Running head: PASSIVE VS. ACTIVE ACCESS TO HYPERTEXT

Influence of passive versus active information access to hypertextual information resources on cognitive and emotional parameters.

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Abstract

Learning with non-linear media has been one of the most prevalent topics in educational computing research during the last two decades. The present study examines the influence of navigation in hypertext learning environments and discusses advantages and disadvantages of hypertext as instructional media. Results suggest that subjects retrieving information by actively navigating hypertext do not differ in knowledge acquisition from counterpart-subjects assigned to a passive condition. In a yoked-control design the subjects in the passive condition retrieved the same nodes in the same sequence resulting from their counterparts' active navigation. Both experimental groups showed a significant increase of self-confidence in content-related knowledge compared with a control group. In order to assess subjects ability to apply their knowledge, participants completed an argumentation task using a concept mapping tool. Both experimental groups showed significantly better performance after the treatment, but did not differ from each other markedly. In addition, active access to hypertext information did not result in higher certainty about subjects' knowledge acquisition (self-ratings) compared to passive access. No evidence was found for increased self-confidence in subjects' argumentation ability resulting from active navigation.

Introduction

What are the advantages of hypertext? The non-linear presentation of information has almost always been called "advantageous" and has been becoming a favourite way of presenting information both on CD-ROM and on the World Wide Web. One important aspect of hypertext is that its navigation is user controlled [1]. Because of the high level of control the user has with respect to the sequence in which information nodes are visited and about the degree of detail with which information is processed, hypermedia seems well in line with the cognitivist perspective of learning (stressing the role of knowledge and of schema construction) as well as the situated view of learning (stressing the role of self-control and construction of knowledge) [2].

A glance upon recent research on learning from hypertext reveals that it foremost deals with a comparison of effectiveness between traditional text and hypertext [3, 4, 5]. Hypertext seems to be quite advantageous in complex and ill-structured domains, especially when users or learners have clear ideas of what to learn and have an adequate amount of knowledge [6]. But is it really necessary to design non-linear information bases? Cognitive load or overhead is one of the problems mentioned most often with hypertext learning [7]. If there is a cognitive overhead which is likely to occur in larger hypertext systems, why should non-linear media then be advantageous? And what happens to learners or users not having any expertise or knowledge in a domain? A combination of non-expertise and cognitive overhead is fatal for any learning process and might indeed hinder it from the very beginning. As a consequence one form of the lost in hyperspace-phenomenon might occur [8]. It is, however, not only the domain specific experiences that trigger successful information retrieval, but also the media specific literacy that is responsible for the learner's success [9]. Most people are still not skilled users of non-linear media, at least not in comparison to their skill when reading linear text. Studying books page by page combined with cognitive delinearizing and chunking of new information is often highly automated. In contrast, starting with new information in a hy-

pertext system and then searching for possible related information that is not connected in a linear manner is new and more difficult. As learners still have to linearize the non-linear information provided by the structure of an author's knowledge, then fit it to their pre-existing knowledge structures, learners' cognitive capacity will necessarily be challenged [10]. Above all, the higher capacity needed for text-processing combined with search strategies and the meta-cognitive processes involved contribute to the difficulties learners have to face when learning with hypertext.

As many studies show, hypertext is indeed a difficult format for many learners, in particular those which lack initial knowledge and/or the cognitive strategies for information selection and structuring [11, 12]. We think, however, that using hypertext to gain knowledge should have motivational and emotional advantages. In particular, it should lead people to feel more in control about the manner in which they select and evaluate information. In addition, they should meta-cognitively be more aware about the limits of their knowledge; this is a possible positive aspect of the – usually negatively connotated – fact that users of hypertext are less oriented about how much information of a certain domain they have seen. If one reads a book or an article about a particular subject, one may have the impression that "that's all there is to know" for the moment. Users of hypertext rarely have this feeling because they usually don't know if they have seen all that matters.

In order to investigate the influence of linear vs. non-linear information presentation on cognitive and emotional parameters we developed a hypertext system for investigational purposes.

In this study we examined the influence of accessing information in an active and non-linear manner vs. accessing the same information in a passive and linear mode. We use the labels "active" and "passive" here in order to distinguish the subjects who navigated the hypertext on their own from those who could not because they were in the (yoked) control group. In particular, we do not exclude the possibility that subjects in the "passive" condition process

the information they receive quite actively. The basic material of this study has been a hypertext on marine pollution. We examined the influence of information processing on cognitive outcomes as well as on emotional parameters. Due to the inadequacy of traditional multiple-choice questions representing a subjects' knowledge structure - especially when the same content has to be learned with different representations - we decided to use another way of testing learners' knowledge. Our way of examining students' understanding was to let them develop an argumentation on a statement about marine pollution. In agreement with Voss and Means we regard the ability of a person to develop and use an argumentation about a specific topic as one of the most important skills in higher thinking [13]. Producing a sound argumentation requires more than just learning and remembering facts. It means learning these facts, storing them, integrating them into existing knowledge structures, remembering them, reproducing them actively and above all using and applying them to new contexts. The experiment below contained - next to traditional rating scales and multiple choice questions - an argumentation task which was not only used to analyse subjects' knowledge structures in a natural and adequate manner, but also to enhance subjects' information processing in the sense of a "cognitive tool" [14].

Marine pollution, in particular the kind due to oil ship accidents, is a prototypical issue that involves not only information processing in sense of reasoning, but also has emotional impact on readers. Readers often report feelings of helplessness and frustration because the feel that they cannot influence the state of affairs but regret the damage done to flora and fauna [15]. We selected this issue as the topic of a hypertext because it allows us to observe possible effects of self-controlled access to information on emotional measure in addition to cognitive and meta-cognitive effects.

Experiment

Design of the study

The study was designed for a direct peer to peer comparison. We assigned each participant in the passive information retrieval condition to a counterpart accessing information in the active condition. This "yoked-control design" should help to control information content and sequence effects in subjects' learning progress whereas in most studies done before information content was kept comparable but sequence effects were ignored. Since humans - as any other biological system – are incremental information processing systems, sequence does affect learning dramatically [16]. Participants had to develop an argumentation concerning a provoking hypotheses regarding marine pollution. In order to develop their arguments, participants could access additional information provided as a hypertext. Access to this additional information was provided in two different ways. In the condition "active access" participants had the possibility to navigate a hypertext system dealing with marine pollution and other marine environmental issues. The hypertext included scientific background information as well as newspaper articles from a German newspaper dealing with marine pollution from the last decade. Participants in this condition were allowed to use the whole hypertext system without any limitations by linear and non-linear browsing as well as by indexed and full text search engines.

In the condition "passive access" all hypertext specific navigation possibilities were removed. Participants in this group were only allowed to follow the path their peer counterpart in the condition "active access" had chosen. They were merely given the possibility to use a button to the next page but had no possibility to influence content or sequence of information presentation. Participants in both conditions received information about content and overall number of nodes of the hypertext system before they started.

Participants of the control group had to perform all test and tasks like both experimental groups without having access to the hypertext system or any other information resource. The assignment of the participants in the "passive access"-condition to their counterparts in the "active access"-condition was done by using criteria of sex, age and discipline of major.

Materials and Tools

We developed the prototype hypertext system "NorthSea" and combined it with the software tool "Inspiration" ™ for argument visualization [17]. Inspiration ™ is a concept mapping tool that, among other things, is suited for the construction of informal argumentation structures. In order to assess knowledge acquisition a special computer-based multiple-choice test was designed in which participants had to answer questions and to announce the degree of certainty about their answer. In addition, we used another scale to assess participants' emotional evaluation (according to appraisal theories) concerning critical incidents causing pollution [15, 18].

The hypertext system "NorthSea"

NorthSea is a hypertext base which offers different ways of accessing information. All components of this information system were developed using Asymetrix ToolBook ™ [19]. One part of the hypertext system provided background information about pollution of the sea caused by different materials, their source and their way of getting into the sea. Furthermore, the system included data about the influences of these materials on flora and fauna and about the resulting risks for ecology, economy and human health. This part included about 300 hierarchically structured and linked pages containing text and graphics. The navigation menu contained possibilities to go back and forth in a linear manner, to jump directly to another page linked associatively and to go back along a participant's own history path.

The second part of the system was constructed using 72 articles from a German newspaper dealing with marine pollution accidents from the last decade. Six categories provided structure for users looking for specific topics in the articles. Both parts - background information and newspaper database - were accessible by a full text search engine. The system automatically tracked users' navigation behavior and provided protocols containing a detailed description of pages visited, time of each visit, search terms used in queries and their results.

Inspiration ™ – A tool for visualising informal argumentation

One possibility to assess a participant's topic related knowledge is to analyse his or her ability and performance in argumentation. In order to develop an argumentation various problem-solving skills are required, especially the "informal reasoning" skills [20]. In contrast to formal reasoning, this kind of argumentation does not require deductive reasoning from premises to conclusions. Informal reasoning skills demand the development of sound arguments. Soundness of informal reasoning can be analysed according to Voss and Means by posing the following questions [13]: Are the statements relevant for the conclusion? Do the statements support a conclusion or are they contradictory? Are there any contradictory statements that form part of an argumentation or is the topic perceived from one perspective only? In order to make argumentation amendable to analysis, different methods to formalize (and then analyse) argumentation have been developed, for instance, by Toulmin for assessing arguments in jurisprudence [21]. For convenient visualisation of arguments we used the Inspiration ™ software. This tool allowed participants to work with a simplified Toulmin-like argument structure. Figure 1 shows a structure developed with Inspiration.

Figure 1: Argumentation in Inspiration ™.

---Insert Figure 1 here---

With Inspiration ™ , participants insert as many statements as required and draw relations between these statements. These relations can be marked with the labels pro or contra. The combination of a relationship drawn between two statements and the statements themselves is regarded as an argument. The net of the interconnection between the statements is called an argument structure.

Figure 2: Example of an argument structure

---Insert Figure 2 here---

This way of representing argument structures allows to record participants' argumentation in form of a graph as it is used in concept-mapping or mind-mapping methods [22]. Each statement is represented in form of a digital card. The relationship to other cards is represented by use of a "+" or "-"-sign at one side of each card (see figure 2).

The knowledge test and the emotion questionnaire

We developed two different scales to assess cognitive and emotional effects resulting from the use of the hypertext system NorthSea. In order to measure participants' knowledge acquisition a special test has been designed. This test was constructed using 18 multiple-choice questions related to three major topics: global change, marine pollution and oil accidents on sea. Previous observations [23] indicated that novices' evaluation of environmental risks is combined with a high degree of uncertainty . This was why we also employed a measure of degree of subjective certainty related to individuals' knowledge. Our measurement combined "traditional" multiple choice items with a one-answer-only option and a chose-as-many-as-you-want option (see figure 3). The second part of each question - the check-box scale - allowed participants to choose as many answers as they wanted.

Figure 3: Prototype scale used in knowledge assessment.

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The basic idea with the check-box scale was to measure participants' uncertainty. The more answers a participant choose for one question or for a whole block, the more uncertain this subject was interpreted to be regardless of whether the original question (left scale in figure 3) had been answered right or wrong. Before it was used in this experiment the scale had been tested on a sample of 35 participants. Its difficulty was computed with P=.44 and its internal consistency with Alpha=.66.

In order to measure affective outcomes we developed a scale assessing the emotional evaluation of critical environmental incidents. Prototype incidents were presented on the screen and participants judged these happenings on a seven-point Likert-scale, indicating how much they were affected regarding different emotions (see table 1).

Table 1: Topics and dimensions of emotional assessment.

---Insert Table 1 here---

Yet another scale had been developed in order to assess to what degree participants were convinced of their own certainty and quality of argumentation. On a seven-point Likert-scale, they announced how much they thought their argumentation would convince others.

Procedure

First, participants worked on the affective scales and the information scales assessing their subjective impression about the amount of being informed. In a second step, the handling of Inspiration ™ was demonstrated by an experimenter. Then, using Inspiration ™ participants practiced transforming the argumentative structure of a newspaper-article into an ar-

gumentative concept map. After being sure that everybody understood the procedure and handling of the argumentation tool, the following provoking statement was given:

"The accident of the oil tanker 'Braer' meant no danger at all for the marine eco system". Participants then had to add statements to this hypothesis using Inspiration ™ without accessing the hypertext-base NorthSea. That is, they developed their initial argument. In the following experimental phase, participants were asked to add further arguments and statements to this initial argument structure. In the condition "active access" participants had the possibility to navigate freely through the hypertext system. In the condition "passive access" participants were only able to navigate in a linear manner through those pages their counterpart from the condition "active access" had visited. Participants in the control group had no possibility to access further information (i. e. they had no possibility to use the hypertext system at all), nevertheless, they were asked to add further arguments. This experimental phase lasted for about 90 minutes for all three groups.

After the treatment, participants completed the scales about their emotional attitudes and their status of being informed. In addition, they had to do the knowledge tests and the self-assessment scale measuring participants' ability to convince others with their argumentation. The experiment ended with the reconstruction of the argumentative structure in the initial newspaper article. The whole procedure lasted 3.5 hours.

Sample

Thirty three subjects participated in this experiment with 11 participants in each condition. All participants were students at the University of Freiburg, Germany. Each participant was assigned to a corresponding participant by using characteristics of age, sex and major of studies ("yoked-control design"). We used this assignment to experimental conditions in order to control for similar experience in hypertext use. Participants received DM 30 (~15 US$) for participation.

Hypotheses

We designed the experiment to test the hypothesis that active access to information systems does not automatically lead to an enhanced knowledge acquisition. We did not expect any differences between the two experimental groups in multiple-choice knowledge tests. Likewise, no differences between experimental groups were expected in the quality of argumentation. As far as meta-cognitive outcomes are concerned, active information retrieval was expected to lead to a decrease of subjective uncertainty and to enhance the self-assessment of being able to convince others with an argumentation in environmental issues.

In addition to these cognitive parameters, we expected differences between groups in emotional outcomes. In particular, we expected active access to hypertext to reduce feelings of helplessness concerning marine pollution.

Results

Self-ratings in pre-post comparison

The statistical analysis of participants' self-ratings related to their current status of information about environmental problems showed significant advantages for the "active access" condition regarding the topics "problems with the ozone layer" (t-test: $t(10) = 1{,}84$, $p<.05$), "marine pollution" ($t(10) = -4{,}94$, $p<.001$) and "oil tanker accidents" ($t(10) = -5{,}84$, $p<.001$). Participants in the "passive access" condition after the treatment felt better informed about "problems with the ozone layer" ($t(10) = -1{,}87$, $p<.05$), "global change" ($t(10)=-3{,}61$, $p<.01$), "dying forests" ($t(10) = -3{,}73$, $p<.01$), "marine pollution" ($t(10) = -4{,}97$, $p<.001$) and "oil tanker accidents" ($t(10) = -5{,}76$, $p<.001$). This was a significant increase between pre- and post-test in all categories except for "heating of the atmosphere". There were no significant increases in the results of the control group.

A group comparison in pre-test suggested no differences between all the three groups in all conditions with one exception. In the category "dying forests" participants of the "active access" condition felt better informed than the other groups (ANOVA, $F(2, 30) = 3{,}65$, $p<.05$), probably a sample artefact.

Analysis of post-test outcomes revealed significant results in the categories "marine pollution" ($F(2, 30) = 16{,}69$, $p<.001$; active access = passive access > control group) and "oil tanker accidents" ($F(2, 30) = 21{,}23$, $p<.001$; active access = passive access > control group).

Table 2: Means of participants' ratings "being informed"

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We assessed participants' self ratings of their own argumentation's quality with the items "I named all important arguments", "My arguments are all correct" and "My argumentation is convincing". There were no differences in pre-test as well as in post-test group comparison. Both experimental groups showed a significant increase in participants' ratings of their "correctness of arguments" (Active: $t(10) = -4{,}49$, $p<.01$; Passive: $t(10) = -3{,}19$, $p<.01$) and their "ability to convince others" (Active: $t(10) = -3{,}73$, $p<.01$; Passive: $t(10) = -2{,}32$, $p<.05$). No significant pre-post test differences could be found in control group's ratings.

Table 3: Means of participants' ratings in "argumentation quality"

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Emotional Outcomes

An analysis of emotional parameters suggests no significant group differences in pre-test as well as post-test related to specific topics and to specific emotions. Comparison between pre- and post-test suggested an overall decrease of emotionality regarding the topics

and all specific emotional attitudes although only the subscale "problems with the ozone layer" ($t(32) = 3{,}31$, $p<.01$) showed a significant decrease.

Table 4: Means of participants emotional ratings

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Differences in knowledge test

The knowledge test presented to all groups after the treatment showed no overall significant differences ($F(2, 30) = 0{,}58$, $p=.57$). Neither did the results in all subscales or the data assessed with the knowledge-certainty-scales ($F(2, 30) = 1{,}25$, $p=.30$). Table 2 shows means of both experimental conditions and control group in different categories assessed with the knowledge test.

Table 5: Domain specific means in knowledge test.

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Quantitative analysis of argument structures

In order to gain quantitative measures from participants' argumentative structures we used different methods from graph theory [24, 25, 26, 27]. We used the number of added argument nodes as well as centrality and diameter of graphs for measurement purposes. Diameter is defined as the maximum length between two nodes in the argumentative structures. In order to compute a measurement for the similarity of two graphs an overlap-index had been computed resulting from the geometric mean of two networks that needed to be compared. For this computation we used the following formula.

Formula 1: Overlap-index.

---Insert Formula 1 here---

s_{jk} (referring to the Geometric Mean) is the value of the Overlap-Index. d_{jk} is the number of nodes in both argumentation networks (before and after treatment), e_j and e_k are the numbers of arguments used only once [25]. This index represents the similarity between two argumentation clusters (here: pre and post argumentation of a Participant). It reaches values between "0" (no coincidence) and "1" (identical).

In order to measure the balance between pro and contra arguments a balance-index according to formula 2 was computed.

Formula 2: Balance-index.

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The Balance-index $B_{i,t}$ is the sum of the number of supporting statements related to a base statement P and rejecting nodes A, with i being the person-index, j the level-index, n the number of levels and t the time. The values of the Balance-Index represent the tendency of a Participant's argumentation. It reaches values between "-1" (extremely one-sided, e. g. only negative statements) and "+1" (extremely one-sided, e. g. only positive statements).

In this analysis we only compared the two experimental groups because the control group had no access to further relevant data from the database. In the "passive access" condition participants added more nodes to their argument structures during the treatment, however, this difference did not become significant ($F (1, 20) = 2,75$, $p=.11$). Analysis of similarity between the structures before and after the treatment showed that participants in the "passive access" condition modified their argumentation more than their active counterparts (computed with the overlap-index: $F (1, 20) = 5,43$, $p<.05$). There was no significant differ-

ence in diameter (F (1, 20) = 0,95, p=1) or balance (F (1, 20) = 0,53, p=.47) of argumentative structures.

Table 6: Means of quantitative parameters of argument structures

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Qualitative analysis of argument structures

In order to evaluate the quality of subjects' arguments, we examined their single statements used for constructing argumentative networks. According to Voss and Means' concept of "soundness" these statements were coded using a "listener's" perspective [13]. Each statement was coded by two judges on the dimensions of "acceptability", "relevance", "emotionality" and "distinctiveness" using five-point Likert-scales. Cronbach's Alpha for the two judges was computed with Alpha=.90 in "acceptability", Alpha=.83 in "relevance", Alpha=.73 in "emotionality" and Alpha=.88 in "distinctiveness". An analysis of variance revealed no significant differences in any of the categories: acceptability (F (1, 20) = 0,50, p=.49), relevance (F (1, 20) = 1,29, p=.27), emotionality (F (1, 20) = 0,05, p=.82) or distinctiveness (F(1, 20) = 0,61, p=.44).

Table 7: Means of qualitative parameters of argument structures

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Summary and discussion

Is passive access to information in electronic documents disadvantageous compared to active and more-self directed information access? This main question of the present study cannot be answered with a clear "yes" or "no". In both conditions learners are involved in constructive and active cognitive processing of text, however, the possibility of free explora-

tion of information resources gives users the chance to control the study progress themselves. Recent research shows that there are many factors that have to be considered when using hypertext as instructional media [11, 28, 29]. The findings of our study suggest that the self-directed sequence or "active access" to text-based information does not always lead to better cognitive and meta-cognitive outcomes than a pre-sequenced presentation ("passive access"). We found that in a hypertext system, passive and active information access lead to similar results in students' self-ratings of their performance, a multiple-choice quiz and an argumentative transfer task. Jacobson, Maouri, Mishra and Colar also conducted a study in which different navigation possibilities in hypertext learning environments were experimentally manipulated [30]. They compared the influence of guided thematic criss-crossing, learner selected thematic criss-crossing and free hypertext exploration on factual knowledge acquisition and problem-solving performance. The performance of participants in knowledge tests in their experiment revealed only slight advantages of free hypertext exploration and learner selected thematic criss-crossing in one of four tested sessions. Both conditions were similar to the "active access"-condition in our study, while the guided thematic criss-crossing might have been similar to our "passive access"-condition (in the three other sessions no significant differences occurred). Furthermore, Jacobson et al. did not find significant consequences of the navigation variable on participants' performance in the problem-solving essays used as measurement of transfer. With exception of the disadvantage of the guided thematic criss-crossing in one of the four tested sessions and an interaction of navigation condition and epistemic beliefs and preferences about the nature of learning and the structure of knowledge, no further effects of self-directed and predetermined navigation were found. This study as well as our own results suggest that providing the same content and just modifying the possibility of accessing this content (actively vs. passively) does not in any case have drastic effects.

It was argued that actively seeking information in hypertext occupies cognitive resources [7]. A passive mode of accessing information does not increase cognitive overhead

whereas in active data access cognitive resources are continuously occupied. The findings of our study do not indicate direct effects of active information seeking or passive information retrieval on cognitive or meta-cognitive outcomes. Our findings do not support our hypothesis that active hypertext access leads to a better ability to reflect one's own learning process. However, regarding the results of the self-rating category "being informed", members of the active group perceived themselves significantly more informed about topics which were actually covered in the hypertext (marine pollution). The passive group members perceived themselves as better informed even on topics that were not addressed in the information system (e.g. "dying of forests"). Thus, the active condition had a more accurate certainty or a minimized "illusion of knowing". This might be interpreted as a slight advantage of user controlled information access because learners in the active condition not only needed to plan their information sequence, they also had to store the information they already had seen in order to optimise their further search.

We were not able to detect any effect on emotional parameters according to appraisal theories. This might be a consequence of an "information flooding" which possibly caused a drastic decrease of emotionality. The general shortcomings of a brief learning phase can be a possible explanation for the missing effects: in order for participants to internalise new knowledge patterns and associated emotions more time is needed.

Overall, we found no significant differences between active, non-linear and passive, linear access to hypertext information. Possibly, as a new non-linear literacy develops, hypertext learning might eventually become more effective and thus the compensation of a cognitive overhead will not be necessary anymore. Our study also demonstrates the utility of argumentation as a method for testing transfer and coherence of learning contents. Analysis of argumentation might be an appropriate method in order to measure knowledge acquisition in addition to multiple-choice questions, rating scales and similar assessment procedures.

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Figure 1: Argumentation in Inspiration ™

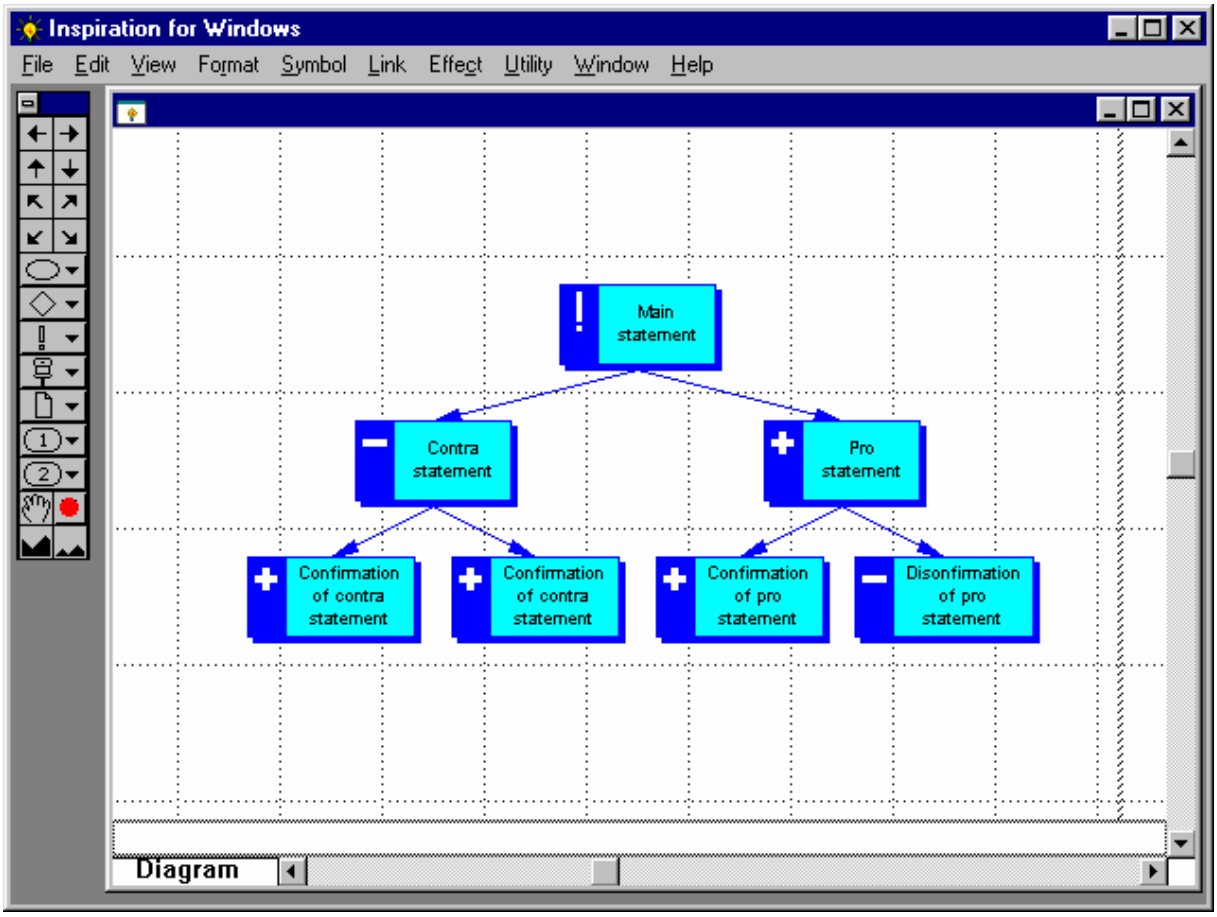

Figure 2: Example of an argument structure

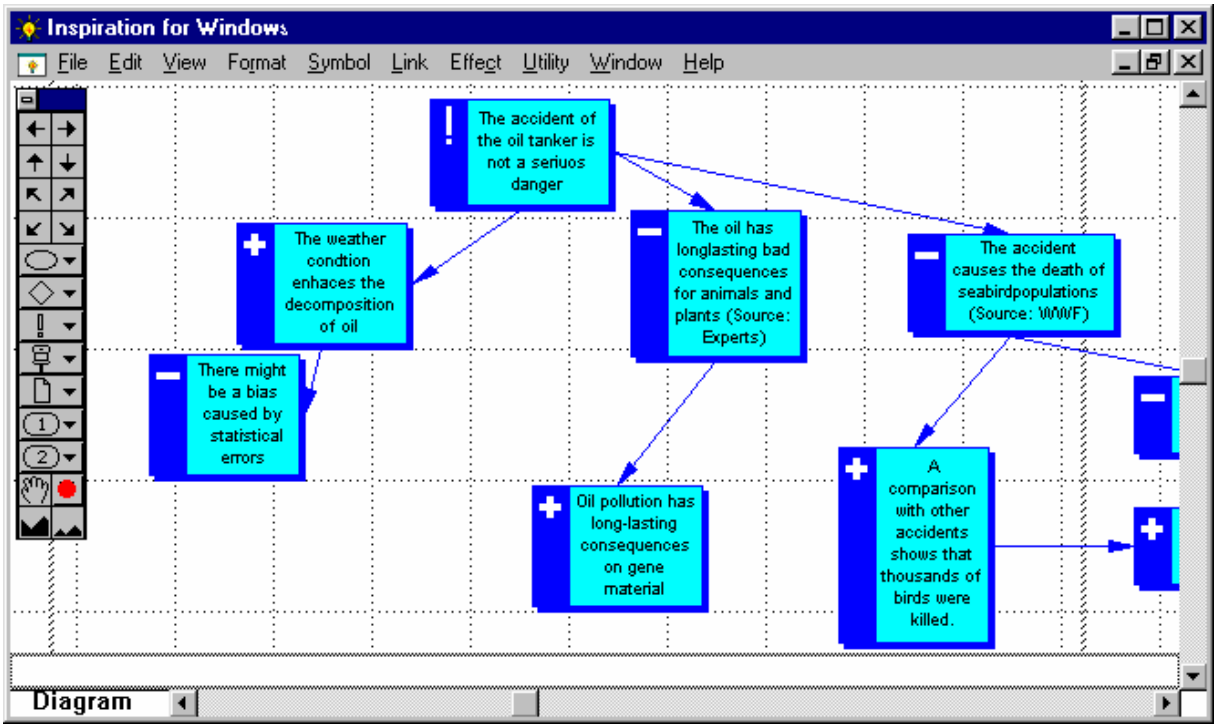

Figure 3: Prototype scale used in knowledge assessment

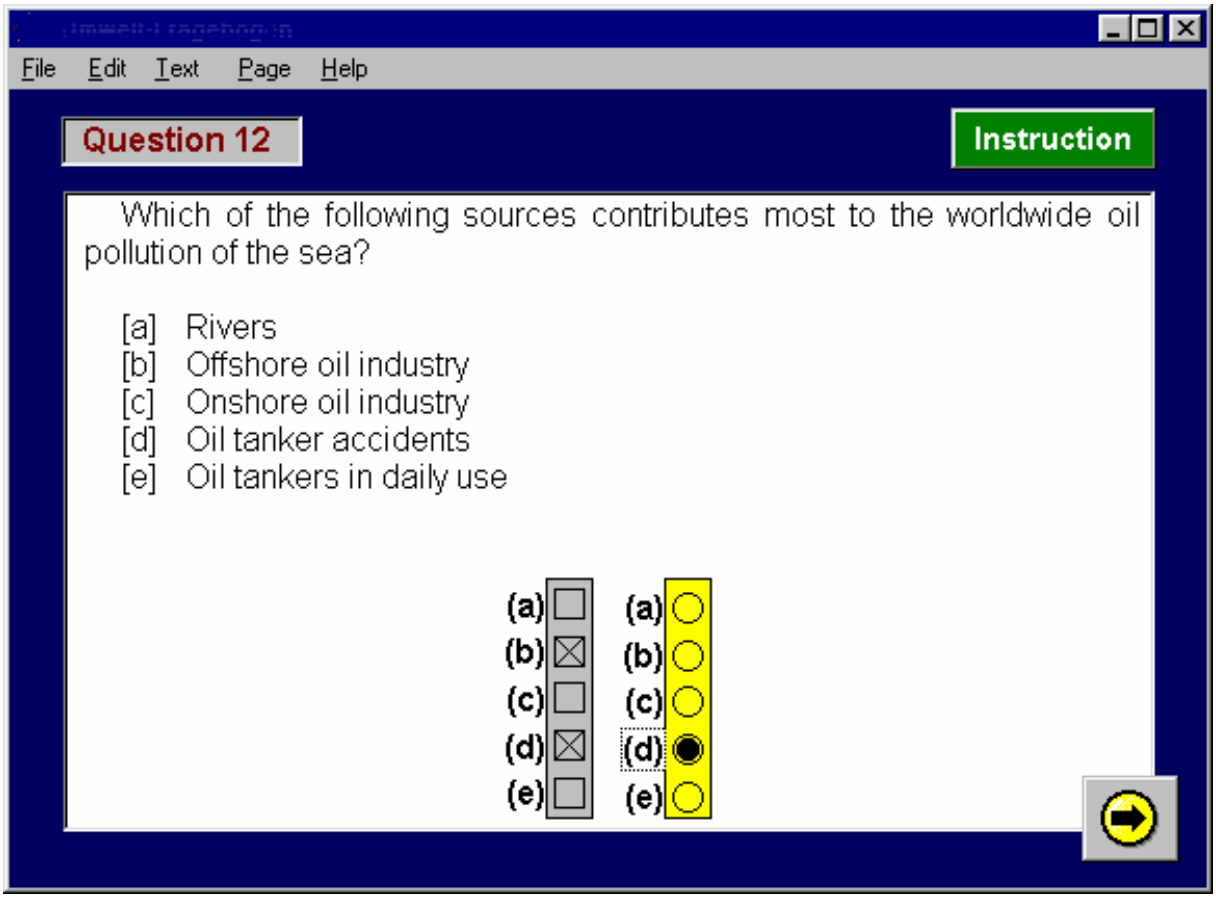

Table 1: Topics and dimensions of emotional assessment.

Specific topic	**Specific emotions**
Problems with the ozone layer	Anxiety
Marine Pollution	Anger
Dying of forests	Resignation
Oil tanker accidents	Frustration
Heating of the atmosphere	Affliction

Table 2: Means of participants' ratings "being informed"

Mean (SD)	**Active Access**		**Passive Access**		**Control Group**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Global change	4,27 (1,1)	4,64 (0,92)	3,82 (0,98)	4,64 (1,12)	3,64 (1,12)	3,73 (1,27)
Problems with the ozone layer	4,27 (1,0)	3,82 (0,87)	3,64 (0,92)	3,91 (0,94)	3,36 (1,43)	3,73 (1,27)
Dying of forests	4,27 (1,1)	4,27 (1,19)	2,91 (1,04)	3,64 (0,67)	3,36 (1,43)	3,46 (1,29)
Heating of the atmosphere	4,36 (1,12)	4,46 (1,51)	3,64 (1,29)	3,73 (1,19)	3,55 (1,64)	3,46 (1,29)
Marine pollution	3,73 (0,9)	5,73 (1,1)	3,36 (0,5)	5,27 (1,19)	2,82 (1,17)	3,1 (1,14)
Oil tanker accidents	2,91 (1,7)	5,73 (1,1)	2,82 (1,17)	5,18 (1,08)	2,73 (1,27)	2,91 (1,05)

Table 3: Means of participants' ratings in "argumentation quality"

Mean (SD)	**Active Access**		**Passive Access**		**Control Group**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
"I named all important arguments"	4,82 (1,4)	5,18 (1,6)	4,09 (1,51)	5,27 (1,35)	4,73 (1,49)	4,73 (1,56)
"My arguments are all correct"	4,09 (0,83)	5,27 (0,65)	4,27 (1,27)	5,18 (0,87)	5 (1,18)	5,36 (1,21)
"My argumentation is convincing"	4,55 (0,93)	5,27 (0,79)	4,27 (1,49)	5,18 (0,87)	4,55 (1,04)	4,82 (1,17)

Table 4: Means of participants emotional ratings

Mean (SD)	**Active Access**		**Passive Access**		**Control Group**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Ozone layer	4,02 (0,76)	3,61 (1,03)	4,17 (0,74)	3,86 (0,81)	3,88 (1,01)	3,61 (1,17)
Marine pollution	3,86 (0,66)	3,58 (0,98)	4,02 (1,08)	3,91 (1,07)	4,06 (1,09)	3,92 (1,21)
Dying of forests	3,8 (0,83)	3,73 (0,84)	3,82 (1,02)	3,65 (0,88)	4,23 (1,02)	4,17 (1,26)
Oil tanker accidents	3,91 (0,68)	4,02 (0,85)	3,92 (0,98)	3,83 (1,14)	4,17 (1,23)	3,94 (1,29)
Heating of the atmosphere	4,15 (0,91)	3,92 (0,84)	4 (0,97)	3,7 (0,91)	3,98 (1,35)	3,83 (1,32)
Anxiety	4,18 (1,17)	4 (1,26)	3,75 (0,89)	3,86 (0,82)	3,68 (1,52)	3,7 (1,84)
Anger	5,16 (1,1)	5,16 (1,23)	5 (1,34)	4,86 (1,47)	4,82 (1,64)	4,73 (1,76)
Resignation	3,25 (0,89)	3,18 (1,19)	3,11 (1,28)	2,89 (1,13)	3,75 (1,34)	3,64 (1,42)
Frustration	3,25 (1,2)	3,14 (1,22)	3,3 (1,45)	3 (1,28)	3,48 (1,69)	3,32 (1,62)
Affliction	2,41 (1,24)	2,32 (1,32)	3,36 (1,48)	3,09 (1,83)	3,61 (1,03)	3,27 (1,23)

Table 5: Domain specific means in knowledge test

Mean (SD)	**Active Access**	**Passive Access**	**Control Group**	**p-value (F (2, 30))**
Knowledge (in fact)	9 (2,9)	7,73 (2,57)	8,64 (3,08)	.57 (0,58)
Knowledge in relation to participants uncertainty	0,5 (0,16)	0,43 (0.14)	0,57 (0,13)	. 57 (0,58)
Subjective uncertainty	0,49 (0,02)	0,53 (0,09)	0,57 (0,13)	.30 (1,25)
Background knowledge concerning sea and oil	2,55 (1,04)	2,82 (0,98)	3 (1,18)	.61 (0,5)
Knowledge about recent happenings concerning oil and sea	4,18 (1,72)	3,27 (1,74)	3,55 (1,86)	.48 (0,76)
Subjective uncertainty concerning oil and sea	0,49 (0,17)	0,56 (0,15)	0,53 (0,1)	.47 (0,77)
Subjective uncertainty regarding recent happenings concerning oil and sea	0,52 (0,17)	0,56 (0,1)	0,67 (0,19)	.09 (2,56

Table 6: Means of quantitative parameters of argument structures

Mean (SD)	**Active Access**		**Passives Access**	
	Pre	**Post**	**Pre**	**Post**
Number of nodes	13,73 (2,69)	22,18 (4,71)	14,09 (3,36)	26,18 (7,59)
Diameter	3 (0,89)	3,64 (0,92)	2,46 (0,52)	3,64 (1,03)
Balance	0,4 (0,15)	0,31 (0,16)	0,41 (0,2)	0,36 (0,19)
Overlap-index	0,78 (0,07)		0,71 (0,08)	

Table 7: Means of qualitative parameters of argument structures

Mean (SD)	**Active Access**	**Passive Access**
Acceptability	3,45 (0,51)	3,65 (0,74)
Relevance	3,68 (0,45)	3,41 (0,63)
Emotionality	1,59 (0,66)	1,54 (0,36)
Distinctiveness	3,43 (0,61)	3,64 (0,61)

Formula 1: Overlap-Index.

$$s_{jk} = \frac{d_{jk}}{(e_j * e_k)^{\frac{1}{2}}}$$

Formula 2: Balance-Index.

$$B_{i,t} = \sum_{j=1}^{n} \frac{P_j - A_j}{P_j + A_j}$$