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Cognitive Tools for Self-Regulated E-Learning

Tracey L. Leacock and John C. Nesbit

Tel. 604 291-4548 604 268-7123

tleacock@sfu.ca nesbit@sfu.ca

Simon Fraser University

Faculty of Education

8888 University Drive

Burnaby, BC Canada

V5A 1S6

Fax 604 291-3203

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Abstract. Working from the premise that students need advanced self-regulated learning (SRL) skills to succeed in e-learning environments, this chapter describes the use of a software application (gStudy) designed to help students take control of their learning and become better self-regulated learners. To address the challenges educators face in developing students' metacognitive monitoring and self-regulatory skills, gStudy's cognitive tools were designed in accordance with current SRL theory. Undergraduate students who used gStudy in an educational psychology course commented that they appreciated gStudy's features and interface and its ability to positively influence their approach to learning. The authors conclude that SRL-fostering software applications such as gStudy may be key strategic elements in institutional transitions to e-Learning.

Keywords: Self-regulated Learning, Cognitive Tools, Metacognition, Computer-based Instruction, Internet-based Instruction, Virtual Learning, Web-based Education, Web-based Instruction, Web-based Interactions, Web-based Learning, Web-based Teaching, Cognitive Load Theory, Collaboration Technologies, Collaborative Learning, Computer-Assisted Education, Educational Technology, Electronic Learning (E-learning), Emerging Technologies, Higher Education, Instructional Technology, Student-Centered Learning, Technological Innovations, Technology Mediated Learning, Technology-Enhanced Learning, Undergraduate Education, Educational Multimedia, Education Research

Greater access to information and a growing need for lifelong learning have increased the importance of self-regulated learning (SRL) research for postsecondary

education (Narciss & Körndle, 1998). More than ever before, students are learning outside regular classrooms, often in online learning environments that require different skills from those needed in on-campus lectures. With virtually unlimited access to information, students must take more active roles in evaluating the quality and relevance of the information available to them and in assessing their understanding of that information (Nesbit & Winne, 2003). This transition brings with it a definite shift in the roles of teachers and of students. While teachers will still be responsible for establishing clear goals and objectives and for guiding students with feedback, there will be greater onus on students to assess whether the strategies and tactics they choose really will help them to meet their educational goals. Although the need for individuals to take responsibility for their learning is growing, students often fail in monitoring whether they are meeting course requirements or advancing towards their goals (Schunk & Ertmer, 2000; Winne & Hadwin, 1998; Zimmerman, 2002).

Cognitive toolsets that help students to become better at monitoring and adapting their learning strategies offer a potential solution to this increased need for SRL in formal coursework and in lifelong learning (Brown, Hedberg, & Harper, 1994). Institutions that can seize this opportunity to produce graduates with strong SRL skills will be recognized as having successfully met the changing demands of education.

Accordingly, this chapter focuses on a software application designed to help students take control of their learning and become better self-regulators. After providing a brief account of SRL theory, we introduce gStudy, a set of cognitive tools developed at Simon Fraser University to support SRL. Throughout, we look at gStudy both as a practical tool that educators can use in their courses to help students, and as a research

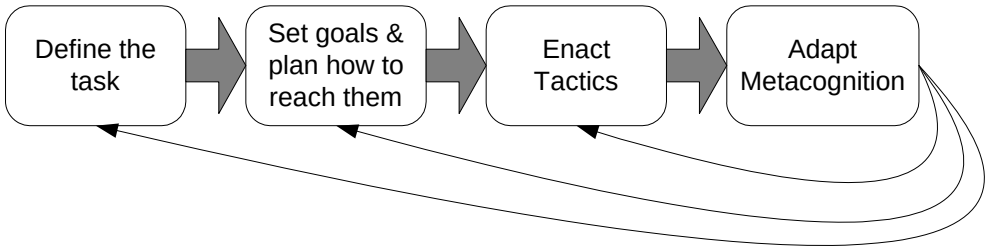
tool that researchers can use to learn more about the theories underlying SRL and their practical applications. We conclude by evaluating the significance of cognitive tools for SRL and applications such as gStudy in the context of institutional transitions to e-learning.

THEORETICAL BACKGROUND

Self-regulated Learning. Self-regulation of learning includes analyzing learning tasks, setting goals, identifying and choosing appropriate strategies for achieving the goals, enacting tactics that fit the chosen strategies, and monitoring, evaluating, and adapting learning activities based on outcomes. Research has demonstrated that students who have strong SRL skills, evidenced by effective goal setting, strategy use, and metacognitive monitoring are more likely to continue to pursue effortful learning strategies required to learn difficult materials (Garavalia and Gredler, 2002; Winne, 1995; Zimmerman, 2001, 2002). Further, the processes and effectiveness of SRL have been shown to be relevant in varied settings, ranging from individual learning to complex problem solving in collaborative settings (Nesbit & Winne, 2003).

Winne (2001) describes a 4-stage model of SRL that can help educators understand where students may be having problems (see Figure 1). In the first stage, the learner must define the required task(s) by breaking the generic assignment down into the specific subtasks the learner will need to accomplish. Students may have difficulty identifying all of the component parts of a large and complex task, such as writing a research-based term paper. Tools that can scaffold students through this process and that can help them to track their decisions are relevant at this stage of SRL.

Figure 1. Stages of self-regulated learning.



Next, the learner must develop a plan to complete the task. In this planning stage, the learner identifies appropriate goals and high level strategies and begins to think about specific tactics or actions that fit those strategies. Students may not be able to recall the appropriate strategy when needed, or they may need to find new strategies for novel learning situations. Cognitive tools that can suggest strategies and tactics (changing recall to recognition) and scaffold students through their use (helping to expand the learner's learning strategy toolkit) can help with both the second phase of SRL and the third phase: enacting the plan.

In the third phase, the learner must take action on the plan. Many factors can interfere at this stage, from poor motivation, to poor skills in reading or note-taking. An effective e-learning environment must include tools that help students implement their plans.

Finally, in the fourth phase, the learner evaluates the success of their actions-so-far and makes any necessary adaptations to stay on track towards completing the task. One of the significant challenges students face in this stage is how to ensure they are evaluating an accurate record of their actions and understanding. Students often overestimate both the amount of time they have spent studying and their understanding of the material they are trying to learn (Winne & Jamieson-Noel, 2002). In traditional teaching environments, students are sometimes encouraged to keep records such as study

journals, but the quality of these records depends very much on the diligence of the record-keeper. Tools that reduce the cognitive load associated with record-keeping will help students to base their evaluations on accurate data, rather than wishful estimates. Easy access to rich data means students can focus on interpreting the data and modifying the outcomes of the previous three phases, rather than on the act of record-keeping.

The principles of SRL may seem straightforward, yet experienced educators know that the process is far from simple or intuitive for most students. Even strong students can struggle if they start off on the wrong track, and weak students can easily be overwhelmed when faced with open-ended tasks. While it may seem at first that it would be more difficult to support SRL in an online environment than in a face-to-face setting, in some circumstances the reverse may be true. The technologies available today allow the creation of tools that complement the teacher's role and help individual students to improve their strategy selection and use, while assuming some of the cognitive load.

gSTUDY: AN E-LEARNING ENVIRONMENT SUPPORTING SRL

gStudy is an e-learning toolset designed to help students develop and use effective SRL strategies as they learn from multimedia resources. As such, it fills a new niche among educational software applications. Whereas e-learning course management systems (CMSs) tend to emphasize tools that the content developer can use to create effective learning environments, gStudy's design acknowledges that what the student does within that environment is at least as important as how the environment is authored. Major CMSs, such as WebCT and Blackboard, provide tools to help instructors set up predefined content, but tools to support interactions generally focus on student-student or student-instructor interactions via synchronous and asynchronous discussions; there is

little explicit support for the intellectual interaction with content that is often central to learning (Moore, 1989).

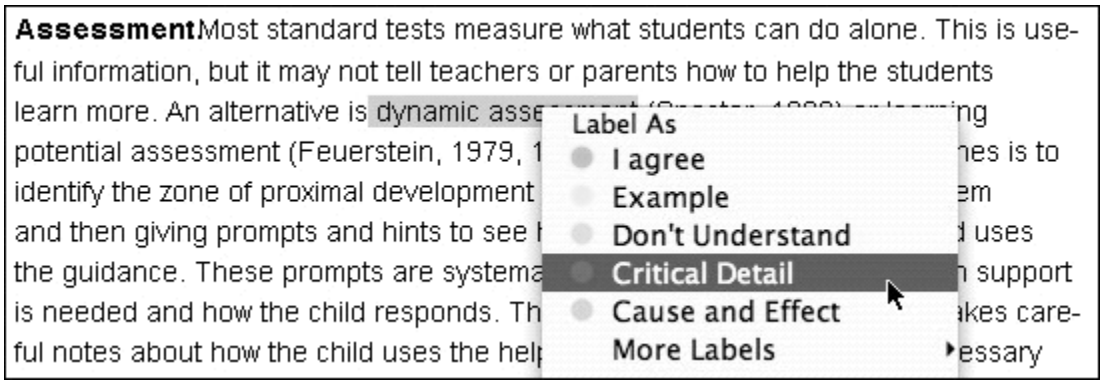
gStudy is different from CMSs in two key respects. First, although instructors will generally still create pre-defined content (gStudy learning kits), the application itself contains a browser that enables students to access any web-based content. Thus students don't have to leave the gStudy environment to conduct online library searches for additional materials for their assignments or to access other potentially relevant online content. Second, whether students are studying instructor-assigned material or materials they have found themselves, gStudy supports student efforts to organize their understanding of new content and make it personally meaningful via a unique combination of mark-up tools and information locating and viewing tools. Although there is some overlap with annotation features available in other applications, such MS Word, Adobe Acrobat, and the Wikalong browser extension (Wikalong, 2005), these applications do not provide the level of pedagogical support and customization of annotation types that gStudy does. We believe that the tools for annotating and organizing content in gStudy constitute a new approach to e-learning software.

gSTUDY TOOLS

Highlights and labels. At the most fundamental level, gStudy provides a labeling tool for highlighting and categorizing content, including segments of text, regions of graphics, and QuickTime frames. Although the tactic of selecting and highlighting may shift the learner to a slightly more active form of engagement, this tactic is usually regarded by SRL theorists as information rehearsal, a fairly superficial form of cognitive processing (Pintrich, 1999). In gStudy, learners also categorize highlighted text by

choosing an appropriate label. Initially, learners are provided with a pre-stocked list of labels such as “critical detail” and “don’t understand” (see Figure 2). Learners can add to this list to create personally meaningful labels such as, “useful for biology class, too.” In the terminology of SRL, learners may plan to use the strategy of categorizing portions of the content in personally meaningful ways such as whether it is familiar to them, new but easy to understand, or difficult and likely to require a lot more study time. The learner can then enact this plan by choosing the highlighting and labeling of selected content as an appropriate tactic. If during review, the learner decides that some segment has been misclassified, the label can be changed with a few clicks.

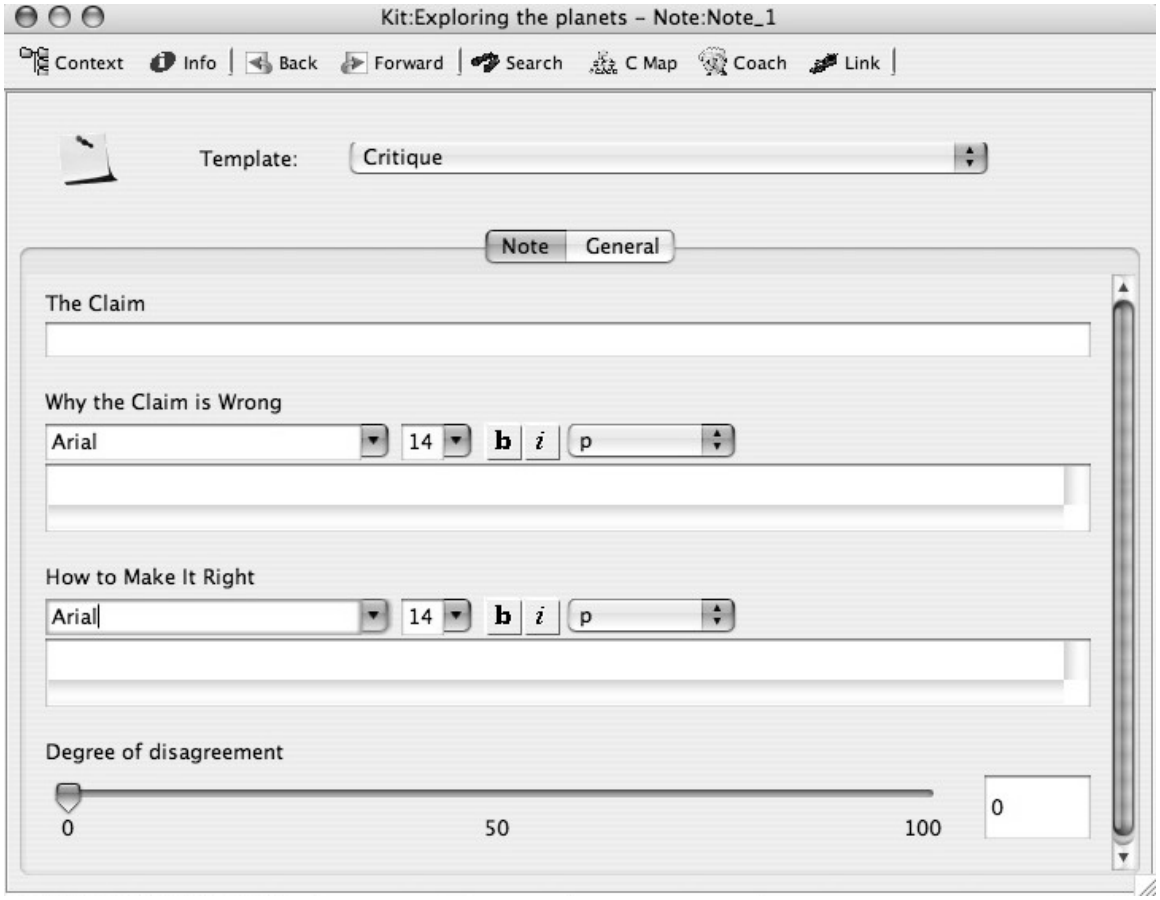
Figure 2. Labeling in gStudy: Selected text will be marked with a “critical detail” label.



Notes. By itself, labeling information as fitting into a category may not entail sufficient processing to gain a deep understanding. Therefore, gStudy also scaffolds generative tactics such as note-taking (Peper & Mayer, 1986; Wittrock, 1989). gStudy provides pre-defined templates for a range of note-types, and, as with labels, instructors and students can add to the default set by creating customized templates. Figure 3 shows the template for a critique note. Notice that this template is not just a blank form with the label “Critique”; rather, it is divided into three text fields (The Claim; Why the Claim is

Wrong; How to Make it Right) and one slider bar (Degree of Disagreement, 0-100) to help students learn what type of information they should be thinking about when critiquing a claim. Learners may choose not to complete the whole template immediately, and the separate fields make it is easy to see which parts are complete and which need to be done at a later date. The default note templates include summary, debate, comment, question, and others, each with its own set of relevant fields for students to fill in. This type of prompting with specific fields helps students assess whether a particular tactic, such as using the critique note template, is likely to be appropriate at a given point in their studying.

Figure 3. Critique note template in gStudy.



The design of gStudy's notes tool is informed by research on the metacognitive components of note-taking, which has shown that judging which content to annotate leads to greater learning than not making such judgments (Igo, Bruning, & McCrudden, 2005). gStudy not only encourages learners to evaluate which information to elaborate on, it also prompts them to consider what type of elaboration (i.e. what note template) is the most appropriate in each case. Providing named templates helps students to think about different types of note-taking when selecting appropriate strategies for learning assigned content, and providing specific fields within the templates helps ensure that learners will be able to act on their chosen strategies effectively. Further, when

monitoring the effectiveness of a given learning plan, learners can easily survey information such as incomplete note fields, variety of note types used, and even total number of notes created to help them assess whether their study plan is working or requires modifications.

Glossary. gStudy supports both instructor and student creation of glossary items. Instructors may pre-populate a glossary with some key terms, and then encourage students to elaborate on these definitions and add additional terms as they study. When students build definitions by paraphrasing provided information, they are performing a type of elaborative rehearsal (Shugarman & Hurst, 1986; Weinstein & Mayer, 1986); we have found that students almost always construct text for notes and glossary items, rather than copying provided information (Nesbit et al., 2006). Students can compare glossaries with one another, use them as flashcards, or engage in other activities to get feedback on their learning. Instructors can also use both the note and glossary templates to pre-populate some annotations, thus providing examples that students can build on in their own learning activities.

Links. Once students begin to annotate their study materials, they can create links between notes, regions of content, and glossary items to help them see the different ways that key ideas interrelate. Explicitly building up connections by linking annotations to previously understood content helps learners to see the structure in new knowledge domains, which in turn, helps them to understand the domains better (Winne, 1995). Links can also help students evaluate how their study plan is going. If the learner's annotations seem to be a collection of unrelated (unlinked) facts, this can serve as a cue

to spend more time understanding how different “bits” of information relate to form a coherent whole.

Views. In addition to the annotation tools, gStudy provides multiple ways for learners to view and review the content and their annotations. When in the default contents view, students can see the original content, along with markers indicating where they have added annotations. Clicking on these markers will bring up the annotations in a new window. Alternatively, students can choose to look only at their notes, only at their labels, or only at their glossary. In each of these views, students see a table of contents listing all of the entries for that category. Selecting an entry brings up the relevant details and enables students to navigate back and forth between annotation and its sources. By allowing students to focus on only certain types of information, gStudy reduces the cognitive load associated with monitoring one’s studying activity, which in turn makes it easier to identify where one’s study plan may need to be adapted.

Search. If learners are unsure where to find some piece of information, or if they want to be certain to find all instances of a word or phrase, they can use gStudy’s search tool, which supports both single keyword searching and more complex Boolean searching. The tool returns hits from instructor-provided course content, other webpages students have saved into their kits, any annotations the student has made or received from collaborators in group projects, and any documents the student has created. This helps students to locate relevant information from across information sources and see connections across different areas of content. As with the different views, the search tool reduces the cognitive load associated with tracking all of the information in a kit, thus helping students to monitor their learning.

Concept Mapping. Concept maps are diagrams that provide an alternative way to represent the information that students typically see only as text. gStudy's concept mapping feature allows students to choose to view and manipulate the content of a learning kit through a node-link interface. Documents, notes, glossary items, and other gStudy objects are represented as nodes. Links between objects are represented as lines. The maps can be created in advance by an instructor, or learners may build their own concept maps as a means of working with the content and looking for gaps in their understanding. Research has shown that the use of concept maps can enhance learning (Nesbit & Adesope, 2006; O'Donnell, Dansereau, & Hall, 2002; van Boxtel, van der Linden, Roelofs, & Erkens, 2002). A concept map showing all content and annotations in a kit can help learners to get a sense of what areas they have been neglecting and what areas show rich interconnections. Maps of subsections of the kit can help students to work with relationships among concepts visually, instead of in a more traditional text-based form.

TOOLS IN DEVELOPMENT

Further to the already-implemented tools described above, development efforts are now focusing on two additional areas: a sophisticated help system and collaborative tools that support SRL.

The Coach. Student-initiated help systems rely on learners to identify when they need help and to act appropriately on this knowledge (Nelson-LeGall, 1981). System-initiated help systems can be useful when students don't realize that they are engaging in maladaptive activities, but such systems often don't have sophisticated enough models of learners to be able to help in all situations (Aleven, Stahl, Schworm, Fischer, & Wallace,

2003). To address the problems associated with either approach in isolation, we are currently prototyping a mixed-initiative help system that will serve three functions:
1) respond to student-initiated questions (e.g., “How do I make a note?”) with factual “how to” answers;
2).promote student understanding of tasks and tactics by providing questions to help students reflect on their studying strategies (e.g., “What types of tools do you think will help you learn this material?”);
3) prompt the student when the system recognizes problematic behaviours (e.g., after the student has made 10 “important” label annotations, the system may prompt the student to think of ways to differentiate the items – to consider how they relate and how they differ by creating more detailed notes about some or all of the items).

We predict that this type of coaching will help students learn how to ask and answer reflective questions about their studying and will thus lead to improvements in SRL. This comprehensive coach system will make use of standard pattern-matching techniques and both general- and domain-specific ontologies that will be interpreted by an expert system (Menon, Shakya & Kumar, 2005; Rao & Kumar, 2005; Shakya, Menon, Doherty, Jordanov, & Kumar, 2005).

Collaboration. The research team is also developing a set of tools to support cooperative and collaborative activities within the gStudy environment (Hadwin, Gress, Page, & Ross, 2005). These tools will enable sharing of annotations and new content files (e.g. team reports) among team members and support scaffolded synchronous chat. By providing a list of common chat roles and role-specific discussion prompts, gChat will help students develop the skills to participate effectively in online chat as a learning

activity and build common understandings of course concepts based on a variety of perspectives. Team members will be able to return to stored transcripts of these text-based conversations and annotate them as they would any other content in their kits.

PUTTING IT ALL TOGETHER

All of the tools in gStudy are designed to work together to support self-regulated learning. Currently, gStudy is most effective in supporting phases 2-4 of Winne's model of SRL (2001). In the planning stage (phase 2), students must identify appropriate strategies and develop a plan of attack for their task. By making tool options explicit, gStudy helps translate the task of strategy and tactic identification from recall tasks to recognition tasks. Students can look at the list of available tools, templates, and views and decide which best fit their current task. When carrying out their plans (phase 3), students are further scaffolded by the fields within note and glossary templates that help students to implement their tactics effectively. Finally, gStudy helps with the monitoring phase of SRL (phase 4) by providing multiple ways for students to look at and filter their annotations, the links they have created across different areas of content, and the content itself. Because students have access to a comprehensive, sortable record of all of the work they have done when studying with gStudy, it is easier to compare effort to outcome. For example, if a student finds they had more difficulty than expected with definitions on an exam, they can easily pull up the relevant glossary items and compare the thoroughness of their definitions and the number of links to related content with the glossary items and links they created for other units. This provides personally meaningful information on the effectiveness of their study tactics, which they can use in developing more effective plans for the next exam.

Because the application records student interactions with course materials and annotations, gStudy can also be useful in helping students to track their approaches to learning concepts and solving problems. Students can use this information to help identify the need to acquire broader schemas for solving classes of problems, as opposed to tunneling in on solving specific instances of problems (Winne & Stockley, 1998). With student consent, researchers can also use this log information to identify effective and ineffective approaches to studying different types of material. This knowledge, in turn, can be used to build better scaffolding for students. Many of these benefits are not easily available in traditional classrooms, but advancements in educational technologies make it possible to provide learners with exciting new tools to help them learn about and improve their approaches to studying and learning.

CHALLENGES

Scaling up. Scalability is a challenge that must be addressed with any widely deployed e-learning environment. In any one educational institution, there may be thousands of students; and across institutions, tens of thousands. This poses potential storage and network concerns. We have demonstrated that gStudy can perform efficiently with hundreds of students in one course, but we have not yet deployed it on a larger scale. However, we have designed the application with scalability in mind. For example, students are able to download their kits onto local machines and then upload only the content they have added. This gives users local access to their study materials without overburdening the network with ongoing high data transfer demands and without requiring the huge amounts of centralized storage capacity that would be needed if users transferred entire kits for each session.

User education. Many students and instructors are not yet familiar or comfortable with working in e-learning environments, and gStudy is a powerful application that is rich in features. This means that no matter how intuitive the gStudy interface is, there will be a need for an education component to orient new users and give them confidence in their ability to learn with the system. Currently, all gStudy users attend a one-hour face-to-face training session and then have continued access to a sample kit in which to explore and play with the available tools. As part of our plan for scaling up, we have developed a tutorial kit to guide new users through what may be their first experience with an e-learning environment. This orientation kit, coupled with the Coach, should provide a good introduction to gStudy.

CASE STUDY: PROMOTING LEARNING SKILLS

This case study describes two primarily face-to-face offerings of a second year educational psychology course in fall 2004 and spring 2005. Approximately 240 students were enrolled each semester. In addition to course objectives in theories and applications of educational psychology, the instructor (Nesbit) introduced goals related to the development of learning skills. These were to raise students' awareness of their study strategies and to improve their SRL skills by supporting student efforts to refine and adapt their learning strategies and beliefs. Part way through the course students were given access to several chapters of their textbook online through gStudy (three chapters in the first offering, four in the second offering; all with the publisher's permission). One tutorial session was dedicated to introducing students to gStudy, which they then used to study the online text material as part of a course assignment.

The Strategy Reflection Assignment. Over the first few weeks of the course, students completed a series of questionnaires assessing psychological constructs that are hypothesized to relate to self-regulated learning. These included the epistemic beliefs inventory (EBI, Bendixen, Schraw, & Dunkle, 1998) and the achievement goal questionnaire (AGQ, Elliot & McGregor, 2001), among others. Near the midpoint of the course students used gStudy for at least two hours distributed over at least two sessions to study one of the online textbook chapters in preparation for an examination. They maintained a descriptive log of their gStudy sessions, including schedules, strategies, and content studied. Students then submitted a reflection assignment in which they drew connections between their studying log and their self-perceptions, as measured by the questionnaires.

Comments by Students. Written reflections from students who consented to participate in an SRL research project were kept as data. Although there were many more positive than negative comments, a representative sample of both types of comments are presented here.

Positive Comments. Students frequently commented that gStudy helped them to learn and has a usable interface.

- "Being able to link one idea to the next allowed me to create a web of ideas rather than single concepts. Working with the text in these ways, methods I do not typically use, enriched my comprehension and engagement."
- "When there was content that needed further attention I could easily link it to a question I composed myself. I do not do this in my usual study system but it proved very useful since I returned to the questions later to test my understanding."

- "I found it very useful to mark the sections of the text that I did not understand to come back to later. This differed from text book studying because I really did return to the areas of confusion."
- "gStudy indicated to me that there are many ways in which I can improve my study routine to enable me to learn and retain information better."

Negative Comments. Some students indicated that they preferred to study with books rather than computers, that they did not need to use all the features provided by gStudy, and that they had difficulty managing the interface.

- "The only part of the kit I found useful was the Quick note [label] function. All of the other functions needed us to provide information to why we chose that link, and I do not study that way."
- "I was not able to glance at a page I had read and interpret what I had highlighted and why. When I study with a text book I can write my own notes and colour code my own highlights."

The student feedback was used to revise some features. For example, newer versions of gStudy allow students to control the colours used for each label type. We are also planning to invest more time in training students to apply self-regulated learning strategies. We believe that these measures will alleviate the problems reported by some students. Overall, the response to gStudy has been positive. We are continuing to conduct usability studies and to evaluate specific features for their impact on learning outcomes.

gSTUDY AS A RESEARCH TOOL

The features and tools described thus far have focused on the benefits of gStudy to learners. We have described how gStudy supports the development of SRL in learners

and how SRL will be a critical area of skill as students move into online learning. However, gStudy has also been designed as a research tool. In fact, the software's capacity to capture data for educational and institutional research is one of its key strengths. If learners consent, gStudy automatically logs which documents they choose to view, which buttons they click, what operations they perform and what content they create. This provides a rich data set with which researchers can examine how learners study in an online environment.

As institutions continue to adopt e-learning technologies, educators are becoming more conscious of the need to evaluate online teaching and learning practices with the same level of scholastic rigor as other areas of research (Huber, 2002; Hutchings, 2000). The use of applications such as gStudy can facilitate this type of research. By looking at the log files and the content of students' annotations, educators can systematically study what students are doing when studying, how their study strategies and tactics evolve, and how this relates to their academic outcomes. This in turn can feed directly back into improved design of online content and learning activities.

gStudy is also useful for demonstrating accountability in e-learning at the institutional level. The data available from gStudy enable institutions to track not only system usage but also actual changes in learner studying patterns. gStudy logs provide the information institutions need to demonstrate the basics, such as amount of time spent using the application. However, because students do their studying right in gStudy, researchers are also able to assess interaction with online content, both quantitatively (e.g., number of notes created) and qualitatively (e.g., level of understanding demonstrated in concept maps). These assessments can then be compared with student

outcomes to meet institutional research needs and accountability commitments (Kelly & Nanjiani, 2005). It is this dual purpose of gStudy – to help students develop and use their SRL skills and to help further empirical research on SRL in e-learning – that makes this application so relevant to institutions moving into e-learning.

CONCLUSION

Transition to Cognitive Tools for SRL in eLearning

Students are demanding greater flexibility in course delivery mode and methodology (Brandt, 2002; Lin, Young, Chan, & Chen, 2005), yet they may not be aware of the corresponding increase in personal responsibility for their learning that comes with such flexibility. It is important to look at the changing needs of students, as educational institutions move to e-learning environments, and to build toolsets to support these needs. By explicitly incorporating tools to foster SRL into transition plans, institutions can make a significant step towards ensuring students are prepared for the new methods of delivering education.

Further, online courses make instructor approaches to pedagogy and implementation of lessons and assignments more visible than they have been in the past. This is coupled with a growing trend towards accountability and the need to demonstrate for university administration and even outside organizations that instructors are effective teachers (Kelly & Nanjiani, 2005; Nichols & Gardner, 2002). Together these increases in student responsibility and institutional accountability have pushed the need for new ways of supporting learners to the fore.

Students who are equipped with the skills required to regulate their own learning will be better prepared to thrive in the new post-secondary environment and will also

have the skills to monitor their lifelong learning needs. By supporting learners' immediate SRL needs and building up their SRL skills through scaffolded support, software applications such as gStudy will help learners succeed.

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