Are Two Modalities Better Than One When Learning From Online Reference Maps?

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Abstract

This study focuses on the effects of map display and modality on learning geographical maps in a computer-based environment. Participants were randomly assigned to four versions of a computer program created by crossing two levels of map display (hypertext vs. rollover) with two levels of modality (audio vs. audio and text). Results showed that the modality factor affects recall and inference test performance of college students in map learning significantly.

Purpose

Technology has improved so much today, that it is easy to teach in ways that are both interactive and communicative. The Internet and the WWW have added a new dimension to teaching and learning. It not only integrates different mediums but also their design, development and implementation. With the paradigm shift from teaching to learning, multimodality offers an excellent way for self-paced and exploratory learning more in tune with the constructivist methodology than the behaviorist methodology. According to Mayer (1997), meaningful learning "occurs when learners *select* relevant information from what is presented, *organize* the pieces of information into a coherent mental representation, and *integrate* the newly constructed representation with others".

Theoretical Framework

Results from over forty studies have shown that geographic maps can be used as cognitive tools to increase the recall of related instructional text. The image of a map is an excellent mnemonic device to associate geographic locations contained in the map with related facts in the text (Kulhavy, Stock, & Kealy, 1993). Maps integrate both feature information and structure information which create an integrated image of the display (Verdi, Johnson, Stock, Kulhavy, and Ahern, 1997). This integration results in an economical unit that makes it easy for learners to switch their attention across an image while simultaneously processing information from a related text (Larkin and Simon, 1987). The feature-to-fact referential connections (Mayer and Anderson, 1992) create additional retrieval cues that learners can use to improve their recall of map and text information (Verdi, et al., 1997).

Paivio's dual coding theory (Paivio, 1986) contends that the cognitive system functions with two symbolic systems that are distinct, yet referentially connected. The verbal system stores information generated through the processing of language while the nonverbal system stores information received during the processing of images. Conjoint retention (CR) theory, an extension of dual coding theory (Paivio, 1986) has been applied to map learning. According to CR theory, maps are stored spatially in the nonverbal system as intact units while text information is stored linearly in the verbal system. The presence of referential connections between these two separate memory stores can help in the study of geographical maps.

Computer environments offer a far greater scope to make use of dual coding theory than print media. It offers far greater scope to use multimedia. Print maps are usually drawn on one page and the opposite page has the narrative. Sorting through the narrative to reference a particular location is not only time-consuming but also leads to extrinsic cognitive load. Extrinsic load can be brought down to a large extent by bringing in the contiguity factor. According to the contiguity principle, instructions in multimedia are more effective when words, pictures and audio are presented contiguously, rather than separately in time or space. The contiguity factor takes into account the severe limitations of the human processing system (Baddeley, 1986) which leads to cognitive load. In a computer environment it is possible to have feature-to-fact referential connections both in terms of temporal contiguity and spatial contiguity as well as an image of the map with or without an accompanying text and audio. Contiguity helps to bring cross-code referential links lowering the cognitive load and thus helping in better cognition of the

geographical content. According to Mayer (2002) spatial contiguity occurs when instructional elements such as text and image or text and audio or image and audio are physically close. In a computer environment this occurs when the instructional elements are on the same screen rather than on different screens. This is achieved by having a roll-over effect. When the cursor is over an image or at a particular location the text immediately pops up or the audio message immediately starts. But since in this situation the text and/ or the audio message pop up immediately on the same screen this could very well be considered to have both the temporal and spatial contiguity simultaneously. However in the hypertext effect the learner selects a map feature by clicking on it with a computer mouse. This opens a new screen with the text and or audio in it. Since separate screens are involved here the instructional elements are separated in time and not space, it can be considered to have temporal contiguity.

This study examines the effects of text and audio (dual modality) and audio only in learning from an online map in temporal with spatial contiguity conditions and temporal only conditions. The question that is being studied is to what extent modality plays a role in learning from an online map. The second question being looked into is under what contiguity conditions modalities affect learning. It is hypothesized that dual modality will influence learning under both contiguity conditions because the feature to text cross-reference is being further augmented by using dual channels of visual and auditory senses. This augmentation should help learners to make better use of their information processing system.

Design and Subject

One hundred and seventy-six undergraduate students from a large southwestern university were randomly assigned to one of four conditions in a 2 X 2 factorial design. There were two levels of map display (hypertext vs. rollover) which were crossed with two levels of modality (audio vs. audio and text) to form the factorial design. Students were given a fictitious map with twenty locations having fictitious names on it. Each location had a fact describing its unique feature. Depending on the condition they were assigned to, students would either receive an audio message (audio modality) or both audio and text message (dual modality) telling them the unique feature of the location. Students could access this information by either clicking on the location (hypertext) using the computer mouse when the embedded text with the narration or the audio alone would open up in a different screen or by placing the cursor on a particular location using the computer mouse when the text with the narration or the audio alone would be presented contiguously with the location. Students received course credit for participation.

Materials

The materials consisted of a computer-based reference map depicting fictitious feature names from the island of Malta and two manipulations of a 470-word text (i.e., hypertext and rollover) containing facts about the features. Text narration with audio could be heard through headphones.

The map contained 20 fictitious features randomly distributed across the map surface. There was one fact associated with each map feature.

Procedure

All participants were given verbal instructions, guiding them to learn as much as possible from the map. All participants were given 20 minutes to study the map. After studying the map, all participants were given three paper-based instruments with two retrieval measures and one inference measure, to determine the effects of the treatment conditions. A free recall measure was used to test participants on the map features and facts they studied for which they were given 10 minutes. Participants were then given eight minutes to take the second retrieval measure which was a map reconstruction task. They were given a sheet with the computer screen border drawn for this task. Finally, a twelve-item multiple-choice test designed as the inference measure was given to assess the participants' ability to make inferences about the information on the map. To correctly answer the items the participants had to infer information from the map that was not specifically stated in the materials. This was viewed as a higher-order thinking task as opposed to free recall. This measure was scored by giving one point for each item answered correctly. All statistical tests were performed with an alpha of .05.

Results and Conclusions

ANOVA revealed a main effect on the modality variable for fact recall $F(1, 73) = 6.008$, $p = .017$. Further analysis revealed significant display type by modality interaction effects on the inference test $F(1, 73) = 5.616$, $p=.020$ and the name recall test $F(1,73) =4.384$, $p=.040$. Analysis of the inference test interaction shows that hypertext (temporal contiguity only) students in the text and audio conditions (dual modality) outperformed students in the hypertext (temporal contiguity only) in the audio only conditions, but the opposite effect occurred in the

rollover conditions. Further, analysis of the name recall interaction revealed that roll-over (temporal and spatial contiguity) students in the audio only condition outperformed students in the roll-over (temporal and spatial contiguity) text and audio (dual modality) condition for the name recall, while the opposite effect occurred for those in the hypertext conditions.

The results are partly in tune with the hypothesis. Dual modality does have a positive effect on learners but not in both the contiguity conditions. It appears to help learners more in a temporal contiguity condition than those in temporal and spatial contiguity, which can be considered as dual contiguity. Dual modality with dual contiguity does not seem to serve its purpose. Dual contiguity with single modality (audio in this case) and single contiguity (temporal in this case) with dual modality seems to do a better job at improving understanding of geographical maps. This could be explained in terms of the cognitive-load theory. Two simultaneous contiguity conditions (rollover) with both audio and visual gives rise to unwanted redundancy. This in turn may generate a heavy cognitive load that is unfavorable to learning (Chandler & Sweller, 1991; Sweller, 1988, 1989; Sweller, Chandler, Tierney, & Cooper, 1990). It is also possible that the speed with which learners read the text could be different from the speed of the audio which might not have been conducive to learning. In the single audio modality this overlapping is absent and learners have performed better. Another possibility could be that learners in the rollover condition have a split-attention problem as they have to use the visual channel for both the image of the map as well as to read the text. Addition of audio to this scenario has not helped.

The hypertext condition does better in dual modality as there is no split attention problem. On clicking on a location the text opens up in a new screen. Since the image of the map is not visible anymore, learners are able to concentrate on the text and audio. But when audio alone is presented learners are unable to get the fact-feature cross-reference.

It is interesting to note that the interference effect is seen only in the inference test and name recall and not in fact recall and name to fact match. Though the trend is maintained, it does not reach the level of significance.

Educational Importance

The results of this study have some practical implications in the use of audio for educators interested in designing online instruction involving geographic maps. Online instruction containing geographic maps should employ the computer's capability to offer different modalities (audio and dual) to enhance learning. This study also provides evidence that using both audio and text to present verbal information may be more effective than using audio alone in single temporal contiguity conditions while the reverse is true for dual contiguity (temporal and spatial contiguities) with single modality.

With digital books becoming more and more common this research has lots of implications as it could lead to better use of technology for improving standards of education.

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