed as a computer test, the timing could reveal whether level of detail influences a subject's ability to identify flipped maps. In another example, suppose a researcher wants to determine subjects' abilities to locate themselves on a map. Using an interactive multimedia test, a researcher could program the computer to record the exact screen placement of a marker. In the example shown in Figure 2, subjects are shown a panoramic photograph and asked to identify their location (both the x,y location as well as the direction) by dragging the correct arrow to the correct location on the map displayed on the screen. The computer records whether the correct arrow was chosen as well as the x,y location of the arrow placement.

Figure 2a: panoramic photograph

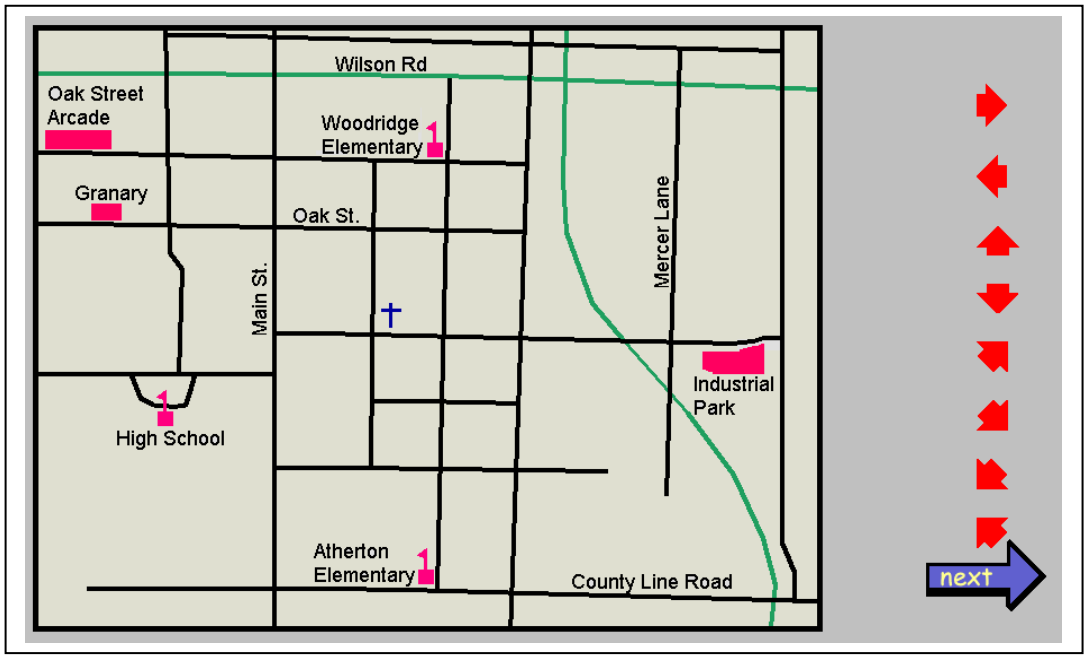

Figure 2b: map with arrow choices

Technological Considerations

The design of interactive multimedia testing devices need not be limited to correct or incorrect answers (although in many cases of cartographic research, such as those outlined above, most designs are limited to this format). In addition to the ability to record correct or incorrect, response time, object placement, and ranked order of responses, the computer can be programmed to "grade" short answer as well as short or long essay responses. A set of key words are stored to provide a bank of answers that are consulted during the response evaluation. This method has been used recently by the Educational Testing Service, which created a program called E-Rater, designed to evaluate essays on the Graduate Management Admission Test. The two essays on the GMAT are computer graded by evaluating syntax, organization, and content (Labi 1999).

More open-ended responses or those requiring more creativity are less effectively scored by the computer. For example, a project may be designed to evaluate a person's mental map developed from listening to or reading a story. If the mental maps are drawn (either on paper or on screen), a computer is less able to evaluate the overall design. However, a researcher can mark specific locations included in the map and, using the computer, conduct a distance or relative location analysis.

Research Tool Design

Designing the research tool requires knowledge of interactive multimedia authoring software (such as Macromedia Director) as well as aesthetic and effective design guidelines for such applications (for design guidelines for dynamic maps see Andrews 1994, Campbell and Egbert 1990, DiBiase 1994, Dorling 1992, Gersmehl 1990, Moellering, 1980, Monmonier 1992, 1996, Peterson 1993, Slocum, Robeson, and Stephen Egbert 1990, Tilton 1994, von Wyss 1996,Weber and Buttenfield 1993). Design guidelines that govern the authoring of interactive multimedia maps as well as digital atlases may be applied to the design of computer administered map-related tests; however the former are created as cartographic display tools, while the later are cartographic research tools. Because the applications are not exactly the same, neither are the

design goals. The researcher must take care to design an effective tool; as a result, ease of use must be of paramount concern. The testing device should not evaluate the subject's ability to use the test, rather their ability in the subject matter addressed in the test. Attention should be paid to aesthetics, as well. A poor selection of color or a poor layout may deflect a subject's attention away from the primary purpose of the testing device. In addition, attention gaining devices, flashing text, fades, swipes, textured wallpaper (background), or other related techniques utilized in many multimedia cartographic products may not be appropriate for testing devices; again, they may deflect subjects' attention.

When designing an interactive multimedia test, researchers should conduct a focus group to evaluate test design, specifically (an additional focus group to evaluate test content may be useful, too). Focus groups usually include 5-10 people and are moderated by a facilitator who encourages focused, in-depth discussion in the areas in which feedback is desired. This qualitative evaluation method has proven useful in evaluating cartographic products (Monmonier and Gluck 1994, Duh et al. 1998, Olson et al. 1998). Focus group evaluation has also been proven to be an effective method for assessing both products (Olson et al. 1998, Duh et al. 1998, Monmonier and Gluck 1994) and education methods (Olson and Brown 2001).

Test Reliability and Validity

Any tool used in research methodology, especially those used as tests in human subject testing, should be evaluated for reliability and validity as they both affect the ability to confidently report results as well as develop strong conclusions. Test reliability refers to the consistency of scores that may be obtained by a person when tested on different occasions. In other words, test reliability is determined by how consistently a test measures a given trait or ability. Several analyses for test reliability may be conducted, depending on the test's construction; researchers select a reliability method depending on what they identify as the potential sources of error. The validity of a test indicates the degree to which the inferences made form the test scores are accurate. In other words, if a test is created to "measure" a person's map rotation ability, the test's validity is the extent to which the test actually does measure map rotation ability. Conducting a validity test of the multimedia (or any other) testing device used in cartographic research can be time-consuming and difficult; but, this step in the research is imperative if the researcher is going to make claims regarding research results. As with reliability, several analyses can be conducted, depending on the application and construction of the testing device. Before the main analysis, then, such tests should be performed on the computer administered test. If using an existing, widely used testing device, the reliability and validity assessments of the test may be acquired from the test's author or owner. Researchers may utilize several methods for testing the reliability and validity of their measurement devices, depending on potential error of the test and how the test scores will be used. For a complete discussion on psychological testing reliability and validity see Anastasi and Urbina (1997).

Determining Usefulness

Computer administered testing devices offer several advantages over traditional pencil and paper tests. As mentioned above, scoring precision (both timing and x,y location) may be the most significant benefit since this precision provides the researcher with more data than can be acquired from the traditional test. The additional data allows for comparisons between test items to a degree that is otherwise unavailable. Another advantage is the ease of data conversion. The test can be programmed to create digital files that are easily transferred into spreadsheet programs, such as Microsoft Excel or quantitative analysis programs, such as SPSS or SYSTAT. Finally, the task of scoring the tests is automated, offering two advantages: the potential of human

error in scoring is greatly reduced and the researcher no longer needs to take the time to score the tests (an arduous task for a test with many questions or many subjects).

These advantages need to be weighed against three potential disadvantages: time, test administration, and cost. First, whether constructing a presentation or a testing instrument, interactive multimedia is often time-consuming and tedious. In many cases, a pencil/paper test may require considerably less time to construct. Second, test administration is complicated by the fact that in most cases, subjects must report to a specific location (where the test is housed). Therefore, computer tests are less "portable" than are pencil/paper tests, which can be taken to the subjects. Third, interactive multimedia may be more expensive. The researcher must have a computer (usually high-end as many multimedia authoring programs require more computer resources than most programs) as well as the authoring software, which may also be expensive (a single copy of Macromedia Director costs as much as $999). Also, if the researcher does not possess the skills to create the instrument, a test designer must be employed. The problem of test administration affects costs as well because providing sufficient initiative to draw subjects to the location usually requires the researcher to incur additional expenses.

In conclusion, a researcher must weigh several factors to determine whether interactive multimedia will play an effective and useful part in the cartographic research methodology. Because usefulness, alone, is not always the only point of consideration (time, budget, subject testing environment are also important factors to consider), a careful evaluation of project purpose and available resources will influence choosing the method of creating, administering, and scoring the testing instrument.

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