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AUTHOR	Beacham, N. A.; Elliott, A. C.; Alty, J. L.; Al-Sharrah, A.
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ABSTRACT

This paper reports initial results from a study which investigated whether different media combinations could be shown to improve students' understanding of computer-based learning materials and to determine whether student learning style affected student understanding for different media combinations. Three groups of participants were given a presentation, each using different media combinations to present a topic. Dual coding theory was used as the basis for designing the presentation. Results indicate that participants' understanding was enhanced when the computer-based learning materials were presented using sound and diagrams. Understanding was worse when materials were presented using text and diagrams. The result supports the predictions of dual coding theory. Furthermore, the results indicate that the sound and diagram combination can improve participants' understanding regardless of their preferred learning style, and that intuitive learners seem to be exceptionally volatile to different media combinations. (Contains 11 references.) (Author)

Media Combinations and Learning Styles: A Dual Coding Approach

N. A. Beacham, A. C. Elliott, J. L. Alty and A. Al-Sharrah
IMPACT Research Group, Department of Computer Science, Loughborough University, UK.
Email: N.Beacham@lboro.ac.uk

Abstract: This paper reports initial results from a study which investigated if different media combinations could be shown to improve students' understanding of computer-based learning materials and to determine whether student learning style affected student understanding for different media combinations. Three groups of participants were given a presentation, each using different media combinations to present a topic. Dual coding theory was used as the basis for designing the presentation. Results indicate that participants' understanding was enhanced when the computer-based learning materials were presented using sound and diagrams. Understanding was worse when materials were presented using text and diagrams. The result supports the predictions of dual coding theory. Furthermore, the results indicate that the sound and diagram combination can improve participants' understanding regardless of their preferred learning style, and that intuitive learners seem to be exceptionally volatile to different media combinations.

Introduction

Many researchers of educational technology agree that learning materials should be designed for all types of learners, and learning styles, not just reflect the tutor's style of teaching (Felder, 1996). An effective way of achieving this is by using multiple media to target combination of media on the different styles of learner. There are many studies about the effectiveness of multimedia and learning styles in educational systems, but very few give an insight into why some combinations of media are more effective than others (Najjar, 1996). One theory that does provide such an insight is Dual Coding theory (Paivio, 1971, 1986).

According to Paivio's (1971, 1991; Clark and Paivio, 1991) dual coding theory, information is processed through one of two generally independent channels. One channel processes verbal information such as text and audio and the other channel processes visual information such as diagrams, animations and photographs. Paivio also advocates two different types of internal representational unit: 'imagens' for mental images and 'logogens' for verbal entities. Logogens are organized in terms of associations and hierarchies while imagens are organized in terms of part-whole relationships. Three types of internal processing are identified: representational - the direct activation of verbal or non-verbal representations; referential - the activation of the verbal system by the nonverbal system or vice-versa; and associated processing - the activation of related presentations within the same verbal or nonverbal system. Whilst it is agreed that a given task may require any or all of the three kinds of processing, it is not clear what and in which order people with different learning styles activate these types of processing. Furthermore, the effect on the learning outcomes of students with different learning styles is not clear when different media combinations are used.

Studies by Paivio and others (Baggett, 1989; Kozma, 1991) suggest that by choosing an appropriate combination of media, learning outcomes can be improved. For example, information that uses verbal and relevant visual illustrations will likely be learned better than information that uses text alone, audio alone, a combination of text and audio, or illustrations alone. Since 1971, dual coding theory has been used as an explanation for the effects of multimedia information on learning in a number of studies (Baggett, 1989; Kozma, 1991; Moreno and Mayer, 2000; Paivio, 1971). Many researchers agree that dual coding theory gives a reasonable explanation for the results of a large number of studies of multimedia learning (Najjar, 1996). The theory is particular useful because it gives an explanation for the way information is processed by human beings and relates this to visual and verbal styles of learning. A number of principles and guidelines for designing multimedia have since been derived from dual coding theory and applied to the development of computer-based learning materials. What is more, this theory seems to be as relevant today as it was some 30 years ago, in spite the advancements in new technology and changes in education (Paivio, 1991; Sadoski and Pavio, 2001).

Even after 30 years, there exist alternative views of memory storage that go against dual coding theory, such as propositional theory (Rieber, 1994). Propositional theorists argue that a transformation takes place of

visual information into a semantic form of storage in long-term memory. The propositional theory disputes the superiority of pictures over words because people process and rehearse pictures more fully than words. Paivio (1991), however, still believes that the evidence shows that dual coding theory has more than held its own relative to the prepositional alternative and that other new theories such as the computational theory "connectionism" remain to be demonstrated.

Although much work has been done to date, more studies are needed to ascertain the effects of multimedia information on learning by students with different learning styles. It has long been acknowledged that dual coding theory can be used to study the effects of visual and verbal learners. However, little is known about the effects of multimedia information on learning by students with other learning styles, such as sensing, intuitive, sequential, global, active, and reflective styles.

One of the aims of the study described in this paper was to ascertain the effects of using multimedia information on learning by sensing and intuitive learners, as well as others, as compared to visual and verbal learners. The purpose of the study was to answer the following questions:

- Can different media combinations improve students' understanding?
- Do scores differ between learning styles for different media combinations?

This area of research was identified as being of particular importance to researchers and authors of multimedia in providing them the necessary background to help select an appropriate combination of media for designing computer-based learning materials that are appropriate for all learning styles.

Experimental Study

To ascertain the effects of using multimedia information on learning by sensing and intuitive learners, three different versions of learning material were presented to three groups of students. One group was shown a version of the presentation containing text and diagrams, a second group was shown a version containing text only and a third group was given a version containing sound and diagrams. Data collected from each group were then compared. The remainder of this section provides further details of the presentation, the group characteristics, and the instruments and the methodology used in the experiment.

Presentation

A learning module, 12 minutes in duration, was developed in order to help assess the effectiveness of different combinations of media (see Figure 1).

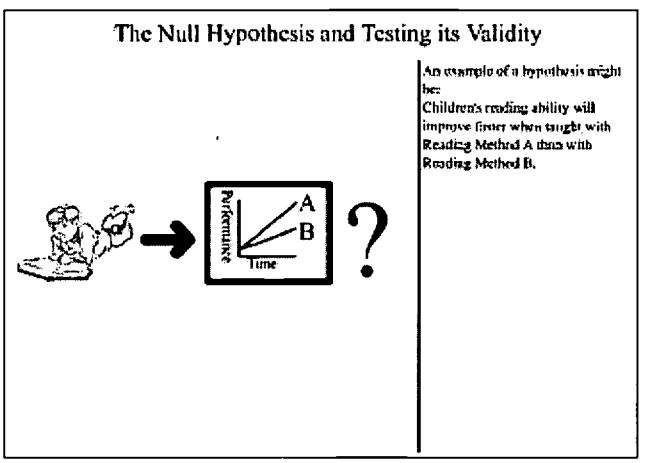

Figure 1: Screen shot of the module on statistics.

The module was developed using Macromedia Flash 5 and was about the topic of the use of statistics in experimental evaluation. The subject area of statistics was selected because it was felt that most students would have little previous knowledge about this topic and those students that did have previous knowledge

about it often found the topic difficult. The aims and objectives of the module were defined and used to produce a series of 'messages'. These messages represented key points that a student needed to learn from the module. The messages were then represented and replicated in a textual, visual and audio form. Three copies of the module were then produced as presentations. Presentation 1 presented the topic using text and diagrams, Presentation 2 using text only and Presentation 3 using sound and diagrams. To ensure that only the media combinations changed, the three presentations ran for the same length of time. Each presentation was then published in an executable form and each was placed on a different but comparable laptop.

Group Characteristics

Forty-four students participated in the study. The participants were from the courses Computing and Management and Computer Science at Loughborough University. The study was carried out as part of a module on Human Computer Interaction, which the participants were taking. In the three groups, there were 13, 14 and 17 participants, respectively. The age of the participants ranged from 20 to 24. The three groups of participants were selected according to there learning style. This criterion was implemented to assure a similar number of participants with the same type of learning style were present in each group.

Instruments

The test instruments employed in this study were a pre-test questionnaire, a revised version of the Felder-Silverman Learning Style Model inventory on learning styles (by Richard M. Felder and Barbara A. Soloman), and a post-test questionnaire. The pre-test questionnaire obtained the participants' familiarity with the statistical terms 'the null hypothesis' and 'significance' using 'yes/no' questions.

The learning style inventory consisted of 44 questions about a learners preferred way of learning and a score sheet for calculating a learners preferred style. The inventory chosen was selected after reviewing numerous different inventories that are available in electronic and/or paper form. We discounted inventories that: (a) would have taken too long to complete in a classroom situation; (b) were aimed at children (i.e. pre-sixteen); (c) were specifically related to visual, auditory, tactile, since we decided these will reveal little new information or interest to us in general; and (d) were difficult to fill-in and could easily be skewed by erroneous answers. The Felder-Silverman Learning Model was used for a number of reasons. It did not contravene the criteria given above and the inventory has been tested and validated, and shown to produce reliable results (Felder, 1996).

The post-test questionnaire consisted of 10 questions on a single doubled-sided piece of A4 paper. The questions were about the learning material contained in the presentation. For each question there was also a field asking participants to identify whether they knew the answer before seeing the presentation, whether the presentation helped them to recall the answer, or whether they had not known the answer before seeing the presentation.

Methodology

All three groups were tested simultaneously in different locations. The aims of the study were explained to the students, taking care not to give away details about the content of the presentations and the expected result. A handout was then given to each student containing the learning style inventory and score sheet. Students were asked to complete the inventory. Instructions were then given to the students about how to complete the score sheet. Afterwards, the students were asked to focus on the score for the learning style category sensing and intuitive learners. This category of learning styles was chosen because the class contained a broad spread of styles. In contrast, the category of visual and verbal learning styles was not selected because the population was predominantly visual. Those subjects who were predominantly sensing learners were equally divided into three groups. Subjects who were predominantly intuitive learners were also equally divided into three groups and each assigned to one of the three sensing groups. Finally, subjects who had a balanced style of learning (neither being predominantly sensing nor intuitive) were equally divided into three groups and each assigned to one of the three 'sensing/intuitive' groups. This resulted in three groups consisting of a random selection of subjects containing a similar number of learning styles. Each group was then placed in a separate

room where they were given one of the presentations. The first group was given the presentation containing text and diagrams, the second group was given the presentation containing text only, and a final group was given the presentation containing audio and diagrams. The audio in the third group consisted of a voiceover that spoke the text given in the first two groups.

Each presentation was presented using a laptop and a data projector. After each group had watched their particular presentation, they were given the post-test questionnaire to complete. Each participant's completed post-test questionnaire was then stapled to his or her learning style inventory and score sheet. This assured that we could compare the scores of those participants with different learning styles. All the learning inventories, score sheets and post-test questionnaires were then collected within the groups.

Having collected the data, the results were then analyzed using a 2 X 3 ANOVA test to identify whether there was a difference in the participants' scores of each group. Further analysis was also carried out to ascertain the effects of multimedia information on learning regarding each of the different learning styles.

Results

As part of the pre-test, participants in the study confirmed whether they knew what the statistical terms 'a null hypothesis' and 'significance' meant. 53.8% of the text and diagrams group, 14.3% of the text only group and 29.4% of the audio and diagrams group indicated that they knew what a 'null hypothesis' was. Similarly, 61.5% of the text and diagrams group, 35.7% of the text only group and 35.3% of the audio and diagrams group indicated that they knew what 'significance' was. These scores are shown in the bar charts in Figure 2. In the overall sample, the majority of participants had no prior knowledge of these statistical terms.

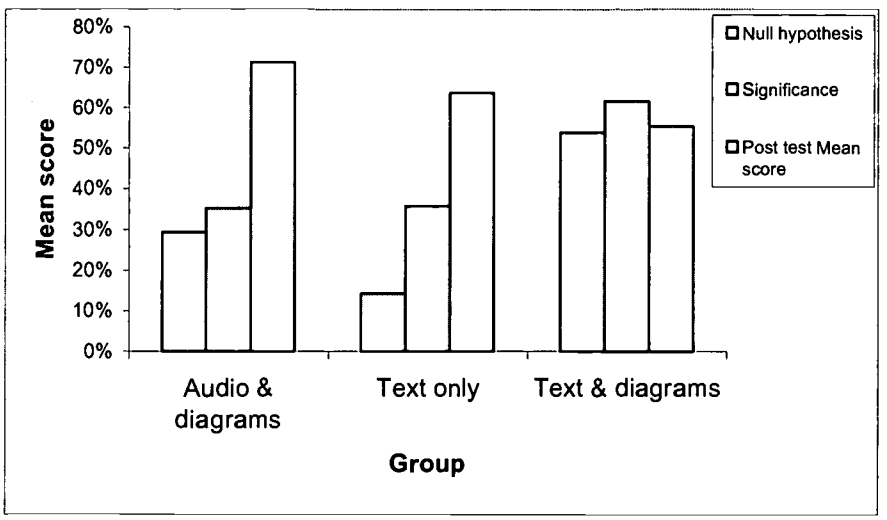

Figure 2: Comparison of prior knowledge with final scores.

Figure 2 also shows each group's post-test mean score after seeing a presentation. Participants who were shown the presentation containing sound and diagrams tend to score the highest marks followed by participants who were shown the presentation containing text only. Participants who were shown the presentation containing text and diagrams tend to score the lowest marks in the study. Interestingly, the text and diagrams group had reported a higher level of familiarity with the subject area than the other two groups (see above), so we would have expected them to do better in the test.

Statistically, overall there was no significant difference between the scores of sensing learners, intuitive learners and balanced learners. However, although not statistically significant, 'sensors' did seem to score higher marks than 'intuitors'. Moreover, as also suggested in the literature on learning theory 'balanced' learners did seem to score the highest marks. The findings seem to support the literature on learning theory that no single learning style is better than another, but balanced learners do seem to perform better overall.

Scores differ between learning styles for different media combinations. For some learning styles, the difference in scores is more evident. In fact, when learning style pairs are compared, one of the two is always

more affected by the change in media, than the other. With the sensing-intuitive pair, there is a statistically significant difference in 'intuitor' scores between each media combination group, but not for the 'sensor' scores. 'Intuitors' noticeably scored the highest marks when shown learning material containing sound and diagrams and performed worst when shown learning material containing text and diagrams. This trend was also true of other learning style pairs and can be seen in Figure 3.

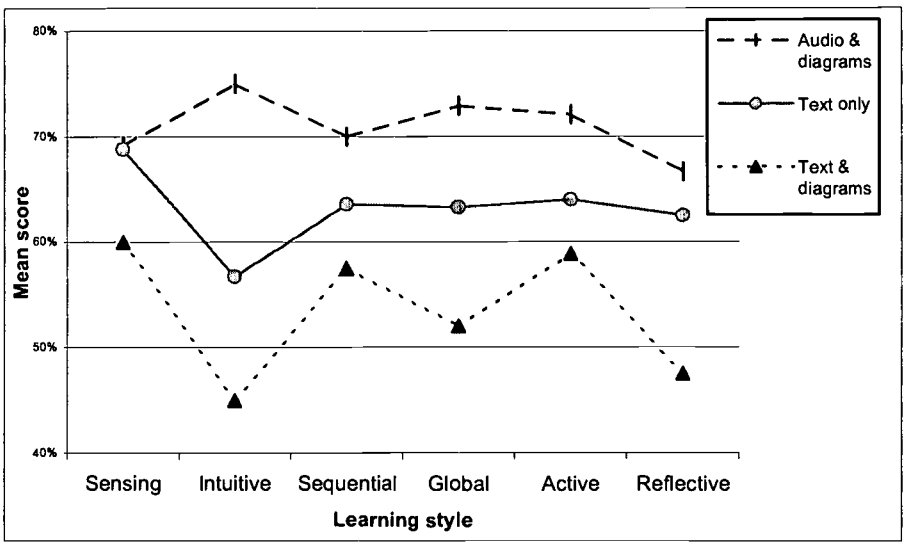

Figure 3: A comparison of learning styles.

'Global' learners tended to be more affected by media combinations than did 'sequential' learners (sequential -global pair). In the reflective-active pair, 'reflective' learners performed much worse with text and diagrams, than with audio and diagrams and with text only. However, the 'active' learners had closer scores for text only and text and diagrams, but performed much better with audio and diagrams.

Discussion

The results from this study offer two main findings. Firstly, different combinations of media, used to present learning materials to students, lead to significant differences in their understanding. Secondly, participants with different learning styles perform differently for different combinations of media. These findings support some of the ideas associated with dual coding theory. Our findings suggest that when information is represented by a verbal and visual combination people recall more items than when using text alone. However, the findings in our study also show that there are cases when a verbal and visual combination can cause people to recall fewer items than when using text alone (in our case text and diagrams). A reason for this might be the way that the text and diagrams were integrated. As a result, students may have been experiencing split-attention effect, an effect covered in cognitive load theory (Sweller et al, 1998).

Whilst our findings suggest that participants with some learning styles score higher than others between each group, this may be because people with particular learning styles are more suited to a type of media. For example, the presentations may have appealed more to sensing learners than intuitive learners because, as dual coding theory suggests, concrete nouns are better remembered than adjectives or abstract nouns. Sensing learner tend to prefer this type of information, whereas, intuitive learners tend to prefer to discover possible connections and relationships. As a result, intuitive learners may not have had the time to activate their preferred types of processing. Of course, another reason may have been because, more sensing learners were using a surface learning strategy and intuitive learners a deep learning strategy (Entwistle, 1997).

A difference in what and which order the students activated types of processing may also account for why participants' scores of some learning styles increased more than others between each group. Since dual coding supports the idea that people learn by connecting new knowledge to prior knowledge, intuitive learners may have been able to exploit this when sound and diagrams were used because time was freed up using this

combination of media. Media synchronization may also have been a factor when comparing the difference in participants' scores between text and diagrams and sound and diagrams because dual coding helps learners to increase interconnections to information already in memory (Baggett, 1989).

A possible explanation as to why the scores of most learners were significantly different between each group is probably the result of the redundancy effect, the split- attention effect and the modality effect associated with cognitive load theory (Sweller et al, 1998).

It is clear that more research is needed to investigate whether there is a relationship between the effects on learning and on different types of learning style and media combinations. At this stage, it is unclear whether similar results would have been obtained given that participants had been divided into groups based on a different learning style category. Further investigation is required to understand why those subjects with previous knowledge about the topic in text and diagrams group were unable to exploit this. More research is also needed to investigate whether special groups of learners with a particular style of learning (such as dyslexics) conform not only to dual coding theory but also to our overall findings. These investigations will help to understand the complex relationship between learning tasks and media combinations. From our research, we intend producing guidelines to help developers of computer-based learning materials and develop an approach for developing Adaptive User Interfaces that change according to style and media combination.

Conclusions

This study of using media combinations to deliver learning materials has produced findings that not only support dual coding theory, but also suggest that students' understanding seems to improve the most when using sound and diagrams to present the learning materials. Furthermore, students' understanding seems to improve for some learning styles more than others. We have learned that the affects of dual coding theory are more influential towards learning styles and in delivery of learning materials than previously thought. These results seem to provide tentative evidence that the media combination used to present learning materials is just as important as the style of learning adopted by the student. If the combination of media is inappropriate, it does not matter which learning style a student adopts. Students will still not perform to their full potential. This finding is particularly pertinent given that more attention is often given by tutors to the way learning materials are taught and not to the types of media used. The use of dual coding theory as an approach to accessing the effectiveness of learning materials is still as relevant today with web-based and mobile learning environments. Further research is needed to determine how some learning styles come to be affected more than others when using different combinations of media.

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