Abstract
This study investigates the navigational patterns and learning achievement of university students with different cognitive styles, on hypermedia learning environments using paging or scrolling. The global–local subscales of Sternberg’s Thinking Styles Inventory, two hypermedia, one using paging, the other using scrolling, a multiple choice achievement test, and a questionnaire to collect the students’ satisfaction on paging/scrolling were used as data collection tools. This study finds that the cognitive style and paging/scrolling, together or separately, neither affected the learning nor the satisfaction of learners. Students with different cognitive styles using paging or scrolling did all learn well, with no statistically significant difference. Also the navigation patterns did not seem to depend on cognitive style; that is, the frequencies of using the navigation tools were not significantly different.

Introduction
The rapid rise in the use of the World Wide Web has brought hypermedia into prominence as a mode of information accessing, learning and teaching (Ford & Chen, 2000). Hypermedia is a methodology or technology wherein the information units are interconnected and the pages can be traversed in many different sequences choosing navigation tools such as site maps, forward and back buttons, home pages, hyperlinks and so on (Ford & Chen, 2000). This way, users navigate between the units of information using the tools provided by the information’s author. The presentation of information in a non-linear format, which differs from the linear organisation of pages in books, or computer-based instruction materials, is the basic rationale behind hypermedia methodology.
The freedom offered by hypermedia methodology may come at a price, because flexibility increases complexity (Ellis & Kurniawan, 2000). Such complexity may cause some learners to lose their orientation, reduce their patience, diminish motivation to learn (Chen & Ford, 1997). This may slow down the access to meaningful and relevant material and lead to a waste of time. Not all types of users/learners have the capability to develop their navigation paths for themselves (Chen & Macredie, 2002; Chen, 2002). Therefore, it is important to clarify the relationships between the users’ individual differences (style, experience, gender, etc), their navigation behaviours (linearly or non-linearly by jumping between the information units) and learning performances in hypermedia in order to determine its usefulness as a teaching/learning tool. For example, system experience was found to be an important variable that affects hypermedia navigation and information seeking behaviour (Chen, 2005; Lee, Cheng, Rai & Depickere, 2005; Oh & Lim, 2005;). Some other studies for example Leong and Al-Hawamdesh (1999), Liu (2003) and Riding and Grimley (1999) concluded that navigation patterns and information-seeking strategies depend on gender. Cognitive style is another frequently observed individual difference variable in hypermedia research, because it is a construct defined as a person’s way of getting and processing information. The present study asks whether there are significant differences between the learning and navigational patterns of students with different cognitive styles in hypermedia where the learning content is delivered in two different designs, paging and scrolling.

**Theoretical background**

**Styles**

In educational psychology, the style concept has been among the major constructs investigated when considering individual differences in the learning context. In that context, there a variety of style constructs, like learning styles, information-processing styles, and cognitive styles. Cognitive style is a term that originated in personality research, but has been adopted by cognitive psychologists to refer to information processing habits which represent a person’s typical modes of perceiving, thinking, remembering and problem solving (Green, 1985). The term *cognitive style* was first used by Allport (1937), and has been described as a person’s typical or habitual mode of problem solving, thinking, perceiving and remembering. Some researches call this concept learning style. For example Enwistle (1981) believed that the terms ‘cognitive style’ and ‘learning style’ meant the same and so used the terms interchangeably, others, for example, Das (1988) considered the two to be different and defined them as separate concepts. According to Green (1985) cognitive style refers to preferences for, or dominant modes of, information processing.

Riding and Rayner (2002, p. 8) defined *cognitive style* as an individual’s preferred and habitual approach to organising and representing information. Similar to this definition, *information processing style*, by Pask (1972); cited in Ford (2000, p. 543) and *learning style*, by Felder and Silverman (1988, p. 674) were defined as the learner’s way to perceive and process information. So, as can be realised, the same concept is named as *cognitive style* by Riding & Rayner; as *learning style* by Felder & Silverman; and as *information processing style* by Pask. Naming the same or similar concepts/constructs
with different terms causes difficulty in understanding and studying such constructs and comparing the findings of the studies (Riding & Cheema, 1991, p. 193). Riding & Cheema also pointed out that (p. 194):

The term ‘learning style’ seems to have emerged as a more common term or a replacement of term for cognitive style in the 1970’s. Indeed, those working under the umbrella of learning style would probably describe themselves as interested in more practical, educational and training applications, thus more ‘action-oriented’, while the term cognitive style has been reserved for theoretical, academic descriptions. (...) One main difference between learning styles and cognitive styles is the number of elements considered. That is, whilst cognitive style is a bipolar dimension, learning style entails many elements and is usually not ‘either-or’ extremes.

When Riding and Cheema (1991) scanned the relevant literature, they found over 30 labels suggesting various styles. They grouped them under two cognitive style dimensions:

1. The Verbal-Imager (V-I) dimension indicating the individual’s thinking in terms of mental pictures or in terms of words,
2. The Wholist-Analytic (W-A) dimension indicating the individual’s approach to processing information as a whole or as pieces of the whole. Table 1 summarises Riding and Cheema’s (1991) W-A styles family with most well-known styles. To measure the W-A and V-I dimensions, Riding developed the Cognitive Style Analysis (CSA) inventory.

Sternberg (1997) defined ‘style’ as a preferred way of thinking. He used the ‘mental self-government’ metaphor to explain an individual’s thought process, approach to problems and events, information perception, organisation and personal management. According to the mental self-government theory, just as a government has various functions (eg, legislative, executive, judicial), forms (eg, monarchic, hierarchic, oligarchic, anarchic), levels (eg, global, local), orientations (eg, external, internal), and leanings (eg, liberal, conservative), individual functioning also has those aspects. Sternberg (1997) called these aspects thinking styles. He created the Thinking Styles Inventory (TSI) to measure these dimensions.

<table>
<thead>
<tr>
<th>Researcher (year)</th>
<th>Wholist-analytic styles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holzman &amp; Klein, 1954</td>
<td>Leveller–sharpener</td>
</tr>
<tr>
<td>Witkin, 1962</td>
<td>Field-dependent–field-independent</td>
</tr>
<tr>
<td>Pask, 1972</td>
<td>Holist–serialist</td>
</tr>
<tr>
<td>Das, 1988</td>
<td>Simultaneous–successive</td>
</tr>
<tr>
<td>Hudson, 1966</td>
<td>Diverger–converger</td>
</tr>
<tr>
<td>Gardner, Holzman, Klein, Linton, &amp; Spence, 1959</td>
<td>Tolerant—intolerant</td>
</tr>
<tr>
<td>Kaufmann, 1979</td>
<td>Assimilator–explorer</td>
</tr>
<tr>
<td>Guilford, 1967</td>
<td>Divergent–convergent</td>
</tr>
</tbody>
</table>
The present study takes in hand the cognitive style as an individual difference variable to investigate the individuals’ navigation behaviour/pattern on hypermedia learning environments. On hypermedia field ‘navigation pattern’ is either linear/sequential or non-linear/global/holistic navigation pattern or behaviour. As it can be remembered the cognitive style is defined as the habitual mode of a person’s perceiving and processing information, and it has two dimensions, which are mostly labelled as analytic/sequential/serialist and holist/global/wholist. The other cognitive style labels like impulsive-reflective, converger-diverger, etc., is not suitable for the purpose and context of our study and also of the studies to be mentioned further on.

Studies on cognitive styles and hypermedia
Cognitive style differences are manifest in an individual’s relative ability to impose his/her own idea of structure on learning materials; some individuals have this ability, while others need to have more explicitly structured learning environments available to them (Riding & Cheema, 1991; Riding & Al-Sanabani, 1998). Because web-based instructional systems feature the potential for displaying different pieces of information on different pages, the need for an individual to understand the overall structure becomes increasingly important (Graff, 2003). Therefore, a user who possesses a cognitive style enabling him/her to understand the structure of the system should derive greater benefit in terms of learning (Graff, 2003).

There are many studies on the effect of cognitive styles on various activities on hypermedia such as navigation, information seeking (searching) and learning. The studies on the relationship between cognitive style and information seeking behaviour have found that sequential/analytic learners tend to follow linear paths, whereas global/holist learners tend to navigate by jumping between information units (Kim, 1998, 2001; Kim & Bryce, 2002; Palmquist & Kim, 2000). A recent study (Atasoy, Güyer & Atasoy, 2008) found no significant effect of cognitive style on navigation pattern. Also, studies on learning in hypermedia and cognitive style reached different conclusions; some found a significant effect of cognitive styles on learning (Dunser & Jirasko, 2005; Graff, 2003), but others found no effect (Calcaterra, Antoniettia & Underwood, 2005; Ford & Chen, 2000).

Regarding on how to present the information on hypermedia, the 2005 web designers have two options in displaying large amounts of information in confined spaces:

1. Information is presented on long pages so that one can see all the data on the page by using the scroll bar to go up and down the page (scrolling).
2. Information is divided into small units and each unit is presented on pages whose length fits the screen’s height so that the content can be seen by using the back and forward buttons (paging).

In some of the studies conducted before 2000, for example, in Piolat, Roussey and Thunin (1997), it was found that shorter documents that require more paging tend to be superior in both performance and preference to longer pages that require more scrolling. As indicated in Bernard, Baker and Fernandez (2002), Schwarz, Beldie and
Pastoor (1983) found that paging was preferred by inexperienced users, but there were no significant differences in task completion time or search performance. However, some others (e.g., Mills & Weldon, 1986) found no difference between the two methods in terms of user performance. Studies conducted after 2000 show that longer pages are preferred by users, especially for seeing the search results. As Bernard et al (2002) noted, a moderate degree of scrolling (50 links per page instead of 10 or 100 links per page) was preferred for search result presentations. In another study (Baker, 2003), it was found that there was no significant difference either in the participants’ ability to answer comprehension questions or in their satisfaction with the reading conditions, and that participants using the short-page condition took significantly longer to read passages than on the scrolling condition. This is somewhat surprising given that Dyson and Kipping (1998) reached the conclusion that paging is faster than scrolling. In Baker’s (2003) study, participants stated that they found the paging condition to be ‘too broken up’ and that they had to keep going back and forth to search for information.

There are studies on cognitive styles and paging/scrolling relationship on learning performance (Baker, 2003; Bernard et al, 2002; Boles, Pillay & Raj, 1999; Ford & Chen, 2001; Graff, 2003). Among them, Boles et al (1999) found that the learning performance of students studying a computer-based instruction material matching their cognitive style was not significantly higher than those studying mismatching material. These researchers called the material ‘matching to analytics’ when information was presented in three pages, and ‘matching to holists/wholists’ when whole information was squeezed into one page. On the other hand, Graff (2003) used two types of web-based instructional materials, one with short pages and the other with long pages. Analytics in the short-page condition were the most unsuccessful ones, and wholists studying in the short-page condition were the most successful. Graff called long-page design ‘matching material to analytics’, and short-page design ‘matching to wholists’. Thus, different researchers have different understandings and concepts of ‘matching and mismatching material to analytics and wholists’. Currently not many studies exist on cognitive style and information presentation on hypermedia using paging/scrolling. The present study aims at contributing to that field with a sample from a different country, Turkey. Its difference from other similar studies apart from having a sample from a different culture is that this study has been built on three cognitive style groups (analytics, wholists and mixed) whereas the previous studies investigated two style groups (analytics and wholists).

**Research questions**

1. Is there any significant difference between the learning achievements of analytic, wholist, and mixed (analytic + wholist) students navigating through hypermedia using paging or scrolling?
2. Is there any significant difference between the navigation tool usage (the indication of navigation pattern) of analytic, wholist, and mixed students navigating through hypermedia using paging or scrolling?
3. Is there any significant difference between the satisfaction of analytic, wholist, and mixed students navigating through hypermedia using paging or scrolling?

**Method**

An experimental study of $3 \times 2$ factorial design with two independent variables was developed to answer the research questions. One of the independent variables was the cognitive style (analytic, wholist, mixed), and the second was the method of seeing the information presented (via paging or scrolling). Dependent variables are the achievement, the navigation tool usage (number of clicks on every navigation tool), and the learners’ satisfaction with paging/scrolling.

Participants were 127 volunteer undergraduate students from the Faculty of Education, Yildiz Technical University, Istanbul, between the ages of 18–25. Fifty-five per cent of the students were male, 45% were female. Male and female data were pooled for the purpose of the analyses.

**Material—hypermedia learning environments**

Two different websites (hypermedia learning material) one using scrolling the other using paging were designed and implemented. Both included exactly the same content on ‘Brain-Based Learning’ and the same visual design (colours, fonts, pictures, location of buttons and menus) and the content was organised in six chapters. The hypermedia program started with presenting an information form to collect demographic data; then a page introducing the process and procedure; and then the learning material, hypermedia 1 or hypermedia 2.

Hypermedia 1 was designed as to use paging, that is, the chapters were divided into parts and each part was presented on one screen. To see a certain chapter forward and back buttons were used. There were around 30 pages to present the six chapters.

Hypermedia 2 was designed as to use scrolling. Each chapter was presented on a long page so that the scroll bar was used to see the rest of the chapter. This design included six long pages to present the six chapters.

The content included not only text but also some pictures to help the learners to visualise and comprehend some of the concepts and the brain structures. So when it is said ‘one page’ it is not something like a Word page, which is full of text.

Navigation tools included were home page, map, forward and backward buttons, table of contents, index, search facility and the hyperlinks contained by the learning content. Hyperlinks were to the other pages of the learning material, to the dictionary items, to additional texts, etc. Additional tools also facilitated the learning, for example, a brief explanation on the subject, objectives of the chapters, summary, dictionary, additional texts.
The hypermedia program presented a multiple choice test of 39 items to measure the achievement after the learner completed studying the content. Lastly, the program offered a small questionnaire to collect the learner’s satisfaction with the hypermedia just navigated to learn the content.

Learners spent approximately 1.5–2 hours to fill in the information form in the beginning, study the content navigating on the hypermedia using the navigation tools they preferred (among all the existing navigation tools), answered the test questions and the questionnaire, and then exit from the program.

The content’s accuracy and the suitability for students’ level were evaluated by five subject-matter experts and a curriculum expert. To evaluate the visual design of the hypermedia, the design using paging has been sent to six instructors working in the Computer and Instructional Technology (IT) departments of various universities; and the design using scrolling has been sent to five different instructors and one instructor technologist. After collecting their evaluations and corrections, hypermedia designs were finalised.

Data collection tools

1. The Turkish version of the local and global subscales of Sternberg’s TSIs was used to distinguish the learners’ cognitive styles. The reason of this choice is (1) the characteristics of the global and local styles in Sternberg’s self-government theory correspond to the characteristics of the cognitive styles, so-called holist/wholist/global and analytical/serialist/sequential in the literature respectively; (2) the reliability of some other cognitive style inventories examined was found to be low; and (3) the Cronbach alpha reliability of the Turkish TSI’s global and local dimensions was found to be 0.76 and 0.79 respectively.

TSI—which has 13 subscales to measure thinking styles in five dimensions—is based on self-assessment; subjects read each statement carefully and scored themselves 7 if the statement fitted them extremely well, 1 if it did not fit at all. The Turkish adaptation of the TSI was created by Fer (2005).

2. Pretest, posttest: both were the same test consisting of 39 multiple-choice questions in knowledge, comprehension and application levels of Bloom’s taxonomy in cognitive domain.

3. Exit questionnaire: this was designed by the researchers to measure the satisfaction with paging or scrolling. It should be noted that the learners did not know of the other design; she/he saw and worked on just one design. The Cronbach alpha of this test was 0.82

4. The computer program was designed and implemented to count and record the use frequency of the navigational tools clicked on by the learners.

Procedure

Two weeks after the students had completed the TSI global–local subscales and the pretest on paper, half of the participants from each of the cognitive styles—analytic,
wholist and mixed—were randomly assigned to one of the two computer labs, one reserved for hypermedia with paging, the other for hypermedia with scrolling, thus forming six ($3 \times 2$) groups.

Data analysis
The distribution of posttest grades was normal, whereas the distribution of other data was not, so both parametric and non-parametric statistical techniques were used for analysis.

The size, pretest and posttest statistics of those six groups can be seen in Table 2. As presented in Table 2, 42 students (33%) were analytic, 55 students (43%) were wholist, 30 students (24%) were mixed; and posttest means were approximately two times the pretest means. Dependent group $t$-tests have also been performed on the six groups’ pretest and posttest means to check the mean differences. The results have shown that the posttest and pretest means were significantly different for all groups in the 0.05 level (For all groups $p = 0.00$).

Results
Cognitive style and paging/scrolling effect were investigated both separately and together for all of the research questions.

Research question 1
‘Is there any significant difference between the learning achievements of analytic, wholist and mixed students using paging or scrolling?’

To investigate the effect of cognitive style alone, a one-way variance analysis was performed. Table 3 shows that cognitive style alone did not make any significant difference in learners achievement, that is, there was no statistically significant difference in all three groups’ learnings ($p = 0.08 < 0.05$).

An independent group $t$-test performed to investigate the effect of paging/scrolling is shown in Table 4.
Table 4 findings indicate that there is no significant difference in post-test grades of the two groups, paging and scrolling (0.33/2 > 0.05). In other words, paging/scrolling alone did not create any statistically significant difference on achievement.

The effect of cognitive style and paging/scrolling together was analysed using two-way variance analysis (Table 5).

As seen from the Table 5, cognitive style and paging/scrolling together did not cause any significant difference in learning achievement of the six groups.

Research question 2
‘Is there any significant difference between the navigation patterns (navigation tool usage) of analytic, wholist and mixed students using paging or scrolling?’

The effect of cognitive style alone on the usage of navigation tools home page, map, table of contents, search, index and hyperlinks was analysed using a Kruskal-Wallis test. No significant difference was found (for all tools, significance >0.05) in the use frequencies of the navigation tools for analytic, wholist and mixed groups. It should be noted that forward and back buttons were not included in this analysis because in paging
condition these buttons were naturally used more, as there were more pages and those needed to be seen using forward and back buttons.

**Research question 3**

‘Is there any significant difference between the satisfaction of analytic, wholist, and mixed students using paging or scrolling?’

A Kruskall-Wallis test was carried out to find out the effect of cognitive style alone on satisfaction from the hypermedia environment (full details are available upon request). The results indicate that cognitive style did not create any significant difference in from the environment (Sig. = 0.80 > 0.05) meaning that all learners are satisfied with the environment, in other words that they can read and learn using paging or scrolling.

A Mann-Whitney-U test was performed to analyse if there is a statistically significant difference on satisfaction of the groups using paging and scrolling. The findings have shown paging or scrolling made no significant difference on satisfaction (significance = 0.22/2 > 0.05).

A Kruskall-Wallis test result was carried out to analyse this and it was found that cognitive style and paging/scrolling, together, did not create any significant difference on satisfaction from paging/scrolling (significance = 0.08 > 0.05) (Table 6).

<table>
<thead>
<tr>
<th>Cogn. style</th>
<th>Paging/scrolling</th>
<th>n</th>
<th>Mean rank</th>
<th>X²</th>
<th>df</th>
<th>Asymp. sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paging</td>
<td>20</td>
<td>78.38</td>
<td>9.82</td>
<td>5</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Scrolling</td>
<td>22</td>
<td>63.93</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytic</td>
<td>PAGING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scrolling</td>
<td>29</td>
<td>64.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PAGING</td>
<td>26</td>
<td>59.69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scrolling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wholist</td>
<td>PAGING</td>
<td>15</td>
<td>69.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scrolling</td>
<td>15</td>
<td>45.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>PAGING</td>
<td>127</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scrolling</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Discussion**

In learning from hypermedia the statistical analyses of the present study showed that,

1. Cognitive style and paging/scrolling, separately or together, did not create any significant difference on the learning achievements of the students.
2. Cognitive style and paging/scrolling, separately or together, did not create any significant difference in the navigational tools usage, which is an indication of their navigation pattern, except that the only significant difference was found in forward and back button usage of the mixed students who used paging; they used forward and back buttons more than the analytics and the wholists did in paging. Also, the mixed group in paging condition used hyperlinks more than the other five groups.

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3. Cognitive style and paging/scrolling, separately and together, did not affect the satisfaction of the students about the hypermedia they navigated and studied.

Obtaining no significant differences in learning and satisfaction is an important finding because this shows that students with any cognitive style can learn equally in such an environment, and be satisfied with both using scrolling or paging. Following is a more detailed discussion of the findings on research question basis.

Discussion of the results for the research question 1: cognitive style and paging/scrolling effect on achievement

In the present study, the result of obtaining no significant difference in the learning of different cognitive style groups supports Ford and Chen (2000). The authors performed a study with 65 graduate students using the CSA of Riding to distinguish between field dependents (FD) and field independents (FI) who reached the conclusion that cognitive style did not affect learning outcomes. Similarly, Calcaterra et al (2005) found out that learning outcomes were not affected by the cognitive style in their study using a relatively sample of 40 students and dividing them into four groups; low and high computer experience and holistic and sequential styles. However, unlike these and unlike the present study, Dunser and Jirasko (2005), who used ILS (Index of Learning Styles) to distinguish the styles, concluded that cognitive styles created difference in learning; in their study on 84 subjects, they found out that sequential learners showed lower performance than globals in hypermedia learning.

Also, cognitive styles and paging/scrolling together did not create any statistically significant difference in achievement. Remembering that the present study was on a sample of 127 students using two hypermedia learning environments, one with 30 short pages, the other with six long pages, the findings obtained were not in agreement with Graff (2003), who concluded that wholists were better with short pages, analytics were better with long pages. That study has been realised on a sample size of 50; subjects were separated as wholists and analytics on short- (23 pages) and long-paged (11 pages) web-based instructional material featuring information on the subject of psychological ethics. Graff called long-page design ‘matching material to analytics’, and short-page design ‘matching to wholists’. The number of studies investigating short and long-page hypermedia and cognitive style are few and on small samples; obviously more research is necessary. Additionally, a consensus on the concept of ‘matching/mismatching to analytics and wholists’ needs to be established among hypermedia-cognitive style researchers.

The researchers of the present study hope that the finding that ‘there is no significant difference in the achievements of students navigating and studying hypermedia learning materials using paging or scrolling’ will make an important contribution to the work of online learning material designers. The traditional approach, especially in relation to the computer-based materials, tend to have a linear or sequential design where all learners are forced into a single mode of pedagogy (Robberecht, 2007). In that mode of pedagogy, the learning content is broken up into small pieces so that every
piece fits on the monitor’s screen and the learner can go forward by pressing the next button and can see the whole content page by page. In such a design, it would not be possible to go forward rapidly and see/scan the whole content at the beginning of the study. The findings of the present study show no difference in learning from long and short pages (i.e., using paging or scrolling), so the decision of using paging or scrolling in the learning environment design may be left to the instructor or programmer, depending on the subject domain, objectives, preferences, etc. Because long-page designs are easier to develop, an instructor might expect his/her students to read and understand the course notes (not being broken up into pieces) he/she put on the Web (or blog).

Discussion of the results for the research question 2: cognitive style and paging/scrolling effect on navigation pattern (navigation tool usage)

Analysis showed that cognitive style and paging/scrolling separately or together did not create any significant difference in navigation tools usage, i.e., the navigation patterns (sequential/linear or non-linear). In the literature, it has been accepted that navigating on hypermedia using forward and back buttons points to a more linear/sequential navigation pattern, whereas using site maps, home page buttons, indexes, etc, points to a freer and more holistic navigation pattern without an adherence to the linear way. For example, Ford, Wilson, Foster, Ellis and Spink (2002)—using CSA—found that FDs navigated sequentially or linearly, whereas FIs navigated more freely using home pages, maps, and so on. Dunser and Jirasko (2005) found—using ILS—that sequential learners used forward and back more than global learners did. Ford and Chen (2000) concluded that FIs made less use of maps and indexes than FDs, so FIs navigated more linearly than FDs. Contrary to these results, Palmquist and Kim (2000)—using GEFT—found that FDs navigated more linearly and sequentially than FIs; FIs navigated more freely than FDs. Lee and Harvey (1999) investigated navigation patterns of hypermedia users and their brain dominance. They found left-dominant subjects navigated linearly and used more analytical methods than right-dominant subjects. Right-dominant subjects interacted with the hypermedia in relatively non-linear and holistic pattern. The functions of the left and right hemispheres of the brain (Jensen, 2000; Ornstein, 1997) seem in parallel or same with the characteristics of FI/FD, analytic/wholist or serialist/holist cognitive styles. Older studies showed FI/FD is associated with lateralisation in hemispheric functioning, with right-handed individuals being more field independent than left-handed individuals (Bloom & Feshbach, 1980; O’Connor & Shaw, 1978, Pizzamiglio, 1974; cited in Green, 1985). Also, Bunderson (1988), who investigated the validity of the HDBI (Herrmann’s Brain Dominance Instrument), said FI/FD were similar to left–right brain dominance.

The existence of different style categories and inventories (such as ILS, CSA, GEFT) used in the mentioned studies, the lack of empirical studies showing one-to-one, exact correspondence of those styles cause difficulties in understanding and comparing the results founded in the related studies.

In the current study, the only statistically significant difference was that in paging condition the mixed group used forward and back buttons more than did either
analytics or wholists. If it had been found that the mixed group used fewer home pages, maps, indexes, search facilities, etc, it might have been concluded that they navigated more sequentially than the others. But as discussed earlier, there was no such finding: in other words, tools such as home page, map, index and search were used without any statistically significant difference by the groups. Therefore, mixed learners’ increased usage of forward and back buttons in paging condition might be interpreted as they have been having difficulty in integrating the content broken up into pieces in short pages. To overcome this, they might have been moving forward and back over the material many times. It needs to be noted here that in paging condition, the mixed group’s achievement is—though statistically insignificant—lower than the wholists’ and the analytics’ achievements. It seems that paging (short-paged environment) caused some difficulty for the mixed learners. It might be useful here to remember that in the present study all students have experience in using hypermedia/the Web, but have no domain knowledge. In a study carried out by Song (2003) on navigation behaviour and domain knowledge, it has been found that people having the prerequisite knowledge in the subject domain moved linearly, whereas people having no prerequisite knowledge went back and forth repeatedly.

The other significant difference was that mixed learners using paging used hyperlinks more than all other groups. Using hyperlinks might be pointing to more motivated learning and/or curiosity; more research is required in this area.

Discussion of the results for the research question 3: cognitive style and paging/scrolling effect together on satisfaction
The analysis showed that nobody felt unsatisfied with either paging or scrolling. Cognitive styles or paging/scrolling together or separately did not create any statistically significant difference on satisfaction. As paging/scrolling did not create any difference in learning, it did not create any statistically significant difference on hypermedia satisfaction. Similar results have been found in for example Nielsen (1997), Baker (2003) and Bernard et al (2002), who point out that hypermedia users have become accustomed to long pages in recent years and they have no negative feeling towards long pages as they did in the first years of the Web/Internet. However, in Dyson and Kipping (1998) the subjects said at the end of the study that the text was too broken up in the short-page hypermedia.

Conclusion
Finding no statistically significant difference in learning achievements and on satisfaction of any cognitive style groups on hypermedia learning environments using paging or scrolling is important because as it could be seen from most of the online learning materials that they have been designed with short pages (using paging). This approach seems to assume that learners prefer paging (short pages) because they can learn in small units, and experience difficulty in long pages. The present study did not reach such conclusions; that is, there was no finding showing that scrolling on long pages caused any negativity either in learning or on satisfaction of learners of any cognitive
style. Long-paged learning/instructional hypermedia using scrolling can be designed, or, at least no restriction on the paging or scrolling can be used.

References


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