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Minimalist Instruction for Learning to Search the World Wide Web

This study examined the efficacy of minimalist instruction to develop self-regulatory skills involved in Web searching. Two versions of minimalist self-regulatory skill instruction were compared to a control group that was merely taught procedural skills to operate the search engine. Acquired skills were tested on Web search tasks and search tasks in an online library catalogue. Self-regulatory skills instruction was found to increase practice time by 25%. However, it did not enhance search performance on the test tasks. Explanations are advanced for these findings and topics for further research are identified.

Keywords: World Wide Web, learning, minimalism, instruction, self-regulation.

Introduction

Information seeking is becoming the buzzword for this decade. Its popularity was probably incited by the proliferation of Internet and the World Wide Web. A rapidly growing number of people search the Web to obtain information for professional and private purposes. The use of the Web for educational purposes is increasing accordingly. This is aptly illustrated by the increasing number of assignments that require students to collect source materials from the Web. The pervasive use of the Web in schools and at home raise the impression that students are able to search the Web. Yet, this is a false impression since nearly half of the second graders from Dutch secondary education consider themselves incapable of operating Web browsers and search engines (Ten Brummelhuis and Slotman, 2000). A comparative study further showed that these findings are consistent with the situation in many European countries (Pelgrum, 1999).

These studies convey the need to teach students the skills to access and navigate the Web. Although literally hundreds of books, articles and Web sites designed to train users to become skilled Web searchers are available, few of these publications appear to have been tested in the classroom or have been developed from the research on the topic (Carroll, 1999). The present research therefore set out to examine how students can best be supported in gaining Web searching expertise.

Minimalist instruction (Carroll, 1990) may foster the development of procedural skills to operate Web search engines. Minimalism originated from the field of software training in the early 1980s. Its development was prompted by qualitative research studies of people learning to use computer applications. These studies revealed idiosyncratic difficulties people encounter when first trying to use software. The minimalist approach proposed a set of design principles and heuristics to anticipate these problems. In short, these principles aim to minimize the extent to which instructional materials obstruct learning and focus the design on activities that support learner-directed activities. Empirical studies have substantiated the instructional efficacy of these principles in teaching novice users the basics of various computer programs (e.g., Carroll, 1990; Lazonder and Van der Meij, 1993; Ramsay and Oatley, 1992; Van der Meij and Lazonder, 1993). In all of these studies minimalist instruction lead to faster training and better learning as compared to other instructional approaches.

However, Web searching involves more than operating search engines. The Web opens up so much information that designated skills to manage the information-flow are called for. That is, Web users need self-regulatory skills to plan, monitor and evaluate their actions. Since the minimalist approach has predominantly been applied to teach procedural skills, it is unclear how it might be extended to support the development of self-regulatory skills. Nor has it been established whether minimalist instruction in self-regulatory skills enhances search performance. Yet it is important to consider these issues because self-regulatory skills are of greater importance to Web searching than are procedural skills (Jacobson and Ignatio, 1997; Marchionini, 1995).

This paper addresses these issues from a theoretical and practical perspective. Section 2 explores the applicability of minimalism to teaching self-regulatory skills. To this end, the characteristics of the minimalist approach are compared to the conditions for successful self-regulatory skill instruction. Section 3 addresses the issue of how the minimalist approach should be extended to foster the development of self-regulatory skills. Two instructional strategies are advanced, and their application in minimalist instruction is described. The sections that follow report a study that attempted to offer initial evidence regarding the efficacy of these strategies to enhance search performance.

Instructional conditions for self-regulatory skill learning

Instructional conditions denote the terms under which the instruction leads to the desired learning outcomes. The present learning outcomes primarily relate to acquiring the self-regulatory skills Web searching entails. The ability to transfer these skills to different information retrieval systems such as online public access catalogues (OPAC) and CD-ROMs is another, probably equally desirable learning outcome.

Three instructional conditions apply to the acquisition of self-regulatory skills. The first is that self-regulatory skills should be taught in context (Boekaerts, 1997; Hattie *et al.*, 1996; Puntambekar and Du Boulay, 1997). Self-regulatory skills are always used within a given task domain. Their spontaneous application in that content area seems to depend on the students’ conditional knowledge about when and where to use particular skills. Without this knowledge, the self-regulatory skills remain inert, and students may fail to invoke them during task performance. The instruction should therefore associate the self-regulatory skills with the circumstances in which they are applicable. This in turn may increase the students' perceived utility of a self-regulatory skill (Shunk and Ertmer, 2000).

The second instructional condition states that there must be ample opportunity to practice the self-regulatory skills (Garner and Alexander, 1989; Vermunt, 1998; Weinstein *et al.*, 2000). Students not only need to understand that a self-regulatory skill exists or when it should be used, they also need to know how to put it in practice. Self-regulatory skills require significant effort to learn; hence, practice should be extensive. Following from the first instructional condition, the opportunities for practice should be designed around authentic tasks.

The third condition refers to the mechanism of cognitive scaffolding (Boekaerts, 1997; De Jong, 1992; Shunk and Zimmerman, 1997; Vermunt, 1998). As self-regulatory skills require significant effort to learn, students can easily become overwhelmed by the number of regulatory activities they have to perform. Scaffolded instruction aims to avoid this problem by offering students an adaptable and temporary support system during the initial phase of the learning process (Boekaerts, 1997). The amount of external support is inversely proportional to the students' level of self-regulation. Initially, a fair amount of external support is given. As students become more proficient, the external support is gradually faded.

The literature on self-regulation presents no instructional conditions for transfer. There is, however, reason to believe that instruction that meets the abovementioned conditions will generalize beyond the context in which it is provided. In case of Web searching, transfer concerns the spontaneous use of self-regulatory skills in searching different information retrieval systems such as OPACs and CD-ROMs. This requires near transfer: the self-regulatory skills are performed in almost identical situations that differ from Web searching only with regard to the operation of the search system.

Near transfer is based on rule automation. It occurs spontaneously when skills automatized in one context are triggered in another, highly similar context. There seem to be three guidelines for the design of instruction that aims at rule automation and, consequently, near transfer (Perkins *et al.*, 1990; Salomon and Perkins, 1989; Van Merriënboer and Paas, 1990). The first one implies that extensive, step-by-step practice is required to automatize a skill. By repeated practice, behavior becomes fast, effortless, and unlimited by processing capacities. The second guideline asserts that practice should be divergent, linking the skills to the contexts in which they will be applied. Although automation facilitates evocation of the elements that are applicable in comparable situations, the instruction should force the skills to adapt to similar contexts, yielding the ability to apply these skills in situations different from the instructional setting.

However, extensive practice on varying, authentic tasks is relatively ineffective. The lack of guidance and modeling during practice seems to impose a high cognitive load. This may cause students to direct their attention to other, nonessential parts of the task; it may even cause them to completely loose track of what they are doing. The instruction should therefore reduce cognitive load and redirect the student's attention to the relevant aspects of the task. This may be achieved by using completion problems to practice a skill (Van Merriënboer, 1997). Completion problems contain a given state, a goal state, and a part of the solution. During practice, students have to complete the partial solution.

These guidelines match with the instructional conditions for self-regulatory skill learning. Both sets of directives advocate ample opportunities for practice in realistic settings. The use of completion problems can be considered a form of cognitive scaffolding (Van Merriënboer, 1997). Both support mechanisms seek to reduce cognitive load by offering external support. Both mechanisms also entail a gradual decrease of external support when learners acquire more experience. As for completion problems, external support comes in the form of a part of the solution to training tasks. During the initial stages of learning, students have to produce a small part of the incomplete solution. As experience increases, the students' share in solving the problem increases accordingly.

These similarities lead to the tentative conclusion that instruction designed in compliance with these conditions will foster the acquisition and transfer of self-regulatory skills. The question then becomes whether instruction designed in compliance with the guidelines of the minimalist approach satisfies these conditions. The essence of the minimalist approach is embodied in the principles and heuristics presented in Table 1. The remaining part of this section discusses if and how these minimalist principles comply with the conditions for successful self-regulatory skill instruction. This in turn provides a brief description of the minimalist approach; a comprehensive overview appears in Van der Meij and Carroll (1995).

Insert Table 1 about here

Minimalist instruction is anchored in the task domain, thus complying with the condition of contextual instruction. This minimalist principle reveals itself especially in the design of practice. Training tasks include genuine activities that represent the core tasks of a domain. Minimalist instruction also advocates ample opportunities for practice. It provides users with an immediate opportunity to engage in meaningful learning activities. Explanations are reduced to the bare minimum and definitions are operational instead of conceptual. That is, they are presented directly before or after the relevant action steps and explain what something ‘does’ rather than what it ‘is’. The gradual decrease of external support (i.e., cognitive scaffolding) pertains to the minimalist principle ‘support reading to do, study and locate’. To support the flexible ways in which people process instructional materials, minimalist instruction capitalizes on the users’ accumulating understanding of the program. Minimalist instruction initially provides detailed guidance and support. Throughout the instruction the amount of external support is gradually reduced as a function of the users’ need for detailed instructional support. Among other things, this requires a gradual fading of action steps. An example of the use of fading techniques can be found in Carroll and Van der Meij (1996).

In addition, the minimalist approach already holds some elements that facilitate self-regulation. Error-information, for example, models problem solving behavior and reduces cognitive load by helping users to detect, diagnose, and correct errors (Osman and Hannafin, 1992). Its presence also invites users to monitor task performance. Action statements like ‘Look on the screen to...’ and ‘Check if the dialog window...opens’ also support monitoring. These prompts replace lengthy explanations in case information can be found on the screen or can easily be inferred.

The length of minimalist instruction may call for some concern, however. Minimalist instruction is typically brief, whereas developing self-regulatory skills requires a considerable amount of practice. Yet, the time on task does not necessarily impede the development of self-regulatory skills. Van der Meij (1999) stressed that minimalist instruction leads to ‘high quality training time’. It reduces training time by 25 to 52%, and at the same time, yields superior task performance. The time learners spent processing minimalist instruction is obviously well spent.

In sum, this section attested that the minimalist approach satisfies the conditions for successful self-regulatory skill instruction. It was therefore concluded that minimalist instruction can support the acquisition and transfer of self-regulatory skills. The question of how minimalism can be larded with self-regulatory skill instruction is addressed in the next section.

Instructional strategies for self-regulatory skill learning

Both theoretical and empirical evidence suggests that embedded instruction is the most effective way to teach self-regulatory skills (Bielaczyc *et al.*, 1995; Hattie *et al.*, 1996; Osman and Hannafin, 1992). However, the joint practice of skills to operate the search engine and self-regulatory skills to manage search behavior may provoke additional cognitive load. Chandler and Sweller (1996) showed that the coordinate handling of manual, keyboard and screen requires considerable mental effort. Adding self-regulatory skills could make it even harder for learners to allocate their attention to the relevant parts of the learning task. The success of embedded self-regulatory skill instruction thus seems to hinge on its potential to minimize the learners' cognitive load (Osman and Hannafin, 1992).

According to Perkins *et al.* (1990), three instructional strategies may serve this purpose. The memory aid strategy starts from the notion that much of the cognitive load in self-regulatory skill learning has a mnemonic character. Learners have to remember a skill, remember when to use it, remember how to use it, and so on. Shifting this load on to an external object (a memory aid) may free processing capacity for other learning activities. The timesharing strategy is guided by the idea of parallel processing. It acknowledges the difficulty involved in simultaneously performing procedural and self-regulatory skills by explicitly prompting the learner to shift attention from executing a search, to regulating search performance. Automation of self-regulatory skills is yet another strategy to reduce cognitive load. Because automatized skills require fewer cognitive resources, the learner can direct more attention to new skills. However, this strategy is inappropriate to accommodate cognitive load during the early stages of skill acquisition. Automation requires extensive practice. Paradoxically, practice only induces automation if cognitive load is properly managed. Worded differently, automation should be the outcome of initial skill learning rather than a prerequisite to it.

Consequently, only the memory aid and timesharing strategy were considered in designing the self-regulatory skills instruction. In the timesharing instruction, self-regulatory skills were taught *concurrent with* the procedural skills to operate the search engine. Brief instruction prompts incited learners to perform a self-regulatory skill every time it was needed. The memory aid instruction introduced the self-regulatory skills *before* the operation of the search engine on the basis of a diagram. This diagram served as a job aid learners could consult in performing practice tasks to learn to operate the search engine. A comprehensive description of the instructional materials appears in the next section.

An experiment was performed to assess the effectiveness of both instructional strategies. This study compared the memory aid and timesharing instruction to a control group that was merely taught to operate the search engine. Both experimental conditions were expected to yield better search performance than the control condition. That is, learners in the memory aid and timesharing condition were expected to outperform their control counterparts on Web search tasks and OPAC search tasks. The memory aid and timesharing condition were compared to reveal which instructional strategy is best suited for teaching self-regulatory skills. No predictions were formulated concerning this comparison.

Several learner characteristics might affect experimental findings. For example, students with high levels of prior Web-experience might show superior search performance during and after practice compared to students with low levels of Web-experience (e.g. Hill and Hannafin, 1997; Khan and Locatis, 1998; Lazonder *et al.*, 2000). The students' level of prior self-regulation might have a similar effect on learning activities and learning outcomes. To anticipate these extraneous effects, the study controlled for the students' level of Web-experience and self-regulation, thus allowing for a valid comparison of instructional strategies. The study did not consider the students' knowledge of the topics being searched. Hsieh-Yee (1998) asserted that domain expertise becomes a factor only after a certain amount of search experience had been acquired. Research further suggests that domain expertise can be left out of account when teaching a homogeneous group of students to search the Web (Lazonder, 2001).

Method

Participants

Participants were second and third graders from a school for secondary education. There were 58 males and 44 females with a mean age of 14.0 (*SD*=0.8). Their level of Web-experience ranged from less than 1 hour to over 200 hours. Participants were randomly assigned to the memory aid condition (*n*=32), timesharing condition (*n*=39), or control condition (*n*=31).

Instructional materials

An introduction manual was designed to familiarize students with the browser and search engine. The manual had a minimalist design and addressed basic procedural skills that were prerequisite to the self-regulatory skill instruction (e.g., entering a URL, following hyperlinks, using task bar buttons). It did not treat the self-regulatory aspects of the search process.

Three versions of minimalist instruction (timesharing, memory aid, control) were designed to teach self-regulatory skills. All versions addressed the procedural skills to operate the search engine, differing exclusively with regard to the instructional strategy to teach self-regulatory skills. The timesharing instruction introduced the self-regulatory skills ‘on the spot’. Throughout the entire manual, self-regulatory skill instruction was integrated with the instructions to learn to use the search engine. The instruction explained the ‘what, how, and why’ of a self-regulatory skill (e.g., Osman and Hannafin, 1992; Shunk and Ertmer, 2000). Instructional support was gradually faded from a full description of a skill, through a brief description, to a question that prompts participants to perform that skill (De Jong, 1992). An illustrative page of the timesharing instruction is shown in Appendix B.

The memory aid instruction addressed the same self-regulatory skills, explained the ‘what, how, and why’ of each skill, but differed with regard to presentation. All self-regulatory skills were introduced before the operation of the search engine. The self-regulatory skills instruction centered on a diagram of the search process (see Appendix A) that was explained and practiced on the basis of a Web search task. The memory aid instruction also used a different fading technique. It merely contained the full descriptions and introduced them in a single sweep in the first chapter of the instruction. Subsequent chapters exclusively dealt with the operation of the search engine (see

Appendix C), but the students were encouraged to consult the diagram in learning to operate the search engine. The diagram thus served as a flexible support tool students could adapt to their own information needs. It was given to memory aid students only.

The control condition contained no self-regulatory skill instruction; it merely addressed the procedural skills to operate the search engine. In this respect, the control condition matched the memory aid and timesharing condition. It addressed the same procedural skills, contained the same instructions, and used the same practice tasks. Hence the design of the control instruction was identical to the instructional materials exemplified in Appendix C.

Questionnaires and tests

Two questionnaires were administered to assess the participants' levels of Web-experience and self-regulation. A background questionnaire determined the participants' experience in working with the Web. It also gathered some personal data such as age, sex, and ethnic background. The Motivated Strategies for Learning Questionnaire (MSLQ) assessed different facets of self-regulation, including self-efficacy, task value, test anxiety, cognitive strategies, and metacognitive strategies (Pintrich *et al*., 1991). The MSLQ contained 53 items; each item was judged on a Likert scale that ranged from 1 (not at all true of me) to 7 (very true of me). The scale 'test anxiety' was not taken into account due to insufficient reliability (α=.68). Coefficient alphas for the other scales ranged from 0.80 to 0.88.

Two tests were used to assess achievement outcomes. A performance test recorded acquired Web-searching skills. It contained four fact-based Web search tasks that were comparable (but not identical) to the practice tasks. These tasks dealt with general topics such as finding the entrance fee to a museum or the data of a sailing camp. A transfer test assessed search performance with a new search system. It consisted of four fact-driven OPAC search tasks that asked participants to find various books on the painter Paul Gauguin.

Procedure

All sessions took place in a computer class equipped with 30 Pentium II computers. Internet Explorer and a Dutch search engine called Ilse (www.ilse.nl) were used to access information on the

Web. A registration program was installed on each computer to record the participants' test performance. It captured the action from screen and saved it as an AVI movie file. The experiment was conducted in nine groups of 16 to 26 students. Each group attended four sessions of 50 minutes each. The time between sessions was one week.

At the beginning of the first session, the participants were informed on the experiment's goal and received instructions. Next, they filled in the background questionnaire and the MSLQ. During the remaining part of this session, participants worked through the introduction manual. The same manual was used for all conditions. The second and third session involved the self-regulatory skills training. Participants received a manual (memory aid, timesharing, or control). The three types of manuals were proportionally divided among the participants in each group. The manuals contained sheets that marked the beginning and end of a session. These sheets also prompted participants to write down the time (as displayed on screen) and to rate the mental effort to grasp the subject matter of that particular session. The tests were administered during the fourth session. After a brief introduction, participants were given 20 minutes to complete each test. A counterbalanced administration was used to anticipate order effects. Participants were encouraged to perform the search tasks in given order, but they were free to relinquish a task. They were not allowed to use their manual or to consult the experimenter during both tests.

Design and analyses

The study used a between-subjects design with instructional condition (memory aid, timesharing, control) as the independent variable and the participants' prior levels of Web-experience and self-regulation as covariates. Web-experience was defined as the time participants' had worked with the Web. Level of self-regulation was indicated by the mean MSLQ scores.

Dependent variables for the training phase were time and cognitive load. Practice time was the time to complete the self-regulatory skill instruction (i.e., the second and third session), which was computed from the sheets in the training manuals. Cognitive load was indicated by the mental effort participants invested to understand the learning content. Mental effort was measured by a single question (“It took me great effort to understand this lesson”) that was administered after each session. Participants answered this question on a scale ranging from 1 (totally disagree) to 5 (totally agree).

Dependent variables for the test phase were learning outcomes (i.e., achievement on Web search tasks) and transfer (i.e., achievement on OPAC search tasks). For both measures, the mean number of completed tasks and successfully completed tasks was scored. Given the time constraints in the test session, higher scores on these measures automatically imply faster task performance. Performance efficiency was indicated by the number of successfully completed tasks to the time to complete these tasks.

The effect of instructional condition on these measures was assessed with MANCOVA’s. Univariate analyses followed when a significant multivariate effect was observed. The test statistics for the covariates are reported in case of significance only. Missing data were excluded on an analysis-by-analysis basis.

Results

Table 2 displays the mean learning activity scores. There was a multivariate main effect of instructional condition on these measures ($F(4,194)=2.79$, $p<.05$). A univariate effect was found for practice time ($F(2,97)=4.96$, $p<.01$). Post hoc comparisons of adjusted means revealed that this effect arose because control participants completed practice significantly faster than participants in the other two groups did. Memory aid and timesharing participants needed an equal amount of practice time. Instructional condition also affected mental effort scores, but this difference did not reach traditional levels of statistical significance ($F(2,97)=2.56$, $p<.10$). The participants’ level of Web experience affected learning activity scores as a covariate ($F(2,96)=4.86$, $p<.05$). Significant univariate effects were found for practice time ($F(1,97)=8.29$, $p<.01$) and mental effort ($F(1,97)=4.64$, $p<.05$). Unstandardized regression coefficients indicated that higher levels of Web-experience were associated with lower amounts of practice time and mental effort. The participants’ prior level self-regulation had no effect on learning activities.

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insert Table 2 and Table 3 about here

Table 3 summarizes the scores on the Web search tasks. Instructional condition had no effect on these measures ($F(6,168)=.73$). Participants in all three conditions completed as many Web search tasks, produced an equal number of correct answers and performed equally efficient. Similar findings were obtained on the OPAC search tasks ($F(6,148)=.82$), indicating that participants in all groups performed these tasks equally proficient. The covariates also yielded no effects on achievement outcomes. Search performance on both types of tasks was not affected by the participants' level of Web-experience and self-regulation.

Discussion

This paper examined whether and how minimalist instruction may support the development of self-regulatory Web searching skills. Theoretical evidence suggests that minimalist instruction may serve this purpose. To validate this presumption, two instructional strategies were proposed and their effect on learning activities and learning outcomes was assessed.

Results obtained during practice indicate that self-regulatory skill instruction extends training time by approximately 10 minutes (i.e., 25%). This increase is probably due to the volume of the instructional materials. Control participants merely learned to operate the search engine, which is obviously less time-consuming than learning to plan, execute, monitor, and evaluate a search. Control participants also seemed to require less mental effort to understand the instructional content, but this difference was not supported by standard measures of statistical significance. Yet the mental effort scores do imply that both instructional strategies are equally fit for managing students' cognitive load.

Contrary to expectations, self-regulatory skill instruction did not enhance performance on Web search tasks. Students in all groups performed these tasks equally successful and efficient. These findings seem to suggest that students in the memory aid and timesharing condition did not develop the self-regulatory skills —or at least not enough to yield superior search performance. However, there may be other reasons why the anticipated effects failed to appear. One is the time constraints in the test session. Students in the memory aid and timesharing condition may have decided *not* to employ the acquired self-regulatory skills because it would penalize them in the sense that they might complete fewer tasks. A second reason is sensitivity of the test. The Web search tasks measured in a holistic manner what the self-regulatory skill instruction intended to improve: search performance. Although this outcome measure is ecologically valid and has substantial practical value, it may not reflect the actual differences in self-regulatory skills. Attempts to reanalyze the data are currently being performed. It should be noted, however, that this is merely a theoretical issue: practically speaking, the self-regulatory skills instruction did not enhance search performance.

Memory aid and timesharing instruction were further expected to enhance transfer. This hypothesis too was not supported by the results. Students in all groups performed equally successful and efficient on OPAC search tasks. One reason for nontransfer is the amount of practice. Transfer may have failed because the instruction was too brief to automatize the self-regulatory skills. This inadequacy can be accommodated by further extending memory aid and timesharing instruction. More practice improves the facilities to automatize self-regulatory skills, which in turn, is expected to enhance near transfer. An alternative interpretation is the distance of transfer. Near transfer occurs when students perceive high similarity between the learning tasks and the transfer task. The OPAC search tasks were therefore designed to resemble the Web searching practice tasks as much as possible. Nonetheless the students might have considered searching an OPAC and searching the Web as distinct activities. In that case, the OPAC search tasks would require far transfer. Clearly, the instruction was not designed to support this type of transfer.

To conclude, this study failed to confirm the assumed functionality of minimalist instruction to develop self-regulatory Web searching skills. The concise nature of minimalist instruction is probably the main reason why this is so. Future research should therefore examine whether extending minimalist instruction with repeated step-by-step practice would overcome this problem. Future attempts should also consider using different transfer tasks. Near transfer might, for example, be indicated by the students' capacity to search the Web with a different search engine. Their ability to search an OPAC would then be considered an instance of far transfer. Comparing students' search performance on these tasks might shed a decisive light on the functionality of minimalism to develop self-regulatory skills.

Despite the lack of supportive evidence, this study holds important practical implications. Educators aiming for students to become proficient Web searchers should carefully consider course duration. The results of this study suggest that extensive repeated practice is required to develop self-regulatory skills. Paradoxically, students typically resent rehearsing the same skills over and over again, causing them to skip most review exercises (Carroll, 1990). The amount of repeated practice should therefore be well balanced, allowing students to develop a skill without loosing interest. Integrating repeated practice in self-regulatory skills throughout the curriculum seems a potentially fruitful alternative, especially since subject teachers increasingly ask students to obtain information from the Web.

References

Bielaczyc, K., Pirolli, P.L., and Brown, A.L. (1995). Training in self-explanation and self-regulation strategies: Investigating the effect of knowledge acquisition activities on problem solving. *Cognition and Instruction,* **13**, 221 – 252.

Boekaerts, M. (1997). Self-regulated learning: A new concept embraced by researchers, policy makers, educators, teachers, and students. *Learning and Instruction,* **7**, 161 – 186.

Carroll, J.B. (1999). Expert Internet information access. *Journal of Educational Computing Research,* **20**, 209 – 222.

Carroll, J.M. (1990). *The Nurnberg Funnel: Designing minimalist instruction for practical computer skill.* MIT Press, Cambridge.

Carroll, J.M., and Van der Meij, H. (1996). Ten misconceptions about minimalism. *IEEE Transactions on Professional Communication,* **39**, 72 – 86.

Chandler, P., and Sweller, J. (1996). Cognitive load while learning to use a computer program. *Applied Cognitive Psychology,* **10**, 151 – 170.

De Jong, F.P.C.M. (1992). *Zelfregulatie: Regulatie van het leerproces en leren reguleren-een procesbenadering* [Self-regulation: Regulation of the learning process and learning to regulate-a process view]. PhD. Thesis, University of Brabant, Tilburg, The Netherlands

Garner, R., and Alexander, P.A. (1989). Metacognition: Answered and unanswered questions. *Educational Psychologist,* **24**, 143 – 158.

Hattie, J., Biggs, J., and Purdie, N. (1996). Effects of learning skills interventions on student learning. *Review of Educational Research,* **66**, 99 – 136.

Hsieh-Yee, I. (1993). Effects of search experience and subjects knowledge on search tactics of novice and experienced searchers. *Journal of the American Society for Information Science,* **44**, 161 – 174.

Jacobson, F.F., and Ignatio, E.N. (1997). Teaching reflection: Information seeking and evaluation in a digital library environment. *Library Trends,* **45**, 771 – 802.

Khan, K., and Locatis, C. (1998). Searching through cyberspace: The effects of link display and link density on information retrieval from hypertext on the World Wide Web. *Journal of the American Society for Information Science,* **49**, 176 – 182.

Lazonder, A.W. (2001). *Learning to search the World Wide Web*. University of Twente, Department of Instructional Technology, Enschede.

Lazonder, A.W., Biemans, H.J.A., and Wopereis, I.G.J.H. (2000). Differences between novice and experienced users in searching information on the World Wide Web. *Journal of the American Society for Information Science,* **51**, 576 – 581.

Lazonder, A.W., and Van der Meij, H. (1993). The minimal manual: Is less really more? *International Journal of Man-Machine Studies,* **39**, 729 – 752.

Marchionini, G. (1995) *Information seeking in electronic environments*. Cambridge University Press, Cambridge.

Osman, M.E., and Hannafin, M.J. (1992). Metacognition research and theory: Analysis and implications for instructional design. *Educational Technology Research and Development*, **40**, 83 – 99.

Pelgrum, W.J. (1999). Curriculum and pedagogy. In *ICT and the emerging paradigm for lifelong learning,* W.J. Pelgrum and R.E. Anderson (eds.), IEA, Amsterdam, pp. 89 – 119.

Perkins, D.N., Simmons, R., and Tishman, S. (1990). Teaching cognitive and metacognitive strategies *Journal of Structural Learning,* **10**, 285 – 303.

Pintrich, P.R., Smith, D.A.F., Garcia, T., and McKeachie, W.J. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. (Tech. Rep. No. 91-B-004). Ann Arbor: University of Michigan, School of Education.

Puntambekar, S., and Du Boulay, B. (1997). Design and development of MIST – A system to help students to develop metacognition. *Journal of Educational Computing Research,* **16**, 1 – 35.

Ramsay, J., and Oatley, K. (1992). Designing minimal computer manuals from scratch. *Instructional Science,* **21**, 85 – 98.

Salomon, G., and Perkins, D.N. (1989). Rocky roads to transfer: rethinking mechanisms of a neglected phenomenon. *Educational Psychologist,* **24**, 113 – 142.

Shunk, D.H., and Ertmer, P.A. (2000). Self-regulation and academic learning: Self-efficacy enhancing interventions. In *Handbook of self-regulation,* M. Boekaerts, P.R. Pintrich and M. Zeidner (eds.), Academic Press, San Diego, pp. 631 – 649.

Shunk, D.H., and Zimmerman, B.J. (1997). Social origins of self-regulatory competence. *Educational Psychologist,* **32**, 195 – 208.

Ten Brummelhuis, A.C.A., and Slotman, K.M.J. (2000). *ICT monitor 1998/1999: Voortgezet onderwijs* [ICT monitor 1998/1999: Secondary education]. Universiteit Twente, OCTO, Enschede.

Van der Meij, H. (1999). *Minimalism afford better user support.* Invited address at the 11th Utah State University Instructional Technology Institute Conference, August 11 – September 3, Logan, Utah, USA.

Van der Meij, H., and Carroll, J.M. (1995). Principles and heuristics for designing minimalist instruction. *Technical Communication,* **42**, 243 – 261.

Van der Meij, H., and Lazonder, A.W. (1993). Assessment of the minimalist approach to computer user documentation. *Interacting with Computers,* **5**, 335 – 370.

Van Merriënboer, J.J.G. (1997). *Training complex cognitive skills*.Educational Technology Publications, Englewood Cliffs.

Van Merriënboer, J.J.G., and Paas, F.G.W.C. (1990). Automation and schema acquisition in learning elementary computer programming: Implications for the design of practice. *Computers in Human Behavior,* **6**, 273 – 289.

Vermunt, J.D. (1998). The regulation of constructive learning processes. *British Journal of Educational Psychology,* **68**, 149 – 171.

Weinstein, C.E., Husman, J., and Dierking, D.R. (2000). Self-regulation interventions with a focus on learning strategies. In *Handbook of self-regulation*, M. Boekaerts, P.R. Pintrich, and M. Zeidner (eds.), Academic Press, San Diego, pp. 727 – 747.

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Table 1

Characteristics of the minimalist approach and their relationship with the conditions for self-regulatory skills instruction

Minimalist principles and heuristics	Instructional conditions
1. Choose a task-oriented approach	**Teach self-regulatory skills in context**
• Design instructional activities that are real tasks	
• Let components of the instruction reflect the task structure	
2. Choose an action-oriented approach	**Provide ample opportunities to practice**
• Provide an immediate opportunity to act	
• Encourage and support exploration and innovation	
• Respect the integrity of the user's activity	
3. Support reading to do, study and locate	**Gradually decrease external support** (i.e., cognitive scaffolding, completion problems)
• Gradually fade out action information	
• Omit information that can easily be inferred	
• Make chapters brief and self-contained	
4. Support error recognition and recovery	
• Prevent mistakes whenever possible	
• Provide error information when actions are error-prone or when correction is difficult	
• Provide error information that supports detection, diagnosis, and correction	
• Provide on-the-spot error information	

Note. Adapted from Van der Meij and Carroll (1995).

Table 2

Mean learning activity scores (and standard deviations)

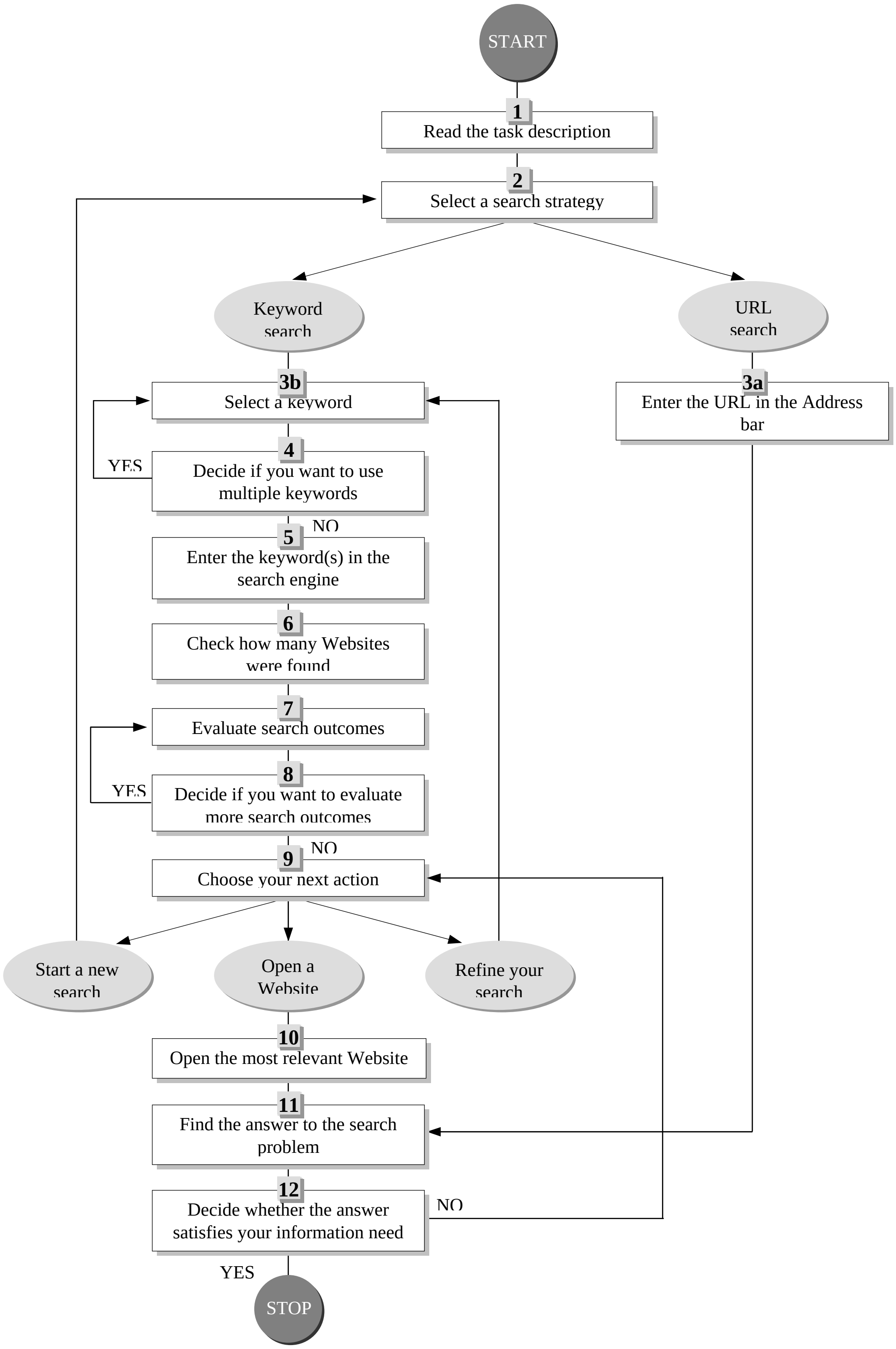
	Training time (min.)	Mental effort
Memory aid	39.9 (11.5)	2.0 (.8)
Timesharing	38.0 (12.2)	2.1 (.9)
Control	30.1 (11.6)	1.6 (.7)

Table 3

Mean test scores (and standard deviations)

	Web search tasks			OPAC search tasks		
	Completed tasks	Successfully completed tasks	Efficiency	Completed tasks	Successfully completed tasks	Efficiency
Memory aid	1.9 (.7)	1.5 (.6)	35.0 (23.1)	2.5 (1.0)	1.6 (.6)	31.1 (27.9)
Timesharing	1.9 (.9)	1.7 (.9)	31.0 (22.5)	2.4 (.9)	1.5 (.5)	27.0 (19.9)
Control	1.8 (.5)	1.4 (.6)	27.0 (16.1)	2.3 (.9)	1.4 (.6)	24.9 (18.6)

Appendix A: Diagram of the search process



Appendix B: Illustrative page of the timesharing instruction

3. Performing a keyword search

Selecting a keyword

1 Click Start

The search engine Ilse appears on the screen.

SEARCH TASK

For your Dutch language class, you have to interpret a text entitled *Whizkids on the electronic highway*. This text was published in Time Magazine. The author, prof.dr. ir. P. Akkermans, frequently uses computer terms like ‘black hole’, ‘URL’, ‘gateway’ en ‘digital literacy’. Find the meaning of these terms in a Web dictionary.

Before you start your search, you have to decide which keyword to search for. Take your time: selecting a keyword is an important step in the search process. A carefully selected keyword will return many relevant Websites. A poor choice of keywords will produce few relevant sites.

This is how you select a keyword:

- Tell in your own words what information you are looking for
- Re-read the search task and write down all terms that may be used as a keyword
- Think of keywords that are not included in the search task

1 Select the best keyword (**Note:** you may select only **one** keyword)

2 Search for that keyword

How many Websites did you find?

Which Websites are potentially relevant?

Is it useful to evaluate more Websites?

Choose your next action. Are you going to start a new search, refine your search, or open a Website?

3 Find the meaning of the computer terms listed in the search task.

Appendix C: Illustrative page of the memory aid and control instruction.

3. Performing a keyword search

Selecting a keyword

1 Click 

The search engine Ilse appears on the screen.

SEARCH TASK

For your Dutch language class, you have to interpret a text entitled *Whizkids on the electronic highway*. This text was published in Time Magazine. The author, prof.dr. ir. P. Akkermans, frequently uses computer terms like ‘black hole’, ‘URL’, ‘gateway’ en ‘digital literacy’. Find the meaning of these terms in a Web dictionary.

1 Select the best keyword (**Note:** you may select only **one** keyword)

2 Search for that keyword

3 Evaluate the search outcomes

4 Find the meaning of the computer terms listed in the search task.