DESIGNING AN INTERNET BROWSER THAT FACILITATES STUDENTS’ LEARNING

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Abstract

This thesis consists of two parts. The first part reports on a literature study about different aspects of internet use, their importance, and which of them can use improvement. Aspects that appear to be essential for effective learning, include the use of self-regulatory processes, a focus on the product of internet use, and the use of knowledge about specific strategies and patterns of internet use. Students’ learning can be facilitated by supporting them with respect to these aspects. An important point to note, is that this support not necessarily consists of explicit tutoring; it can also be accomplished by developing better tools to access the internet.

The second part of this thesis takes the first part’s findings to a more practical level, discussing the idea of developing a modular, document-based application architecture, and using this architecture as a research platform for examining functions to facilitate learning. The key claim I pose, is that using a document-based application architecture can play a prominent role in facilitating students’ learning, because it fits onto our current knowledge about student’s internet use and learning.

Samenvatting

Deze thesis bestaat uit twee delen. Het eerste deel bespreekt een literatuurstudie naar welke aspecten van internetgebruik belangrijk zijn en welke hiervan verbetering kunnen gebruiken. Hieronder vallen het gebruik van zelf-regulerende processen, de aandacht voor het produkt van internetgebruik en het gebruik van kennis betreffende specifieke strategieën en gedragspatronen. Het leren van scholieren kan verbeterd worden door ze te ondersteunen met betrekking tot deze aspecten. Hierbij is het belangrijk op te merken, dat dit niet noodzakelijk extra begeleiding door docenten vereist; het kan ook gedaan kan worden door middel van het ontwikkelen van betere programmatuur.

Het tweede deel van deze thesis telt de bevindingen van het eerste deel naar een meer praktisch niveau. Het behandelt het idee een modulaire, document-gebaseerde applicatie architectuur te ontwikkelen voor gebruik in een onderzoeksplatform. In dit platform kunnen dan functies onderzocht worden, die het leren van scholieren kunnen verbeteren. Mijn belangrijkste stelling is dat het gebruik van een document-gebaseerde applicatie architectuur een belangrijke rol kan spelen in de verbetering van hoe scholieren leren, omdat het aansluit op onze huidige kennis over hun leren en hun internetgebruik.
Chapter 1

Introduction

The internet plays an increasingly important role in today’s classrooms. Internet use has become one of the primary sources of information, partly replacing traditional learning material, such as books. Students are increasingly expected to use the internet effectively for the information they need. This causes the success of learning to become heavily dependent on the extent to which the skill of effective internet use is mastered, just like learning from books depends on the skill to read. As a consequence, in the past couple of years, it has become clear that extra educational attention to the use of internet itself is needed. But how can students be helped to use the internet effectively?

Different approaches to this task have been taken, nearly always focusing on explicit tutoring, which asks for extension or adjustment of the curriculum. In this thesis a different approach is discussed, which focuses on the tools that are used to access the internet. This approach exploits the fact that the internet can be accessed in many ways, and that the way it is accessed greatly influences the effects of internet use.

The purpose of this thesis is twofold. First, it gives an overview of the theoretical background that is relevant for designing an internet browser that facilitates students’ learning. I will report on a literature study about different aspects of internet use, their importance, and which of them can use improvement. This first part, which constitutes chapter 2, on the one hand stands on its own; it can be read independently from the rest of the thesis. It is both the most theoretical as well as the most general part. The second part on the other hand, which constitutes chapter 3, builds onto the theory of the first. It presents the idea of developing a modular, document-based application architecture, and using this architecture as a research platform for examining functions to facilitate learning. The key claim I will pose, is that making an internet browser document-based makes sense given our current knowledge of students’ internet use, and that it can have a prominent role in facilitating students’ learning.
Chapter 2
Learning by Using the Internet

In this chapter the theoretical background for designing an internet browser that facilitates students’ learning is discussed. Although this discussion largely abstracts from the actual role of an internet browser, the choice of aspects to discuss and the manner in which they are discussed, is greatly influenced by the ultimate goal of developing such a browser.

This chapter consists of the following sections: Section 2.1 serves as a preparation for sections 2.2 through 2.5, explaining the domain, used terms, aim, and working method of this thesis. Section 2.2 stresses the importance of self-regulated learning and metacognition. Section 2.3 suggests that greater focus is needed on the product to which internet use leads. Section 2.4 discusses different behavioral patterns, how these relate to highly qualitative and effective internet use, and how knowledge about these patterns can be used to advantage. Section 2.5 summarizes the most important findings. And section 2.6 concludes with some comments on future research.

2.1 Preparation

In this section I will make clear what the domain of this thesis is, how terms are interpreted, what exactly my aim is, and what working method I will use.

2.1.1 Restrictions

In this thesis a particular type of internet use is considered, namely that in which the user’s intention is to learn something specific. By “specific”, I mean that the user knows what has to be learned, for example the answer to a certain question, the meaning of a certain concept, or information about a certain topic. Notice how this contrasts with ‘randomly browsing and looking around’ (which is fairly common practice). This restriction I will call the restriction to effectivity, and its relevance for this thesis will become clear later on.

Another restriction concerns the type of users. There is great diversity in the ways people use the internet and the motives they have for using it, which makes it hard to discuss the use of internet in its completeness. Therefore I will confine the discussion to students. This focus appears to be justifiable, because the use of internet plays an increasingly important role in learning by students, and in education the restriction to effectivity is particular suitable.
2.1.2 Definitions of Criteria for Internet Use

In this thesis, the use of internet is considered as being aimed at learning, so we should also consider the effect of learning. Because learning is “the acquisition of knowledge or skills through experience, practice, or study, or being taught” (Oxford American Dictionaries), this effect of learning concerns newly acquired knowledge or skills. Besides this effect – which I will call the direct effect, because it directly influences the user – internet use has another important effect: found information may be made available for later use. I will call this the indirect effect, because it can influence the user only via information carriers in his environment (e.g. notes, bookmarks). The definition for the effect of internet use I will use is:

- **Effect of internet use**: The influence of internet use on the state of the user himself and of information carriers in his environment.

But the main focus is more restricted: Regarding “the state of the user himself”, we are especially interested in his knowledge and skills. And regarding “information carriers in his environment”, we are especially interested in how they can provide the user with knowledge.

Thus examples of the effect of internet use are to remember what has been found, or to have adjusted ones opinions (both direct), have information stored to disk, or have it written on paper (both indirect).

In addition to the effect of internet use itself, it is important how it is achieved. Preferably it costs the least amount of time possible, is fun, and does not cause any frustration. Other relevant characteristics can be identified, but I will only consider these three, because I believe they are the most important. In referring to these characteristics, I will use the following definition:

- **Quality of internet use**: The degree to which achieving the effect of internet use costs the least amount of time possible, is fun, and does not cause any frustration.

Notice that – according to their definitions – the effect and quality of internet use do not overlap; quality of internet use does not include the effect and the effect of internet use stands apart from how it is achieved. One can expect them to correlate, though.

2.1.3 Aim

To find out how an internet browser can help to improve the effect and quality of internet use, this chapter tries to answer the following question:

*On which aspects of internet use does its effect and quality depend, and – given the current situation – which of these aspects can use improvement?*
The second part of this question (which aspects can use improvement) serves to emphasize the focus on practical use. It expresses the relevance of aspects which cause suboptimal effect and quality, because knowledge about these causes is useful to improve learning.

My aim is not nearly to give a complete overview of effect- and quality-related aspects. By focusing on what appears to be readily improvable, I hope to underpin a few of the possible suggestions for improving learning by use of the internet.

2.1.4 Working Method

Internet use is quite a complex process. All kinds of subprocesses, levels of processing, and types of patterns, strategies, methods, and users can be identified. This causes most studies to focus on certain aspects of internet use, for example only a certain subprocess, or a certain level of processing. Therefore understanding internet use in its completeness asks for combining findings of several studies.

Combining studies does complicate our task in a couple of ways:

1. Studies approach internet use from different perspectives. Although this provides us with more information, it also makes it more difficult to compare and combine findings. For example, one study could focus on observable actions while the other focusses on underlying processes. This dissimilarity relates to different goals, which have to be projected onto one goal, that is, the goal of this chapter.

2. Studies use different terms and models to understand and describe internet use. This complicates the task of being consistent, clear, and specific.

To deal with these difficulties, in the next section I will present an overview of my interpretation of relevant terms, levels, and relations. This should help to use terms consistently without deviating from the use of terms in the original articles. Furthermore it should help make clear on what each study focuses.

2.1.5 Clarification of Used Terms and Relations

The purpose of this section is threefold:

1. Make clear the interpretation of used terms.

2. Make clear the interpretation of relations between the concepts these terms represent.

3. Express different levels of abstraction.

Figure 1 depicts the collection of most important concepts, which concepts relate to each other, and to which level of abstraction they belong.
A relation exists between connected concepts. This relation can be of different types. For example, the relation between process and behavior is causal: processes lead to behavior. The relation between behavior and elementary action is compositional: behavior consists of elementary actions. The interpretation of the depicted terms (and their relations) I will use, is as follows:

- **Elementary action**: An isolated, observable interaction between the user and the world, for example clicking a link, or taking a note.

- **Pattern**: A combination of elementary actions that show a recurrent structure with certain characteristics.

- **Behavior**: All observable interactions between the user and the world.

- **Strategy**: A plan of action of the user, which is a result of cognitive processes by the user, and which leads to behavior.

- **Cognitive process**: A mental process of any kind, such as planning, making choices, but also processing of incoming information, emotion processes, etc. This can be either conscious or not.

- **Metaprocess**: A process that is part of metacognition (see section 2.2.1). A metaprocess is heavily influenced by the goals of the user, and to a large extent controls other processes. An example of a metaprocess is reflection upon one’s own thinking.

- **Goal**: A characteristic of the result of internet use the user desires. This can influence processes both direct as well as via metaprocesses.
• **User:** The user is influenced by the world, he has goals, and in him processes take place.

• **World:** Of which everything is part, such as the user and his behavior. Besides the concepts that are depicted, the world also contains everything else, such as the used tools, and information carriers such as note blocks.

### 2.2 Self-Regulated Learning and Metacognition

When students use the internet to learn, they usually do this by themselves. They have to regulate their own learning, for example by setting goals, making plans, and self-evaluate. This causes us to speak of self-regulated learning (SRL), about which a lot of research recently has been done. Findings of this research show how self-regulatory processes lead to success in school, and should be helpful in answering our question. This section first discusses the article of Zimmerman (2002) about SRL, with the aim to stress the importance of SRL, describe the structure and function of its processes, and come up with methods for improving its application. Then I will discuss Roger's study (2001 and 2004) about the applicability of a model of SRL to internet use.

#### 2.2.1 Importance of Self-Regulated Learning and Metacognition

Zimmerman discusses student’s self-regulation as a way to compensate for their individual differences in learning. This approach originates from the late 1970s and early 1980s, in which a new perspective on student’s individual differences began to emerge: “Students’ deficiencies in learning were attributed to a lack of metacognitive awareness of personal limitations and an inability to compensate.” Metacognition is defined as the awareness and understanding of one’s own thought processes (Oxford American Dictionaries).

Examples of effects that justified this new perspective, were that students who set specific and proximal goals for themselves displayed superior achievement, or that even only asking students to self-record some aspect of their learning led to ‘spontaneous’ improvements in functioning (Shapiro, 1984, in Zimmerman, 2002). The degree to which this kind of effects plays a role is hard to determine, but researchers as well as educationalists should realize (and more and more they do realize) the potential of improving learning by focusing on metacognitive processes. These key self-regulatory processes include:

“(a) setting specific proximal goals for oneself, (b) adopting powerful strategies for attaining the goals, (c) monitoring one’s performance selectively for signs of progress, (d) restructuring one’s physical and social
context to make it compatible with one’s goals, (e) managing one’s time use efficiently, (f) self-evaluating one’s methods, (g) attributing causation to results, and (h) adapting future methods.” (Schunk & Zimmerman, 1994; 1998, in Zimmerman, 2002)

The level of learning has been found to “vary based on the presence or absence of these key self-regulatory processes ” (Schunk & Zimmerman, 1994; 1998, in Zimmerman, 2002). Later on I will get back to some of these processes.

Furthermore it is important to appreciate the role of self-regulation in the development of lifelong learning skills. The processes that will be needed to perform newly presented tasks – for which one often does not explicitly learn – heavily depend on the ability to self-regulate, and the metaprocesses that make self-regulation possible. With better developed high-level processes, one can more easily adapt to new tasks, because it causes low-level processes to be more flexible and adjustable.

A third argument for the importance of high-quality self-regulatory processes concerns their relation to a student’s motivation. Motivation plays a crucial role in SRL, because the initiative has to come from the student. Unfortunately, a lack of motivation is not rare, and interest is easily lost. According to Zimmerman, “the motivation of novices can be greatly enhanced when and if they use high-quality self-regulatory processes, such as close self-monitoring.” If a student notices his progress in learning, his level of self-satisfaction will increase, as well as the belief in his efficacy to perform at a high level of skill (Schunk, 1983, in Zimmerman, 2002). Zimmerman states:

“Clearly, their motivation does not stem from the task itself, but rather from their use of self-regulatory processes, such as self-monitoring, and the effects of these processes on their self-beliefs.” (Schunk & Zimmerman, 1994; 1998, in Zimmerman, 2002)

2.2.2 Structure and Function of Self-Regulatory Processes

To give a clearer idea of the structure and function of SRL, Zimmerman discusses the phases and processes of SRL that are identified by social learning psychologists. These include the forethought phase, consisting of processes that occur before efforts to learn, the performance phase, consisting of processes that occur during behavioral implementation, and self-reflection, consisting of processes that occur after each learning effort. I will discuss the most relevant of these processes shortly.

- Forethought phase: The two major classes of the forethought phase processes are task analysis and self-motivation. The former involves goal setting and strategic planning. The latter concerns beliefs about learning, such as the belief in self-efficacy, or the belief in certain consequences of learning.
• **Performance phase:** The two major classes of the performance phase processes are self-control and self-observation. The former involves the deployment of methods or strategies, for example the use of imagery, self-instruction, attention focusing, and task strategies. The latter, self-observation, involves self-recording personal events or self-experimentation to find out the cause of events.

• **Self-reflection phase:** The two major classes of the self-reflection phase processes are self-judgement and self-reaction. Self-judgement involves comparing performance against some standard, and attributing one’s errors or successes to certain causes. Self-reaction involves changes in feeling – for example an increase in self-satisfaction – as well as adaptive or defensive responses, such as modifying an ineffective learning strategy (adaptive), or dropping a course (defensive).

This short summary of relevant processes stresses the complexity of SRL: its effectiveness depends on a great number of processes. This means that there are several possible causes of unsuccessful learning, and that learning could be improvable in multiple different ways.

Zimmerman describes the differences between experts and novices in terms of these phases and processes. An example of these differences is that “novices fail to engage in high-quality forethought and instead attempt to self-regulate their learning reactively,” while experts “set hierarchical goals for themselves with process goals leading to outcome goals in succession”. Another difference is that “learners who make comparative self-evaluations are prompted to attribute causation to ability deficiencies …, and this will produce lower personal satisfaction and prompt defensive reactions,” while experts “self-evaluate their performance against their personal goals rather than other learners’ performance.” Knowledge about these differences can be exploited to support unsuccessful learners.

### 2.2.3 Teaching Students to Become Self-Regulated Learners

Despite of the first word of his article’s title, “Becoming a self-regulated learner: an overview”, Zimmerman does not get into details about how to improve the application of self-regulatory processes. He states that “research on the quality and quantity of students’ use of self-regulatory processes has revealed high correlations with academic achievement track placement as well as with performance on standardized test scores” (Zimmerman & Martinez-Pons, 1986, in Zimmerman, 2004) and that “recent research shows that self-regulatory processes are teachable and can lead to increases in student’s motivation and achievement” (Schunk & Zimmerman, 1998, in Zimmerman, 2004). But the only concrete suggestions for helping students to become self-regulated learners are rather minimal:
1. Give them choices regarding academic tasks to pursue, the methods they use, or the partners they study with.

2. Encourage them to establish specific goals for their academic work.

3. Teach explicit study strategies.

4. Ask to self-evaluate their work or estimate their competence on new tasks.

5. Assess their beliefs about learning, such as self-efficacy perceptions or causal attributions.

These suggestions can be helpful in facilitating students’ learning when they use the internet, but they do not directly fill in with the aim of this chapter. They all concern curricular methods, while this thesis focuses on the tools that are used to access the internet. Thus the question becomes: how do the used tools relate to these suggestions?

Each of Zimmerman’s suggestions contains a verb – give, encourage, teach, ask, assess – which denotes actions that teachers should perform. But of course it’s not these actions themselves that are the goal, but the effects they are aimed at. For example, students should be asked to self-evaluate their work in order to make them self-evaluate their work. However, a situation in which students self-evaluate their work may also be created in some other way, without explicitly asking students to. In doing this, one has to take into account that it is more probable that students self-evaluate if they:

1. Know what self-evaluation is,

2. Know its use,

3. Know a method to do it,

4. Can easily perform this method,

5. Find this method effective, and

6. Like to use this method.

About the same holds for Zimmerman’s other suggestions.

Factors like the six above strongly depend on the student’s working environment, of which – in the case of internet use – the used tools are a central part. Thus by designing the proper tools, one may raise the probability of students to self-evaluate, or more generally: one can hopefully raise the probability of students to behave like good self-regulated learners.
2.2.4 Practical Validation of the Relevance of Self-Regulated Learning for Internet Use

Although learning by use of the internet clearly is a form of SRL, it may differ from the way SRL traditionally is viewed. For example, because of the internet’s complex structure it may be harder to attribute causation to results, or to set goals for oneself. Therefore it could be more important that those processes take place effectively. Or it could be less important because of a lack of feasibility, namely when those processes can not take place effectively. Obviously, to validate the applicability of theories of SRL to internet use, results from real world studies about internet use are needed. In this section Rogers and Swan’s study (2001) about the applicability of Corno and Mandinach’s self-regulation model (1983) to searching the internet is discussed. This study confirms the importance of high-quality self-regulation, and the differences between users in the way they use the internet to learn.

Unfortunately, Corno takes a different perspective on SRL than the one discussed in previous sections. She defines cognitive engagement as interactions of two processes: acquisition and transformation. During information processing, the acquisition process metacognitively controls the transformation process. The relative degrees to which these two processes take place correspond to four forms of cognitive engagement, of which the one with both processes taking place to a high degree is labeled self-regulation. Corno divides the transformation process into the following subprocesses:

- **Selectivity**: Discriminating among stimuli, and distinguishing relevant from irrelevant information.

- **Connecting**: Searching for familiar knowledge, and linking familiar knowledge to incoming information.

- **Planning**: Organizing a task approach sequence or performance routine.

And she divides the acquisition process into the following, transformation-regulating processes:

- **Alertness**: Receiving incoming stimuli, and tracking and gathering information.

- **Monitoring**: Continuous tracking of stimuli and transformations, researching, planning, and self-checking.

In my opinion this perspective, in which acquisition metacognitively regulates transformation, is not very logical. For example, I do not see how the receiving of incoming stimuli regulates any of the transformation processes; it only precedes them, or is a prerequisite for those other processes to take place. Besides, it not clearly concerns metacognition – the awareness and understanding of one’s own thought processes.
Despite of this criticism, I believe Rogers’ study to be compatible with the view of SRL presented earlier. The main difference seems to be that Corno and Mandinach’s self-regulation model tries to describe the interaction between lower and higher level processes in terms of observable behavior. This makes the model easier to bring into practice, but also causes it to miss the target of describing the underlying processes. This observable behavior may, though, suffice to investigate the application of higher-level, metacognitive processes. One can, for example, expect the receiving of incoming stimuli to be an indicator of self-motivation, because it is a sign of alertness and alertness is a result of motivation. Actually, the measurement of higher-level processes thus is the measurement of lower-level processes, even actions, which – given the difficulty of direct measurement of cognitive processes – is inevitable. This brings up the task of finding the actions that indicate the application of certain processes. I will presume the correctness of the coding that Rogers used to map actions onto processes, but I realize this is not very well founded and therefore forms a weak point of this thesis.

Rogers let 80 undergraduate students, ranging in age from 19 to 25 years, perform one of eight internet tasks. During performance their behavior was observed and coded into one of five categories, corresponding to the processes of the model. The frequencies then were counted and analyzed. Rogers concludes:

“The findings ... support the conceptual independence of the two processes of acquisition and transformation and so support the efficacy of the Corno and Mandinach model of forms of cognitive engagement for identifying self-regulation in the process of gathering information from the internet.” (Rogers, 2001)

She also performed an agglomerative cluster analysis of the data and looked for congruence of groupings with the four forms of cognitive engagement. She found a natural breaking point of four, with each cluster corresponding to one form of cognitive engagement. This confirms the applicability of the Corno and Mandinach model of SRL to internet searching. And more importantly, it confirms, or at least indicates, the applicability of SRL theory to internet use in general.

2.2.5 Recommendations about Student Learning

In a more recent article (Rogers, 2004) about her study as discussed in the previous section, Rogers gives “curricular and instructional recommendations for accomplishing and supporting student learning in both internet searches and regulation of their own searching behaviors.” She describes different search patterns, and gives concrete suggestions for facilitating students’ learning. I will not discuss the six search patterns she observed, because behavioral patterns will be extensively discussed in section 2.4, based on a study of Guinee (2003). Instead I will summarize the most rele-
vant of her ideas about high-quality SRL. Rogers’ recommendations fall into three categories – pre-search activities, specific strategies and patterns, and post-task reflection – which correspond to Zimmerman’s three phases of SRL. I will only discuss the first two categories, because I consider these most relevant for this thesis:

1. **Pre-search activities**: Before starting to search the internet, it would be useful if students thought a bit about the vocabulary associated with their subject. For example, students could make a concept map of the various meanings associated with individual words, so they would learn which search phrases to use. Another useful pre-search activity would be to model and discuss the ways in which searches are initiated (Rogers does not go into detail about how this could be done).

2. **Specific strategies and patterns**: In her discussion of the different behavioral patterns that subjects displayed, Rogers repeatedly stresses the importance of combining selecting processes (discriminating among stimuli, and distinguishing relevant from irrelevant information) and connecting processes (searching for familiar knowledge, and linking familiar knowledge to incoming information; see section 2.2.4). “Students determine the relevancy of new information by recognizing elements from previous knowledge. In internet searching, links pursued as relevant must be evaluated in the context of the task and previous information acquired.” To successfully combine these processes, she thinks that students should be “summarizing and developing their own integration of ideas,” using split screens to compare and contrast information, and performing tasks like taking notes and reading for content nearly simultaneously.

One can question what exactly these findings are based on. Rogers bridges the gap between observations and conclusions by means of an interpretation that can be considered speculative. I believe it to be very reasonable though, especially because it fits in with the ideas about SRL presented earlier. Just like with other forms of learning – for example from printed media – stressing the importance of activities like discussing strategies, comparing information, and taking notes, makes sense.

### 2.3 Focusing on the Product

To make clear the central point of this section, in section 2.3.1 I will take another perspective on the task of learning by use of the internet. This perspective will fit nicely on the definition of effect of internet use given in section 2.1.2. (Actually the definition is based on this perspective, so this is no miracle). In section 2.3.2 I will discuss the role of an internet browser in a particular part of this task, namely the retaining of found information, and in section 2.3.3 I will discuss the relation with SRL and metacognition (section 2.2).
2.3.1 Information Gathering: Search, Find, and Retain

Learning by use of the internet generally involves the gathering and processing of information. A student has a certain need for information, therefore accesses the internet, searches for the information, hopefully finds it, and if he does, then does something with it. This section is about the hypothesis that most present-day browsers do not function optimally with respect to that last step: doing something with the found information. One has to take into account that the gathering of information by use of the internet consists of two parts:

1. Searching and finding of relevant information, which includes navigating and interpreting of information.

2. Retaining of information. Finding information only has an effect if found information will be remembered by the user, is being stored to disk, is being printed out, or is being made available for later use in any other way.

2.3.2 The Role of an Internet Browser in Retaining Information

Despite of the necessity of the second part, internet browsers generally seem to focus on the first part: the delivery of information. Of course some common functions concern the second part, like saving, bookmarking, and printing of internet pages, and a history of visited pages. But I think this is rather minimal. For example, the structuring of information with respect to a certain task is completely left to the user. If one is working on a project and wants to store different kinds of found information – like images, fragments of text, and whole pages –, and wants to structure them – maybe fitting them in a hierarchy, or adding comments –, one has to leave the browser and make use of other applications. Some people, for example, make a special directory for their task and store all kinds of information to it: images, pages, text. Other people put everything into one text document, including images and hyperlinks. Of course one does not fully depend on the computer; some people write things down on paper, or tell them to their friends and hope they will remember. These behaviors seem to suffice most of the time, but I believe them to have the following disadvantages:

1. They cost an unnecessary great amount of work.

2. Users may be focused on the possibilities the browser provides and therefore not even consider the use of such options.

3. They require certain skills, such as the use of other applications, or switching between applications. Users might not have these skills.
4. Even if people successfully perform such actions, the result probably does not give a clear overview of the found information. For example, if one stores a number of files to disk, these files have to be opened separately to show what they contain.

5. The result can have any structure and thus lacks consistency. This makes it harder to be interpreted by someone else, or at a later moment.

I think that these disadvantages can be decreased by means of an internet browser that plays a more prominent role in the retaining of found information, both helping to store it and to structure it. My expectation is that this could make the task of retaining found information – and thus obtaining the desired effect of internet use – easier and quicker to perform. Not less important, I believe that it could make it more likely that users perform the actions that are necessary to retain information, because they become more apparent and readily available. Last, I think that browsers could help raise the consistency of structure and the accessibility of retained information.

For a successful shift of focus to the retaining of found information (the focus of students as well as developers and researchers), I think it would be useful to approach internet use not merely as doing something, but rather as making something, thus focusing on its product. How this can be realized will be discussed in chapter 3.

2.3.3 Relation with Metacognition and Self-Regulated Learning

Up till now, I have discussed self-regulation and focusing on the product independently; but actually they are strongly interdependent. More focus on the product of internet use might stimulate and help the use of different kinds of self-regulating processes in several ways:

1. Forethought phase – task analysis – goal setting: A more concrete idea about what the product can be, makes it easier to think of what the effect of internet use should be. Ideas about possible components of the eventual product can be thought of as building blocks for setting a goal. For example, if the product will consist of a number of stored sites, along with ratings, one could want the product to contain at least three sites with ratings of four out of five. It should be noted that goal setting can take place implicitly: by imagining what the result of internet use can be, one often is setting goals automatically. To successfully perform this imagination, one mentally needs to grasp certain useful ideas about possibilities and their meanings. In this process, components of a product might function as grips, which make grasping easier.
2. Performance phase – self-control – the deployment of methods or strategies: If an internet browser supports in making a product, then the number of deployable methods and strategies increases. Or at least they could become easier to deploy. For example, if it is easier to store fragments of text, the strategy of first storing a lot of fragments and at a later moment selecting the most relevant ones, becomes easier to deploy; especially if the browser also can give an overview of the fragments, showing where they come from and when they were added. (Of course there is also a drawback on having more possibilities.)

3. Performance phase – self-observation – self-recording of personal events and self-experimentation: If a browser can show a user the result of his work so far, it helps in keeping an eye on how things are proceeding. It could also, for example, give information about time spent, thereby supporting the comparison of different strategies.

4. Self-reflection phase – self-judgement – comparing performance and attributing errors and successes to causes: This is comparable to the previous point, only this one is relevant afterwards. If using an internet browser results in a product, the result of efforts becomes more concrete and observable. Furthermore, a browser could give information about the way the product was made, thus helping the user to attribute errors and successes to causes. For example, it could show a map of visited pages and followed links, highlighting the pages that have become part of the product. On such a map a user can see which choices (starting points or followed paths) led to success (useful components of the product).

5. Self-reflection phase – self-reaction – changes in feeling: For example, the user's degree of self-satisfaction might increase, if he sees and feels glad about the product of his efforts.

Another important advantage has to do with the level of processing. If the user actively takes part in making a product, one can expect him to be more cognitively engaged, process information at a deeper level, and therefore remember more of it. This relates to ideas found in constructionism, which uses “building, constructing, and knowledge-representing as central metaphors for a new elaboration of the old idea of learning by doing rather than by being told” (Harel & Papert, 1990).

In chapter 3 it will become more clear how focusing on the product can be achieved by giving the browser a document-based application structure.

2.4 Strategies and Patterns of Internet Use

The subjects of the two previous sections – self-regulated learning, and focusing on the product – had a relatively high level of abstraction, namely the level of processes
and metaprocesses. This section descends in level of abstraction, describing different possible strategies and action patterns, and how these relate to the quality and effect of internet use.

According to the interpretation presented in section 2.1.5, strategies are unobservable – they are a user’s plans –, while action patterns are observable – they consist of observable actions. Another difference (or another way to view the difference) is that strategies give rise to behavior, while patterns are part of behavior. Despite the difference, I will discuss strategies and patterns simultaneously, because they are interconnected to a large degree: action patterns are a reflection of strategies, and have corresponding characteristics. For example, if one uses the strategy of revisiting pages often, this results in a pattern of actions with at least one important corresponding characteristic: often revisiting of pages. But we should not forget that there is no one-to-one relation:

1. Behavior depends on more than just strategies; strategies are plans of action – of which the user is aware –, but of course the user is not aware of everything that determines his behavior.

2. The actual behavior does not have to correspond to the intended behavior; execution of a plan can fail, and cause behavior to differ from the intended strategy.

3. Strategies are more general than actions. For example, strategies can prescribe action sequences for a wide range of possible situations, while eventually only a number of these sequences will be performed.

Although the most obvious question would be what strategies are best to deploy, I will focus on behavioral patterns and not go into much detail about strategies. The reason for this is that behavior is easier to research, and knowledge about the desired behavior should still help to realize it. With respect to the three points mentioned in the previous paragraph, I believe that:

1. A user can be aware of and plan the most important characteristics of his behavior, and the influence of strategies thus is substantial.

2. The biggest difficulty does not lie within the execution of plans, but in the planning itself, and the influence of wrongly executed plans thus can be ignored.

3. The fact that a certain situation occurs, makes it more likely that this situation is likely to occur. The most important aspects of strategies (aspects that determine action sequences that not only are prescribed, but also executed) thus can be expected to be tested earliest.

I will first discuss research about the different behavioral patterns that internet users exhibit, namely Guinee’s study (2003) about internet search strategies (in the litera-
ture often no clear difference between strategies and behavioral patterns is made). The goal of this is to get an idea of the patterns that students’ internet use show, how often these different patterns occur, in what kind of users they do, and which of them lead to success. Then I will discuss how knowledge about behavioral patterns might be used to model, or even influence a user’s behavior, and how this relates to SRL.

2.4.1 Internet Search Strategies

The goal of Guinee’s study was to evaluate and describe the internet search strategies of adolescent learners. According to the way I have described terms though, it only concerns behavioral patterns. She focused on the following three subtasks: 1) locating information; 2) constructing search strings; and 3) recovering from unsuccessful search attempts.

Guinee let 132 eight graders, with a mean age of about 13.8 years and experience in computer use, conduct two internet search tasks. Firstly, they had to answer questions like “how many actors have played James Bond?” Secondly, she let them perform an internet-based research project in the course of several weeks, collecting information about their personal hero and presenting it in a poster or slide show. The used browser tool was eTrekker (Grogan et al., 2000, in Guinee, 2003), which is developed by the Center for Applied Special Technology to provide scaffolding for students as they plan, search, and organize internet inquiries. I will discuss the results briefly, focusing on the most relevant ones:

1. Locating information: Three patterns were found:

1.1. Dot-com formula: Many students substituted their research topic into the formula “www.myTopic.com”. This now and then works, but more often it does not. Reason for this is that web sites are created by companies or individuals, and they therefore do not represent research topics.

1.2. Shopping mall: More experienced users can take advantage of the categorical structure of the internet, starting their search from a site with a broad range of information. For example, one might know a site about the category of information to which desired information belongs, and search further from there. In this approach problems arise when a student does not know where to start, or starts at the wrong place.

1.3. Search engine: When students could not think of a site to start their search, they often used search engines. Success of this strategy depends on the use of effective keywords, which is discussed in the next paragraph.
2. *Constructing search strings*: Seven patterns in the construction of search strings were found, of which some appear to be more useful than others:

2.1. Single term: In 43.7% of their search attempts, students submitted their broad research topic to the search engine.

2.2. Topic + focus: 37.0% Of attempts consisted of a combination of two terms, a topic and a focus. The effectiveness of this method was shown by a negative correlation between its use and the overall number of search attempts.

2.3. Multiple terms: Students used more than two terms in only 27.7% of attempts, although it often is even more effective than the topic + focus method.

2.4. Phrase: In 42.1% of attempts students used a phrase like “actors that played James Bond”. This method is less effective than discrete term methods.

2.5. Question: 31.8% Of search attempts consisted of a complete question, such as “how many actors played James Bond?”

2.6. Combination: 19.9% Consisted of a combination of discrete term and natural language methods such as phrases or questions, for example “James Bond + number of actors.”

2.7. Repeated concept: In 32.8% of attempts students used a term multiple times, for example “James Bond + James Bond actors.”

3. *Recovering from unsuccessful search attempts*: Four patterns in recovering from unsuccessful search attempts were observed:

3.1. Switching topics: Many students seem to “take a reactive stance to searching the internet, re-framing their inquiries around what can be easily found.” This can be considered dysfunctional if information about the original subject is available, but the student did not find it due to his poor choice of keywords. If information is not available, and deviating from the original subject does not cause any problems, it can be considered an adaptive technique.

3.2. Visiting additional web sites: Most students enter several sites a search engine comes up with, sometimes continuing well beyond the first twenty results. Whether this is useful depends on the used search string. More experienced users check the relevancy of found sites by reading their descriptions, before they enter one. Another characteristic of more advanced internet use is trying a new search if the obtained results do not seem relevant.

3.3. Trying new keywords: It can be very effective to substitute synonyms or variations, narrow or broaden the focus, or check keyword spelling. This does require computer-speak though: “the ability to anticipate what words or phrases
will appear on a relevant web page and the knowledge of how a search engine will process search strings.”

3.4. Changing search engines: This can be useful if another search engine better fits one’s search needs, for example because of the domain, or because of the way results are organized. But again, if not finding the appropriate information is a result of the use of poor keywords, switching search engines will not help.

A few comments are in place here:

1. The used subjects are quite young; one can doubt if the same holds for older students.

2. The statements about usefulness of behavioral patterns can be questioned, because the study is not really experimental. An example of how this can lead to wrong conclusions, is the following: The authors state that the collected data “suggest that repeating concepts within a search attempt is not an efficient search method, as using higher percentages of repeated concepts was associated with making more scavenger hunt search attempts.” But actually the use of repeated concepts can not have any consequences; the phrase “James Bond + actors” returns exactly the same results as “James Bond + James Bond actors”. The found correlation must have had another cause: worse searchers more likely make the mistake of using useless keywords, such as repeated concepts.

3. Which patterns occur depends on the used tools, search engines, and tasks (which, of course, is inevitable).

Nevertheless, this study gives a useful indication of the structure in adolescents’ internet use, and how it varies. In the next section, I will mainly discuss behavioral patterns in general, letting the discussed patterns only function as examples.

2.4.2 Using Knowledge about Behavioral Patterns

In facilitating students’ internet use, the role of knowledge about behavioral patterns is twofold:

1. A student can use knowledge about his behavior to improve it. Insight in behavioral patterns plays an important role in metacognition and self-regulatory processes, because it relates to insight in both important characteristics of behavior, and how these relate to successes and errors.

2. Knowledge about a student’s behavior can be used by someone or something else to describe his behavior, model it, or provide support for it. This can be done by a teacher, but also by the used tools. For example, an internet browser could make use of user modeling to support the student in learning.
Guinee confirms the importance of knowledge about behavioral patterns:

“Students need to become more metacognitive about their searching so they understand what makes a successful or unsuccessful search. This involves learning to recognize the patterns of unsuccessful searches and to apply techniques for transitioning to more effective ones, such as trying new keywords or search engines.”

Just like with SRL, it is important to appreciate the role of the environment in raising the probability that students develop knowledge about behavioral patterns, and that they use that knowledge to improve their learning (see section 2.2.3).

2.5 Conclusions

Summarizing the previous sections, the answer to our question (on which aspects of internet use does its effect and quality depend, and – given the current situation – which of these aspects can use improvement?) consists of three aspects:

1. The presence or absence of self-regulatory processes strongly influences the level of learning, and plays an especially important role in the development of lifelong learning skills, and in a student’s motivation. The application of self-regulatory processes – like task analysis and self-motivation during the forethought phase, self-control and self-observation during the performance phase, and self-judgement and self-reaction during self-reflection – should be stimulated to support successful learning. I believe that in order to do this, tools can be designed that raise the probability that students know these self-regulatory processes, their use, and methods that are associated with them; that they can easily perform these methods, find them effective, and like to use them. Furthermore, relevancy judgement and comparing of information play a prominent role in effective gathering of information. Ideally, students summarize and develop their own integration of ideas, combining selecting and connecting processes.

2. Greater focus on the product of internet use is needed. Retaining found information is an essential part of information gathering, but in the current situation, it is not well supported. It would be useful to approach internet use not merely as doing something, but rather as making something, so that the focus on the product automatically increases. I think that an internet browser could and should help to store and structure found information, thereby making it easier and quicker to obtain a high effect of internet use. Greater focus on the product also stimulates and helps the use of different kinds of self-regulatory processes. Besides, it results in higher cognitive engagement and deeper processing of information. Both direct and indirect effects of internet use depend on focusing on the product.
3. Knowledge about behavioral patterns – for example with regard to locating information, constructing search strings, or recovering from unsuccessful search attempts – can be exploited in several ways. On the one hand, a student can use it to improve his behavior; this is strongly related to metacognition and self-regulating learning. On the other hand, someone or something else, for example the internet browser, can use it to describe, model, or give tips about the student’s behavior, thereby supporting him in learning. Again, I believe that by means of the environment the probability that students reflect upon their own action and that they develop insight in behavior and consequences, can be raised.

2.6 Future Research

Based on these findings, an internet browser can be developed that in a higher degree facilitates students’ learning. To understand what functionality this browser exactly should exhibit, future research should try to answer the following questions:

• What functionality can stimulate and support the use of self-regulatory processes?

• How can students and developers be stimulated to focus on the product of internet use?

• How can a browser help to store and structure information?

• And how can knowledge about behavioral patterns be collected and used to advantage?

To answer these questions, I propose that a modular research platform will be developed, in which new functionality can be tested. In this platform it should be easy to add new functions, test how they work in practice, and test if they facilitate learning. This way we can determine more easily which functionality fits best onto our current knowledge about student’s learning and internet use, and optimally supports students in learning by use of the internet.

In the next chapter I will convey the point that this research platform should be document-based.
Chapter 3

Document-Based Internet Browsers

The next question to answer, is what functionality a browser should exhibit to optimally facilitate students’ learning. In this chapter I will give a partial answer to this question. I will discuss the idea of making internet browsers document-based, and try to convey the point that document-basedness can play a prominent role in facilitating learning.

The previous chapter concluded with the proposal to develop a research platform in which new functionality can be tested, and to give this platform a modular architecture, so it would be easy to add new functionality. Document-basedness however, does not concern such an easy to add function; it is a fundamental application architecture characteristic, and thus – like modularity – has to incorporated in the application’s design from the beginning on. I therefore will propose to give the research platform a document-based application architecture.

In the first three sections I will abstract from this goal of developing a document-based research platform, and discuss the idea of document-based internet browsers in general. In the last section, Future Research, I will come back to the idea of developing a document-based research platform.

Section 3.1 discusses what a document-based application architecture is, and what it means to use one. Section 3.2 discusses advantages of a document-based internet browser, relating it to findings of chapter 2. Section 3.3 presents a prototype internet browser with a document-based application architecture. And section 3.4 concludes with some comments on future research.

3.1 Document-Based Application Architecture

Although the word “document” is not uncommon in computer jargon, the meaning of “document-based” has proven not to be self-evident. It is quite an abstract term; but I will try to keep the discussion of its meaning as concrete as possible. I will do this by giving examples of document-based applications, comparing document-based internet browsers to other document-based applications, and picturing a scenario of typical use of a document-based internet browser. But first I will discuss what a document-based application architecture is according to the Apple Developer site.
3.1.1 What a Document-Based Application Architecture Is

Of all descriptions of document-based applications I have come across, I found the one on the Apple Developer site the most clear and complete:

“A document-based application is one of the more common types of applications. It provides a framework for generating identically contained but uniquely composed sets of data that can be stored in files. Word processors and spreadsheet applications are two examples of document-based applications. Document-based applications do the following things:

• Create new documents.
• Open existing documents that are stored in files.
• Save documents under user-designated names and locations.
• Revert to saved documents.
• Close documents (usually after prompting the user to save edited documents).
• Print documents and allow the page layout to be modified.
• Represent data of different types internally.
• Monitor and set the document’s edited status and validate menu items.
• Manage document windows, including setting the window titles.
• Handle application and window delegation methods (such as when the application terminates).” (Apple Developer site)

This description is about the document-based application architecture that is used in Apple’s own application environment, Cocoa, but it also applies to document-based applications in general. I would like to add the following characteristics:

1. In a document-based application the user can work on several documents in parallel. That is, multiple documents can be opened simultaneously, which normally do not influence one another.

2. After a document is saved to disk, it can be opened at any later moment. It will then be in exactly the same state as prior to saving, and the user can continue working on it.

The document itself can be described as follows:

“Conceptually, a document is a container for a body of information identified by a name under which it is stored in a disk file. In this sense, however, the document is not the same as the file but is an object in memory that owns and manages the document data.” (Apple Developer site)
Note the word “object”, which indicates the appliance to an object-oriented programming environment; more generally, the document can be any data structure in memory. The continuation of this description applies specifically to the context of the Application Kit, which is one of the standard frameworks of Cocoa. I give this description instead of a more general one, because it is concrete and therefore probably easier to understand:

“... a document is an instance of a custom NSDocument subclass that knows how to represent internally, in one or more formats, persistent data that is displayed in windows. A document can read that data from a file and write it to a file. It is also the first-responder target for many menu commands related to documents, such as Save, Revert, and Print. A document manages its window’s edited status and is set up to perform undo and redo operations. When a window is closing, the document is asked before the window delegate to approve the closing.” (Apple Developer site)

For readers who are not familiar with object oriented programming, the above description might be hocus pocus, but the main thing to extract from it, is that a document is responsible for everything that needs to be done with the contents of a certain file: representing it, displaying it in windows, changing it, et-cetera.

### 3.1.2 Examples of Document-Based Applications

First, let us consider word processors. Most word processors are document-based. This seems to be reasonable, because they handle the electronic counterpart of paper documents. Despite of this similarity, a word processor not necessarily is document-based. According to the previous section’s description, if it does not generate “identically contained but uniquely composed sets of data”, and identifies those sets by names under which they are stored in disk files, it is not a document-based application. So even if a text editor provides the ability to print (and thus produce paper documents), it does not have to be document-based; for example because it stores all data (text) in one and the same file. An example of such a word processor is the application Stickies, “for putting Post-it note-like windows on the screen, with short reminders, notes and other clippings” (Wikipedia). This example serves to illustrate that not the resemblance to paper documents is what makes an application document-based, but the way in which data are handled.

The phrase “identically contained but uniquely composed sets of data” implies that a document-based application can generate multiple sets. Furthermore, those sets have to be similar in some respect – mainly in structure – (a word processor’s documents could, for example, always contain page lay-out settings, such as borders, and a body
of text), and dissimilar in some other respects (for example different page lay-out settings per document).

A less obvious type of document-based applications, but one which shares important characteristics with document-based internet browsers, are project-based programming environments. Consider Xcode as an example. In Xcode you work in projects, which are “repositories for all of the information needed to build one or more software products” (Apple Developer site). These projects are documents. Their contents point to files – which are documents themselves – and alongside represent all information necessary to ‘glue things together’. This example illustrates several things:

1. A document can represent something more complex and more abstract than paper documents.

2. Not everything that is part of the document has to be completely stored in the associated file. For example, in case of source files, only references are stored. Because source files also can function as documents, a document thus can point to and make use of other documents.

In the next section these two examples of document-based applications will be compared to a document-based internet browser.

3.1.3 How a Document-Based Internet Browser would Work

Because there currently are no document-based internet browsers (as far as I know), after only having read the previous two sections, it might still be difficult to picture how one would work in practice. To make things more concrete and easier to understand, in this section I will compare a document-based browser to other kinds of document-based applications. Subsequently, I will picture a scenario of typical use of a document-based internet browser.

In the previous section it was mentioned that a word processor document bears great resemblance to a physical document. The same kind of analogy can be drawn for documents of a document-based internet browser. This analogy is not as as strong as in the case of word processors, but it does help to picture what documents of a document-based browser are. Suppose you are gathering information about a certain subject (without using a computer). You read the newspapers and a couple of magazines, in search of interesting articles. You cut out anything that might be useful, and put it aside. Furthermore, you go to the library and copy some pages of some books. You keep all this together along with your own notes, tidily put in an archive. Then this archive – including its contents – is the physical counterpart of an internet browser document. Just like this archive, an internet browser document can contain
multiple sources of information, of different kinds. It can contain information found at different locations, and also information you have made yourself.

An important difference between such an archive and an internet browser document though, is that the latter can be much more dynamic. It is, for example, possible to only store the address of a certain internet page, which would mean that the document changes if the internet page changes. Furthermore, the kinds of information and the relations between different sources of information are not equal. In this sense, an internet browser document bears greater resemblance to programming projects (such as discussed in the previous section).

Just like in case of a programming project, an internet browser document has a key role in integrally controlling the performance of a certain task, in the case of the browser the gathering of information. It constitutes an instrument to manage everything that is associated with this task. Anticipating on the next section, about advantages of such a browser, a document-based browser thereby makes it easier to group things according to the tasks they are associated with.

To make things more concrete, consider the following scenario, which should give an idea of how a document-based internet browser would be used in practice. It is not about specific details – because these can differ between different document-based browsers –, but about the overall way of working. The basic assumption is that a user wants to gather information about a certain subject.

First of all, the user opens the browser, or if it already is open, creates a new document. In the window that appears, internet content can be viewed, just like in any other browser. It contains an address bar, buttons to go to the previous or next page, et-cetera. In other parts of the same window the contents of the document can be viewed and/or edited: a history of visited pages, links to relevant images, notes, or whatever other data that could possibly be stored. If the user, for example, wants to store a certain internet page, he clicks on a button and the page becomes part of the document in which he is working. If he makes a note, it also becomes part of the document. More general: whatever is done, it is done in a certain document, and whatever the effect, it affects only the document. The consequence is that all data become associated with one document or another. By using one document per task, data are automatically grouped per task. These task-associated documents can be stored, copied, transferred, shared, and be changed at any later moment.

In the next section I will discuss the advantages of a document-based internet browser, relating it to findings of chapter 2.
3.2 Advantages of Document-Basedness

Making an internet browser document-based has advantages that are related to each of chapter 2’s three main parts:

1. Self-regulated learning (SRL) and metacognition (section 2.2),
2. Focusing on the product (section 2.3), and

I will not discuss these points separately, because they are strongly interconnected. Instead, I will sum up what advantages I believe a document-based browser to have, and at each point indicate to which of the three parts it is related. I will divide these advantages in three classes, which are: 1. Focus on the product, 2. Framework, and 3. Integral control management. The discussion of the last class is the most extensive one, and is therefore further subdivided in: 3.1. Structuring found information, 3.2. Adding one’s own information, and 3.3. Patterns of internet use.

1. Focus on the product: Making a browser document-based constitutes quite a different approach to the use of internet from the traditional one, because it means that internet use becomes the construction of something, namely a document of found information. In this it connects to the main idea of section 2.3, which was that the focus of both developers and users should shift to the product of internet use. A greater focus on the product could make the retaining of found information (see section 2.3.1) easier and quicker to perform. Partly because of this, and partly as a direct result of greater focus on the product, the retaining of found information would also become more likely to occur (section 2.3.2). An example of how a document-based browser could play a role in this, is an interface object that helps to easily store pages, text, or images (for example by dragging and dropping).

Furthermore, a greater focus on the product can stimulate the use of high quality self-regulatory processes, as discussed in section 2.3.3. These processes are important for a high level of learning, the development of lifelong learning skills, and a student’s motivation (section 2.2.1).

2. Framework: The previous point was about the relation with the second part of information gathering, namely the retaining of information (section 2.3.1). But making a browser document-based does also relate to the first part: searching for and finding relevant information. A document forms a framework in which information can be stored, but also from which information can be extended, connected, judged, compared, and contrasted. This connects to Rogers’ recommendations about student learning (section 2.2.5). Rogers stresses the importance of
combining selecting processes and connecting processes, and thinks that students should be “summarizing and developing their own integration of ideas.” A document can function as the appropriate instrument to do this, because it can contain multiple types of information and be used to view them: previously acquired information, the student’s own knowledge (e.g. notes or graphs), and newly found information. Furthermore, information can easily be grouped according to the task it is associated with (section 3.1.3).

3. **Integral control management**: The remaining advantages that I will discuss, concern functionality which in theory can be realized in any type of browser, but which is much easier and more suitable to implement in a document-based browser. The reason is that a document functions as an instrument to manage everything that is associated to one task. Because information contained by one document can be expected to belong together, the domain for performing certain tasks is clearer than in non-document-based browsers. In other words: a document functions as the logical place for performing certain tasks, because it defines a domain for those tasks. In the following tasks this can be used to advantage:

3.1. **Structuring found information**: One important function that most current internet browsers are missing, is in helping to structure found information. Structuring information can have several advantages, such as a deeper level of processing by the user (section 2.3.3), and a product that is easier to interpret (section 2.3.2). This also relates to the previous point, about Rogers’ recommendations about student learning.

For example, if you would want to make it possible to store pages into a tree-like hierarchy, it would help to have a document-based architecture. Each document could function as the ancestor of pages that are stored while working in the document. Inside the document, further subdivisions could be made, for example by the use of folder-like structures. The other way around (up in the hierarchy), the place of a document between its siblings, and under its parent, would be handled by the file-system (which also uses folders and sub-folders). In figure 2 an example of this structure is depicted. To differentiate between file-system folders and folders inside documents, the corresponding images are mirrored.
Figure 2: Hierarchy inside and outside of documents

Of course such a tree-like structure can also be made by merely using the file system, by adding some extra folders and storing information in separate files. But this has a lot of disadvantages. Most importantly, the supported functionality to structure information would not be specialized for the task at hand: internet browsing. See section 2.3.2 for a more elaborate discussion of the advantages of structured documents above nested folders.

Other ways to structure information could be offered as well, such as mind mapping. Furthermore, it could be possible to switch dynamically between different ways of structuring and viewing information. And the document could automatically manage and update information.
3.2. *Adding one's own information:* This point can be seen as an extension of the second point, *Framework*. In addition to information that has been found on the internet, a document might contain other information, such as notes, labels, and ratings. A browser in which found information not only can be stored and structured, but also extended with extra information, forms an appropriate platform to develop one's own integration of ideas (section 2.2.5). Options for relevancy judgement for example, could make it easier to remember the relevancy of pages. Besides, they could stimulate the deployment of relevancy judgement, simply because they afford a way to do it (section 2.2.3). The same holds for comparing information: a browser could give options that help to compare information, for example by showing different pages side by side. Again, a document-based application architecture would make it easier to realize this kind of function, because documents afford a logical place to do it.

3.3. *Patterns of internet use:* As discussed in section 2.4, with regard to behavioral patterns a browser can fulfill two roles:

1. It can stimulate students to self-reflect and develop insight in their behavior, and in its consequences.

2. It can describe, model, or give tips about students' behavior.

Fulfilling the first role could partly be realized by what already is described in point 1, *Focus on the product:* a greater focus on the product can stimulate the use of high quality self-regulatory processes. Most obviously, to self-reflect, it helps if there is something concrete to reflect upon, namely a document. Moreover, in case of a document-based application architecture, other efforts to help fulfill one or both of these roles could take advantage of the following facts:

1. All behavior can be tracked and stored inside of a document in which the behavior takes place.

2. All behavior in one document can be expected to 'belong together': and be associated to the same task.

3. A document can function as the logical place to show/view behavior and its consequences (descriptions of it, models of it, or tips about it).

Obviously, the discussed advantages partly overlap, and a different partitioning could have been made. Nevertheless, I hope that this summary makes clear why I believe a document-based application architecture to be beneficial. The next section will shed some more light on how all this relates to practice.
3.3 An Internet Browser Prototype

In this section I will discuss the prototype internet browser that I have implemented: Mnemonic. The goal of implementing this prototype was threefold:

1. To test what unforeseen difficulties lie within the design and implementation of a document-based internet browser.
2. To test how working with a document-based browser feels like, and if it fits my expectations.
3. To be able to show other people in an easy and practical manner what a document-based browser is and how it works.

My goal was not to develop a fully functional internet browser, that is: a browser with all functionality one normally expects a browser to have. For example, Mnemonic supports neither download management nor indication of loaded resources; every other browser does, but for Mnemonic’s purpose I did not consider it to be essential. These and other differences between Mnemonic and other internet browsers make it, for the present, hard to compare how document-based and non-document-based browsers work in practice. Therefore I think this is a task best left for future research. I will come back to this in section 3.5.

In section 3.3.1 I will discuss the tools and techniques used to develop Mnemonic. In section 3.3.2 I will present Mnemonic itself, discussing its user interface and main functionality. Section 3.3.3 concludes with an evaluation of how Mnemonic fulfills its goal.

3.3.1 Technical Details

Mnemonic is a cocoa-application written in objective-C. Cocoa is an object-oriented application environment designed for Mac OS X, which helps to create user friendly applications easily and quickly. Its user interface is defined in two files, made with apple’s Interface Builder (Interface builder). These files are called nib files. One nib file declares the objects that are necessary to instantiate a document. The other declares all other objects, such as the menu bar. Mnemonic makes use of three frameworks: the two standard cocoa frameworks, Foundation Kit and Application Kit, and the Web Kit, which “provides a set of core classes to display web content in windows, and by default, implements features such as following links clicked by the user” (Web kit objective-c programming guide). Furthermore, Mnemonic’s application architecture is based on the Model-View-Controller design pattern (Cocoa fundamentals guide), which classifies objects according to three possible roles: encapsulating data and basic behavior (model objects), interacting with the user...
(view objects), or intermediating between model and view objects (controller objects). To effectively propagate information through objects, Mnemonic makes extensive use of binding technology, which is a “collection of technologies that reduces the code dependencies between models, views, and controllers, automatically synchronizing views when models change.” (Cocoa bindings reference)

3.3.2 Functioning

As said in the introduction of section 3.3, Mnemonic is not meant to be a fully functional internet browser. Besides, the functionality it does provide, not yet takes optimal advantage of our current knowledge about students’ learning by using the internet, or more specifically: of the findings of chapter 2. Despite of its suboptimal functioning, Mnemonic fulfills its purpose; how a document-based browser can be developed best, is a question I do not yet try to answer.

Figure 3 shows a documents’ window when the document has just been created. The window consists of three parts:

1. At the top is the toolbar, which contains the address bar, and buttons for the most important functions.
2. On the left is the web-view.
3. On the right is the special view, in which different kinds of document-related information can be displayed. This view is recognizable by its blue bar at the top.

Both the web-view and the special view can be hidden, in which case the other view takes up all available space.
By using the group of five buttons at the right-hand side of the toolbar, or through the menu, different kinds of document-related information can be displayed. Currently implemented information types are:

- **Overview of Entries**: Entries are internet pages with associated information, such as names, addresses, icons, comments, labels, ratings, and dates of creation. (See figure 4.) The upper part of this special view contains a table of all entries. Entries can quickly be revisited by using the small buttons in the left column of this table. The lower part contains a number of tabs with information about the selected entry, such as a preview of the site, and comments about the site.

- **General Comments**: These comments are not associated with any internet site. Multiple comments can be made, given names, collapsed, uncollapsed, and changed in size. (See figure 5.) In contrast with entries, these comments are an example of information that is not related to any internet site.

- **Images**: Images can be stored, along with their source. (See figure 6.) They can be given names, the dates of creation are stored, and via a button next to their address they can be viewed in their original context. Contrary to figures 4 and 5, in figure 6 the web view is hidden. This is just to show different options; if the web-
view is hidden does not depend on the displayed kind of document-related information.

Document History: Gives an overview of the pages visited while working in the current document. (See figure 7.) By clicking a row, a page can be revisited.

General Info: Gives information about the number of entries, general comments, images, visited pages, and label types. (See figure 8.)

Figure 4: Overview entries

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The remaining application-specific buttons in the toolbar can be used to do the following:

- Switch between three different viewing modes: web only, standard, or special only. The standard view consists of both the web-view and the special view, with a small split-bar between them to distribute the available space.

- Add the current page to the overview of entries.

- Drop images to store them. This way images can still easily be stored if the special view is hidden (if it is not hidden, images can be dropped anywhere on the special view to store them).

The last two buttons, on the right-hand sight of the toolbar, are standard buttons to change fonts and colors.

Figure 9 shows all functions that are available via the menu bar. Their names speak for themselves, except for the menu item “Edit Labels”. This item brings up a little window (figure 10), in which items of the label-menu (used to label entries, as shown in figure 4) can be added, changed, and removed.
Figure 9: Menu bar functions

Figure 10: Labels entries panel

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3.3.3 Evaluation

The goal of implementing Mnemonic was threefold:

1. To test what unforeseen difficulties lie within the design and implementation of a document-based internet browser.

2. To test how working with a document-based browser feels like, and if it fits my expectations.

3. To be able to show other people in an easy and practical manner what a document-based browser is and how it works.

About the second and third subgoal I can be very short, so I will discuss these first. My discussion of the first subgoal will be more extensive.

2. To test how working with a document-based browser feels like, and if it fits my expectations.

What can I say? I have used it, have ‘felt’ it, and I have to say that it exceeded my expectations. Using it felt far more natural than I had expected, and I was surprised by my own contentment about what I had ‘made part of my documents’. Of course my opinion is not very objective, and of course I have the advantage of exactly knowing how Mnemonic works, so we will have to wait for future research to reveal how other people experience working with document-based internet browsers.

3. To be able to show other people in an easy and practical manner what a document-based browser is and how it works.

This purpose Mnemonic only fulfills partly. On the one hand, Mnemonic exhibits functionality which anybody can understand (e.g. rating of internet pages), and which a lot of people consider useful. Furthermore, the majority of people understands that opening and saving of documents is very different from how things work in regular internet browsers. On the other hand, not many people agree that working with Mnemonic is fundamentally different, which I think it is. The fact that this is a very difficult point to convey, is the most evident insight I have come to develop as a result of showing people Mnemonic. The consequences of this will be discussed in the following paragraphs.

1. To test what unforeseen difficulties lie within the design and implementation of a document-based internet browser.

In its essence, implementing a document-based internet browser appears to be pretty straight-forward. I made use of the Xcode project template *Cocoa Document-based Application*, which already implements the opening and saving of
multiple documents (although they do not yet have content), their windows, and the foundation for standard functionality, such as undo management. The global architecture this template provides, did not need any adjustments. This indicates that an internet browser globally can have the same architecture as standard document-based applications.

One of the main design tasks, is to divide the available space over ‘things to be shown’ (which I from now on will call views). Because I found it essential that extra functionality did not go at the expense of original functionality, I wanted it to be very easy for the user to only view the web, hiding everything else. Therefore it seemed logical to put everything else than the web-view, the address bar, and a few buttons, together in one, easily hidable view (the special view). In this view different types of information (or technically: different sub-views) can be accessed with a tab-like system (the group of five buttons in the toolbar). This approach works fine for Mnemonic, but for the design of a more extensive document-based internet browser it will not suffice; if a larger number of views becomes available, it does not provide enough structuring to keep things clear and accessible. Therefore it will be necessary to reconsider the viability of this approach – to fit as much extra functionality as possible into one view – and probably it will be better to come up with a more complex solution. For example, the use of extra windows should be considered.

As a result of extended functionality, a number of other difficulties arises as well. First, although documents afford a way to store information, it is not desirable to store all information in documents. For example, a bookmarked dictionary, or a bookmarked search engine, should be available from any document and thus not be stored inside a document. The user rather should have the possibility to store them globally, that is: in a place where the application can access it directly. This distinction between document- and application-related information is found in any document-based application (e.g. document names versus application preferences), but in the case of document-based internet browsers it presents a problem: because the type of information is the same on different levels, it becomes harder for the user to keep the two apart. The same problem holds for histories: documents should contain their own history of visited pages, but a global history should also be available.

The same kind of difficulty exists at a lower level, namely on the level of document-related versus page-related information. For example, in Mnemonic the user can make comments that are related to certain internet pages (in the lower part of Overview of Entries), but he can also make comments that are not related to specific pages (in General Comments). Again: it should be clear to the
user what information is associated to what. And again: this is extra difficult to accomplish, because the type of information can be the same on different levels.

Another difficulty lies in the way information can be stored. There basically are two possible ways: store the information itself, or only store a reference to it (for example an internet address). Both ways have advantages and disadvantages: only storing a reference is very easy to do, but because of the speed at which the internet changes, content which the user intends to preserve may change or even disappear. Storing the information itself guarantees that it stays unchanged, but it also costs more time and disk-space. I think the most desirable solution would be that references are stored in whatever situation, and that the user decides if the information itself is stored as well; and if so, the user should be able to access both the original information as well as the information to which the stored reference points. But how should this functionality be afforded in an easy and understandable way?

This is the kind of questions for which smart solutions still have to be found. A document-based architecture makes it appealing to add all kinds of functionality, but this should not happen at the expense of usability.

Even if a document-based browser's functional structure is very intuitive, logical, clean, recognizable, and whatever more, the question remains if people will know how to use it. This certainly should be doubted; not because of the difficulties discussed so far – which are consequences of a document-based architecture –, but because of the document-basedness itself. People simply are not used to document-based internet browsers. So chances are high that they will try to use them as if they are regular internet browsers. To tackle this problem, two approaches can be taken. The first approach is to explicitly teach students how to use a document-based browser. But as mentioned in the introduction, explicit tutoring is exactly what I want to avoid! The other, preferable approach is to design a document-based internet browser in such way that students will automatically and gradually learn to understand its functioning, just by using it. Of course this is a very hard task, which I not even have begun to execute. But because of the possibilities a document-based architecture provides, I think it would be worth trying.

Last, let me stress that whether learning really can be facilitated by means of a document-based internet browser depends on the extent to which its functioning takes advantage of the possibilities that a document-based architecture affords. For example, adjusting to such a different browser may only pay off if the user can structure information in a very intuitive way. In the next section, about future research, I will raise a number of questions concerning the optimal exploitation of a document-based application architecture.
3.4 Future Research

The previous chapter concluded with the proposal that a modular research platform is developed in which new functionality can be tested. This should help us to understand what functionality an internet browser exactly should exhibit to optimally facilitate students’ learning.

In this chapter I have practice anticipated on this task, namely by trying to convey the point that making internet browsers document-based can play a prominent role in facilitating learning. We can not yet test in practice the truth of this statement, but I believe that – given the findings of chapter 2 – it is a suitable and valuable approach.

Unfortunately, document-basedness is not something you can add to an application later on; it has to incorporated in the application’s design from the beginning on. Therefore, if we are going to develop a research platform, we have to decide if we make it document-based or not. To help make this decision, we could first try to make a ‘normal’ document-based internet browser (one which not yet can be used as a research platform) and test it in practice. But I think this way we would not be giving document-basedness a fair chance. The reason for this is the following:

As said in the previous section, wether learning really can be facilitated by means of a document-based internet browser depends on the extent to which its functioning takes advantage of the possibilities that a document-based architecture affords. Because we do not yet know how to optimally take advantage of these possibilities, our first attempts to build document-based internet browsers would probably fail to prove the advantages (as does Mnemonic). Before we can get real insight in how document-based internet browsers work in practice, different things should be tried out. We simply do not yet know a lot about document-based internet browsers.

Therefore I propose to take a chance and give our research platform a document-based application architecture. As said earlier, I think there is enough reason to believe that in the end it will be beneficial. But how should this platform be composed? Besides incorporating modularity, the platform’s design should handle the difficulties discussed in the evaluation of Mnemonic (section 3.3.3). Thus the following questions should be answered:

- What is the best way to structure a document-based browser’s functionality?

- How can the difference between document- and application-related information best be made clear to the user?

- How can the difference between document- and page-related information best be made clear to the user?
• What is the best way to let users choose if only the reference to a page is stored, or also the page itself? And what is the best way to let them choose between following a stored reference to a page, or accessing the original, stored version of the page?

• How can students be helped to understand the document-based approach and way of working? Or how can they be stimulated to find out?

Once a research platform is developed which resolves these difficulties (or affords possibilities to resolve them) and lets researchers and developers try out new functionality easily, we can concentrate on how to optimally exploit the document-based application architecture. The questions that were raised in chapter 2’s section on future research will then have to be seen from a new perspective, namely from the perspective of a document-based application architecture. These questions were:

• What functionality can stimulate and support the use of self-regulatory processes?

• How can students and developers be stimulated to focus on the product of internet use?

• How can a browser help to store and structure information?

• And how can knowledge about behavioral patterns be collected and used to advantage?

More specifically, future research can try to answer the following kind of sub-questions:

• Is it useful to explicitly support students in their self-regulation? For example, documents could contain a list of goals, or steps to be taken. Students could set goals for themselves, or follow a default schedule (e.g. first describe the needed information, then search for that information, then check whether it is found). Or are the indirect effects of document-basedness on SRL, such as stimulation as a result of higher focus on the product, sufficient?

• How can the product of students’ internet use be made more rewarding, in order to optimally stimulate their efforts?

• What general behavioral characteristics can be deduced from specific behavior a student exhibits inside a document? And can this be used to help students work more efficiently?

Of course the following question would continually play an especially important role:

• How do students work with a document-based browser and the specific functionality it provides? And what are related advantages and disadvantages?
Eventually it should become possible to make a righteous comparison between document-based and non-document-based browsers, and answer the following question:

- What are the advantages and disadvantages of a document-based application architecture compared to a non-document-based one?

Last, I want to discuss a more futuristic area of research. A document’s contents might not only be informative for the person that has made it, but also for other people. Suppose that information in documents can be shared between people. Then the collection of documents people produce, becomes to form a new body of information. This new body of information can be considered a layer which sits on top of the internet. This layer would consist of meta-information, because it is information about information (user-generated information about the internet’s information). The surplus value of this layer would not lie in its information types or structure, but in the way it is generated: because it is generated by information consumers instead of information suppliers, it would describe the internet’s contents in a subjective manner. This can be very useful, because certain groups of people need the same information and think the same about this information. Consider the following example:

Suppose someone puts a picture of his dog on the internet and labels it “Sam”, because that’s its name. The chance that other people than that person’s friends or relatives will find the dog’s name interesting, is minimal. The chance that other people will find it interesting that it is a dog, is much bigger. But from the description this is not clear, so the chance that someone who is looking for pictures of dogs will find Sam’s picture, is very small. Suppose now that another person coincidentally stumbles on the picture, stores it inside of his document (because of whatever reason), and labels it – logically – “dog”. Then this new information could be used to help dog-searching people find Sam. The underlying assumption is that if someone calls Sam a dog, then other people might also consider Sam to be a dog.

Although this is a very simple example, it shows how one person’s internet use can mean something to someone else. It is an example of how knowledge can be extracted from a user who is actively processing information. The same kind of thing can be done with other types of information. For example, internet pages can be related to subjects, to user groups, and to other pages

An important point to note is that – once people make documents – no extra effort is needed to gather information. While users store and structure information for themselves, they implicitly contribute to the totality of available information. We are far from realizing this kind of functionality, but I think it is a nice idea to think about, and I believe it can help us to picture how internet browsing eventually should be.
Bibliography

Cocoa bindings reference. Retrieved September 11, 2006, from Apple Computer, Developer Web site:  

Cocoa fundamentals guide. Retrieved September 11, 2006, from Apple Computer, Developer Web site:  


Interface builder. Retrieved September 11, 2006, from Apple Computer, Developer Web site:  


http://www.oup.com/us/


Web kit objective-c programming guide. Retrieved September 11, 2006, from Apple Computer, Developer Web site:  

Wikipedia. Retrieved December 27, 2006, from Wikipedia Web site:  
http://en.wikipedia.org/wiki/Stickies