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Cognitive Load Theory and Library Research Guides

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Abstract:

Online library research guides are instructional tools that most libraries provide for their patrons. With greater flexibility in web programming and new products like Springshare's Libguides librarians have multiple venues for guide creation. This paper seeks to assist research guide editors in assessing their guides based on cognitive load theory. This theory is based on the idea that cognitive capacity for learning is limited and that techniques can be developed to help learners avoid cognitive overload. Addressing the three main sources of cognitive load gives librarians a framework in which to create meaningful and useful research guides.

Cognitive Load Theory and Library Research Guide Design

With the proliferation of the internet and the exponential growth of information resources, college students are faced with a seemingly unlimited supply of information. Research has shown that students predominantly use the Internet to locate information for their educational as well as private and professional purposes. Although early Internet studies once focused on the mechanics of using web browsers and search engines, educational studies focusing on the cognitive and metacognitive aspects of searching are now emerging. It has been recognized that "studying electronic documents can cause feelings of disorientation and cognitive overload" (Lazonder & Rouet, 2008, p. 757). Librarians have seen this dilemma and sought to help students make their way through this vast amount of information using library research guides. Research on the effectiveness of online research guides is still relatively in its infancy as is research in cognitive load theory. Cognitive load theory seeks to reduce or manage the working memory load, or cognitive load, in order to assist learners in developing meaningful learning experiences. A closer look at cognitive load theory and ways to help students manage cognitive load gives librarians new perspective for creating pedagogically-sound research guides. Although it is often assumed that "technology-based tools can enhance student performance when they are integrated into the curriculum and used in accordance with knowledge about learning," librarians, who often see the confused look on students' faces during the research process, realize that "the mere existence of these tools in the classroom provides no guarantee that student learning will improve; they have to be part of a coherent education" (Bransford, Brown, & Cocking, 1999, p. 216). It is imperative that librarians work with faculty and other campus constituents to relate research guides to the curriculum and culture of their respective campuses.

Librarians have been creating guides since the 1950s, when booklists or bibliographies of recommended readings on a particular topic or genre were first produced. In the 1970s MIT librarians coined the term "Pathfinder" and marketed and sold these new guides to other libraries as research tools. This venture proved unsuccessful because librarians preferred to customize guides for their own libraries. These guides have morphed into web pages, available on most library websites, and provide links to reference materials, databases, journals, and web sites within a particular discipline (Vileno, 2007). Because the term pathfinder is used primarily by librarians, terms like "library subject guide," "research guide," "pathfinder," or "libguide" are used synonymously in its place.

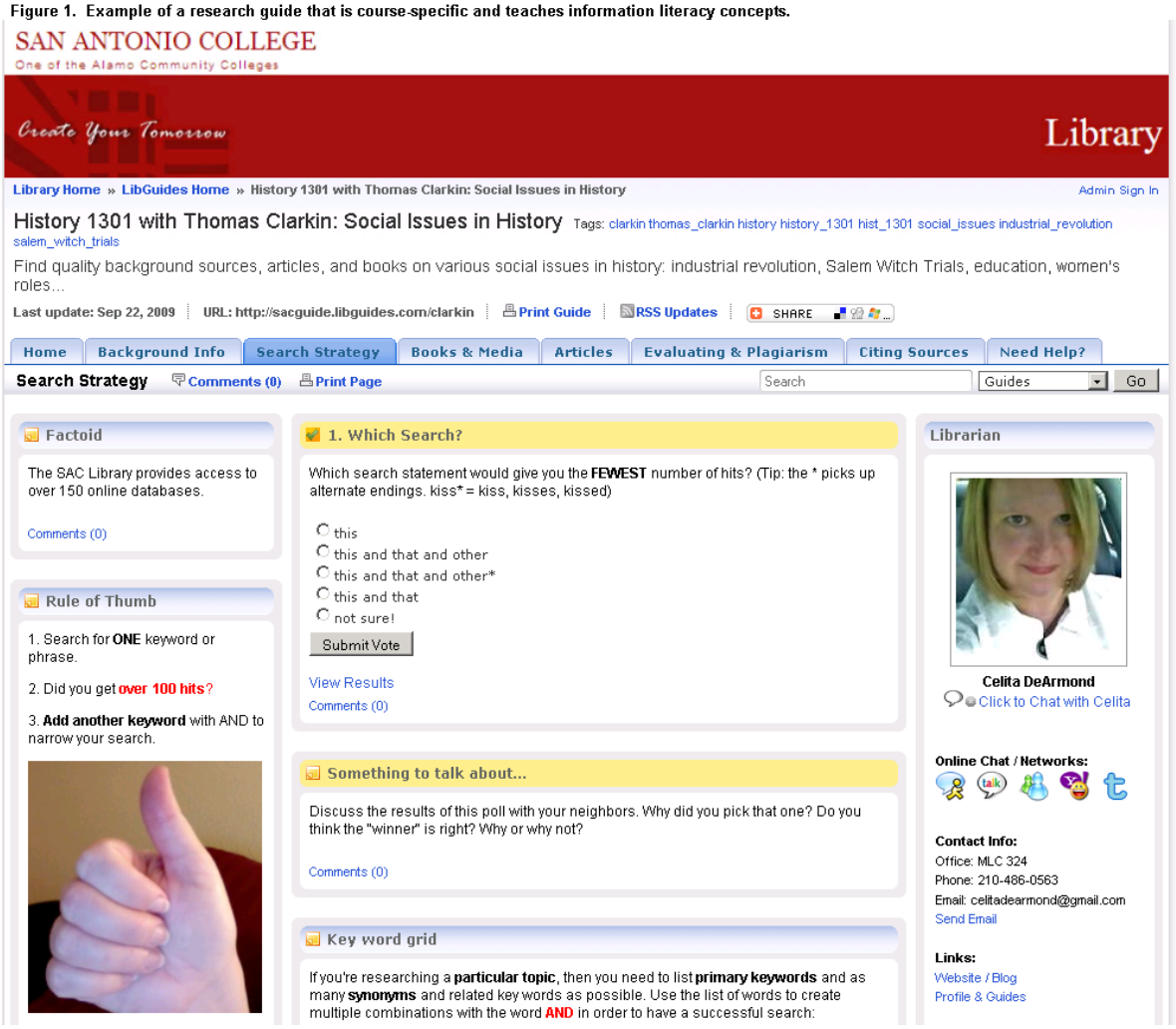
Cognitive load theory is based on the idea that cognitive capacity for learning is limited, and that learners are often "overwhelmed by the number of information elements and their interactions that need to be processed simultaneously before meaningful learning can commence" (Paas, Renkl, & Sweller, 2004, p. 1). Cognitive load theory posits that techniques to help learners free their working memory load must be used so that the information and its processes may be stored in the long term memory. Schema, "the general knowledge that serves to select and organize incoming information into an integrated meaningful framework" (Mayer, 2008, p. 79), must be constructed by the learner and should be encouraged by sound instructional design. Once lower level schemas have been formed, learners can integrate higher level schemas into their long term memory. As more schemas are added, the process by which they are used becomes unconscious and more memory is freed to learn new tasks. With more extensive practice, schemas can "become automated thereby allowing learners to further bypass working memory capacity limitations" (Paas et al., 2004, p. 2). Effective research guide design will encourage both the construction and automation of schemas.

In order to reduce or manage the working memory load cognitive load theory focuses on three main types of cognitive load: intrinsic, extraneous, and germane. Intrinsic cognitive load is the amount of cognitive processing required to learn the basics of the material and depends on the complexity of the material presented. Extraneous or ineffective cognitive load occurs when the amount of cognitive processing is overtaxed and the information presented is disorganized or not relevant to the task at hand. It does not allow students to use their working memory to develop appropriate schema. Germane or effective cognitive load occurs when learners effectively organize and integrate the new material into their working knowledge (Mayer, 2008; Sweller, 2005; van Merriënboer & Ayres, 2005). In order to design effective instructional experiences librarians must try to manage intrinsic load, minimize extraneous load, and promote germane load. "If the learner must waste cognitive resources on extraneous processing, then the learner may not have sufficient capacity remaining for intrinsic and germane processing" (Mayer, 2008, p. 24). The implications for the instructional design of effective research guides are obvious. By addressing each cognitive load librarians will be able to create research guides that are easier for students to use. Students, in turn, will learn ways to complete research assignments and become effective information users.

Although intrinsic cognitive load cannot be eliminated, it can be lessened by segmenting the research process into smaller parts or providing direct access to materials. After completing a study of college students' use of research guides at San Jose State University, Staley (2007) recommended that the guides be organized not only by broad subjects, e.g. "organizational management," but into smaller subjects, e.g. "accounting and finance" or "aviation management" (p. 130). In other words breaking a topic down into smaller chunks helps decrease intrinsic cognitive load. Staley also suggested linking directly to departmental web pages, of which students had some working knowledge. Links for specific journal titles or links to journal subjects' lists, rather than just to the long alphabetical list of titles helped students access relevant information readily.

Two additional studies recommended taking the process one step further to guides created for individual courses that addressed course-related assignments (Somerville & Vuotto, 2005; Ladner, Beagle, Steele, & Steele, 2004). Somerville and Vuotto also challenged librarians to work closely with faculty in order to combine discipline and information literacy concepts thus maximizing the students' ability to recall the information in academic, work, and personal environments. During the yearlong design process of an agribusiness research portal, librarians and faculty based content decisions on faculty-determined course learning outcomes, departmental mission objectives, and college accreditation agency critical thinking skills. San Antonio College librarians have created libguides for individual courses that also show students the research process (Figure 1). Library terminology needs to be avoided or defined, since most students still lack familiarity with these terms (Augustine & Greene, 2002). A webpage defining library terms will assist students if they forget basic terms they have learned or will serve as a backup for jargon that faculty assume that students understand, e.g. "stacks" or "peer-reviewed."

Figure 1. Example of a research guide that is course-specific and teaches information literacy concepts.



Extraneous cognitive load must be reduced in order to help students navigate research guides more effectively. Several effects have been described in the literature and can contribute to research guide design improvements (Sweller, 2005; van Merriënboer & Ayres, 2005; Mayer 2008). The "signaling effect," where clear and precise headings signal the organization of material, are one of the easiest yet most often overlooked areas of an effective subject guide. Dahl (2001), in her analysis of 45 library research guides from nine higher education institutions, recommended that headings be clear and consistent across the library website, but also said that "defining the scope of the pathfinder and keeping it manageable help users to know whether it is appropriate for their needs and allows the pathfinder to be reasonably comprehensive without being excessively complex" (p. 233-234). Adding keywords and basic definitions helps the student choose whether or not to continue using that guide or to try a different one. Brief descriptions and definitions of the listed resources and databases also provide signals for students' comprehension before they follow the links to subsequent web pages, as was found in Jackson and Pellack's research (2004). The University of Maryland's libraries unifies its subject guides by creating templates for librarians to use which creates a clean and consistent look across its website (see Figure 2).

Figure 2. Research guides that use standard language across their guides, based on templates.

Guides to Info. Resources > Agriculture and Natural Resources > Fisheries and Aquatic Sciences

Last revised: August 2009

Fisheries and Aquatic Sciences

Scope: This guide covers the major reference sources in the field, including fisheries, aquaculture and aquatic sciences. For information on related topics, readers can also consult the UM Libraries guides on Wetlands and Water Quality, Chesapeake Bay and Agriculture. Email the subject area specialist at sgagnon (@umd.edu) or call (301)405-9098 for more information.

Table of Contents

Locating References Using the Catalog

To locate books, search the library Catalog. Keyword searches will locate words and terms when they appear in the title, subject headings or notes of a record. Limit your search by adding additional terms or otherwise narrowing the scope of your search. Examples of words and terms you may wish to use to retrieve books on the subject of Fisheries and Aquatic Sciences include:

Aquaculture	Fish-culture	Fishes--Breeding
Aquatic animals	Fish populations	Integrated agricultural systems
Coastal zone management	Fisheries	Marine resources conservation
Fish as food	Fishery conservation	Oceans--Environmental aspects
Fish communities	Fishery law and legislation	Water--Pollution
	Fishery management	

The search box below will open the Catalog and launch your search in a new window.

word/s anywhere search

These terms can also be used to locate materials in other online resources such indexes and abstracts (See section below). Please note: These terms represent only a small sample of all searchable concepts. For more specific searching instructions, please Ask Us!

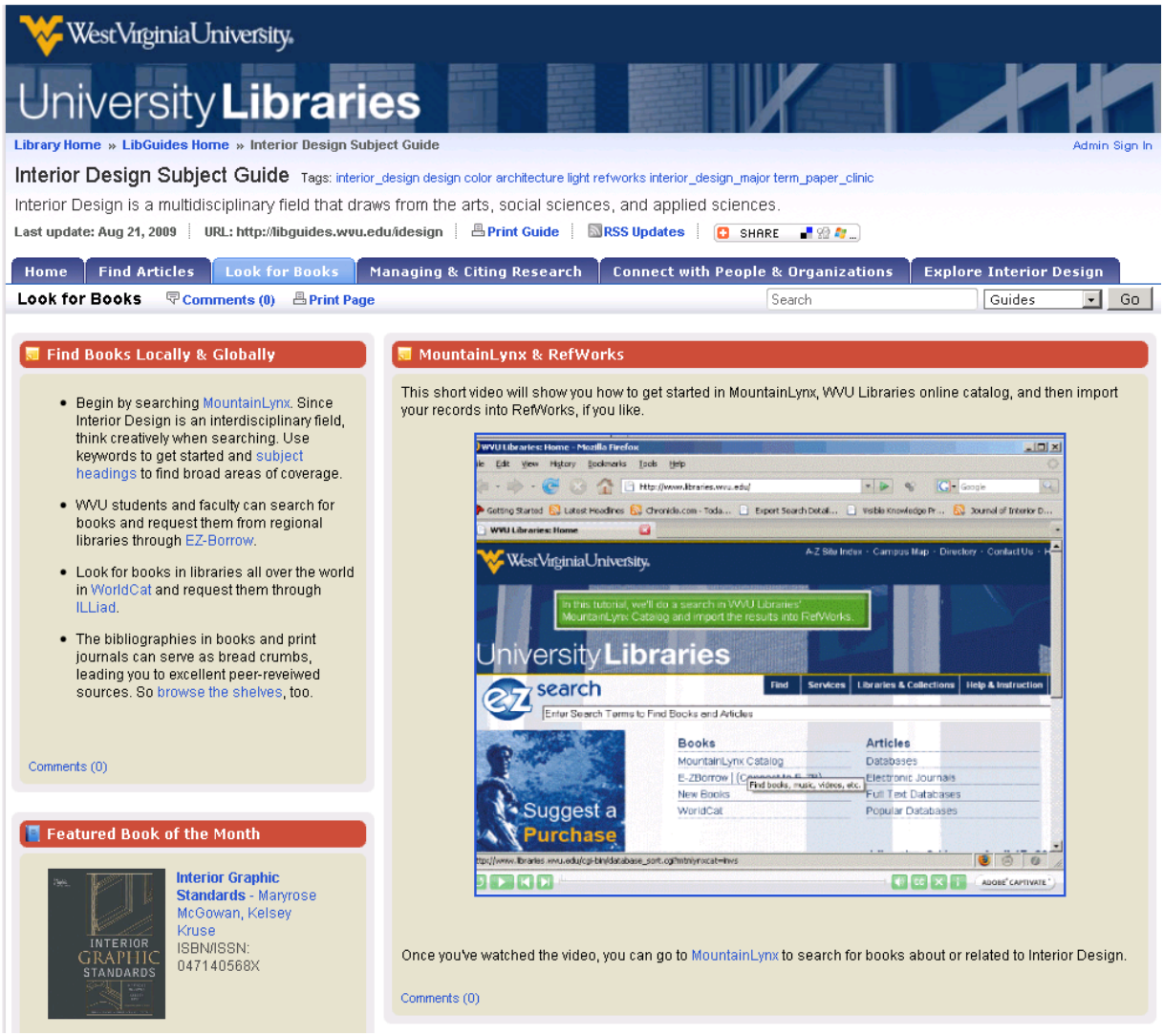
▲ return to top

The "worked example effect" allows learners to study examples that provide solutions to the problem. "A worked example, by reducing or eliminating search, reduces extraneous cognitive load and so facilitates learning" (Sweller, 2005, p. 26). Although librarians typically try to teach students how to do research themselves, there may be times when providing a worked example, such as a link to a stored search or to multiple databases, is appropriate. Depending on the objective of a class assignment or the time involved, a student may need to get directly to an information resource rather than learn the intricacies of searching for it. Ladner et al. (2004) described coursework where the focus was placed on primary literature engagement. Students needed to access and read primary source material, so librarians created links to several resources using a "stored searches" technique. These direct links "would simulate the "Google-type" keyword search… but would actually have professional database search strategies embedded in them" (p. 333). Links to searches done on the Internet showed contrasts, so students could learn the difference between the Internet results and library-provided database results. For those students who were sincerely interested in understanding and searching databases, instructions and tutorials were provided but not required. By using "stored search" links students can reduce extraneous cognitive load by eliminating difficult and time-consuming search processes.

A third way to reduce extraneous cognitive load is to reduce the amount of extraneous, or redundant, information (the "redundancy effect"). Eliminating redundant and "wordy" information frees up more of the student's memory for completing the research project immediately at hand. For example, rather than repeating the database instructions, the detailed search strategies for <u>one</u> database might be described with the remaining databases merely listed (assuming they can be searched basically the same way). Because a "wall of unfriendly text is not too inviting" (Tchangalova & Feigley, 2008), using succinct wording helps the students avoid cognitive overload.

The modality effect, where verbal material is presented in spoken, rather than written form, has not been studied specifically in relation to library research guides. Links to video formats on research guides do exist, but for the most part, they are long linear tutorials. Written instructions for using a database and diagrams depicting screenshots may now be simplified by inserting a short video that demonstrates a simple technique. Technology to produce brief snippets of spoken words is still relatively new; however, software like Camtasia or Jing are fairly easy to use and produce small-sized files appropriate for embedding into a research guide (See Figure 3). "If multiple sources of information that are required for understanding are all presented in visual form (e.g., a written text and a diagram), they are more likely to overload the visual processor than if the written material is presented in spoken form, thus enabling some of the cognitive load to be shifted to the auditory processor" (van Merriënboer & Ayres, 2005, p. 7). Students will therefore increase their working memory capacity because they will not have to split their attention between multiple sources of visual information. They will add more complex schemas to their memories through visual and auditory processes. (Of course, care should be taken to ensure that subject guides retain their accessibility for students with disabilities.)

Figure 3. Illustration of a brief video embedded in a research guide to teach how to search the catalog.

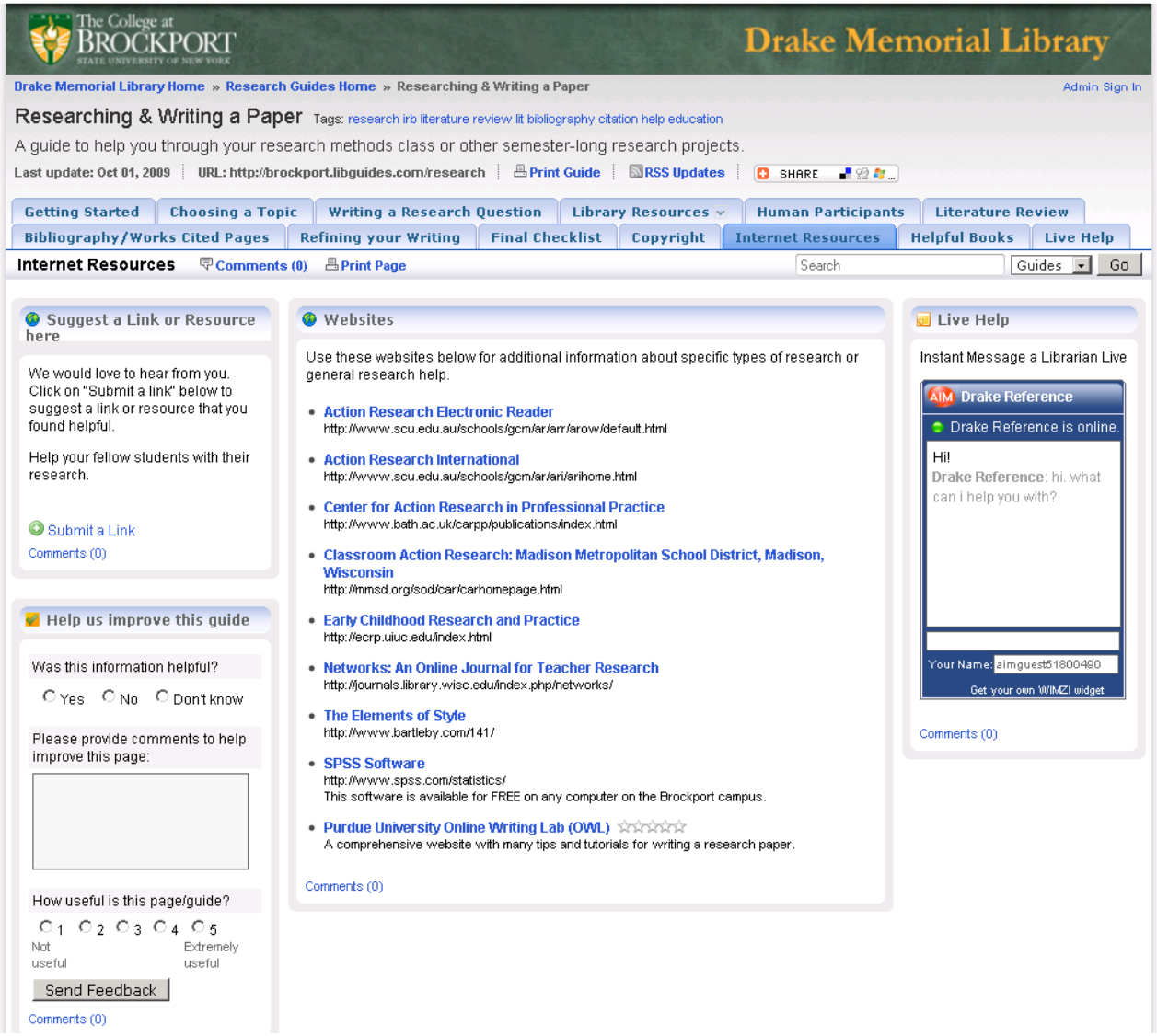


Germane cognitive load, the third and final component of cognitive learning theory applies to research guides that "promote meaningful learning when they include essential verbal and nonverbal materials and learners are allowed to interact or reflect about the relationships between them with the help of structured personalized guidance" (Moreno, 2006, p. 66). Conversational style in writing, such as using "I" or "you" rather than the third person, helps students to connect with the material more easily than when written in a formal style (Mayer, 2008, p. 489). Allowing students to manipulate databases rather than watching a tutorial alone allows them to process new information and creates a meaningful learning environment (Moreno, 2006). Two user experience library articles regarding research guides found that without personalization, the guides were less likely to be used. Hemmig (2004) examined library research guides and found a gap between the students, or users of the guides, and the design of the guides. He recommended that guides be designed with the overall learning experience in mind and that more attention be paid to "research guide design than resources selection and web page layout" (p. 79). Personalization and customization, two concepts that today's students familiar with web 2.0 tools expect, must be considered and implemented into research guide design. Through usage statistics and usability

studies Reeb and Gibbons (2004) found that students do not relate well to research guides. "Students lack a mental model that includes subject guides, while librarians have a mental model that supports their value and purpose" (p. 127). Students often lack an understanding of what a discipline is, but librarians typically organize guides by discipline. With increasing interdisciplinary college curriculums students often have a difficult time choosing a subject guide when their topic is interdisciplinary. Reeb and Gibbons' (2004) solution to this problem was to tailor subject guides directly for individual courses and deliver them to students through course management software. For institutions that are much larger or lack adequate funding for such a project they recommended creating discipline-level research guides but linking them directly at the course-specific level.

A part of the germane cognitive load that is especially difficult for librarians to create and assess, is that of encouraging students to reflect on what they have learned in order to become self-regulated learners. Personalization of subject guides leads students toward generative processing, where students actively construct their own knowledge. Students need to take ownership and management of their learning activities, which may be hard for librarians to encourage when they are not the course instructor and do not have particularly strong personal ties with students. "Self-regulated learners are particularly needed in the information age, where students are exposed to many sources of information in many different forms" (Mayer, 2008, p. 423). Research guides, especially those that help to guide learners through the various steps and processes of research, will motivate students to learn and remember how to navigate and use a wide variety of information resources. The College at Brockport's research methods guide was designed to help students through a research project from its inception to its final product and serves as point students can reference throughout the semester (see Figure 4).

Figure 2. Research guide that shows personalization, interactivity, and promotes self-regulated learning.



Applying principles from cognitive load theory will further enhance the effectiveness of research guide design. "A subject guide that incorporates the cognitive processes to completing course assignments . . . would more closely parallel students' mental models" (Staley, 2007, p. 132). Focusing on the cognitive processes that students must use to navigate information resources and helping them to reduce cognitive load will encourage self-regulated learners who are capable of constructing their own knowledge for research processes. As they progress through their college career, they will construct schemas for their own research that they will use later in their professional careers and personal lives. By taking responsibility for the own learning, they will be better equipped for their careers and personal lives, as 21st century skilled information users. Practical suggestions for incorporating principles of cognitive load theory into research guide design follow:

1. Tie guides to the course-level whenever possible rather than to the broad subject area.
2. Use terminology that is clear and consistent across the library website and provide a guide for basic library and research terms.
3. Provide links to a set of core journal titles or to a relevant subject listing.
4. Include video clips and other visual components to provide students with another source for learning skills.
5. Provide clear descriptions of each research guide's purpose and for each resource listed in the guide.
6. Use conversational, not formal, style in the guides: Use "I" and "you" as opposed to the third person.
7. Keep text to a minimum: Break up text by using lists or boxes or add images to prompt users' memory as they develop a schema for research and their topic.
8. Increase interactivity using polls, feedback forms, or tutorials.
9. Add a human element by including librarian contact information, pictures, and/or live chat.
10. Assist students in developing self-regulated learning strategies by breaking down the research process into smaller parts.

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