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Efficacy of a map on search, orientation and access behaviour in a hypermedia system

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Abstract

Many researchers have proposed hypertext and hypermedia as superior learning environments over traditional linear-based approaches. At the same time, reports of disorientation amongst students working in these environments has become a topic of major concern. The study reported in this paper sets out to investigate the efficacy of the provision of maps on students' ability to search, orientation and access information in a hypertext-based learning task. The domain used required students to learn about the theory of tectonic plates. The results indicate that the greater use of maps led to less relevant searching behaviour and less effective search effort. In conclusion, it is argued that the concept of the spatial metaphor has not served the designers and students of hypertext and hypermedia environments well. Further, it is proposed that designers of non-linear learning environments would be better served by concentrating on the fundamental usability of their systems rather than attempting to introduce navigational aids, which themselves are a symptom of poor design. © 2000 Elsevier Science Ltd. All rights reserved.

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1. Introduction

It has been proposed that hypermedia and hypertext systems may have much to offer the information age. The idea that access to information will determine the success, or failure, of an organisation is not new. Indeed, the initial ideas behind hypermedia can be traced back to a much quoted article printed in *The Atlantic Monthly* in July 1945 by Vannevar Bush entitled As We May Think. Bush argued that the access to, and communication of knowledge had made a significant contribution to the outcome of the Second World War. He argued further that

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traditional methods of transmitting the information (e.g. scholarly journals and books) were inadequate for the task. This observation was based upon Bush's task of orchestrating some six thousand American scientists in the application of science to warfare. He found problems associated with information management that could not be resolved by the available systems. This led to his rather radical (in its time) proposal for the MEMEX system:

> A [...] device in which an individual stores his books, records, and communications, and which is mechanised so that it may be consulted with exceeding speed and flexibility (Bush, 1945, pp. 106–107).

Bush was able to foresee this device as a tool for augmenting human activity. It took the next 40 years, however, for this to become an electronic reality. In the 1970s Nelson, took this one step nearer by laying down a way of implementing Bush's ideas in an electronic medium. Nelson (1974) argued that each user in a hypertext network could also become an author, by structuring and changing the material in his or her own individual way. This was a futuristic vision of hypertext. As Nelson stated:

> the structure of ideas is never sequential... In an important sense there are no subjects at all; there is only all knowledge, since the cross-connections among the myriad topics of this world simply cannot be divided up neatly (Nelson, 1981, pp. 1/14).

Hammond and Allinson (1988) suggested that hypertext would lead to the more efficient production of electronic material and could empower users to take full control over what they chose to view. In a study that was concerned with the exploration of performance differences in structured and unstructured electronic environments, the structured condition had a presequenced training and practice modules whereas the unstructured condition, allowed trainees to determine their own sequence of modules. Stanton and Stammers (1990) report improved performance in an unstructured environment (hypertext) compared to a structured environment (linear).

2. Getting lost in hyperspace

Hypermedia environments offer quick access to a large amount of information under multiple formats (text, image and sound) associated to a unique freedom of getting a special piece of information. Nevertheless, this main characteristic of hypermedia systems encompasses a powerful potential that is responsible for a phenomenon often described in the literature as *getting lost in hyperspace*.

There are numerous accounts of users becoming lost in hypertext systems (Conklin, 1987; Kim & Hirtle, 1995). The writers and researchers tend to assume that this is due to the complexity of the "electronic space" in which users are operating. Consequently, the solution is seen in terms of adequate aids for navigating through this space. The concept of navigation is a meaningful one in a hypertext system in the sense that we can view users' actions as a movement through electronic space (McKnight, Dillon & Richardson, 1989).

The disorientation problem in hypermedia environments has two facets that we should consider: (a) the first is rooted in the intrinsic nature of hypertext, constituting mainly a browsing problem that occurs as a result of the environment's complexity; (b) the second results from the cognitive demands that hypermedia systems impose on their users and is called cognitive overhead (Conklin, 1987; Kim & Hirtle, 1995).

Conklin defines *cognitive overhead* as "the additional effort and concentration necessary to maintain several tasks or trails at one time" (Conklin, p. 40) and points out that this phenomenon is one of the main disadvantages of hypertext.

The phenomenon of "getting lost" in hypertext, according to Hammond and Allinson (1989) could be the result of users being unable to find the required information, becoming "disoriented" within the available options (Nielsen, 1989), losing their way in their journey through "space", or being unable to formulate appropriate actions for the screen they are viewing. It is possible that subjects became lost to the extent that they did not know where they were or how to return to where they had come from. In a study reported by Nielsen it was apparent that subjects had great deal of difficulty in remembering which buttons should be selected for backtracking despite the use of a package called *Guide*.

Edwards and Hardman (1989) identify three distinct situations when the users feel lost: (a) not knowing where to go next; (b) knowing where to go but not knowing how to get there, and (c) not knowing the current position relative to the overall hypermedia structure. Foss (1989) describes two undesirable consequences of browsing observed in users of hypermedia systems: (a) problems of digression (e.g. becoming distracted by other information); (b) problems of attention (e.g. loosing the thread of investigation).

In many instances it is difficult to know whether reports of getting lost (which are generally anecdotal rather than substantiated), result from hypertext itself or poor implementation. If the phenomenon of getting lost results primarily from the nature of hypertext, then there seems little point in continuing its development. Why should people use a system which results more often than not in them becoming lost, confused and frustrated than in finding the information they seek? This could lead to users rejecting hypertext. We believe, however, that hypertext does have much to recommend it, and would be loathe to accept this argument.

It might be expected that getting lost is an artefact of poor design (De Young, 1990; Stanton & Baber, 1994). While hypertext can provide a wealth of information to be interlinked, the practice of arbitrary linking which appears prevalent today must lead to disorganised and unstructured collections of information. This results in the antithesis of Nelson's conception of a "docuverse".

3. The spatial metaphor

The use of spatial metaphors and the design of maps is a common solution to disorientation problems. Using a map as a browsing tool is based on the assumption that the information network is somehow similar to a geographical environment. This has led to the use of the concept of "electronic space", which can be represented in the form of a map, and through which users navigate. This situation leads to the fact that, generally, most of the hypermedia environments are conceived as spatial ones, based on the spatial metaphor, that may be explored by the same rules used in the physical ones. "Space" as used in this context, however, has a well-defined meaning, as the collection of objects and activities contained within a specific domain, e.g. a similar fashion to its use in finite state architecture. However, much current research in hypertext appears to use the term "space" in its everyday sense, i.e. as a physical relationship between objects.

The analogy between navigation in physical environments and information environments was proposed by Canter, Rivers and Storrs (1985) who emphasise the analogy of the psychological processes involved in both domains. They recognised that it is fruitful to establish a direct parallel "between navigating concrete environments, such as cities or buildings, and navigating data. After all, such parallels are implicit in the navigation metaphor, so it is worth establishing whether or not there is a fruitful analogy between the psychological processes involved" (Canter et al., p. 93). Thus, users should develop a spatial cognitive representation of the information environment.

The use of a well-known metaphor — the travel holiday metaphor — proposed by Hammond and Allinson (1989) seemed to help the users to understand the navigation facilities, such as guided tours, maps and indexes. In the same way, the use of the tourist metaphor (embodied by a map) tries to provide some of the same orientation assistance to hypermedia users as the one given to the tourists. That is why a navigation map, which gives the user an overview of the hypermedia prototype's content organisation, could be appropriate in a learning context because the map can help them to re-establish the context.

Trumbull, Gay and Mazur (1992) described a study that used the house metaphor to provide a context in which thematic and spatial associations could occur while the user navigates through a specific hypermedia environment (the Bughouse). They concluded that the use of an organising metaphor seems to be an effective design strategy for aiding navigation and information finding in a hypermedia program. They also state that "the spatial metaphor seemed to work on two levels: finding one's way to content and finding one's way in the process of exploring the new 'territory' of a hypermedia program" (Trumbull et al., p. 326).

4. The use of maps as help tools

Based upon the spatial metaphor, the provision of a map has been suggested to be beneficial to hypertext users. There have been a number of studies investigating the use of maps, but very little substantive evidence can be drawn from them. The use of a map in a hierarchical system to seek information could facilitate this task more effectively than an index or no assistance at all (Billingsley, 1982). Another study performed by Hitch, Sutcliffe, Bowers and Eccles (1986) investigated the use of menu and map interfaces to retrieve information from a hierarchically organised geographical database. Findings suggested that maps are supportive for naive users and permit the use of more efficient, rapid modes of operation for experts.

Hammond and Allinson (1988) compared the use of maps with no maps, on performance of a database enquiry task. They found that, although the performance appeared superior for subjects using the map, there was no statistically significant difference between groups. Beard and Walker (1990) have shown that providing a map window produces superior performance than not providing a window. However, their subjects were asked to search for words contained in hierarchical tree diagrams. In other words, the study showed that, performance on a spatial task was better if subjects were provided with spatial information than if they were not. Therefore, we do not feel that this study can be taken as evidence to support the use of maps for any type of searching tasks.

A study in which the effects of hypermaps and hotwords on recall, reference time, accuracy and satisfaction were investigated among students learning statistical material led to the following conclusions: (a) disorientation seemed to be a problem in both the hypermaps and the hotwords; (b) in terms of students' satisfaction, hypermaps appear to be superior to hotwords (the reduction in confusion and frustration may be due, in part, to the structure of the maps making links between frames more related to the structure of the knowledge domain); (c) although not significant, there was a trend toward greater efficiency of maps than hotwords (Reynolds & Dansereau, 1990).

In contrast, Stanton, Taylor and Tweedie (1992) have shown that, on an information search and retrieval task, maps actually impaired performance. The provision of maps led not only to poor performance, but also to less perceived control and inferior development of "cognitive maps" when compared to a group without maps. This suggests that maps may hamper efficient use of a hypertext system.

A pilot study, performed by Schroeder (1994), which examined the effects of two different navigation tools on the achievement of structural knowledge compared the use of graphical browsers (with an explicit structure) with the use of hotwords embedded in the instructional text (without an explicit structure). This author found that graphical browsers might provide a degree of structure for the user, but it was not evident from the results that all learners internalised this structural knowledge (those with high prior knowledge had a better performance); the use of hotwords rather than a graphical browser resulted in lower achievement, especially on those with lower prior knowledge. Schroeder states "maps or graphical browsers of structural knowledge allow the user of a hypertext system to navigate from node to node through the structure as they portray the links between concepts spatially" (Schroeder, p. 788).

Recker (1994), provided students with two navigation methods for moving between screens of instruction. The first, a global navigation tool, provided learners with a map of top-level topics, each listed on a button; the second, a local navigation tool, was implemented by providing two buttons on each instructional screen, which learners could click on to move to the next and previous top-level instructional topic, respectively. Results obtained from this study suggested that the existence of a distinct global navigation tool was an important and reliable facility in the hypertext system. Furthermore, the ability to use this facility appeared to be a separate, identifiable cognitive skill. These aspects taken together should imply the importance of providing high-level navigational aids within hypermedia. In addition, Beasley and Waugh (1995) assessed the relative effects of hotwords and two distinct cognitive mapping architectures (spider maps and hierarchical maps) on users' disorientation in a hierarchically organised hypermedia environment. They showed that the presence of a properly constructed cognitive map could diminish disorientation in the user. In this investigation, learners in the "hierarchical maps" treatment reported feeling significantly less disorientated than learners in the "hotwords" treatment. However, no statistically significant differences in perceived disorientation were found between learners in the "hotwords" treatment and learners in the "spider maps" treatment.

5. The use of a navigation map

An empirical study, which purpose was to look at the efficacy of a navigational map to help students to explore a hypermedia environment, was undertaken (Sousa, 1996). Although the results of previous studies were not convergent, we would expect that the presence of a navigation map should be an appropriate tool to improve navigation during the searching process.

5.1. Research design

Given the exploratory nature of this study, we chose a correlational/causal-comparative approach. First, correlational methods were used to clarify the use of a navigational map (frequency of visit and time spent looking at) through the identification of relationships among variables — task-test scores and a set of ratios defined to measure specific parameters, such as: search, orientation, access and time. Our correlational hypothesis is that the use of the map was related to the remaining variables.

Although the discovery of correlational relationships does not establish a cause–effect connection we would like to try to gain an idea about causality relationships. Therefore, we used a causal-comparative method to enlighten some possible causes and effects between the use of the navigational map and students' orientation, access to the required information, and task-test scores.

5.2. Participants

A total of 22 high school students attending a rural secondary school in Portugal participated in this study. They were attending a 12th grade geology class; the 15 females and 7 males were between the ages of 17 and 21. This was a convenient sample.

5.3. Hypermedia prototype

We developed a hypermedia prototype to explore the efficacy of the navigation map in accessing specific information. This prototype, named "Planet Earth: A Living Machine" ("O Planeta Terra: Uma Máquina Viva"), was about the theory of tectonic plates (a global theory of geology). It consisted of 42 screen-pages related by multiple links. Information (text and images) was presented in each screen-page. The students had access to several tools from any screen-page by clicking on icons, notecards to individual comments, animations and hot words. On each screen-page navigation tools were available. These tools allowed students to go from one area to another by using on-screen commands (e.g. forward, backward and back), by clicking on the thematic topics (I, II, III, IV, V and VI), the "Main Menu, or the "Map" (represented as a compass), as shown in Fig. 1.

The focus of this study was on a specific tool: the navigation map. The map provided a global overview of the content, as shown in Fig. 2. It was a content list that allowed the students to: (1) get a summary of the topics presented in the prototype; (2) access to any screen-page they wanted; and (3) follow their trail throughout the content, giving information about the screen-pages already visited and the ones remaining (using a colour code). We did not represent the multiple links among screen-pages because it would be space-intensive and consuming.

5.4. Instrumentation

This study included a task-test as an instrument to gather data from the instructional session with the hypermedia prototype. Previously we undertook a study-pilot to test the instrument validity in 5 subjects. Experts also reviewed the task-test. Both activities conducted to some revision and defined the final format of the instrument. In the task-test the students were required

Fig. 1. Example of a screen-page of the "Planet Earth: A Living Machine" hypermedia prototype. This is a sample of the thematic topic of Wegener's theory. The access to the thematic topics is located on the left edge of each screen and the navigational tools (including "Main Menu" and "Map") are located at the bottom of the each screen.

to answer 12 task-questions during the work session. The aim was to get students to search for requested information and record it. Each task presented would require students to find the right pathway through the hypermedia network to retrieve the information.

A log file of each student's interaction was also used as a data gathering instrument. The hypermedia prototype included a specific function that allowed the recording of students' interactions within the prototype, as shown in Fig. 3. The data collected were:

- student's code, sex, age and frequency of computer use of each student;
- name of the visited screen-page;
- name of the objects clicked in each screen-page;
- time spent in each screen-page;
- frequency of visit to each screen-page.

The use of log files as data collection instruments are often used in researches about navigational issues (Canter et al., 1985; Schroeder, 1994; Trumbull et al., 1992).

5.5. Procedure

This study included a drill and practice session where some basic information about how to use a keyboard, and a mouse, as well as, information about navigational issues (for example, how to

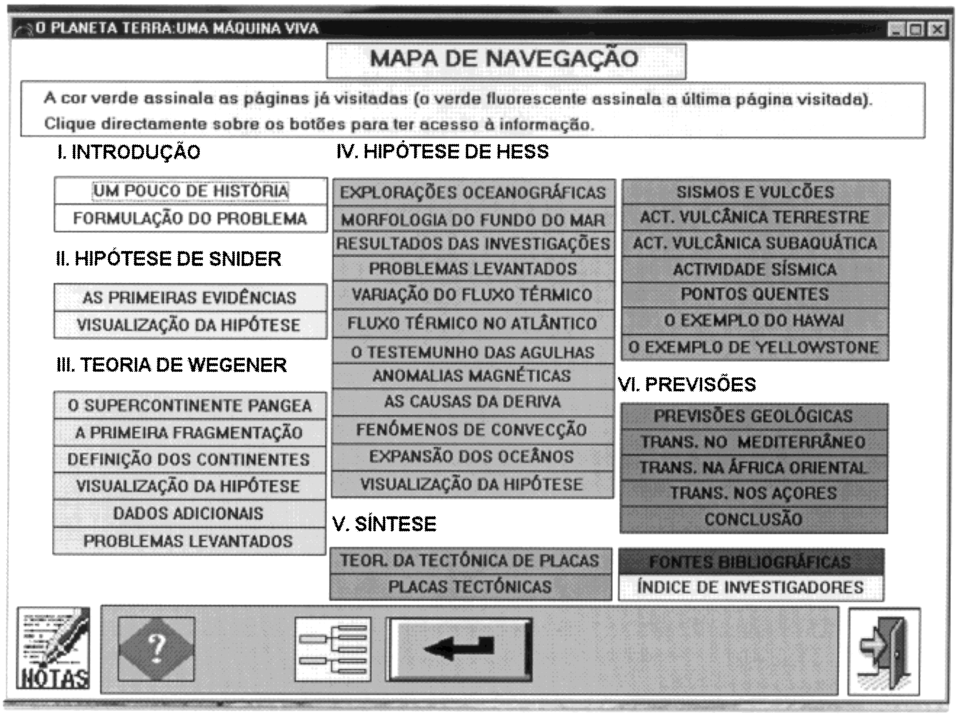

Fig. 2. The navigation map included in the hypermedia prototype. This map provides a global overview of the content. Under each thematic topic there is a list of sub-topics that can be easily accessed by clicking on the respective title.

quit the program, how to go forward and backward) was given. The purpose of this session was to get participants familiar with a computer and a hypermedia environment. However, the use of the hypermedia prototype described above, was the main session. We started this session by giving a brief explanation of the purpose of the study, some instructions concerning the main aspects of the prototype interface, and explaining about the task-test. After that we invited the students to work through the hypermedia prototype at individual computers. They had a maximum of 50 min (time of regular class) for exploring the hypermedia prototype and fill out the task-test.

5.6. Data analysis

The data analysis was based on the use of a navigational map (frequency of visit and time spent looking at) and on the score obtained in the task-test (students could obtain a score in the task-test ranging from 0 to 100), frequency of visit and time spent in each screen-page visited. The remaining data were gathered using the log file that recorded a list of information nodes selected by the student. These included screen-pages, objects, hotwords and buttons. After that each student's traversal path listed in the log file was compared to an ideal path, predefined by the authors. This predefined path referred only to the information nodes (screen-pages, objects, hotwords and buttons) relevant to perform the tasks presented in the task-test. To deal with this data we used a set of ratios as a measurement of the student's interaction through the information

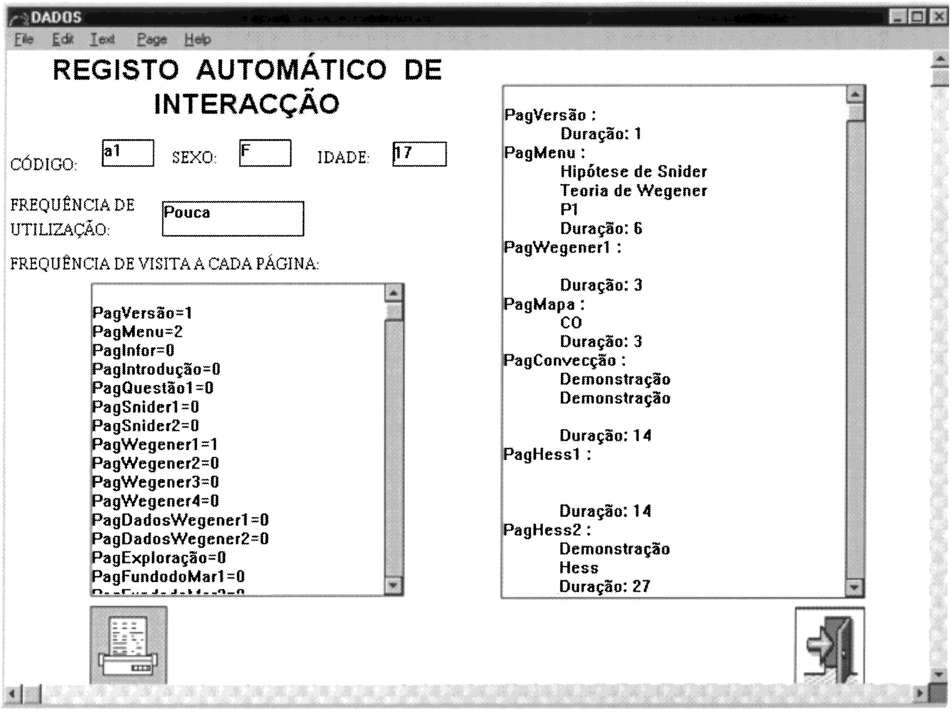

Fig. 3. The screen-page of the log file used as a data gathering instrument.

network. The ratios used in this study were developed in previous studies (Dias & Sousa, 1997; Sousa & Dias, 1996). They were adapted from previous research in the field (Gillingham, 1993; Stanton et al., 1992).

The ratios were specified by the following parameters: search, orientation, access and time. They measured aspects concerning the access to information, the orientation within the prototype, the search of information, and the time spent in the information nodes, as shown in Table 1.

5.7. Results

Data obtained from the task-test outcomes showed a mean score of 57.7 (out of 100). Analysing individual performance in the task-test, we verified that the majority of the students had a score greater than or equal to 50.

Search ratio, orientation ratio, access ratio and time ratio data were computed for each subject and the results are shown in Table 2.

The data showed that students were sub-efficient in gathering the required data and seemed disorientated. On the other hand they accessed a large amount of relevant information and spent some time viewing it.

To understand the use of the navigation map we employed two parameters: number of visits and time spent looking at the map. The results are shown in Table 3. It is important to report that a total of 7 students (32% of the sample) never visited the navigation map.

Table 1
Summary of the ratios used on data analysis

Ratios	Description	Meaning	Interval
Search	$\frac{\text{Number of information nodes of the predefined path visited}}{\text{Total number of information nodes of the predefined path}}$	Measures the amount of relevant information accessed by the students It is equal to 1 if all relevant nodes are visited and equal to 0 if none of them have been visited	[0, 1]
Orientation	$\frac{\text{Number of information nodes of the predefined path visited}}{\text{Total number of nodes visited by the student}}$	Measures the degree of disorientation because it determines the precision of information retrieval It is equal to 1 if the student is correctly oriented and only visited relevant information node and equal to 0 if none of them have been visited and the user is utterly bewildered	[0, 1]
Access	$\frac{\text{Number of information nodes of the predefined path}}{\text{Number of information nodes of the predefined path} + \text{number of nodes visited unnecessarily}}$	Measure of efficient information access It is equal to 1 if the student is efficient and equal to 0 if he/she is completely inefficient	[0, 1]
Time	$\frac{\text{Time spent in information nodes from the predefined path}}{\text{Total time spent in information nodes of the prototype}}$	Measures the efficiency of information access and distinguishes the students who have spent time in important screen-pages from those who have spent time in important and unimportant screen-pages This ratio is 1 if time is spent only on important screen-pages and 0 if time is spent only on unimportant screen-pages	[0, 1]

Table 2
Ratio results

Ratio	Minimum	Maximum	Mean	Standard deviation
Search	0.55	0.95	0.79	0.12
Orientation	0.05	0.36	0.13	0.07
Access	0.05	0.47	0.16	0.09
Time	0.46	0.77	0.59	0.77

We used a non-parametric statistical procedure as a result of the small size of the sample ($N=22$) — the Spearman correlation coefficient and the Kruskal–Wallis one-way analysis of variance by ranks.

Correlation analyses between data variables were completed using the Spearman correlation coefficient between data variables (number of visits and time spent looking at the map, orientation, access, search and time ratios, and task-test scores). The results are shown in Table 4. Only the correlation coefficients (*rho*) higher than 0.30 are reported. We used a 0.05 level of significance, which is customary, used in educational research.

Table 3
Results of navigation map use

	Minimum	Maximum	Mean	Standard deviation
Number of visits	0	29	7.8	8.2
Time spent (s)	0	566	160	165.8

Table 4
Spearman correlation coefficients (*rho*) between variables and its description[a]

Variables	*rho*	Description
Frequency of visit to the map versus search ratio	−0.33	Low negative correlation
Frequency of visit to the map versus orientation ratio	0.57	Reasonable positive correlation
Frequency of visit to the map versus access ratio	0.65	Reasonable positive correlation
4. Frequency of visit to the map versus time spent in the map	0.94	High positive correlation
5. Time spent in the map versus search ratio	−0.31	Low negative correlation
6. Time spent in the map versus orientation ratio	0.62	Reasonable positive correlation
7. Time spent in the map versus access ratio	0.68	Reasonable positive correlation
8. Access ratio versus orientation ratio	0.92	High positive correlation
9. Time ratio versus task-test	0.58	Reasonable positive correlation

[a] Level of significance = 0.05.

Correlation analysis between variables showed:

(a) a high correlation coefficient between frequency of visit and time spent looking at the map (0.94). This showed that those were adequate parameters to measure the use of the navigation map as they are highly correlated;
(b) a negative correlation coefficient between frequency/time of visit to the map and search ratio (−0.33 and −0.31, respectively) that shows an inverse effort, that is, more visits to the map, less relevant search; more time spent on it, less search effort. We stressed that search ratio measures the amount of information accessed by the user that is relevant to the task so that it seems that the map did not help too much;
(c) in spite of a reasonable positive correlation between frequency/time of visit to the map and orientation ratio (0.57 and 0.62, respectively) as between frequency/time of visit to the map and access ratio (0.65 and 0.68, respectively) seem to suggest that there was a tendency that the subjects who accessed the map more often were better scored. However orientation and access are the ratios that have the lowest values (0.13 and 0.16, respectively) as can be checked from Table 2;
(d) a high correlation coefficient between access ratio and orientation ratio (0.92) suggested that a more efficient access to information led to a higher degree of orientation.

From the analyses of the frequency of visits to the map tool in the hypermedia prototype we identified three modes of use among the subjects. The first group visited the map rarely (less than or equal to 5 times) during the session; the second group visited the map frequently (between 6 and 10 times) during the session; and the third group visited the map a lot (greater than or equal to 11 times), as shown in Table 5.

Table 5
Frequency of visit to the navigational map

Number of students	Number of visits to the map
10 (45%)	$\leqslant$ 5
5 (23%)	6–10
7 (32%)	$\geqslant$ 11

Table 6
Time of visit to the navigational map

Number of students	Time spent looking at the map (s)
9 (41%)	$\leqslant$ 100
7 (32%)	101–250
6 (27%)	$\geqslant$ 251

Time spent by the subjects on the map tool led us to identify also three groups of performance during the session. The first group spent a short time looking at the map (less than or equal to 100 s); the second group spent a moderate time in the map (between 101 and 250 s); and the third group spent a longer time (greater than or equal to 251 s), as shown in Table 6.

As an attempt to enlighten some possible causes and effects between the use of the navigational map and the remaining variables statistical comparisons were made. The Kruskal–Wallis one-way analysis of variance by ranks was used to analyse the differences between the three different groups identified concerning the use of the navigational map with the ratios (search, orientation, access and time) values, and the task-test scores. This test was used at a 0.05 level of significance.

First we compared the three groups that differed in number of visits to the map — frequency of visit to the map, as shown in Table 7. The results showed significant differences between the frequency of visit to the map relatively to the orientation ratio ($H_{(2)} = 10.0$, $P < 0.05$) and to the access ratio ($H_{(2)} = 11.8$, $P < 0.05$). These results suggested that the frequency of visit to the map

Table 7
Kruskall–Wallis test results between the three groups that differed in number of visits to the map[a]

	Frequency of visit to the map				
Groups	$\leqslant$ 5	6–10	$\geqslant$ 11		
Variables	Mean rank	Mean rank	Mean rank	H	p
Search ratio	12.5	14.3	8.1	4.4	0.203
Orientation ratio	6.9	13.6	16.6	10.0	0.007
Access ratio	6.6	13.6	17.1	11.8	0.003
Time ratio	9.9	13.2	12.6	1.3	0.565
Task-test	9.1	17.3	10.9	5.8	0.062

[a] Degrees of freedom = 2. Level of significance = 0.05.

could have influenced the value of the orientation and access ratios. We also found a value of $H_{(2)} = 5.8$ ($P = 0.06$) for the variable task-test. Although not significant, the present value showed some differences among the three groups of frequency of visits to the map relatively to the score obtained in the task-test. The group that visited the map between 6 and 10 times had the highest mean rank score and probably was responsible for the almost statistical differences among these groups. These could be interpreted as an indication of the cognitive overhead experienced by some students. We verified that the students who visited the map 6 or 10 times were the ones who got the highest scores in the task-test. We may suggest that the students who visited the map many times (more than 11 times) have experienced a high degree of cognitive overhead due to: (a) the great amount of information accessed; (b) the great number of decisions that they should take increased by the task of using the navigation map. As a result they did not do so well in the task-test.

Secondly we compared the three groups that differed in the amount of time spent looking at the map — time spent in the map, as shown in Table 8. There were significant differences between the time spent in the map relatively to the orientation ratio ($H_{(2)} = 6.8$, $P < 0.05$) and the access ratio ($H_{(2)} = 9.5$, $P < 0.05$). These results suggest that the time spent in the map have influenced the value of the orientation and access ratios. Although not statistically significant the differences ($H_{(2)} = 5.2$, $P = 0.06$) relatively to search ratio can be interpreted as the more time spent looking at the map, the more relevant information were found by the students. However, the group who spent the longest time in the map had the lowest mean rank, which means that the students who spent less time in the map ($\leqslant 250$ s) were the ones who found more relevant information.

As a summary, we might say that the differences among the groups of frequency/time of visit to the map relative to the orientation and access ratios could be interpreted as the presence of the map in the hypermedia prototype was used as an anchor by the subjects, in order to promote the orientation and the information access. However, and based on the low values of orientation and access ratio (see Table 2), a high number of subjects were disorientated and inefficient in access information, which means that the map was not so useful as we could expected.

5.8. Findings

In spite of some of the limitations of the study such as, the size and type of sample, the particularities of the map used, and the constraints of a confined hypermedia environment, we might

Table 8
Kruskall–Wallis test results between three groups that differed in the amount of time spent looking at the map[a]

	Time spent in the map				
Groups Variables	$\leqslant$ 100 Mean rank	101–250 Mean rank	$\geqslant$ 251 Mean rank	H	p
Search ratio	13.4	13.5	6.3	5.2	0.063
Orientation ratio	7.4	12.7	16.2	6.8	0.033
Access ratio	6.6	13.0	17.1	9.5	0.007
Time ratio	10.0	12.6	12.5	0.9	0.666
Task-test	9.6	15.0	10.3	3.1	0.216

[a] Degrees of freedom = 2. Level of significance = 0.05.

argue that for this particular study the frequency of visit to the map and time spent looking at it did not mean orientation in the process of organising and accessing relevant information.

These findings are consistent with the those of Stanton et al. (1992), who argue that the provision of a map results in poorer performance, less use of the system, lower perceived control, and poorer development of mental representations when compared to a condition with no map present. Nevertheless, we used a different research design that did not include the representation of cognitive maps. Perhaps it is not wise to assume that a map that helps performance in a spatial context also forms an aid in a hypermedia environment as defended by (Dias & Sousa, 1997; Stanton, 1994; Stanton & Baber, 1994).

The results of this study suggests that researchers and designers of hypermedia learning environments need to be cautious when they design such environments based only on the spatial metaphor. We defend the fact that the electronic environments present intrinsic characteristics that do not permit a linear transfer and appropriateness of the geographical environments characteristics'. We defend the fact that the use of maps in an electronic environment seem not provide the expected benefits when compared to maps used for orientation in geographical environments.

6. Discussion

The translation of the concept of "mathematical space" into "electronic space" has led to the inappropriate adoption of a spatial metaphor; this adoption may have occurred unwittingly, but the notion of hypertext as space appears to have been accepted without question by the community. While the concept of space may be a useful metaphor for designers, much like the flowchart in conventional programming, there is no inherent reason why this concept should be foisted upon the user. While the metaphor allows designers to lay out information and decide on the placing of links, there is no guarantee that users will conceive the same links or layout. Indeed, Simpson (1991) has pointed out that the increased flexibility of hypertext documents makes the construction of cognitive maps extremely difficult. This leads to the essential question which hypertext has not faced to date: if there can be more than one "route" to a piece of information, and if there can be more than one "route" away from that information, how can users develop a map which is sufficiently complex to show the possible routes, and yet be sufficiently simple to permit ease of recall? Providing the user with a map need not accurately reflect the relationship between nodes nor need it present the user with the assumptions employed by the author in designing the hypertext document. We are then left with a mismatch between authors' assumptions and users' goals; a mismatch, which may be exacerbated by the provision of a map. How can hypertext be made easier to use? Before discussing this point, let us consider some other attempts to tackle this problem.

Previous solutions to the problem of getting lost in hypertext packages appear to take four forms (Stanton & Baber, 1994). One of them is related to the providing of a map. This allows operations to be performed by the users to take them to required nodes. Another solution seeks to reduce, or eliminate, the users' need to navigate. The third is to provide some means of reviewing or previewing a user's progress through the application. And the fourth allows users to jump straight to nodes. While each of these solutions has a limited set of advantages within specific applications, they represent symptoms of the current ills of hypertext rather than cures.

The simplest means of eliminating navigation is through the use of "guided tours" (Trigg, 1988). A guided tour uses a string of linked nodes, which the user moves through by pressing a button marked "next". In reality, this is little more than page turning. It is difficult to reconcile the provision of such "guided tours" with the conception of hypertext as non-linear documents. Furthermore, Stanton and Baber (1994) have argued that learning is most effective when the learner can direct it.

Hagelberger and Thompson (1983) and McKnight et al. (1989) have found that if users encounter difficulties, they tend to return to the "home" page, and begin their search again. Furthermore, McKnight et al. found that subjects tended to spend a disproportionate amount of time in the contents and index pages, and then jump straight to required nodes. Lee, Whallen, McEwan and Latrémouille (1984) have found that in complex menu systems, users tend to access twice as many menus as necessary in order to retrieve information. This suggests that people are not using complex information systems efficiently. As we mentioned at the start of this article, this is probably due to poor design.

Nielsen (1993, p. 144) states that, "Navigation is best for information spaces that are small enough to be covered exhaustively and familiar enough to users to let them find their way around". But this implies that, as a concept for hypertext, navigation is most effective when it is least needed. It is not clear, from the studies reviewed above, whether users actually navigate hypertext in the way designers imagine them to.

7. Final remarks

The concept of navigation in hypertext relies upon the premise that users can formulate global plans for their interactions. That is, users can decide upon a route through the "electronic space" which will lead to the information they desire. This not only contradicts the proposal of hypertext as a browsing tool, it also goes against some former research. Draper (1984) found that expert users of UNIX could only recall a fraction of the commands they used, but could use UNIX efficiently for their work. Mayes, Kibby and Anderson (1988) found that experienced users of Macintosh computers had difficulty in remembering the screen layout for a number of tasks, but had no trouble in performing those tasks. These studies suggest that human–computer interaction is characterised less by the use of specific, declarative knowledge concerning the precise commands etc. to use, and more by procedural knowledge, relating to the context in which the tasks are to be performed. Suchman (1987) has proposed an account of "situated actions", in which activity is performed in response to changing cues from the computer the user is working with. This does not mean that users' actions are simply responses to prompts. Rather, the information on the computer screen can suggest a number of alternative courses of action to the user. Payne (1990, p. 190) has termed this "interface as resource for action". This suggests that the hypertext designer needs to concentrate on providing users with appropriate cues at the decision points within the interaction: i.e. information that cues choice in a manner that enables users to pursue their intended goals or formulate new ones. This should serve to decontextualise the information and make use of hypertext more purposeful.

Bearing in mind, the discussion of people using hypertext, it should be apparent that users tend to be very task specific in their activity. If they cannot perform the task they require, they will often return to the first page and try again. Such behaviour is both very inefficient, and very common. How can we reduce this inefficiency?

If we return to the navigation metaphor, briefly, we can see that conventional accounts of navigation skills consist of three stages (Wickens, 1990; Anderson, 1990). People first learn prominent landmarks, then learn routes between these landmarks. Finally, people will be able to fill in the detail and produce a more complete survey of the area of interest. However, as we have already stated, such behaviour only applies when there are fixed and invariant relationships between objects. This is not the case in hypertext. Therefore, the provision of either route or survey information is both misleading and mistaken. We suggest that the notion of landmarks could be useful, but their meanings need to be carefully considered.

In physical space, a landmark is a prominent feature within a crowded visual field. In hypertext, the visual field is, generally, restricted to a single screen and consequently is much simpler. Landmarks would function less as physical orientation devices, and more as current mode indicators. Several researchers have used landmarks with some success in hypertext, but the prevailing navigation metaphor has led to their usefulness being played down; designers are still seeking more complex navigational information, when they should be addressing the usability of their systems.

In summary, simplicity of the interface and tools to support the users' actions seems to offer the solution to "navigation" problems. For example, the provision of bookmarks, URLs and simple buttons (forward, back and home) may be far more effective with well-designed hypermedia rather than constructing map-based navigation to cope with poorly designed hypermedia environments.

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