Enhancing learning from hypertext by inducing a goal orientation: Comparing different approaches

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Abstract

As learning from hypertext requires a high degree of self-monitoring, having a clear learning goal in mind should enhance learning. Our concern in this study was to investigate three different kinds of approaches for inducing learning goals: A Tutorial provided external and specific learning objectives, a Goal-Based Scenario (GBS) for inducing external and general learning goals, and a Strategy training leading to internal goal generation. A hypertext resource was combined with each of these three learning arrangements. The three conditions were compared regarding learning outcomes and motivational effects. Overall 60 adult participants participated in our study. Results suggest that GBS students are more motivated, acquire a better overview and are better able to apply their knowledge in an argumentation task. Students in the Tutorial performed better in fact-related knowledge-tests as a result of their direct accomplishment of learning objective, but failed to create a coherent overview on the topic and were less motivated. Participants that received a strategy training on self-questioning failed to apply this meta-cognitive strategy in order to formulate their own learning goals when working with the hypertext.

Keywords

Computer-Based Training - Hypertext - Goal-Based Scenario - Structural Knowledge - Argumentation - Transfer - Situated Learning

The application of hypertext in instructional settings: comparison of integrated hypertextual information in learning scenarios

Instructional effects of hypertext

With the growing popularity of the World Wide Web, materials presented to learners in form of hypertext (and hypermedia which is used equivalently here) have become a major instructional resource. Hypertext is considered an important form of instructional technology not only because of its availability in schools and at home, but also because recent educational research emphasizes the advantages of active, self-directed access to learning materials (Jacobson and Spiro, 1995; Jonassen and Wang, 1993; Spiro and Jehng, 1990). Research exploring the educational applications of hypertext has demonstrated improved learning outcomes for students using hypertext as opposed to other studying materials (Jacobson et al, 1996). On the other hand, research has also shown that this medium is not always an effective learning resource. In particular, it has been demonstrated that aptitude-treatment interactions occur, resulting in a learning advantage for students who already are somewhat knowledgeable about a domain or who have well-developed learning strategies and cognitive competences (Jonassen et al., 1993; Tergan, 1997; Dillon and Gabbard, 1998).

On close inspection, the following problems have been identified:

- Experienced learners actually do not need an exploring strategy. They prefer a direct strategy in order to find the information they are looking for. Less experienced learners may benefit from a guided instruction rather than from exploration (Jacobson et al., 1996; Zumbach et al., in press).
- Accessing a hypertext system according to current needs assumes that a learner has a clear representation of the goals and possible operators to reach that goal. It is unlikely that novices have such a representation, hence the ”lost-in-hyperspace”-phenomenon may occur. Direct or guided instructions are suggested as a way of generating such goals (Gruber et al., 1995; Schnotz and Zink, 1997).
- Adaptivity in hypertext systems is poor. Usually there is no possibility of changing the information or the context. There is no program-adaptivity according to learners knowledge, skills, attitude, needs, beliefs, motivation, etc. like in Intelligent Tutorial Systems or simulations (e.g. Eklund and Sinclair, 2000).

- Breaking a globally coherent information base into small pieces (i. e. nodes) may result in a patchwork of small knowledge units from which learners can not derive a sound representation. (Folz, 1994; Rickheit and Strohner, 1993).
- The direct representation of a cognitive structure in hypertext form is an interesting way of representing an author's view of a specific domain. The learner still has to encode the information and to make inferences in order to understand the given information. Every learner has to build his or her own representation and to linearize/delinearize the text (Bransford et al., 1972; Bransford and Johnson, 1972; Rickheit and Strohner, 1993). This process occupies cognitive resources and, taking the additional planning of search strategies into account, a ”cognitive overload” is likely to result (e. g. Conklin, 1987; Gerdes, 1997).

In the light of this inconclusive evidence, it is our main conclusion that hypertext is not a new learning paradigm, it is merely a new learning resource (Bosnjak et al., 1997), a very valuable one as such. In order to be turned into a learning paradigm, hypertext needs to be more integrated with other instructional measures. Our first and foremost goal in this study is to demonstrate and compare the effectiveness of inducing of two additional measures: induction of a goal orientation via strategy training, and a authentic, motivating learning tasks. These two routes are exemplary for two different approaches to improve learning. One approach is to empower the learner by enhancing his or her cognitive competencies; the other approach is to improve the learning environment.

Cognitive strategies relevant for hypertext learning

When investigating learning outcomes with hypertext we need to direct our attention to cognitive processes involved in non-linear information processing. Metacognitive strategies are very important in order to learn successfully from non-linear text. First of all, a learner has to be aware of the goal at hand: What is the purpose of navigating and reading a hypertext system? What kind of information do I want to obtain? What am I expected to know in the end? Secondly, information retrieval must be conducted: How can I get a hold of relevant information? Did I visit and store all relevant nodes in the hypertext? Which nodes are not relevant? Furthermore, what do I already know about the topic? How can I integrate new facts with my experience and knowledge? How am I able to remember this vast amount of knowledge? Last but not least: How can I apply my new knowledge to everyday tasks?

These questions suggest that metacognitive processes involved in learning from hypertext are problem solving processes in their own right. Considerable cognitive resources must be invested for planning and monitoring the information retrieval process. These resources – the cognitive overhead - cannot be used for processing the learning content. In fact, these cognitive processes are necessary in order to guide one's traversal through the hypertext space and to avoid the "lost-in-hyperspace"-phenomenon.

An appropriate method to face these difficulties the establishment of learning goals. Learning goals are a prerequisite to effective knowledge acquisition whenever a learner is faced with a rich environment and/or situations where the learner pursues multiple goals. Learning goals –i.e., descriptions of the intended learning outcomes – are necessary for self-monitoring and for other tasks: Determining when learning should be attempted, focusing attention on goal-related features of the performance task, selecting information search and learning strategies, determining when learning is completed or should be interrupted – all this requires a learning goal in situations where these decisions are left to the learner (cf. Ram and Leake, 1995). Ng and Bereiter (1991) among others provide empirical evidence that different learning goal orientations result in different learning outcomes.

One possible way of enhancing the induction of learning goals is to provide strategy-training in order to support self-regulated learning skills (e. g. Alexander and Judy, 1988; Boekarts, 1997). A second method of inducing learning goals is to provide a learning environment that induces goals. Possible design approaches that support goal induction can be found in situated learning approaches like, e.g., Cognitive Apprenticeship (e. g. Brown et al., 1989), Anchored Instruction (Cognition and Technology Group at Vanderbilt, 1990, 1992) or the Goal-Based Scenario Approach (e. g. Campbell and Monson, 1994; Schank, 1994; Schank and Cleary, 1995).

Strategy training to foster self-monitoring

Questions of how a goal orientation can be induced in learners and what kind of effects this has have been extensively studied in research on the processing of (linear) text. Although this research analyzes comprehension of linear text, the meta-cognitive skills should be almost the same for comprehending hypertext. Bruning et al. (1995) identify five more or less effective strategies that have been analyzed: (1) Determining importance, (2) summarizing information, (3) drawing inferences, (4) generating questions, and (5) monitoring comprehension. As many readers are able to recall what they just have read but are not able to determine what has been important and what not, the determination of importance is an important skill that can be trained (e.g. Glover et al., 1980). The second skill to be mentioned here is the ability to summarize text passages in an adequate manner. Examples for effective training programs are Palinscar and A. Brown's reciprocal teaching based on peer-tutoring (Palinscar et al., 1987) or a more teacher guided approach based on rules as described by King et al. (1984). Research has also demonstrated that inference making can be trained and is effective (e.g. Raphael and Wonnacot, 1985) and that self-monitoring of reading comprehension (Grabe and Mann, 1984) can be trained.

In this paper we stress the role of generating questions in order to enhance reading comprehension and knowledge acquisition. Studies suggest that self-questioning trainings enhance reading comprehension and are comparatively easy to learn (e.g. King, 1995; King et al., 1984). A major function of self-questioning is the generating of self-defined goals. This includes goals about what to read, what further information is worth to be looked for, what needs should be met in order to improve understanding etc. In contrast to goals provided from the outside, for example by a teacher or a tutor (or a computer program performing this role), self-questioning provides learners with the opportunity to define their own objectives to pursue. This approach is more in line with a constructivist view on learning and hence particularly well suited for the combination with hypertext learning.

Another method of inducing learning goals is to provide a learning environment that strongly demands learners' focusing on goals. An example for such a learning environment is found in the Goal-Based Scenario approach.

Making hypertext learning more focused: Goal-Based Scenarios

The GBS approach to computer-based training has been developed by Schank and colleagues at Northwestern Universities (Schank, 1994; Schank and Cleary, 1995, Schank et al, 1994; Schank et al., 1999). It follows the tradition of situated learning approaches like Cognitive Apprenticeship (Brown et al., 1989; Collins, 1994) or Anchored Instruction (Cognition and Technology Group at Vanderbilt, 1990) and includes features of both. In a GBS learners are confronted with a problem situation. The problem situation is equivalent to a goal or mission that learners try to solve by using learning resources. This kind of learning environment teaches a set of target skills by providing an opportunity to learn these skills while achieving a desired goal (Schank, 1994). This is done by either defining the context of a GBS-mission through the mission itself as well as the story in which the learner is embedded or by containing the structure of the mission's possible operations and the mission focus (Collins, 1994; Schank, 1994; Schank et al, 1994). In general the design of a mission depends on the domain and the knowledge and skills that GBS-users are expected to acquire.

Research questions

Our main research question is not if learning goals are effective in fostering learning; we take this as being sufficiently demonstrated by former research, some of which reported in sections above. Rather, we are interested in comparing the relative effects of different instructional methods aimed at inducing goals in learners. In particular, we are interested in comparing a method that aims at enhancing cognitive competence - a strategy training - with a method that aims at optimizing the learning environment - a goal-based scenario.

Given the importance of a goal orientation for learning from linear and non-linear text, we compare three approaches to induce such goals in learners: (a) a Tutorial that provides explicit goals by means of stating objectives and assessing them with multiple choice questions, (b) a Goal-Based Scenario that provides goals implicitly by giving the learner a role to play in a task scenario, and (c) a Strategy training that provides general goals by fostering question asking. The Tutorial served in this study as the control condition. In many studies on hypertext learning, learning effects are only assessed by means of a single criterion measure, typically a recall or reconstruction task. Because of the multiple effects hypertext learning can have, one-dimensional assessment is not ideal. We decided to use a multitude of effect measures, not only focusing on learning but also on motivational outcomes. Learning effects were assessed not only by testing for factual knowledge, but also by measuring structural aspects of knowledge gained and by assessing the applicability of the knowledge gained by means of an argumentation task.

Experiment

We compared performance of two groups of participants that had to learn from non-linear text with a third group of participants which learned from a (linear) tutorial presentation. Overall, three groups were included in this study: *Strategy* (hypertext preceded by a training in asking questions), *GBS* (authentic task in form of a Goal-Based Scenario including the hypertext), and *Tutorial*, which served the function of a control group. The domain information was the same in all three treatment forms. Instead of just using retention measures a number of dependent variables (described below) were employed.

Procedure

We used a one-factorial design in this study. Participants worked individually. Their main task was to develop arguments concerning the effects of oil spills on the maritime ecosystem. Participants had access to (computer-based) information in order to develop their arguments. Pretests included assessment of motivation, structural knowledge and participants' initial arguments (i.e., those produced from memory, without access to further information). After the treatment motivational parameters were assessed, followed by concept-mapping of structural knowledge and assessment of final arguments. In the GBS and Strategy condition the same block of multiple-choice questions were administered as used in the Tutorial treatment building the final part of the assessment.

Independent variable

The independent variable was the instructional treatment in the following three forms: Tutorial, 'pure' hypertext with strategy training and tools, and Goal-Based Scenario. The three treatment forms are explained in the 'Materials' section.

Dependent variables

The following dependent variables were measured: (1) structural knowledge by means of concept mapping techniques; (2) quantitative and qualitative aspects of arguments (i.e. relevance, acceptance, rationality and distinctiveness); (3) motivation by means of a rating scale; (4) factual knowledge by means of 56 multiple-choice questions; and (5) frequency of tool usage (in GBS and Strategy group only).

Control variables

We controlled for the variables (1) computer literacy (self assessment) and (2) domain knowledge before treatment (by means of the structural knowledge assessment in the pretest).

Sample

Overall 60 participants between the ages of 17 and 53 took part in this investigation. Each program was completed by 20 randomly assigned participants. Mean age was 28.47 (s=8.11), 31 participants were male, 29 female. Participants have been recruited from university students as well as interested High School teachers and colleagues. For participating in this study no reward was given.

Materials and Treatments

Materials for realizing the treatment conditions

Materials were developed in order to realize the three different instructional treatments and to allow for a fine-grained assessment of learning and motivational outcomes. The basis for the three instructional treatments was a textbook on the ecology of oceans and a number of newspaper reports on large oil spills caused by accidents of oil tankers. We constructed a Tutorial, a GBS and a pure hypertext (for the Strategy condition) based on a subset of the information contained in these sources. Each experimental treatment consisted in the application of one of the three program forms and several additional instructions. Common to all treatment conditions was the experimental task to develop arguments concerning the effects of oil spills on the ecosystem. Time for task completion was held constant across all three treatment conditions (65 minutes).

Tutorial

The Tutorial consisted of seven coherent and independent modules, each presented by the computer. The students could handle the sections in any order, but all parts had to be studied. For each part there was a time limit established which the students had been informed about beforehand. Each module ended with eight multiple-choice questions concerning the current lesson. After each question an immediate feedback was provided and in case of mistakes students were offered a remedial action (going back to pages containing the answer). When a participant reached the time limit of a lesson, he or she was automatically taken to the quiz section of the lesson. The Time limit was imposed in order to make the overall time spent comparable across experimental conditions. Time limit for each lesson was computed by dividing the overall time needed (measured in some pre-runs) divided through the amount of textual information presented in each lesson.

Strategy treatment (including the hypertext program)

Participants in the Strategy condition received a training in asking critical questions before turning to studying the hypertext and working on their tasks. The questioning training was similar to King's (1995) Critical Thinking Questioning. It was presented to participants in form of a short tutorial containing practical examples of analyzing, comparing, and evaluating the causal relationships of facts and information. Three lessons were designed to teach these components.

The hypertext in the Strategy condition contained the same information as the seven lessons in the Tutorial it was, however, presented as an entity. Information units were also linked across ”lessons”; a ”lesson” in the Tutorial was presented as a ”chapter” in the hypertext version. A time limit for accessing the hypertext was imposed, being equal to the overall time given to participants in the Tutorial condition.

Goal-Based Scenario (GBS) treatment

In the GBS condition, participants did not receive any strategy training, but began to work in the role of a newspaper editor, using the resources of the GBS program. Participants were told that they had to write a comment for this newspaper concerning an oil tanker accident. Information about this accident was given to them by a simulated telex. This third program had been designed in a manner inspired by Goal-Based Scenarios (e. g. Campbell and Monson, 1994; Collins, 1994; Schank, 1994; Schank et al., 1994). The following components of a newspaper office were simulated: participants received in periodical intervals five messages by a telex in order to provide a narrative anchor. These messages included reports about a fictional oil tanker accident and included provoking theses on the relationship between oil, sea, and marine pollution. Furthermore, a telephone was implemented ”on screen” by means of which one could listen to various ”experts”, representing different stakeholders (e.g., the oil industry, environmental organizations, regulatory organizations). The same hypertext as in the above mentioned program was included in order to provide an archive of background information. Participants had to write an article about an oil accident using a word pad. The time limit was the same as in the Strategy group.

Materials for Assessing Dependent Variables

Assessment of motivation

In the pre- and posttest participants were given five rating scales ranging from 1 (very little) to 5 (very much): (1) How interesting does this program seem to you? (2) How exciting is this program? (3) Do you think that the duration of this program was too long? (4) Did you enjoy using this program? (5) How much do you want to continue with this program?

These questions have been chosen in order to represent intrinsic motivation factors of students using the different program types. Following Keller's (1983) model of motivation, we regard the subjective emotion of ”enjoyment” as a central factor representing intrinsic motivation. Similar results are mentioned by Malone (1981), suggesting ”thrill” as an indicator of motivational activation. In addition, Csikszentmihalyis (1985) concept of ”flow” inspired the questions about duration and the intention to continue working with the program. An analysis of this 5-item scale for 60 cases revealed a Cronbach's Alpha of 0.82 and an average inter-item correlation of .52. A factor analysis showed one factor with loadings of 0.82 for “Interest”, 0.76 for “Excitement”, 0.63 for “Duration”, 0.87 for “Enjoyment” and 0.79 for “Continuation” with a total explanation of variance of 61%.

Assessment of structural knowledge

We consider assessment of structural knowledge as important in the context of learning from hypertext because learning with hypertext should foster the acquisition of this type of knowledge. We define structural knowledge following Jonassen et al. (1993, p. 4) as ”(...) knowledge, that mediates the translation of declarative into procedural knowledge and facilitates the application of procedural knowledge, structural knowledge is the knowledge of how concepts within a domain are interrelated. (...) structural knowledge provides the conceptual bases for why; it describes how the declarative knowledge is interconnected”.

We assessed structural knowledge in our study using a computerized version of concept mapping (Bonato, 1990; Dansereau et al., 1979; Scheele and Groeben, 1979, 1984). Participants were given twenty concepts which they had to relate to each other by means of links. Each link was depicting one of the following semantic relationships: (1) Is an example for (hierarchical structure); (2) Results in (chain structure); (3) Help through (cluster), and (4) In contradiction to (cluster)

Assessment of arguments

Participants were assigned to perform an argumentation task in pre- and posttest. For this task a table consisting of two columns was given. Participants had to analyze and argue for and against the given hypothesis ”Oil tanker accidents are no danger at all!”. They had to write pro-statements into one column, contra-statements into the other, always structuring their own statements on different levels and enriching their arguments with examples (see Figure 1).

*** Insert Figure 1 about here ***

The elements participants provided during pre- and post testing in the context of the argumentation task were analyzed according to the following dimensions derived from Voss and Means (1991):

- Acquisition of statements: When is a statement added, before or after treatment?
- Directionality: Is an argument in favor or against the given base-statement?
- Relevance: How relevant is a participants statement related to the topic discussed?
- Acceptability: How acceptable is a statement?
- Distinctiveness: How specific is a statement?
- Rationality: How emotional/rational is a statement?
- Content-type: Which topic is addressed by the statement?

The main purpose of this instrument was to measure the applicability of students' knowledge. Would students be able to use new information in an argumentation task? Furthermore, would they make inferences and transfer new knowledge to this task?

Hypotheses

Hypothesis 1 - Structural knowledge: All groups were expected to enhance their topic-related structural knowledge as an effect of the respective treatment. Participants in the GBS-group who can create and develop their goals in interaction with the program were expected to develop a better model of the domain including correct representations of relationships between single concepts and a more coherent overview. In the two other groups we hypothesized no such advantage, as in the Strategy group learners generate goal but not necessarily the right ones and in the Tutorial condition the given goals were expected to provide a rather "isolated-facts"-view of the domain as opposed to the overall impression. The students participating in the Tutorial condition were not expected to generate their own goals while interacting with the program.

Hypothesis 2 - Fact-related knowledge: Here, we expect advantages for the Tutorial group. The task required students to recall single facts fostered by given learning objectives through the program. By providing clear goals they should have the highest amount of free cognitive resources for performance since there should be no overhead from building own goals as well as inferences or search strategies. We expect there to be a cognitive overhead for both of the other groups due to planning and evaluating the information search. The GBS condition was expected to lead to a significantly better recall of single facts compared to the Strategy group because single facts are a necessary prerequisite for understanding the overall model of the domain. It is part of the guided instruction of the GBS to understand events and explain why fact X and fact Y are part of a structure Z. Participants in the Strategy group were expected to have less intention to get an overall knowledge-base of factual knowledge.

Hypothesis 3 - Argumentation: All groups were expected to display a more ”sound” argumentation (Voss & Means, 1991) after the treatment. The GBS group was hypothesized to show a more sound argumentation than both other groups.

Hypothesis 4 - Motivation: Higher motivation was expected in the GBS-mode, while in the Tutorial and the Strategy-condition a decrease of motivation was anticipated. This decrease may result from the lack of challenge and the need of transferring the knowledge into an applicable situation in the Strategy condition. The one-sided learner control and lack of feedback relevant to learners' intentions will lead to an incoherent planning of learning goals. The one-sided program control in the Tutorial does not respect learners needs and intentions.

Results

Motivational parameters:

Participants' answers to the five motivational items on the rating scales which were scored from 1 (lowest) to 5 (highest). We tested the differences between the groups (with the non-parametric Kruskal-Wallis test) since the requirements for normal distributions were not met in every variable.

Comparing pretest values across the three experimental groups yielded no significant differences, with one exception: On the continuation item (”How much do you want to continue with this program?”), the tutorial group had a lower value than the other groups.

More interesting than the pretest values were the posttest scores. Testing of the one-sided hypothesis revealed significant higher values in the GBS-condition compared to both other groups. The GBS group was on the average more excited about their treatment and more willing to continue than the other two groups.

*** Insert Table 1 about here ***

There were no significant differences found between the Tutorial and the Strategy-group (overall and single items; see Table 1 for specific means). However, the GBS kept students’ motivation continually on a higher degree than the Tutorial (overall score; Kruskal-Wallis test: $H(1, N=40) = 4.15$, $p<.05$) and the Strategy group (Kruskal-Wallis test: $H(1, N=40) = 4.47$, $p<.05$).

Differences between pre- and posttest scores revealed that for the Tutorial group, there was a significant increase in feeling ”bored” (Wilcoxon: $Z=-3.23$, $p<.01$) and a corresponding decrease of the wish to continue working with the program (Wilcoxon: $Z=2.22$, $p<.05$). The overall motivation value for the Tutorial showed a significant decrease (Wilcoxon: $Z=2.37$, $p<.01$).

Participants in the Strategy group who worked with the pure hypertext showed a significant decrease in their scores of ”excitement” (Wilcoxon: $Z=2.73$, $p<.01$), ”duration” (Wilcoxon: $Z=2.83$, $p<.01$), ”continuation” (Wilcoxon: $Z=3.41$, $p<.001$), and in the overall value (Wilcoxon: $Z=3.38$, $p<.001$). In both groups, ”interest” in the subject matter did not change.

For the GBS group the results are quite different. No significant pre-posttest differences were found, indicating that motivation and interests did not change significantly over time – in particular, they did not decrease. An analysis of interaction between all groups showed further significant results (Kruskal-Wallis test: $H(2, N=60) = 4.74$, $p<.05$) in favor of this different trend for the GBS group (see Figure 2).

*** Insert Figure 2 about here ***

Structural knowledge

The concept maps constructed by the participants during pre- and posttest were scored with the following method. First, an ”expert” concept map was constructed, capturing all important relations between the twenty concepts. Then for each participants’ concept map an overlay index was calculated by coding each exact match between the relations of the participants' and the experts' map with a value of 1.0, and each acceptable, but not quite correct match with a value of 0.5. No penalty was administered for false relations.

There were no significant differences between groups in the pretest (see Table 2). In the posttest, the group means showed significant differences in the overall value (Kruskal-Wallis test: $H(2, N=60) = 6.01$, $p<.05$). The scores for correct, direct relation-matches showed significant differences between all groups (Kruskal-Wallis test: $H(2, N=60) = 4.06$, $p<.05$). With respect to the scores for acceptable relations, no significant differences were found (Kruskal-Wallis test: $H(2, N=60) = 0.29$, $p=.86$).

*** Insert Table 2 about here ***

A pre-posttest comparison showed significant gains in all groups (Tutorial: Wilcoxon, $Z=1.94$, $p<.05$; Strategy: Wilcoxon, $Z=2.57$, $p<.01$; GBS: Wilcoxon, $Z=3.92$, $p<.001$). Scores in the GBS group increased significantly more than in the Tutorial (Kruskal-Wallis test: $H(1, N=40) = 3.57$, $p<.05$) and in the Strategy-group (Kruskal-Wallis test ($H(1, N=40) = 3.74$, $p<.05$). The increase for the Strategy and the Tutorial-group was almost identical (Kruskal-Wallis test ($H(1, N=40) = .0007$, $p=.98$; see Figure 3).

*** insert Figure 3 about here ***

Fact-related knowledge

Answers given in the multiple-choice test had been coded with ”1” for correct and ”0” for wrong. Table 3 contains the resulting scores, attention needs to be paid to the fact that these are mean values for thematically defined groups of items. The difficulty of this test was computed with 0.4.

*** Insert Table 3 about here ***

These results show a consistently higher score for the Tutorial group. The other two groups did not display significant differences, with one exception for the category ”What is marine pollution?” (Kruskal-Wallis test: $H(1, N=40) =3.15$, $p<.05$). Group contrast showed significant differences between the Tutorial and Strategy condition in the categories ”Pollution of different seas.” (Kruskal-Wallis test: $H(1, N=40) =3.57$, $p<.05$), ”Newspaper articles on the oil tanker ‘Braer’” (Kruskal-Wallis test: $H(1, N=40) =2.88$, $p<.05$), ”Newspaper articles on the oil tanker ‘Sea Empress’” (Kruskal-Wallis test: $H(1, N=40) =6.29$, $p<.01$) and the overall mean (Kruskal-Wallis test: $H(1, N=40) =5.82$, $p<.01$). Contrast comparison of Tutorial vs. GBS-condition showed differences in ”What is oil?” (Kruskal-Wallis test: $H(1, N=40) =5.49$, $p<.01$), ”Shell and Brent Spar.” (Kruskal-Wallis test: H (1, N= 40) =5.33, p<.05) ”Newspaper articles on the oil tanker ‘Sea Empress’” (Kruskal-Wallis test: H (1, N= 40) =10.29, p<.001) and the resulting overall mean (Kruskal-Wallis test: H (1, N= 40) =8.73, p<.01).

Argumentation

Participants' statements from the pre- and posttest argumentation task were analyzed quantitatively (number of statements) with respect to their quality, their content and their relationship to other arguments. For the analysis of arguments, we used a coding scheme that incorporated elements from research on informal logic and argumentation theory (e.g., Toulmin, 1958), but mainly relied on categories developed in problem solving research considering informal reasoning by focusing on enthymemes (i.e. incomplete arguments; Voss et al., 1989; Voss and Means, 1991). Table 4 provides more details.

*** Insert Table 4 about here ***

Most of the categories in Table 4 required inferences from the side of the raters coding participants' statements. However, this is not really a problem because that is what informal argumentation is about: somebody bringing forth an argument should make sure that a ”neutral” person (here: the rater) would accept his argument as being relevant and sound. The agreement between two raters was computed for 36 randomly chosen propositions from all three conditions. Therefore we computed “intra-class”-correlation-coefficients according to Winer (1971) and Bortz and Döring (1995). The content-rated categories reached satisfying values for Acceptability ($r_1 = 0.82$; adjusted $r_k = 0.89$), Relevance ($r_1 = 0.71$; $r_k = 0.83$), Emotionality ($r_1 = 0.57$; $r_k = 0.73$) and Distinctiveness ($r_1 = 0.85$; $r_k = 0.92$).

In the pretest, no statistical differences in qualitative as well as quantitative measures were detected between groups. In the posttest, the GBS-group showed a significantly higher production of pro-arguments for the given statement compared to the other groups (H (2, N=60)= 5.02, p<.05). This is the main reason why the GBS-group also produced significantly more statements that referred directly to the provocative claim than the other groups (Kruskal-Wallis test: H (2, N=60)= 5.18, p<.05). Between the Tutorial and the Strategy condition no quantitative differences were found. With respect to scores for the quality of arguments, the GBS-group scored higher for soundness and relevance and was lower with respect to emotionality ratings (see Table 5).

*** Insert Table 5 about here ***

A more specific analysis of content-related statements showed a difference in the number of terms produced concerning the dimension ”other consequences of pollution” (Kruskal-Wallis test: H (2, N=60)= 7.19, p<.05; GBS>Strategy>Tutorial).

Regarding changes between pre- and posttest scores, there was a consistent trend in all groups towards higher scores in the posttest. This is true for both the number of arguments (Table 6) and the qualitative measures (Table 7).

*** Insert Table 6 about here ***

*** Insert Table 7 about here ***

There were no significant differences found in emotionality.

We also calculated some measures that described the structure of the argument tree, using graph-theoretical parameters (e.g. Weber, 1994). An ”Overlap-Index” using Formula 1[1]was computed in order to compare the similarity between the pre- and posttest argument tree:

*** Insert Formula 1 about here ***

With respect to this overlap index, no significant differences were found (Kruskal-Wallis test: H (2, N=60)= 1.18, p=.28; group specific means were $\bar{x}$=0.7 in the Strategy condition, $\bar{x}$=0.68 in the GBS condition and $\bar{x}$=0.58 in the Tutorial condition.

An additional measurement used to compare argument trees is the so called ”Balance-Index”. It shows the balance between pro and contra arguments and is computed according to Formula 2[2]:

*** Insert Formula 2 about here ***

For this index, only the GBS-group showed a significant change from pre- to posttest (Wilcoxon: Z= 3.05, p<.01). The GBS-group had a more balanced argument structure in the posttest.

Summary and Discussion

The empirical results in this study support findings of others that novice learners confronted with a new domain encounter serious problems when learning with pure hypertext. They have to get an idea of what to do with the information and how to build a coherent mental structure of the content. They have to generate a learning goal, search for missing information, evaluate the given facts and constantly check whether their goals or their general understanding is still valid. In our experiment we were able to show that a Goal-Based Scenario with integrated hypertext bases is best suited to use the advantages of this non-linear medium while at the same time minimizing the disadvantages. An authentic scenario with a given "mission" goal allows a highly interactive exchange between learner and program that supports general guidance and feedback without restricting learners' freedom in achieving the necessary skills and knowledge. This kind of interactivity provides students with the choice to develop their own subgoals. In contrast, in our Tutorial program students' choice has been limited to simple decisions that did not change the way of knowledge presentation. Our assumption was verified that the degree of choice in combination with a clearly challenging goal would be the most motivating condition.

Regarding knowledge acquisition we had the hypothesis that the combination of guided and self-directed learning in the GBS-group would be the most effective way of studying and finally understanding not only isolated facts but also their interrelationships and the nature of the entire system. We were able to show that the GBS-condition led to significantly better results in the dependent measure "Structural Knowledge" as assessed by a concept-mapping method. Although we expected participants in the Strategy condition to be superior in obtaining a structural overview of the domain, there was no significant difference to the Tutorial group. Participants in the Strategy condition had the knowledge about adequate strategies and the opportunity to employ them, but they did not make use of them in order to acquire and create global coherence. They had no clear conception of what to do with the information in the hypertext and may perhaps have been handicapped by cognitive overload.

As hypothesized, the Tutorial enhanced fact-related learning to a higher degree than both other conditions, while the GBS supported this kind of knowledge acquisition only marginally. The Tutorial can be seen as an adequate strategy to acquire factual knowledge. The structure of the lesson and the questioning combined with immediate feedback led participants into a fact-oriented knowledge acquisition style. Acquiring an overview of the topic did not seem necessary to the students in the Tutorial condition because it was not necessary in order to meet the given learning objectives. As this form of knowledge is important to understand relationships of concepts within the domain, the GBS-group performed well in this task as well. The Strategy-condition mislead students to work on single units separately instead of acquiring information about all available topics.

A main intention underlying the GBS treatment was to encourage students to generate their own hypotheses or subgoals and to evaluated them by using further information from the hypertext. In fact, students formulated new subgoals and engaged actively in the interaction with the program. Despite the critical-questions training the Strategy condition learners browsed through the hypertext-base, only randomly gathering information without any clear goal or assumption and without building systematic representations.

Finally, the results in the argumentation tasks partially support our hypothesis regarding transfer and the application of the freshly gained knowledge to a different context. The Strategy training did not lead to easily transferable knowledge. The lack of intentionality and the undirected browsing through the hypertext-base did not result in a broad knowledgebase by means of which such arguments could have been produced. The other two groups reached higher performance levels in the argumentation task. Although the GBS-group showed a better performance than the Tutorial group, this difference was not significant. We argue that a broad base of fact-related knowledge might be enough in order to develop a profound argumentation, however, additionally clear ideas or overviews about a domain lead to higher quality of arguments.

The results, taken together, show that it is possible to induced goals conducive to deeper knowledge acquisition by designing the environment “right”; learners don’t have to be given specific objectives from the outside (as in tutorials), nor do they have to be explicitly trained in goal induction (as in our Strategy condition). If the learning environment includes role play elements and allows for interaction, as was the case in our Goal-Based-Scenario-like condition, than in addition to cognitive effects motivation is comparatively high as well. This is not to say that strategy training is less preferable than providing a challenging environment. Before such a generalization can be made, further considerations need to be taken into account. For instance, we looked only into effectiveness, not efficiency: Given that strategy trainings can be developed which muss less effort than complete learning environments, that initial benefit may not justify the increased costs. Another, and psychologically more important problem is the transfer issue: Based on our study, we can not claim that learners who worked in the GBS condition will induce learning goals in situations where they are not provided with the elements of GBS. The effects of the strategy training may well transfer to other learning situations. In the words of Salomon, Perkins and Globerson (1991), distinguishing between learning *with* media and learning *from* media may proof crucial for our concerns as well. Learners may learn well with the GBS, but may not sufficiently internalize strategic knowledge in order to transfer to other learning situations.

What does this study suggest in terms of instructional implications? We think that hypertext as an isolated media is not adequate for teaching novice learners. More direct guidance is be necessary whenever students are confronted with entirely new domains, for example, at the beginning of a course in school or university. Effective learning with hypertext demands from learners to have a clear representation of learning goals.

Acknowledgements

This research has been supported by a grant of the German Science Foundation (DFG) to Peter Reimann (RE 814/9-2). We would like to thank Sabine Koch and Vernon Chaney for additional work on this paper.

Notes

[1] 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. 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).

[2] 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).

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Table 1: Motivational parameters (posttest)

Dimension	Kruskal-Wallis test	$\bar{x}$; σ Tutorial	$\bar{x}$; σ Strategy	$\bar{x}$; σ *GBS*
Interest	H (2, N= 60) = 0.83, p =.33	3.60; 0.99	3.65; 0.87	3.85; 0.77
Excitement	**H (2, N= 60) = 4.75, p <.05**	**3.35; 0.77**	**3.05; 0.37**	**3.50; 0.47**
Duration	**H (2, N= 60) = 5.99, p <.05**	**2.65; 1.19**	**3.10; 1,15**	**3.60; 1.20**
Fun	H (2, N= 60) = 2.88, p =.24	3.45; 0.99	3.50; 0.68	3.90; 0.41
Continuation	**H (2, N= 60) = 5.15, p <.05**	**3.10; 1.88**	**3.40; 1,31**	**4.00; 1.05**
OVERALL	**H (2, N= 60) = 5.82, p <.05**	**3.23; 0.71**	**3.34; 0.51**	**3.77; 0.38**

Table 2: Means and variances in the structural knowledge test

Category	$\bar{x}$ **Tutorial**	σ **Tutorial**	$\bar{x}$ **Strategy**	σ **Strategy**	$\bar{x}$ ***GBS***	σ ***GBS***
Exact Match	5.90	4.73	5.20	7.54	5.40	6.57
Acceptable Match	1.05	0.68	1.20	1.54	1.50	2.47
Overall value pretest	**6.55**	**3.97**	**5.80**	**5.56**	**6.15**	**5.45**
Exact Match	7.00	6.63	6.26	5.98	8.20	8.59
Acceptable Match	1.16	1.40	1.37	1.60	1.65	2.13
Overall value posttest	**7.58**	**7.30**	**6.95**	**4.76**	**9.03**	**6.83**

Table 3: Results regarding fact-related knowledge

Topic	$\bar{x}$; σ **Tutorial**	$\bar{x}$; σ **Strategy**	$\bar{x}$, σ ***GBS***	**Kruskal-Wallis Test**
What is marine pollution?	0.47; 0.034	0.41; 0.049	0.49; 0.028	H (2, N= 60) = 3.33, p =.09
What is oil?	**0.41; 0.033**	**0.33; 0.022**	**0.28; 0.026**	**H (2, N= 60) = 5.89, p <.05**
Pollution of different seas.	0.34; 0.036	0.22; 0.038	0.29; 0.020	H (2, N= 60) = 4.34, p =.05
Some newspaper-articles on oil catastrophes and particular tanker averages	0.33; 0.018	0.31; 0.035	0.26; 0.021	H (2, N= 60) = 1.82, p =.20
Newspaper articles on the oil tanker ”Braer”	0.60; 0.045	0.48; 0.052	0.55; 0.019	H (2, N= 60) = 3.75, p =.08
Newspaper articles on Shell and Brent Spar	**0.40; 0.044**	**0.33; 0.029**	**0.26; 0.019**	**H (2, N= 60) = 5.74, p <.05**
Newspaper articles on the oil tanker ”Sea Empress”	**0.68; 0.043**	**0.49; 0.039**	**0.46; 0.020**	**H (2, N= 60) = 11.37, p <.01**
Overall value	**0.46; 0.009**	**0.37; 0.014**	**0.37; 0.007**	**H (2, N= 60) = 9.67, p <.01**

Table 4: Coding of Participants' argumentation

Form of Classification	Description	Values
Status	Time statement has been generated.	Before treatment. After treatment. A both times.
Pro/Con	Is the statement supporting a claim or is it critical about a claim	”Pro” and ”Con”
Relevance	How relevant is a statement related to the given hypothesis, i.e., to which extent is the statement to the point?	“1” (not relevant) to “5” (very relevant).
Acceptability	How acceptable is a statement? (Acceptability, relevance and balance [see below] are indicators for soundness of arguments according to Voss and Means, 1991)	“1” (not acceptable) to “5” (very acceptable).
Distinctiveness	How specific is a statement?	“1” (global statement) to “5” (very specific statement).
Emotionality	How emotional/rational is a statement?	“1” (very rational) to “5” (very emotional).
Content specific domain	Which topic is addressed by the statement?	Consequences for the environment. Other consequences (e. g. economic). Protecting the environment. Causes of pollution. Something else.

Table 5: Qualitative differences in argumentation

Qualitative Description	$\bar{x}$ **Tutorial**	$\bar{x}$ **Strategy**	$\bar{x}$ ***GBS***	**Kruskal-Wallis Test**	**Significant relation**
Acceptability	3.11	2.67	3.43	(H (2, N= 60) = 8.53, **p<.01**)	*GBS* > Strategy
Relevance	3.08	2.81	3.44	H (2, N= 60) = 6.50. **p <.05**)	*GBS* > Strategy
Emotionality	2.12	1.96	1.42	(H (2, N= 60) = 9.19, **p <.01**)	*GBS* < *Tutorial* *GBS* < Strategy
Distinctiveness	2.79	2.68	2.77	(H (2, N= 60) = 0.61, p =.36)	n. s.

Table 6: Differences in number of arguments in pre- and posttest

Category	**Group**	**Wilcoxon (N=20)**	
		Z	**P**
Supporting statements	Tutorial	1.73	**<.05**
	Strategy	3.18	**<.001**
	GBS	3.72	**<.001**
Rejecting statements	Tutorial	3.3	**<.001**
	Strategy	3.35	**<.001**
	GBS	3.21	**<.001**
Overall value	Tutorial	3.03	**<.01**
	Strategy	3.72	**<.001**
	GBS	3.82	**<.001**

Table 7: Qualitative differences in argumentation in pre- and posttest

Category	**Group**	**Wilcoxon (N=20)**	
		Z	**P**
Acceptance	Tutorial	3.29	**<.001**
	Strategy	3.64	**<.001**
	GBS	3.14	**<.001**
Relevance	Tutorial	3.31	**<.001**
	Strategy	3.22	**<.001**
	GBS	3.10	**<.001**
Distinctiveness	Tutorial	2.21	**<.05**
	Strategy	2.80	**<.01**
	GBS	3.10	**<.001**

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Figure 1: Argumentation-Editor.

Given statement: Oil tanker accidents are no danger!	
Pros	**Cons**
1. S‘s statement 1.1 Example for 1. 1.2 A second detail 2. Statement 2 2.1 Example 3.	1. S‘s statement 1.1 Example for 1. 1.2 A second detail 2. Statement 2 2.1 Example 2.2 ...

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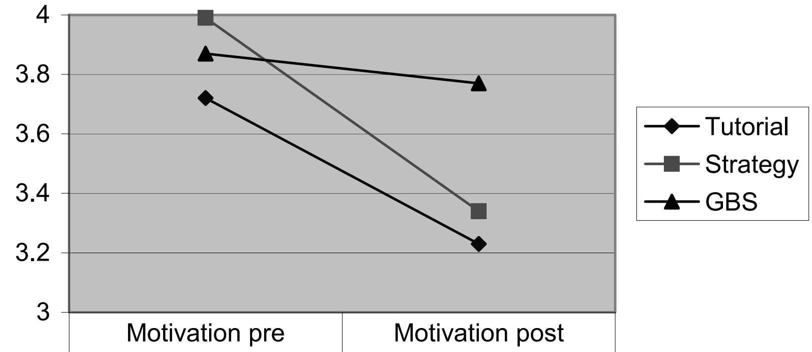
Figure 2: Motivational parameters (means).



	Motivation pre	Motivation post
Tutorial	3.72	3.23
Strategy	3.99	3.34
GBS	3.87	3.77

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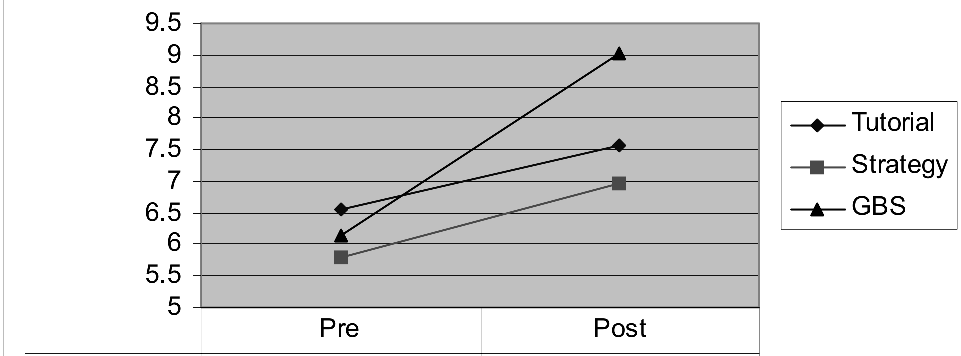
Figure 3: Group means in structural knowledge test.



	Pre	Post
Tutorial	6.55	7.58
Strategy	5.8	6.95
GBS	6.15	9.03

Formula 1: Overlap-Index.

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

Formula 2: Balance-Index.

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