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Case Study

COURSE DELIVERY THROUGH THE WEB: EFFECTS OF LINEAR / NONLINEAR NAVIGATION AND INDIVIDUAL DIFFERENCES IN ONLINE LEARNING

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ABSTRACT

This research describes a study that examined the influences of cognitive style (as assessed by the CSA- Riding 1991) and Learners' Prior Knowledge on student recall performance of the contents of online course presented via two navigational formats (linear sequential navigation version versus nonlinear free navigation version). The contents of the course were presented as four modules/subjects comprising four video basic skills in text, pictures and video formats. The first module presented the types of shots used in video production, while the camera angles, composition of shots and camera movements were introduced in the three successive modules respectively. The study was investigated with a group of Egyptian students in the School of Specific Education, Ain Shams University and Fayoum University (n= 300: 161 females and 139 males); their ages ranged from 19-22 years. The subjects were randomly assigned to either a linear version of the course or a nonlinear version. The linear presentation allowed participants to see one topic/level at a time, in a predetermined order, but allowing backtracking and learner control of time. The nonlinear presentation version of the contents allowed subjects to choose any topic at each level similar to hierarchical menu and also allowed browsing and full access to all material and links. In order to assess participant prior knowledge, a questionnaire for measuring experience in content areas, using computer and internet was built with the participant checked on the knowledge checklist. Verbal/Pictorial recall was used to measure student's understanding of the presented content. The participants' scores on the recall test, scores on the prior knowledge questionnaire and participant's ratios on both cognitive style dimensions were analyzed by means of analysis of variance.

Key Words: Cognitive Style, e-learning, hypermedia, navigation, prior knowledge.

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INTRODUCTION

As one of the most recent developments in learning technology, web-based learning as a unique hypermedia program, which utilizes the World Wide Web (WWW), stands to offer a significant contribution to the improvements of delivering meaningful instructional material. One of the main features of web-based learning (hypermedia) is that there is not one linear path through the program but a multitudes of branches in which a learner can explore a subject topic at his/her own pace. That is, learners have the freedom to choose their learning paths allowing them to have more control over their learning. These features and many others have increased the importance of the WWW as a way of delivering instruction[1].

However, not all types of learners have the capability to develop navigation paths through the web material by themselves. Therefore, educators and designers of web materials should be more concerned with examining its effectiveness because instruction is not merely displaying information; rather it requires an integrated fit that considers the content, individual differences of learners and the delivering method to achieve success. Taking individual differences into account should bring the system to the users rather than the other way around. Based on this, designing appropriate e-courses through a hypermedia learning environment requires an understanding of the learners characteristics and features that might affect how they interact with particular learning environment. Such characteristics may include cognitive style, gender, motivation, age, prior knowledge and many other characteristics. Once the features are determined, the delivery method could be easily adapted in a way that better suits the target learner.

COGNITIVE STYLE

Cognitive style is an individual preferred and habitual approach to organizing and representing information[2]. Riding[3] and Riding and Cheema[4] suggested that learners differ in terms of two fundamental and independent dimensions of cognitive style: The wholist-analytic (WA) and the verbal-imager (VI) dimension (see figure1a). These two dimensions of style may be assessed using the computer-presented Cognitive Style Analysis[3] (see Appendix) as shown in figure 1a.

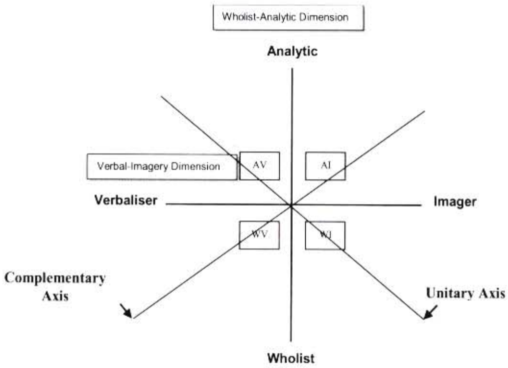


Fig. 1a: The wholist-analytic and verbal-imagery dimensions as proposed by Riding and Cheema.

1. Wholist-Analytic Dimension of Cognitive Style: The wholist-analytic dimension of cognitive style describes the habitual way in which an individual processes and organizes information: Some individuals will process and organize information into its component parts (described as analytics or independent learners); others will retain a global view of information (described as Wholists or dependent learners). For Wholists there is the danger that the distinction between the parts of a topic may become blurred. For analytics, the separation of the whole into its parts may mean that one aspect of the whole may be focused on at the expense of the others and hence its overall importance exaggerated. Very low correlations ($r = 0.05$) have been reported between the wholist-analytic dimension of cognitive style and intelligence as measured by the British Abilities Scale[5]. The wholist-analytic dimension is derived from the work of Witkin et al.[6]

2. Verbal-Imagery Dimension of Cognitive Style: The verbal-imagery dimension of cognitive style describes an individual's habitual mode of representation of information in memory during thinking. Verbalizers "consider the information they read, see or listen to, in words or verbal associations'; imagers on the other hand, when they read, listen to or consider information, experience "fluent spontaneous and frequent pictorial mental image"[7]. The verbal-imagery style affects the processing of information and the mode of representation and presentation that an individual will prefer and this is likely to affect the type of task they will find easy or difficult. However, it is important to note that both groups can use either mode of representation if they make the conscious choice, e.g., Verbalizers can form images if they try, but it is not their normal, habitual mode. Very low correlations ($r = 0.12$) have been reported between the verbal-imagery dimension of cognitive style and intelligence[5].

3. The Complementary-Unitary Styles: A person's style will be a combination of their position on each of the two fundamental dimensions. The style characteristics of a person may either complement or duplicate one another, depending on the characteristics. It is possible to order the style characteristics on the basis of the degree to which, in combination, they offer complementary facilities. For example, consider an analytic-imager. Since the analytic aspect of their style will not provide an overview of a situation, they could attempt to the whole view aspect of imagery to supply it. If another person were a wholist-verbalizer, then since the wholist facility does not support analysis, they might use the "analytic" property of verbalization as a substitute. By contrast, a wholist-imager only has a whole facility available, with no style that may be pressed into service to provide an analytic function.

4. Cognitive style and hypermedia learning: The two orthogonal dimensions of cognitive style have been shown to affect learning performance in several ways. Douglas and Riding 1993[8] found that when 11-year-old pupils were presented with a prose passage for recall, Wholists did best when the title of the passage was given before the passage was presented, rather than at the end, although this had little effect for Analytics. This was attributed to the Wholists, who are less able to structure material, being helped by a title at the beginning to give some organization to the material. Riding and Sadler-Smith[9] with 14-19-year-old students, compared performance on three differently structured versions of computer-presented instructional material. The three versions presented the same information about five topics. Version L had large steps with large chunks of verbal information with line diagrams. Version O comprised small steps of verbal information interspersed with pictorial or diagrammatic content, plus Overviews at the start, before and after each topic and at the end. Version S was as Version O with small steps but minus the overviews. The four styles were grouped as Complementary (Wholist-Verbalizers and Analytic-Imager) and Unitary (Wholist-Imager and Analytic-Verbaliser). In terms of the recall efficiency, different ways of structuring the material had a large effect on performance for the two Complementary style groups, with the small-step format being most effective. For the Unitary groups, the structure had relatively little effect, with the groups performing in an 'average' manner irrespective of the format.

Witkin et al.[6] used the term, field independence, to describe individuals who are individualistic, internally directed and accept ideas through analysis. On the other hand, field dependent individuals prefer working in groups, are externally directed, influenced by salient features and they accept ideas as presented. Research shows that field independent learners outperform field dependent learners in various conventional and web-based learning settings due to their different characteristics[10]. In the past decade, many studies have examined the significance of cognitive style in hypermedia learning. Some of these studies looked at relationships between: One is the structure of hypermedia documents and cognitive styles[11], another is cognitive style, performance and navigational style[10] and the other is cognitive styles and linear and non-linear learning[12,13]. Findings of these studies showed that learners with different cognitive styles react differently in non-linear interaction, which is the main feature of hypermedia programs. Wang, Hawk and Tenopir[14] examined users' interaction with the Web. The Embedded Figures Test (EFT) was applied to determine students' cognitive styles as either field dependent or field independent. Their results revealed that field dependent individuals might experience more difficulty in navigating on the Web and might get confused more easily than those with a strong field independence tendency.

Furthermore, Palmquist and Kim 2000[15] investigated the effect of cognitive style on hypermedia learning. The Group Embedded Figure Test (GEFT) was administered to identify subjects' cognitive styles. They found that field dependent students tended to follow links prescribed by the designers and experienced more disorientation problems. As a result, they suggested that field dependent learners, especially when novices, might need special attention from the interface designers. Similar results were obtained from a study conducted by Chen and Ford[16], in which a hypermedia program was presented with nonlinear structure to give students an introduction to artificial intelligence. Riding's Cognitive Style Analysis (CSA) was administered in order to identify participants' levels of field dependence. The results indicated that field independent students found the structure of the hypermedia program clear. On the other hand, field dependent students experienced more disorientation problems.

Ford and Chen[10] examined student learning in a hypermedia system designed with learner control features that taught the design of Web pages with HTML. The results showed that field dependent and field independent students preferred to use different subject categories. Field dependent students preferred to learn HTML with examples. On the other hand, field independent students preferred to see the detailed description of each HTML command. Similar findings were also obtained by Liu and Reed[12], who examined the different learning strategies used by thirty-three international college students in a hypermedia instructional program. Relatively, field independent individuals enjoyed independent learning in hypermedia systems provided with high levels of learner control.

PRIOR KNOWLEDGE

No doubt that prior knowledge is one of the most important variables that affect learner's manner in dealing with hypermedia learning system. Several studies have indicated that learners with different levels of prior knowledge perform differently in hypermedia learning systems, with low prior knowledge and high prior knowledge learners showing different preferences to the use of hypermedia courses and requiring different levels of navigational support[17]. According to Spires and Donley[18] the contrast between high and low prior knowledge lies in the differences in the organization of their conceptual structures. A study by Jenkins et al.[19] indicated that when searching for medical information, low and high prior knowledge participants showed different information seeking strategies. Experts focused on locating detailed information by using depth-first strategies, beginning at the first link on the initial site, then following links provided by the site and form site to another, until they found a suitable site. By contrast, novices showed a breadth-first strategy, following the first link of the initial site,, then going back to the initial site and following the second link without exploring any links offered in depth.

A study by Last et al.[20] indicated that students with high prior knowledge of the content were better able to navigate easily and remember where they had been and decide how to go; in contrast, low prior knowledge students seemed to suffer much from frustration while performing their tasks. Rouet and Levonen[21] indicated that getting lost in hypermedia learning systems is highlighted in low experienced individual as they lack the conceptual structure of the domain to orient their interaction with the hypermedia system. Vansickle[22] found that low prior knowledge students developed more experiences in the use of the WWW when they had additional support from teachers and librarians. McDonald and Stevenson[23] found that when providing three types of content structures (hierarchical, nonlinear and mixed) to low and high prior knowledge participants, navigation performance patterns were different. Navigation performance was assessed in terms of subjects' speed and accuracy in answering questions and locating particular nodes. A study by Potelle and Rouet[24] indicated that a hierarchical map improved performance for low prior knowledge learners more than a network map and an alphabetic list.

MATCHING AND MISMATCHING DESIGN

A "match" is when an agreement on certain characteristics exists between two individuals or an individual and his/her environment. In education, a match indicates that a student is able to benefit from a specific type of instruction; otherwise instruction develops into "frustration" and "disconfirmation", suppressing learning[25]. A large number of studies, which examined matching instructional materials with levels of individual differences of learners, have indicated that learning in matched conditions may in certain contexts be significantly more effective than learning in mismatched conditions. One of these studies was done by Ford and Chen[26]. They examined the effect of matching and mismatching cognitive style with instructional material on student learning a as shown in figure 1b. Two versions of hypermedia learning systems were designed with program control paths, including the breadth-first and depth-first versions. In the depth-first version, each topic was presented in exhaustively before the next, which was presented in the same way (i.e., Serial condition). The material was classified into seven levels in depth. In contrast, the breadth-first version gave an overview of all the material prior to introducing detail (i.e., holist condition) and included twelve categories in breadth. The results showed that students whose cognitive styles were matched to the design of hypermedia learning system performed better. Field dependent learners in the breadth first version outperformed field independent learners, whereas the reverse was true with field independent learners outscoring field dependent learners on the depth-first version. Moussa[2] found no support for the previous claim and his results showed a different pattern. With 479 participants from a university in Egypt, five version of a learning material were designed to give student either a whole or an analytic view of a room. The Cognitive Style Analysis (CSA) was used to classifying subjects to Wholists (Field dependent) and Analytics (Field Independent). The results showed that students performed better in mismatched conditions but learning was depressed in matched conditions.

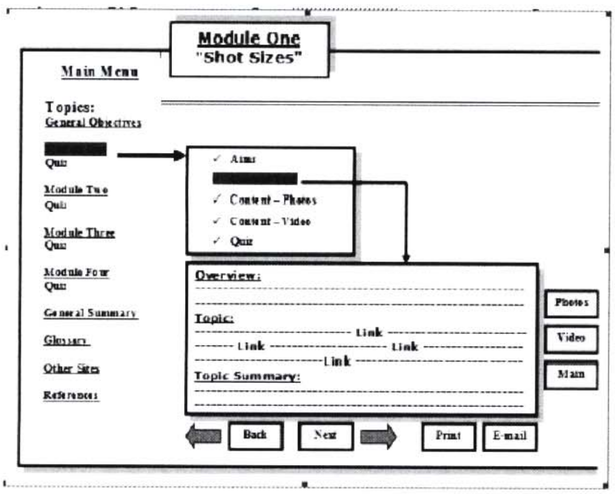


Fig. 1b : Instructional material on student learning.

AIMS AND QUESTIONS

The major aim of the present study was to investigate the possible interactions among navigation type in online course, cognitive and prior knowledge of learners, as conditions for recall of the course contents. More specifically, the aim was developed to address the following questions:

What is the effect of cognitive style on subject recall of the course contents?

What is the effect of navigation type on subject recall of the course contents?

What is the effect of prior knowledge of learners on subject recall of the course contents?

What are the effects of interaction of cognitive style, prior knowledge and navigation type on subject recall of the course contents?

METHOD

Participants

The subject pool consisted of 300 undergraduate students (139 males, 161 females) between the ages of 19 and 22. They all completed the course materials, the Cognitive Style Analysis (CSA), prior knowledge questionnaire and the performance measurement. The whole sample was drawn from the Faculty of Specific Education, Ain Shams University and Al-Fayoum University, in Egypt. The sample was drawn from the Department of Educational Technology (Al-Fayoum 200 and Ain Shams 100).

Materials and Procedures

1. Assessment of Cognitive Style. The computer-presented Cognitive Styles Analysis3 was used to determine a pupil's position on the two fundamental cognitive styles, which was indicated by two ratios; the Wholist-Analytic ratio and the Verbal-Imagery ratio. The background to the development of the Cognitive Styles Analysis is given in Riding and Cheema4. The Cognitive Styles Analysis was individually administered in a computer room in the Educational Technology Department with 15-20 learners per session (Appendix A).

2. Assessment of Prior Knowledge and Recall. Prior Knowledge was assessed on basis of two variables; one is topic content previous experience and the other is knowledge about one using computer, (b) using the internet and navigation tools. This was done on the basis of a 20-item questionnaire. Subjects were also required to respond to a four point scale, ranged from

I. Very little experience.
II. Little experience.
III. Good experience.
IV. Very good experience and to place a check next to each item in the questionnaire. The check list consists of instructions asked subjects to "please place a check mark next to the item that apply to you" followed by a list of 20 items. The pictorial/ verbal multiple recall test consists of 40 questions; the first 20 questions were in the type of true and false; 10 questions were in the form of multi-choices and the rest of questions were problem solving questions.

5. Materials. Two online courses were created to present the contents of four video basic skills in four modules. The first module presented the types of shots used in video production, while the camera angles, composition of shots and camera movements were introduced in the three successive modules respectively. Both sets of the e-courses were part of the video production course taught by the first researcher in the Department of Educational Technology, Ain Shams University. Both sets of the courses were developed and adapted from "techniques of video production book"27. The scientific content of the courses was designed using Adobe Flash Applications, with a simple user interface being created to enabling subjects to interact and browse through the contents. After designing the user interface screens, the courses were uploaded on to one of the Learning Management System (LMS) Environment which is called Moodle. This type of environment was chosen because:

1. It is easy to install on almost any platform that supports PHP, requiring only one data base.
2. It is simple, lightweight, effective and low-tech browser interface.
3. It is the environment used to deliver all electronic courses for all Egyptian Universities and accredited by the National Center for E-Learning which is part of the Supreme Council of Universities in Egypt.
4. It is suitable for 100% online classes, as well as supplementing face to face learning. The linear navigation version of the course was created to allowing subjects to browse the content in a predetermined sequential order. This version of navigation presented subjects with the ability to move through the database one screen at a time either next (forward) or back. Elements such as where the user is in a sequence or how to move to a different direction were a main concern in this version. We used a technique of highlighting content to show the user what is being studied at present time. Links hiding was another technique used to remove the links not ready to be studied from the main menu. For the content had been studied, line deletion (strikethrough) was used to remind the user that the deleted topics already studied before. The nonlinear free navigation version of the course was designed to give subjects all freedom to navigate through the content in any direction and also enabled subjects to see all topics and contents and all links. This version was created as hierarchical menus and so the user was able to move through the content in terms of main ideas to minor ideas or visually clicking to see what was in a small component such as videos and photos. The nonlinear version also provided the user with several links related to the content which were not found in the linear version. Beside this, the nonlinear version presented the user with more options for printing and emailing contents. Figure 2 shows the user interface templates (Linear- right side and nonlinear- left side) used in the present study.

4. Procedures. The subjects were randomly assigned to one of the two e-courses (linear versus nonlinear). 152 participants enrolled in the linear version of the course and 148 in the nonlinear version. The experiment was conducted during the second semester (Sunday 6th April – Monday 28th April 2008). The application procedures included two phases: The study phase and the testing phase and both phases were done using computer. The number of participants attended per session was between 8-20 subjects. Prior to application, students were given induction session explaining the purpose of the experiment and what they would be asked to do. Then, they were given a consent form to read and sign. Immediately on finishing the consent form, the participants were asked to take a seat and adjust their position in front of the computer screen to take a 20-item prior knowledge questionnaire. They were allowed 10 minutes to complete the checklist. After taking the prior knowledge questionnaire, students were asked to take the Cognitive Style Analysis (CSA) to determine levels of Wholist-Analytic and Verbal-Imager Style. Administration of the CSA took approximately 20 minutes. The Verbal-Imagery style ratio of learners ranged from 0.22- 4.61 (mean= 2.4, SD=.45). The Wholist-Analytic ratio ranged from 0.17- 3.64 (mean= 1.9, SD=.56). Each of the two cognitive style dimensions was split into two sections. The Wholist ranged from 0.17- 1.08 and the Analytics ranged from 1.09-3.64. The Verbal-Imagery ratio was split into two sections and these were Verbalizers 0.22-1.06, Imagers 1.07- 4.61.

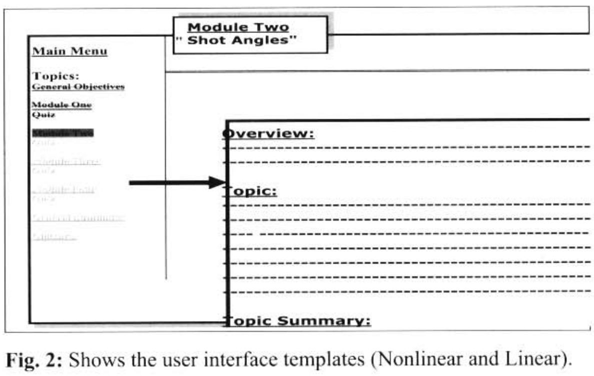


Fig. 2: Shows the user interface templates (Nonlinear and Linear).

After making sure all participants had understood the instructions and procedures, they were asked to log in for the e-course. Password and username were required for each participant. One week before the experiment, each participant was told his/her password and username. By logging, the participant would only see one version of the hypermedia program, either a linear presentation or a nonlinear presentation. The administrator of the program directed the subjects to the suitable version of the course based on the participant's data which stored in the data base. Two and a half hours were allowed for each stu dent to use the program and complete the study task. The started time and the end time were recorded.

After finishing the study phase, the experimenters announced that they were going to pass out the instructions for the pictorial/verbal recall test. Participants allowed five minutes to read the instructions. The test was administrated on the computer and each student was allowed 20 minutes to submit the responses. When the time was up, the test items were blocked, allowing only for submitting the answers.

RESULTS AND FINDINGS

An analysis of variance of navigation type (linear vs. nonlinear) by prior knowledge (high vs. low) as independent variables was conducted on the data with the recall as the dependent variable. The analysis showed many significant differences and a summary of the main effects and interactions are presented the three sections that follow:

1. **Navigation by Cognitive Style.**

When the analysis involved navigation type by cognitive style, the findings indicated a significant interaction ($F=788.340$; df 3, 284; $P< 0.00$), with the analytics did better than wholists on the nonlinear version of the e-course but the wholists were superior on the linear version of the course. For the verbal-imagery style, verbalizers outscored Imagers on the nonlinear presentation, whereas the Imagers excelled on the linear presentation. This finding is illustrated in figure 3 and 4.

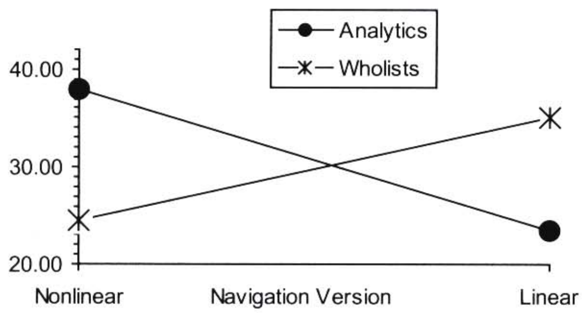


Fig. 3: Effects of Wholist-Analytic Style by Navigation.

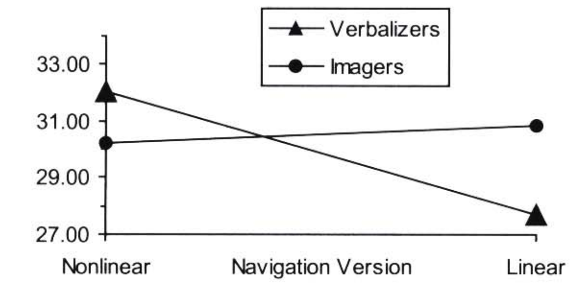


Fig. 4: Effects of Verbal-Imager Style by Navigation.

2. **Navigation by Prior Knowledge.**

When the analysis involved navigation type by prior knowledge, the findings indicated a significant interaction ($F=19.039$; df 1, 284; $P< 0.00$), where learners with high prior knowledge do better than learners with low prior knowledge on both versions of navigation presentations, but the effect of prior knowledge is clear with the linear sequential version of the e-course, with high knowledge subjects recalling more of the contents than low prior knowledge subjects. Another important aspect of the results could be seen in the figure, which shows that learners with low prior knowledge do better on the nonlinear navigation presentation than on the linear navigation presentation. The last finding needs more investigation. Figure 5 presents the results of this section.

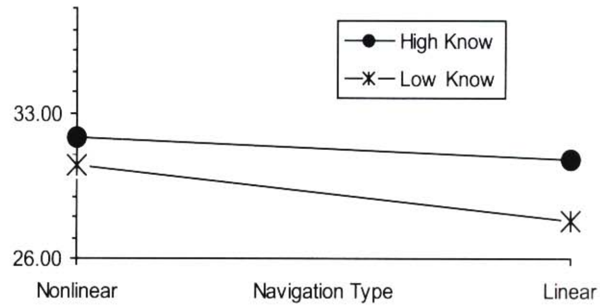


Fig. 5: Interaction of Prior Knowledge by Navigation Type.

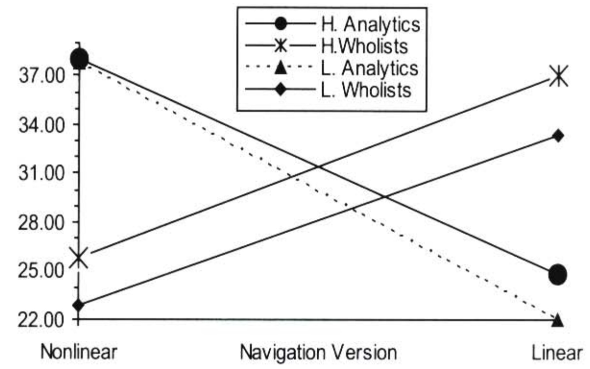


Fig. 6: Wholist-Analytic Style by Navigation Type by Prior Knowledge.

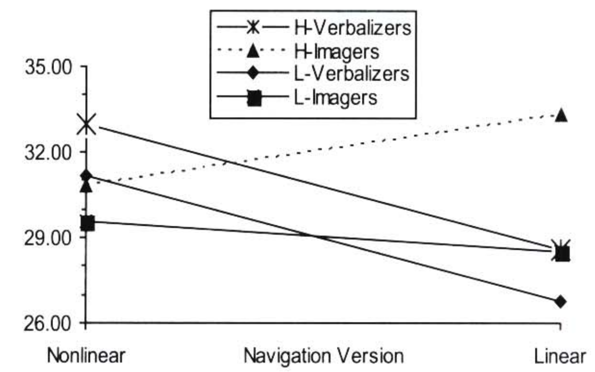


Fig. 7: Verbal-Imager Style by Navigation Type by Prior Knowledge.

3. Navigation by Prior Knowledge by Cognitive Style.

When the analysis involved navigation type by cognitive style by prior knowledge, the findings indicated a main interaction ($F=7.976$; df 3, 284; $P< 0.00$) and this interaction is displayed in figure 6 and 7. It can be seen in fig 6 and 7 that in the nonlinear navigation presentation, the analytics do better than the wholists regardless of whether they are high or low prior knowledge learners, whereas the wholists are superior to the analytics with the linear navigation presentation regardless of prior knowledge. For imagers and verbalizers, high prior knowledge subjects do better than low prior knowledge subjects with both navigation presentations, but the difference is clear with imagers on the linear condition, but the difference is steady with verbalizers on both conditions. Analytics with high prior knowledge are better than analytics with low prior knowledge on the linear presentation.

DISCUSSION

Discussion and implications for designing electronic courses

This section presents the discussion of findings and results and their implications for instructional designers of electronic courses and hypermedia materials. The focus of discussion is presented in the light of questions and hypotheses of the study and will be presented in two sections:

1. Summary of Overall Recall of independent Variables
2. Summary of Interaction of Independent Variables

1-Summary of Overall Recall of independent variables

With respect to the effects of the independent variables, Cognitive style, prior knowledge and navigation type, the study indicated that for prior knowledge variable, recall was best when learners were high knowledgeable in content areas, internet and computer. One possible reason for this result is that high prior knowledge learners with their deeper understanding of the subject matter; they might have used their background knowledge of the subject domain to guide their learning; they might also have developed their own strategies depending on their knowledge of using internet and computer to assist them in browsing the contents. Low prior knowledge learners, on the other hand, because of lack of prior experience of the subject domain, internet and computer, they might have addressed several problems such as disorientation.

A number of studies indicated that learners with different levels of prior knowledge benefited differently in hypermedia learning systems. Some of these studies pointed out that prior knowledge may influence the degree of disorientation in hypermedia learning. For example, a study by Last et al.[20] found that students with high prior knowledge of the content were better in navigate easily in a hypermedia learning system, remember where they had been and decide how to get to where they wanted to go. Low prior knowledge learners seemed to suffer more from disorientation and frustration while performing the task. Similar results were obtained in a study by McDonald and Stevenson[23]. They found that subjects with insufficient prior knowledge of the topic demonstrated more disorientation problems than subjects with high prior knowledge. A design principle might emerge from the previous finding, which suggests that instructional hypermedia designers of electronic courses who wish to make a difference in students' learning and increase engagement in active processing of the learning material should incorporate prior knowledge as a factor in designing the courses, because different levels of prior experience may produce different processing and different performance outcomes.

With respect to the effect of cognitive style, the present study indicated that cognitive style had no effect as such, but its effect appeared when involved and interacted with other variables. This result may be expected since cognitive style is different from ability. The basic difference between them is that performance on all tasks will improve as ability increases, whereas the effect of style on performance for an individual will be either positive or negative depending on the nature of the task. It follows from this that for an individual at one end of a style dimension, a task of a type they find difficult will be found easier by someone at the other end of the dimension and vice versa[28].

With respect to navigation type, the study revealed that the nonlinear navigation presentation of the e-course was better than the linear navigation presentation in facilitating recall of the contents of the course. This result may be expected since the first version of the course gave subjects more freedom and control and so subjects in the free nonlinear navigation were able to manage their resources and were able to benefit from the several links and sites provided with this version of the course and as a result, learning increased. According to this result, one could say that designers of e-course should provide users with multiple navigation tools to allow them to structure their own navigation strategies. When several navigation tools are provided users can choose any of these tools to develop their own strategies to access information according to their preferences.

2-Summary of Interaction of Independent Variables

2a. Cognitive Style and Navigation

In the present study, two electronic courses were presented to subjects; the first presentation version was free-nonlinear presentation which could be called "global presentation version"; the second presentation version presented information in a "sequential linear fashion". The results of the present study revealed that wholists did better on the linear sequential navigation presentation of the course than on the free nonlinear navigation presentation of the course. By contrast, the analytics did better on the nonlinear navigation condition than on the linear navigation condition (see figure 3, 4). This interaction showed that on both versions of the course there was a crossover for the wholists and analytics from parts (linear sequential navigation version) to wholes (nonlinear global free navigation version). Similar results were found with the verbal-imagery style. Verbalizers did better than imagers on the nonlinear navigation presentation version, whereas the imagers outscored verbalizers on the linear navigation presentation version.

In the light of the findings, the two adaptive presentation materials were designed to present two design principles; one may be called capitalization which means that the instructional presentation capitalizes on learner's assets providing individuals with the same skills they already have; the other may be called compensation which means that the instructional presentation supplants individuals with the missing skills they require to perform on the task. The current results of the experiment support the compensation design principle and do not lend any support for the capitalization design principle.

For wholist-analytic style, because the nonlinear navigation presentation gave students a global view by providing them elements such as a table of contents, a summary, an overview of information and free navigation options and links, analytic learners with their greater ability of disembedding were able to break up the whole view patterns with the nonlinear condition. Wholist learners, on the other hand, who have some difficulty sorting out details probably, were able to have an analytic view with the linear sequential navigation presentation which provided information step by step with "next" and "back" buttons. Decreasing in performance for wholist learners on the nonlinear version of navigation and for analytic learners on the linear version of navigation may have happened because linear version provided information in parts step by step and thus exaggerated the analytics tendency in analysis, which might have affected the overall performance. Similarly, the nonlinear version of navigation capitalized on wholist learners' assets, increasing their tendency in seeing the wholes and this might have resulted in the inability of distinguishing the parts of the situation.

The results in this section are consistent with Riding and Rayner[29] hypothesis that wholists and analytics could be affected by the external structure of learning materials to a different degree and probably both imposed some structure upon the material internally. This contrasts the view of Witkin et al.[6] that filed independent learners (analytics) impose structure upon the learning material while field dependent learners do not. In the present study it appears more convenient to say that the wholists and analytics were influenced by structure of condition to a different extent. While the wholists imposed their own integrated view upon the linear sequential navigation version, the analytics imposed some internal analysis upon the whole view presented with the nonlinear navigation presentation. The findings are also supported by the Aptitude-Treatment-Interaction (ATI) hypothesis[30] in that the instructional material should not provide learners with the skills they can produce by themselves. The present results also supported by the study of Liu and Reed[12] who found that student's cognitive style affected their performance and navigation strategies when learning from the Web. Analytics in their study tended to jump freely from one point to another using the index tools, whereas wholists tended to follow the sequence from the beginning to the end.

For verbal-imagery style, a similar pattern was observed. The results showed that there was a crossover with the verbal-imagery style, with recall being better for the imagers on the linear navigation condition, while for the verbalizers the nonlinear navigation condition was better in facilitating recall. One possible reason for this result could be that imagers particularly wholist-imagers were able to have their own overall picture from the imagery facility and the linear navigation presentation assisted them in getting the missing skill (analysis) and thus performance increased with linear version of the e-course. Similar results were found with verbalizers; they were better than imagers on the nonlinear version of navigation. Analytic verbalizers, who have an analysis skill, were able to get a whole view with the nonlinear version of material. Their performance on the linear version was the worst because they might have not been able to compensate for the missing whole skill; their internal representation system and the external structure of the learning material could not provide them with the whole picture they require to perform on the task and thus performance was depressed.

Based on the aforementioned discussion, one could say that instructional designers of hypermedia and web-based learning materials who wish to make a difference in student's learning and increase engagement in active processing of learning materials should incorporate a wide variety of navigation styles and types that emphasize wholes and parts in their design. A major design principle comes out from the results discussed in this section is that when adapting electronic courses to learners' cognitive style the structure of the learning material should not be driven by the idea that learning increases when structure of the material capitalizes on learners' assets but by the idea that learning increases when the structure compensates for lacking in learners skills and their ways of processing information.

2b. Prior Knowledge and Navigation

Besides cognitive style variable, the second important independent factor in the current study was learner's prior knowledge. Prior knowledge in the present study included previous experience in the content and previous experience in using computer and internet. The present study found that learners with high prior knowledge did better than learners with low prior knowledge on both versions of navigation presentation, whereas low prior knowledge learners did better on the nonlinear navigation version than on the linear navigation version (see figure 5). This result may be interpreted as high prior knowledge learners were able to organize their conceptual structure, whereas low prior knowledge subjects had disorganized conceptual structure. Thus, high prior knowledge subjects were able to navigate easier in the content regardless of the navigation type. Probably low prior knowledge subjects were lost in the structure feature of the course, whereas high knowledge subjects, with the help of prior knowledge, engaged in deep processing of the content. This result is supported by previous work which pointed out that subjects who lacked sufficient prior knowledge demonstrated disorientation problems than subjects with high prior knowledge[20-23]. The last result which indicated that low prior knowledge subjects did better on the nonlinear version of the course than on linear version may need more investigation.

2c. Prior Knowledge by Navigation by Cognitive Style

The present study was created to investigate the possible interactions of cognitive style and prior knowledge with two types of navigation presentations. With respect to the interaction of cognitive style by prior knowledge by navigation type, the results indicated that when the order of cognitive style was analytic-verbalizer, analytic-imager, wholist-verbalizer, wholist-imager, recall performance showed improvements on the linear version of navigation regardless of prior knowledge, whereas when the order of cognitive style was reversed, learning performance increased on the nonlinear version of navigation regardless of prior knowledge. This order may suggest a continuum; at one end of the continuum are the analytic learners and at the other end are the wholist learners. Analytics were the best on the nonlinear version of navigation but were the worst on the linear version of navigation. The reverse was true for the wholists; with the linear version of navigation presentation increased the wholists' scores whereas the worst scores were recorded for the wholists on the nonlinear navigation version.

As for prior knowledge, wholist students with high prior knowledge showed better recall overall than wholist students with low prior knowledge particularly in the linear version of navigation. Analytic students were not affected by prior knowledge with a margin improvement in the linear version in favor of high knowledgeable learners; they showed a similar pattern in both navigation versions regardless of prior knowledge. For the verbal-imagery style, the pattern of results was the same, with imagers with high prior knowledge being better than imagers with low prior knowledge on the linear version of navigation, but verbalizers were not affected by prior knowledge on both versions of navigation. According to this result, one may say that wholist learners and imagers showed more reliance on prior knowledge; they made use of their prior knowledge to support performance on the task; they are less able to structure material, being helped by the prior knowledge to give some organization to the material. Figure 8 shows by contrast, it could be said that analytic learners and verbalizers are less reliance on their prior knowledge to support performance; rather they relied on their own style characteristic to perform on the task. This result may fit nicely with the findings of Sadler-Smith and Riding[31], who found that, in terms of locus of control, analytics preferred to have control themselves rather than to be controlled. Figure 9 shows the interaction of cognitive style by prior knowledge on the linear navigation version.

Based on the results above, designers of web-based learning materials and multimedia designers who want to increase learners' engagement in information tasks should consider prior knowledge as a critical factor in designing materials that suit who list learners. Prior experience in content areas, knowledge of using computer and internet may be a perquisite for good performance of who lists and Imagers since their style characteristics may prevent them from developing sufficient strategies to cope with tasks not matching their styles.

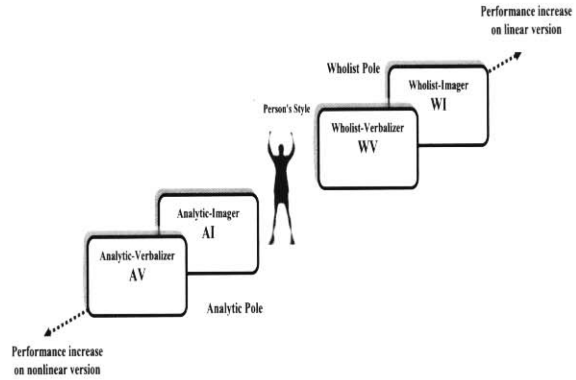


Fig 8: Direction of increase in performance of cognitive style by navigation.

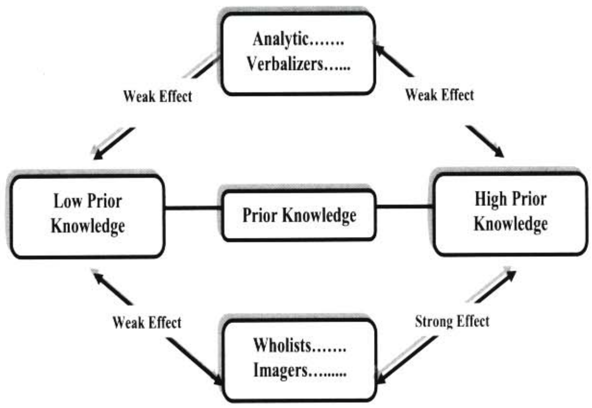


Fig. 9: Interaction of cognitive style by prior knowledge on the linear version of navigation.

APPENDIX

THE COGNITIVE STYTLE ANALYSIS (CSA)

The Cognitive style Analysis measure was developed by Riding[3] to assess the person's position on the two fundamental cognitive style dimensions: The Wholist-Analytic and Verbal-Imagery. The instrument comprises three sub-tests.

The first sub-test: Verbal-Imagery Style

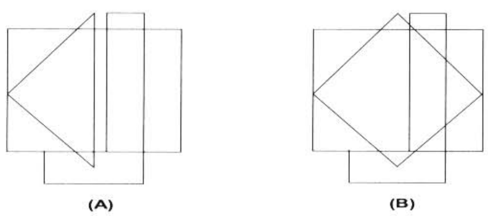
This measure provides the subjects with 48 statements about the relationships between two words and the subject's task is to decide whether each statement is true or false. 24 statements concern the conceptual relationship (if A is a type of B) and the other 24 concern the visual appearance of items (if A is the same color of B). One statement is presented per screen and the subject has to decide upon it. Two example statements from the test are shown below:

OAK and BEECH are same TYPE
SNOW and FLOUR are same COLOR

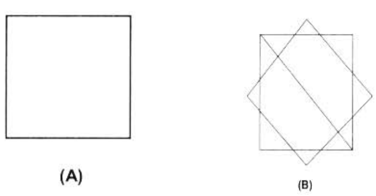
Riding assumes that shorter correct response times will be shown by Verbalizers for conceptual similarity statements since they are verbal in nature and cannot be represented visually. By contrast, Imagers are likely to respond very quickly to statements concerning visual appearance since answers can be given from the mental images.

The second and third sub-tests: Wholist-Analytic Style.

This part of the test comprises two sub-tests. In the second sub-test, each screen displays two geometric shapes (A and B) and the subject's task is to determine if the shape on the left (A) is the same as the shape on the right (B). An example is shown below:



In the third sub-test, each screen again displays two shapes (A and B), but this time, asks the subject to decide whether the simple shape on the left (A) is contained within the more complex shape on the right (B). An example of the items in this part is illustrated below:



Riding assumes that speed on the second sub-test indicates global information processing (Wholist) since the task requires subjects judging similarities. Speed on the third sub-test indicates high analytical skills (Analytic) since the task requires subjects to disembed a simple shape from the complex one

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