Effects of Precomputer Website Framing on Student Recall and Knowledge Restructuring

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This study examined the effects of student-created paper-based website frames on their recall and knowledge restructuring. Statistical and observational comparisons were made of 25 students’ knowledge and web page products in Frame and Nonframe groups. The Nonframe group outperformed the Frame group on the posttest immediately after class lectures. While both groups improved in their knowledge of content after the authoring activity, the experimental (Frame) group had a statistically superior improvement in test scores (n=18) and out-performed the control group (the group without the precomputer framing activity) on the final recall test. Implications of the study are reported and future directions discussed. The results are intended to inform researchers and teachers about how to reverse a trend among students who prefer to approach website programming as a technocentric design activity that is largely dependent on the capabilities of the computer system.
Student website development, like student writing, is a medium of self-expression and of public scrutiny. Increasing numbers of teachers and students are designing pages for the World Wide Web (WWW or Web). Instead of typing assignments, teachers and students are authoring their own web pages. Whether automatically coded by a web page editor or handwritten by a web page programmer, web page development requires authoring in Hypertext Markup Language (HTML). HTML is easy to use, can be made to produce aesthetically pleasing web pages, and permits rapid prototyping of new design ideas because its links are not “hardwired.” The advantage of HTML documents is that they can be read by nearly any browser on a variety of platforms (i.e., Mac, PC, Unix, Vax, Windows). With a basic skill in writing HTML tags, a beginner can create HTML documents in a text-editing program or a word processing program. Although they are not absolutely necessary for creating a home page, website editors can be beneficial because they simplify the process of creating HTML documents by automating the HTML coding. They also allow the user to easily preview their work (Tanner & Hood, 1997). The rapid prototyping capability of HTML qualifies it as developmental software for use in school settings.

Despite the capability however, technological possibilities using attributes of the Web do not automatically transfer into more effective teaching and learning. Instead, it takes a deliberate and careful design to integrate technology into education (Bostock, 1998). The authors believe that there are at least four factors that contribute to students’ successful mental restructuring of knowledge for personal construction of a website:

1. The first factor is the teacher’s belief that student knowledge is socially constructed from experience through discovery, characteristic of research on social construction of knowledge sometimes associated with constructivism (Crook, 1991; Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989).

2. The second factor that contributes to students’ successful mental restructuring of knowledge for personal construction of a website is minimal teacher intervention to ensure that students engage in the construction themselves. Bostock (1998) correctly noted that “Students cannot feel ownership of their learning if the learning goals and methods are strictly defined by the tutor. There must be room for choice and negotiation on the content and methods of learning.”

3. The third factor is some kind of structured guidance during the website programming process, including organising devices such as templates. Story (1998) found that organizers are needed whatever the media of instruction, and that organizers themselves can be delivered by a variety of
media. Johnson (1997) recommended that technology teachers use web page samples as a base for teaching students how to design different types of web pages. Tanner and Hood (1997) recommended the use of a paper-based flowchart to develop a logical master plan for creating each level or area of the web page and will lead the user through a logical design progression.

4. The fourth factor that contributes to students’ successful mental restructuring of knowledge for personal construction of a website is a product that is at once good and good looking; the message as well as medium is properly represented. For example, a recent study (Boshier, Mohapi, Moulton, Qayyum, Sadownik, & Wilson, 1997) classified 127 educational websites into: “Glitter in the Absence of Substance,” “The Drab and Nameless Award,” or “The Madonna Award for the Best-Dressed Web Course.” The researchers recommended that web authors “dress for success and ask themselves- how I can make this course attractive, accessible and interactive?” (p. 348).

The challenge for educators has been to ensure that additional features associated with the website development process are used to enhance learning rather than to detract from it. At issue is how students will exploit computer capabilities to make the website composition activity beneficial. While there may be some inherent motivational appeal associated with interacting with computer technology, using machines to learn from cannot guarantee an enhanced learning experience. Some features of the software (graphics, audio, fonts, color, etc.) may mean that student manipulation of the composition may actually detract from involvement with the topical content, and result in students doing little more than “game-playing” with the software features (Stemler, 1997).

The purpose of this research was to ensure that features associated with website development process were used by the students to enhance their own learning rather than detract from it. Toward this end, a teacher-made, print-based template served to assist students as they restructured school lessons into a personal expression on a public document on a school’s Web site. Implied in this restructuring of textual data is that students’ interpretation of the text for website presentation changed their mental organization of that information. The focus of the study was on whether or not the web design activity added or detracted from students’ mental restructuring process.
BACKGROUND

This section presents some background and elaboration of the four factors discussed previously. First, socially constructed knowledge is linked to the oral tradition exemplified by the Socratic teaching method. Second, minimal teacher intervention is recommended through the implementation of general guidelines. Third, structured guidance during the website programming process is discussed. Finally, ensuring the goal of website development includes attractiveness, accessibility, and interactivity.

Social Constructivism

The first factor that seems to contribute to successful mental restructuring of knowledge for personal construction of a website is the teacher’s approach to knowledge as a socially-constructed student experience, also known as “social constructivism” (Crook, 1991). Social constructivism is a contemporary view of educational technology characterized by (Perkins, 1991): (a) that the subject matter must be matched with students’ capabilities and interests; (b) that students already possess the requisite primary learning and support strategies; (c) that the topic should be manageable—narrow enough to be interesting, yet broad enough to be within the students’ scope and level; (d) that the task requirements contain few definite answers, some unresolved issues and ill-defined problems, some overlapping constructs to be sorted through and several levels of challenges with built-in dilemmas; (e) that constructivist goals require performances which are either beyond the information given (BIG), or without the information given (WIG); and, (f) that student assessment should test student comprehension of the content and metacognition.

As a teaching method, social constructivism is traceable to Plato’s dialogue “The Meno” (Plato: 82 in Allen, 1966, p.110). Through oral discourse and a rough sketch made with a stick in the dirt, Socrates showed his colleague Meno how a slave boy could learn geometry. Plato’s point was that “...seeking and learning are nothing but re-collection” (Plato: 82 in Allen, 1966, p. 108).

Socrates: You see, Meno that I am not teaching him anything, only asking. Now he thinks he knows the length of the side of the eight-feet [sic] square.
Meno: Yes.

Socrates: But does he?

Meno: Certainly not.

Socrates: Now watch how he recollects things in order- the proper way to recollect.

In this case, the slave boy’s knowledge was socially constructed in the presence of his teacher (Socrates) and an observer (Meno). Notably, Socrates’ questioning strategy was partially dependent on his awareness of the existence of some kind of prior experience in the slave boy, as well as his cognitive abilities to interpret the meaning in the questions to retrieve that knowledge from his memory. Social constructivism has been re-discovered in educational technology (Crook, 1991). Recent literature is replete with variations of Socratic teaching methods applied to educational computing settings, including: cognitive apprenticeship, reciprocal teaching, (Collins, Brown & Newman, 1989) procedural facilitation (Scardamalia, et al., 1989), and others. Similarly, this research focuses on high school students’ knowledge of contemporary facts that are socially constructed from their own experiences with some prompting from the teacher.

Minimal Intervention

A second factor that seems to contribute to students’ successful restructuring of knowledge is that teacher interventions should be of a general nature. Spires and Donley (1998) recommended that teachers de-emphasize their authority and transmissonal delivery of literary knowledge, in favour of resocializing students to consider their own personal knowledge relevant to the learning experience. To optimize understanding from the text, students need to take an aesthetic stance when reading. The aesthetic stance can produce high levels of understanding of the information in terms of students’ uses of inferences, analogies, and generalizations (Glassman, 1990; Rosenblatt, 1989). Less intrusive methods of teaching with technology provide more opportunities for students to engage in design problems themselves. One effect of less intrusive teacher intervention with computer technology has been a perceived reduction of anxiety in some teachers who initially had felt that they did not always have sufficient educational computing
knowledge, skills, and resources to keep-up with the changes (Bartholomew & Hulett, 1996; Mann, 1994; Ross, 1991).

**Structured Guidance**

The third factor that seems to contribute to students’ successful mental restructuring of a body of knowledge for personal construction of a website is that there should be some kind of structured guidance during the website programming process, that is, an organizing device such as a template. In the ancient exemplar, Socrates asked questions and used a stick in the sand to draw the pictures—but the slave boy deduced the answers in his own way, in his own words. Socrates used a stick in the sand to great effect, albeit more like a blackboard and chalk than a drill and practice program. Today, teachers rely on a black or whiteboard on which to illustrate, make references, and prototype their ideas and proofs as they explain their topic. In this way, the teacher’s explanation in combination with the illustrations, ideas, or proof, guide students to restructure their own thinking about the topic or deduce the answers in their own way, and in their own words.

**Instructional design template.** A “template” can be introduced to students in a nonconstructive manner, as a vessel into which the proper amount and type of information content is poured by the teacher; or it may be used to promote constructive thinking, as a virtual stick in the sand. Information templates however, are different from instructional design templates. Information templates simply inform the user, but they do not teach. Unfortunately some information templates are labeled as instructional design templates, or rather instructional templates. For example, Gregory and Brown (1997) described how to develop a website using a template for writing HTML. Hergert (1995) created a modular, multimedia attitude assessment system from a template developed with authoring software. Information templates sometimes have instructional benefit for some users, but they are not instruction, despite the labeling (West, Farmer, & Wolff, 1991).

In educational settings, designers and teachers favour “instructional design templates” (West, Farmer, & Wolff, 1991), and like Socrates, use their templates, again more like a blackboard and chalk. An instructional design template is a sketch or text passage organized specifically to promote efficient and effective acquisition of knowledge and skill. To be effective, the template must encourage annotation and illustrations about the subject matter in a way that promotes the successful accommodation and assimilation of knowledge and skills by the student.
Perhaps the best contemporary instructional design template is the “Electronic Trainer” developed by Professor David Merrill and associates (Merrill & ID2 Group, 1998). Electronic Trainer was designed to automate the instructional design process for educators. Electronic Trainer was drawn directly from Component Display Theory (Merrill, 1983). Instructional designers using Electronic Trainer are prompted to choose from declarative-, procedural- or strategic- knowledge type templates, and then from associated events of instruction templates, namely: instruction, practice and feedback. In this way, Electronic Trainer is more than simply a vessel for dumping information, yet less than a constructivist learning environment. Other instructional design templates are automated for special purposes. Zhao (1998) described the development of an integrated web-based educational environment using the software eWeb for educational activities in a range of organizational and theoretical contexts over the Internet. Mann (1998) reported a study with teachers to determine how they used WebCT, a sophisticated tool for teaching, testing, and grading students online, and a learning environment for collaborating, chatting, and submitting assignments. Ward and Tiessen (1997) described the theory-based authoring kit AliVe! consisting of resource management, collaboration, and coordination tools for schools. Undoubtedly, teachers could make good use of such programs, when they are available.

**Advance organizer.** When Socrates drew the geometrical shapes in the sand, they were intended to represent abstract geometry; they were advance organizers. Advance organizers were initially conceived of as brief paragraphs of text originally to be used to present material at a higher level of abstraction, generality and inclusiveness than the content to-be-learned (Ausubel, 1960). It was thought that advance organizers should be processed by readers before they encounter to-be-learned content (hence the advance part of the concept). However, research showed that Ausubel’s textual conceptualization of an advance organizer did not consistently facilitate learning (Pressley & McCormick, 1995). In 1975, Barnes and Clawson recommended the integration of schema theory into Ausubel’s original conception of advance organizer, followed by a re-conceptualization of advance organizer, suggested by Derry in 1984. According to Derry’s variation, learners were encouraged to use the advance organizer to adjust their mental model of the material to be learned. For example, Cardinale (1991) introduced an advance organizer to preservice teachers to provide external conditions conducive to building a mental schema about learning computer components. It appears that advance organizers only work when they activate...
prior knowledge and relate it to the new content to-be-learned. Advance organizers contribute to learning when: (a) learners know the materials in the organizer; (b) learners already have an active schema to assimilate that which followed the advance organizer; (c) specific attributes of the text to be learned are delineated (such as whether or not the text was structured along the same lines as the organizer) (Pressley & McCormick, 1995). Sto-ry’s (1998) review of the literature on advance organizers reported that researchers now believe “advance organizers to be an important part of instructional design, that organizers are needed whatever the media of instruction, and that organizers themselves can be delivered by a variety of me-

Multi-purpose frame. Throughout the 1970’s and 80’s, diagrams began to appear to help structure the textual information in an advance organizer. Mayer and Bromage (1980) included a diagram and text relating locations on the computer screen to objects familiar to readers. West, Farmer, and Wolff (1991) recommended putting the advance organizer in a multi-

A fundamental principle of the frame design is step size, which is the amount of information presented in any one frame (Rieber, 1994). Step size
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is an important consideration given the tendency to overload web pages, requiring the user to scroll down through the information. Computer-assisted instruction (CAI) research (Stemler, 1997) suggests that too much information on any one screen (i.e., large step size) will require small font sizes and can be difficult and annoying to read. Too little information on one screen (i.e., small step size) will require a list of hypertext links to other screens on the Home Page. A list of hypertext links to other screens on the Home Page would require the user to click back and forward between the linking pages and the Home Page while maintaining their train of thought. In this way, a small step size may be inefficient and annoying. The most acceptable step size appears to be up to 1 1/2 pages of information per frame. Each web page should scroll about that much. The rest of the information can be placed in hypertext links.

When the design is only single, unrelated frames, the designer is concerned for the frame protocol. When the designer must design two or more related frames, the designer should be concerned with the procedural protocol (Rieber, 1994). Frame protocol is “the consistent designation of various zones for specific uses” (Hannafin & Peck, 1988, p.175). Although it is acceptable for the frame protocol to change at the same Web site, in general frame protocol should remain consistent. It is usually helpful to think of a frame as a collection of two or more zones in which the certain types of information are presented consistently (Rieber, 1994).

Most web pages’ frames include a title zone, a graphic zone, a text zone, a zone of hypertext links, and a mail zone. The title zone is presented at the top of the frame and usually shows the name of the person or organization in a large font. Sometimes a hard rule is placed under the name across the entire frame delineating the title zone from the graphic zone. The graphic zone usually has a small personal or company graphic and digitized picture of the person or institution, followed by a hard rule across the frame which parses the graphic zone from the text zone. The text zone requires the user to read textual information. Again a hard rule across the frame separates the text zone from the zone of hypertext links. Hypertext linking is the most distinguishing characteristic of the web technology; the capability of linking a word printed on a web page to another page located at another Internet site. So the meaning of the printed word should clearly epitomize the content on the web page to which it has been linked. And again a hard rule across the frame usually separates the zone of hypertext links from the mail zone. The mail zone is usually located at the very bottom of the web page and simply shows the hypertext link to e-mail program located on the user’s hard drive, permitting the user to communicate asynchronously with the au-
thor of the website. Figure 1 is part of a paper-based frame used in our studies, illustrating the first three zones. This paper aid has been used by a subject to think out his web page design.

Easily accessible icons tend to foster web pages showing a heavy reliance on icons and graphics which are usually cosmetic. These icons and graphics are often used in place of textual information because they take-up less space. However, icons and other graphics can also be confusing or distracting to some users. The distribution of emphasis refers to designing a frame so that a user is more likely to attend to the most important information and less likely to dwell on or be distracted by other information (Rieber, 1994).

Figure 1. Portion of a frame used by a student in our investigations
Constructivism and multipurpose frames. “Building web pages is among the most constructivist activities that learners can be engaged in, primarily because of the ownership that students feel about their products and the publishing effect” (Jonassen, Peck, & Wilson, 1999, p. 28). Nevertheless, feelings of “ownership” are usually accompanied by cognitive load associated with constructivist tasks that require more mental effort than didactic methods of instruction. Constructivist tasks can contain few definite answers, unresolved issues or ill-defined problems, overlapping constructs to be sorted through, and several levels of challenges with built-in dilemmas. Furthermore, when expectations for support do not match that of the learning environment, some students may begin to feel frustration, and eventually anxiety associated with the frustration.

The multipurpose frame serves to provide a platform for active discussion and debate about the content. Prior knowledge activation is accomplished through debate around the frames. The multipurpose frame becomes the medium for student writing, drawing, and discussing ideas, and procedural questioning from the teacher can be used to facilitate constructivist thinking (Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989). So the frames are necessary but insufficient to activate prior knowledge. Reading and socialization are considered necessary yet insufficient to activate prior knowledge. It is the combination of reading, socializing, and the frame that activates prior knowledge and relates it to the new content.

Evidence of constructivist learning with a multipurpose frame therefore, can be determined by: (a) collecting and classifying student verbalizations (Mann, 1997); (b) observing students as they interact online or in the classroom about their ideas and writing for erasing and re-writing on the frame; and (c) watching them draw and redraw on the frame; in short, sharing ideas using the frame.

In sum, website design is a common Internet phenomenon wherein teachers use general or instructional design templates to orient and inform students. More recently however, students are developing templates that favour a technocentric design, giving students a repertoire of colours, animation, and stylistic graphical elements for their presentation, often to the detriment of the curricular topic or content. The idea that the inclusion of a multipurpose website frame as a pre-computer activity may improve student websites is untested. The research reported here begins a program of testing the use of multipurpose frames to encourage less technocentric and more instructionally relevant activity. Despite their differences, the critical similarity among all these templates is a teaching approach that says in effect, “Using my rough sketch, represent (literally, re-present, as Socrates would have said) what you believe to be true now about the concept.”
Good Content, Good Looks

The fourth factor that appears to contribute to students’ successful websites construction is a desired outcome that is at once good and good looking. By the end of the Socratic lesson, the slave boy had made erasures with the stick in the sand and re-drawn some of Socrates’ illustrations to clearly re-present his restructuring of the problem and its solution. The desired outcome was at once good and good looking.

Good content. The increase of design activity on the Web has not diminished the requirement for proper delineation of objectives (behavioral, cognitive, and social), learning resources, and proper student testing. Since Socrates’ time, teachers have been ultimately responsible for setting learning objectives, choosing and creating learning resources, and developing tests. Often the kind of knowledge sought is verbal (declarative), requiring students to interpret printed text. In general, assessing the interpretation of text should reveal something more about the kind of inferences made by students about the instructional materials. Constructivist literature argues for the important roles of readers’ personal knowledge and experiences (Spires & Donley, 1998). Glassman’s (1990) levels of text interpretation are one way of examining students’ inferences from textual information. This scale is at once parsimonious, yet more in-depth than surface-deep comprehension:

Level 1: Literal Interpretation—Student has read the lines verbatim, and copies directly from the source. The student has recalled or recognized detail, or a sequence of events, a cause and effect relationship, a comparison or character trait.

Level 2: Inferential Interpretation—Student has read “between the lines,” and makes a value judgment. The student has made statements of implicit information, has inferred supporting detail, a sequence of events, a cause and effect relationship, a comparison, character trait, or has interpreted figurative language.

Level 3: Critical Interpretation—Student has read “beyond the lines,” analytically. The student has made a judgment of reality/fantasy, judgments about fact/opinions, judgments of worth.

Level 4: Creative Interpretation—Student makes an emotional response. The student makes an emotional response to the content of the story on a personal level. “The dismissal of informational text
as requiring less personal engagement on the part of the reader is un-
fortunate not only because it is inconsistent with broader constructivist
assumptions, but also because it has led to a potentially valuable ap-
proach being overlooked” (Spires & Donley, 1998, p. 250).

The shift of focus in contemporary education from fact gathering to
constructed meaning suggests the need to broaden pedagogy to help stu-
dents take advantage of the full continuum of responses (Spires & Donley,
1998. In this way, text interpretation can be a useful measure of student un-
derstanding of a concept or principle.

**Good looks.** Good design in the organization of content is as important as
good content. An emerging problem with students operating in an unstruc-
tured open laboratory environment however, is the tendency for them to
concentrate on layout and design features unrelated to the teacher’s objec-
tives. Specifically, the problem discussed in this article is the presence of
technocentric design in their website programming. In a school setting,
where content is still considered more important than the characteristics of
the student’s presentation, technocentric approaches to website program-
mazz are problematic. But educational website programming needn’t be-
come technocentric. Planning skills for programming can be learned inde-
pendently of the syntax of the HTML language. Fay and Mayer (1994) for
example, found that a group pretrained in design wrote final computer pro-
grams that were shorter, more modular, more efficient, and more flexible
than the group without design pretraining. So while excellent design ap-
ppears to be a necessary condition of excellence in computer programming,
excellence in computer programming capability does not appear to be a
necessary condition of excellent design.

There is a growing number of general guidelines for assessing the de-
sign of student and school websites, a subset of which include the term (at
least) “instructional design.” These studies are mainly of an ethnographic
nature, are socially and contextually oriented (e.g., Powers & Mitchell,
1997), and focused on student collaboration or data retrieval from the Web.
In recent years, website design guidelines have become ubiquitous (Tweddle,
Avis, Wright, & Waller, 1998), many accessible from the Internet itself.

One such website design guideline was used in an American web page
design contest, called “W4: The Web Winners Design Contest” (Web Win-
ners, 1996). W4 offered generic aesthetic criteria for assessing the aesthet-
thetic design of student and school web pages. Academically, aesthetic
responses include higher levels of understanding of literature in terms of
students’ use of inferences, analogies, and abstract generalizations
(Spires & Donley, 1998). The website for W4 was sponsored by MicroSoft and Digital Equipment Corporations, among others. At the time of writing, the criteria were accessible on the Internet (Web Winners, 1996). The contest was intended to determine the best-designed home pages (not entire websites or collections of pages). W4 had a Individual/Home User category within a section called “K-12 Educational,” which states that “pages created by students, or by a class as a whole are associated with an educational curriculum.” Excellent page design was considered to make visiting the home page a memorable one. The qualities that have made the website design winners stand out are presented below. The categories published on the website are very general, but nevertheless correspond to classifications published in peer-reviewed educational literature, namely:

**Overall Impact.** The “Overall Impact” category is concerned with the integration of artwork, type and other elements on the home page. Overall impact corresponds to “first impressions” under the accessibility criterion in Boshier, et al., (1997, p. 330). Overall impact also corresponds to “aesthetic and affective aspects” under Criterion 11 in Oliver, Wilkinson and Bennett (1997, p.7) with questions such as: “Does the document follow accepted graphics design principles (e.g., balance, unity, proportion, and simplicity) (11.5)”?

**Quality of Artwork.** The “Quality of Artwork” category prescribes that graphics should be well designed and of high impact, and any photos used should complement the subject matter of the page. Artwork should be original or material the creator of the home page has permission to use. Quality of artwork corresponds to “level of enjoyment,” “evidence of verve/imagination,” “would recommend to others,” and the impact of glitter under the “attractiveness” criterion in Boshier, et al., (1997, p. 330). Quality of artwork also corresponds to “aesthetic and affective aspects” under Criterion 11 in Oliver, Wilkinson, and Bennett (1997, p.7) with questions such as: “Is the design so complex that it detracts from the content?” (11.9); “Are readability and legibility guidelines followed (Sufficient colour, and tone contrast between text and background, font size, doesn’t use all caps)” (11.3).

**Type.** The “Type” category recommends that a well-designed page is one that uses type sizes and formats that easily lead users around a screen. “Type” corresponds to “user friendliness” under the “attractiveness” criterion in Boshier, et al., (1997, p. 330). Type in this sense, also corresponds to “aesthetic and affective aspects” under Criterion 11 in Oliver, Wilkinson, and Bennett (1997, p.7) with questions such as: “Does the document follow accepted text design principles (e.g.,
appropriate use of headers, and limited amount of type styles and sizes) (Criterion 11.2)."

**Speed of Display.** The “Speed of Display” category is based on the assumption that the best home pages are ones that don’t keep a user waiting through long download times. Speed of display corresponds to “ease of connection” under the “accessibility” criterion in Boshier, et al., (1997, p. 330). Speed of display also fits the “information structure and design” category under Criterion 5 in Oliver, Wilkinson, and Bennett (1997, p.7) with questions such as: “Does the site offer a variety of features in addition to delivering content (e.g., provides e-mail links for further information, downloads, ordering fields, discussion lists)?”

**Navigation Tools.** The “Navigation Tools” category recommends that links to other material on a Web site should be logical and seamless. The user shouldn’t have to think about how to get from Point A to Point B. It is the responsibility of the designer to guide users to additional material within the website.” “Navigation Tools” corresponds to “links to outside sites” and “alluringness of links” under the “attractiveness” criterion in Boshier, et al., (1997, p. 330). Navigation tools also corresponds to the “quality of the links” category under Criterion 10 in Oliver, Wilkinson, and Bennett (1997, p.7) with questions such as: “Are the links clear and understandable”? (10.1). “How reliable are the links (are there inactive or references to sites that have moved)?” (10.13).

**STUDENT WEBSITE DESIGN**

Student website design using authoring software such as AliVe! (Ward & Tiessen, 1997) or eWeb (Zhao, 1998) has been examined, as in a recent study (Mann, 1998a) of student teachers using WebCT (Goldberg, 1998). The authors have several reasons to prefer off-line student website design using a paper-based, multipurpose frame in a classroom setting.

Off-line student website design does not require immediate access to a computer station to complete the design work, which may be a concern to a budget-conscious school. The design work can be done as a home assignment or in an environment where computers are a shared resource. Therefore, off-line website design using a multipurpose frame should have greater generalizability than a study of student website design using authoring software. Also, time requirements for teacher and student training and practice of a paper-based tool would be considerably less than that for software
authoring tools (Goldberg, 1998; Mann, 1998b; Ward & Tiessen, 1997; Zhao, 1998).

Furthermore, off-line design may correspond more directly to mental restructuring than online design using authoring software. The slave boy in Plato’s Dialogue learned geometry by: (a) listening to Socrates’ verbal questioning, which elicited language-like mental representations in the boy, and; (b) interpreting the outline Socrates sketched with a stick in the sand, which elicited spatial mental representations in him. Evidence of his geometry learning became clear when the boy began to construct his own referential connections between language-like and spatial mental representations. The products of this learning exercise included the boy’s restructured verbal explanation of the content using the stick to illustrate his understanding, and his own restructured diagram. Similarly, High School students could learn the content by: (a) listening to their teacher’s verbal questions which could elicit language-like mental representations in them, and; (b) interpreting information from a textbook, web sources, pamphlets, and the multipurpose frame etched on paper which would elicit spatial mental representations in them. Students could learn the content as they made referential connections between the language-like and spatial mental representations. It seems plausible that the offline activity—with the structure of a multipurpose frame and a pencil and paper medium with which the student is fluid and familiar—is more likely to elicit students’ own restructured verbal explanations of the subject matter and their own restructured diagrams. The online authoring tools may instead distract the student into the technocentric activity of exploring a new medium and the capabilities of the tool.

Research concerns are the principal reason this study adopts offline website design using a print-based, multipurpose frame in a classroom setting rather than online student design. The issues raised about training and computer access argue for better generalizability and validity using the offline frame. But a more pragmatic research concern is the host of conditions multimedia researchers must control for, that may account for the observed impact on learning (Lookatch, 1998). Fewer factors to control in the study means fewer confounding factors to contaminate the results of the study. Confounding factors could include differential backgrounds, fonts and font sizes, borders, shading, colouring, speech annotation, students’ computer skills, or comfort with the equipment. If these elements appeared (or were trained) under a design tool available in an experimental treatment, they would introduce capabilities and motivational factors that do not appear in a control treatment.

In sum, it seems likely that off-line design will contribute to students’ mental restructuring of a body of knowledge through design of a website.
Offline design is more appropriate for our investigation than online design tools. This appears to be untested with website development technology; we hypothesize that students who are permitted to organize the content of their websites on paper prior to creating their website can recall and organize their knowledge better than if they had developed their websites directly online.

**METHODOLOGY**

A study was conducted on student development of a website using of a paper-based, multipurpose frame.

**Subjects and Environ**

The subjects were a stratified sampling of high-, middle- and low-ability students (n=25) enrolled in an Economics class in an Eastern Canadian high school. Fourteen males and 11 females aged 16 to 18 made up the study sample. Subjects were all from middle-class families, the majority with two-parent homes. The population at this mid-town school is predominantly Anglo-Saxon and Irish protestant extraction with a smaller number of Irish catholic students. All subjects in this study fit this general profile.

The school has done relatively well for the region in terms of technology acquisition. The school is fully networked with approximately 170 PC stations for some 600 students in operation in a variety of labs and units. Some formal training in Internet and computer skills is provided in individual classes, and class assignments. Typically however, any given class represents a wide range of skill levels. Subjects learned the requisite skills through peer interaction, or by obtaining assistance from the classroom or school resource teacher.

Since the subjects involved in the study were under legal age, consent had to be obtained from their parents and school officials. The class list of 25 was divided into pairs by a random draw. (One student was excepted from the draw. The teacher selected a subject he felt, on the basis of the student’s history, was unlikely to attend class. As predicted, this subject never attended any class during the course of the study.) The 12 pairs were randomly assigned to experimental or control conditions. There were five females and seven males in the control group, six females and six males in the experimental group.
Materials

The materials were chosen specifically for this study. A unit on “Money and Banking” was prepared for a Level-2 Economics course. The textbook for the course was supplemented by advertising pamphlets from five major chartered banks and a local credit union, presenting their services and operations. This unit is usually taught with a textbook and through classroom lecture. A print-based web frame was prepared for experimental subjects, as described in the procedure section.

Instrumentation

Three methods were used to assess the relative impact of the use of a website frame on subjects’ organization and recall of unit content. First, a 10-item multiple choice test of literal content was part of the instructional unit. This was a teacher-prescribed unit test, and for this study it served as a pretest, posttest, and final recall test on the factual content of the unit. Second, two levels of website analysis were performed; and third, subject interviews followed the web page authoring.

A separate inventory of basic computer skills (Reuter, 1996) was also applied before the experiment, as an entry behaviors test of computing skills. The objective survey of skills included e-mail, Internet, and multimedia components.

Analysis Methods

Two levels of analysis were applied to the subject websites, namely: general aesthetic criteria (Web Winners, 1996) and textual interpretation (Glassman, 1990). These two levels of analysis were believed to be more comprehensive than a single instrument. In this study, web page judging was based on “W4: The Web Winners Design Contest” page design in three classifications: “excellent,” “good,” “poor.” The categories of judging were:

- overall impact,
- quality of artwork,
- type, and
- navigation tools.
The “speed of display” criteria was not used in this study. Since web pages were linked only locally, there was no possible variation in display speed.

Using the text interpretation instrument, each submission was examined for its literal, inferential, critical and creative interpretations of the instructional unit on Banking. Glassman’s approach (Glassman, 1990) to text interpretation was used to determine the quality of subject writing on the web page. In this study, writing about the banking system on a subject website was taken to indicate depth of subject thinking about the banking system. Exemplary writing about the banking system on a subject website would satisfy all four levels of text interpretation shown below. As a refinement, level 1 was divided into two categories, to help distinguish copying of source material from literal recall.

- Level 1. Literal Interpretation—has read the lines, copies directly from the text.
- Level 1A. Exact copy of text source.
- Level 1B. Variation or paraphrase of text source.
- Level 2. Inferential Interpretation—has read between the lines, makes a value judgment.
- Level 3. Critical Interpretation—has read beyond the lines, analytical.
- Level 4. Creative Interpretation—makes an emotional response.

Procedure

The procedure sequence in this study was adopted from experience studying a different type of outcome (i.e., technology instruction), but with a similar group structure (Mann, 1997; Mann, 1995). The final schedule of activities incorporated the normal class schedule; three 50-minute sessions per week. The entire process lasted 2 1/2 weeks and comprised the following steps:

1. parental and institutional consent (in advance);
2. computer skills inventory (5 min.);
3. random assignment and pretest on “Money and Banking” (10 min.);
4. 2 traditional lecture-style sessions on “Money and Banking” (50 min. each);
5. buffer lesson (45 min.);
6. posttest on “Money and Banking” (10 min.);
7. information and instruction session for authoring activity (15 min.);
8. three sessions of interaction with either: web page development software (control group); or the multipurpose frame followed by the web page development software (treatment group) (50 min. each);
9. final recall test on “Money and Banking” (10 min.); and
10. interview with subjects (20 min. each pair).

Following the skills inventory (step 2), and pretest (step 3), the usual lecture presentation for this unit was provided (step 4). Previous offerings of this curricular unit had used five 50-minute lecture periods. For this study, the lecture portion was shortened to two 50-minute periods, providing three periods for subsequent activities. Next, a 45-minute buffer lesson on the topic of “Business Marketing” (step 5) was placed between the lecture-style sessions on “Money and Banking” (step 4) and the posttest on “Money and Banking” (step 6) to minimize direct copies, (labeled as literal—Level 1—on the interpretation scale) which could result from students’ recollections of the lecture sessions. The expectation was that the utilization of a website frame would subsequently change the frequency of inferential (Level 2), critical (Level 3), and even creative (Level 4) interpretations of money and banking.

These steps (1 through 6) were conducted with all students meeting as one class as usual. In the information session (step 7), the subjects were divided into pairs and the experimental and control groups were separated into two different rooms with computer facilities for the remainder of the study. Subjects in both conditions were requested to produce a web page representing the major chartered banks in Canada. All subjects were assigned a specific banking institution and informed that their individual contributions were to be linked to a common “home page” for the completion of the assignment. Three focus questions were provided to suggest content to the subjects:

- “How is this bank different from the Bank of Canada?”
- “What are the services provided by this bank and how much do they cost?”
- “Why would someone choose this bank to do their banking?”

Pairs of students in both conditions were then provided the commercial pamphlets promoting their particular assigned bank. These were the standard advertising pamphlets for each institution, which had been gathered from branches of the respective banks. Control subjects were to produce
Effects of Precomputer Website Framing

page layout design and content as a combined task. (This is analogous to our ancient exemplar, wherein the slave boy gets a stick and the sand but without an initial structure from which to work.)

All procedures were identical for the two groups until to this point. Experimental subjects were given a print-based web page frame with a title zone, a graphic zone, a text zone, a zone of hypertext links, and a mail zone prior to gaining access to a computer. (Again, analogous to the ancient exemplar, now the slave boy gets a stick and the sand and Socrates’ initial template. Unlike the analogy, this template contained only design zones, no content.) The title zone was presented at the top of the frame to show the name of the person or organization in large font. The graphic zone was a space usually reserved for a small personal or company graphic and digitized picture of the person or institution. The text zone was shown below the graphic zone. And a space separated the text zone from the zone of hypertext links. In this study, hard rules were not used to delineate zones in the web page frame. Finally, a space separated the zone of hypertext links from the mail zone located at the very bottom of the web page. The expectation was that the inclusion of a multipurpose website frame in the precomputer experimental condition would improve the subjects’ recall and knowledge restructuring. Experimental subjects were instructed to use the frame as they wished to develop a web page. They were informed that a complete page design was required before they entered their information on the computer.

In the remaining three 50-minute sessions (step 8) subjects operated in the usual manner for the open resource centre at the school; they worked on their assigned problem and exchanged information among themselves and with the resource teacher in an unstructured fashion. The only restriction was the experimental group could not access their computer station until their page design was complete. No such restriction was applied to the control group.

The final recall test (step 9) and interviews (step 10) were the final part of the procedure. Interview questions were prepared in advance, and focused on the structure and nature of the subject activity, and their thoughts about the final product. The interviews were conducted in private with each pair of subjects.

RESULTS

Although there was a substantial range in scores on the skills pretest inventory (step 2), these scores did not show any strong or significant correlation with either test performance or scores on the textual interpretation or
aesthetic scales. A possible explanation lies with the nature of the lab environment; since subjects could freely exchange information and ideas, it was a simple matter for the subjects to draw on their peers for expertise in creating their pages. In fact, this kind of free exchange characterizes the approach to social constructivism at this school. One subject’s particular pre-existing skill might as easily show up in someone else’s page as part of their final product.

Table 1 summarizes student performance on all three administrations of the multiple-choice test (steps 3, 6, and 9). The pretest scores indicate similar prior knowledge (average 6.43 items correct for the control group versus 6.00 for the experimental group). A large (and statistically significant) difference appears in the posttest, which followed the lecture sessions. The control group outperformed the experimental group in this test, 7.78 versus 6.56 items. This result was unexpected; all subjects attended the same lectures and no treatment had been applied at this point. Examination of attendance and general performance data on the subjects produced no explanation of this result. On the final test (step 9, following the web authoring activity), while both groups improved their performance, the experimental group overcame their lower scores and even marginally outperformed the control group. A repeated measures analysis of variance confirms this effect shows up as significant \([F(1,16) = 5.08, p < 0.04]\), as the interaction between test scores (the repeated measure) and the group variable. The other significant effect is the overall improvement in test scores \([F(1,16) = 8.69, p < 0.01]\) over time. This confirms that while both groups improved their scores during the student authoring activity, the improvement by the experimental group was significantly greater.

Attendance for the test varied, reported as number of subjects \((N)\) in Table 1. While there were three instances of truancy, students missed class sessions mainly due to other school projects or activities. While it affected the data gathering, it was decided not to artificially alter the attendance pattern, as it is part of normal student activity at this school. The result for the repeated measures analysis is robust in any case; restricting the analysis to the students who attended all sessions \((N=15)\), yields significance for the same factors.
Table 1
Mean Scores on 10-Item MC Achievement Test

<table>
<thead>
<tr>
<th>GROUP</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Final test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Mean 6.43</td>
<td>7.78</td>
<td>8.20</td>
</tr>
<tr>
<td></td>
<td>N 7</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Std. Dev. 1.13</td>
<td>.97</td>
<td>1.32</td>
</tr>
<tr>
<td>Experimental</td>
<td>Mean 6.00</td>
<td>6.56</td>
<td>8.22</td>
</tr>
<tr>
<td></td>
<td>N 8</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Std. Dev. 1.60</td>
<td>1.33</td>
<td>1.20</td>
</tr>
<tr>
<td>Total</td>
<td>Mean 6.20</td>
<td>7.17</td>
<td>8.21</td>
</tr>
<tr>
<td></td>
<td>N 15</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Std. Dev. 1.37</td>
<td>1.29</td>
<td>1.23</td>
</tr>
</tbody>
</table>

Five out of the six pairs in the control group submitted final web page products. One pair did not complete the web page, as the subjects were absent on the last day of web page production. However, in the experimental group only three of the six pairs submitted web page products. Again, absenteeism prevented one pair in the experimental group from producing a web page. Two other pairs were still familiarizing themselves with web page production when the study ended; they did not have sufficient time to transfer their design to the web. The difference in the groups’ activity (i.e., the experimental treatment) had an impact; since the control group did not have a precomputer segment to their activity, they had more lead time to acquire the basics of web page production.

The results of the textual analysis of the web pages are given in Table 2. Because of the low participation rate the reliability of data set is a concern, but it still offers some interesting insights. A chi-square test of the group totals shows significant difference in the relative frequency of the text categories due to the higher contribution of level 2 text segments in the control group. \[c^2 = 8.63, p < 0.035\]. More striking is the lack of higher-level text segments in general (no contributions at level 4). This may be indicative of the instructions—the stated goals and focus questions for the web page being principally literal material.
Table 2
Textual Analysis of Web Pages

<table>
<thead>
<tr>
<th>Group</th>
<th>Web Page</th>
<th>Frequency of Text Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1a</td>
</tr>
<tr>
<td>Control</td>
<td>Pair 1</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Pair 5</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>94</td>
</tr>
<tr>
<td>Experimental</td>
<td>Pair 1</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>236</td>
</tr>
</tbody>
</table>

Averages were computed from the three point aesthetic scale, with ratings re-coded for this purpose (poor = 0, good = 1, excellent = 2). There was only a single rating of excellent, for the navigation component of one of the control group’s pages. Other than in the navigation component, the experimental group as a whole marginally outscored the control group in all other categories. Although these results are not statistically significant, they do reinforce the raters’ contention that the control groups pages tend to be “over-designed,” with an emphasis on graphics and other elements that are exciting, but do not necessarily complement the information content of the pages. (This latter evaluation was based on subjective reports of the raters, obtained after the rating was performed; the rating itself was blind.)

In general, there is evidence from the performance test that the treatment produced more learning. Results from the aesthetic and textual interpretation, while not statistically convincing, are consistent with the hypothesis that the control group would be less inclined to relate the structure of their page designs to the information content.

Informal observations were also recorded. The observers switched rooms (treatment) halfway through each session. Their reports concur that over 80% of the questions raised by subjects in the experimental group concerned the text content of their web pages, whereas over 80% of the questions raised by subjects of the control group concerned web page formatting and operation of software. It was also reported that the control group was noticeably more physically active, with constant verbal exchanges among and between the pair groupings, and the atmosphere of the room was more...
boisterous in general. This finding indicates that the experimental group was more intent on their webpage design, were more focused, and exerted greater individual mental effort. Bias may exist in this data because the observers knew the hypothesis and assumptions of the study when they reported.

Findings from the postexperimental interviews revealed an interesting orientation in the subjects’ perception of their tasks. In response to the questions, the control subjects had a tendency to discuss the page layout, whereas the experimental subjects had a tendency to discuss construction of the content. As typical examples, compare a portion of the responses to the question “Did you talk to other people in your group or class?” from two pairs of subjects:

Control pair: We helped another group on how to put in a color and how to get it to work. We asked Ms. Walsh a lot of questions, how to run the program, how to make links, which buttons did what in HTML, where to put stuff. There’s a lot of codes in HTML that we didn’t know how to use.

Experimental pair: I asked people how far they were in their pages. We looked at other subjects; notes, especially the girl next to us. We didn’t want our answer to be simple and we knew she was smart so we asked her about the info. ‘Where did you find that answer?’ We couldn’t take her answers because she was doing a different bank.

Another key distinction that appeared in the interviews was the control group tendency to adopt an organizing strategy. The most common strategy was for one subject in the pair to concentrate on researching their topic and the other subject to take responsibility for the page construction. This was particularly popular if one subject was better or more interested in the relevant computer skills.

Control pair: J did the HTML. I looked for information in the pamphlets. We discussed colors and so on, like the HTML… and then what to include from the banking… We didn’t take any notes, J put it directly on the page.

In contrast, the experimental group was given an organizing structure (frame) which they had to complete, around which their work focused. The following excerpt illustrates this focus, which was clearly reported by four of the six pairs in the experimental group during the interviews. The subjects are talking about adding things to the existing frame, in response to the same question as the previous excerpt, “How did you organize your activity?”:
Experimental pair: We each did a rough draft and then did a draft together. We talked about how we would approach it, and to what extent we would add things.

Subjects did not report explicitly choosing an approach to the task, but rather reported extrapolating their approach from the instructions they were given. This is where the structuring role of the frame technique may come into play. The following are responses to the question “Why did you organize your work that way?” (As background to these responses, the control group reported transcribing material from the sources onto the web page with their page editor, and the experimental group reported making notes from which they composed a paragraph for each focus question.)

Control pair: We didn’t really think about it. That’s just the way it happened... It is almost that you had to do it that way, like because we only had a couple of classes. It would have to be done quickly, so it would go faster that way.

Experimental pair: We were asked to identify the idea, and organize them first on paper. Then you did them first on paper before they go onto a web page.

Four out of the six experimental pairs explicitly reported dislike or disapproval of the pre-computer activity. One student commented, “It would have been easier to use the computer...it was needless to write it all down. Easier to get on the computer in the first place.” It was difficult to say to what extent this attitude indicated a dislike of the activity itself—using the organizing frame—and what extent it was a result of delaying their access to the computers. Ironically, one of the control group pairs suggested their page content would have been improved by writing drafts before doing their computer activity.

As part of the interview, students were asked to sort and rank a list of activities with respect to their authoring sessions, first in terms of the amount of time occupied by the activity and secondly, according to how helpful that particular activity was in completing their assignment. The results of these rankings are illustrated in Table 3. The rankings reinforced the other results from the interviews and general observations. In terms of perceived use of time, subjects in the experimental group rank “taking notes or writing out notes” and “discussing information for the web page” significantly higher than control subjects, and rank “typing information into your web page” and “discussing how to make a web page” significantly lower. This reflects the relative amount of time spent on web page elements, as opposed to composing page content by the two groups. In terms of helpfulness,
the experimental group ranked “reading materials and information” much lower than the control group, and “discussing information for the Web page” higher than the control group. In fact, the relative helpfulness ranking of these two activities was reversed between the two groups! This was consistent with the observation of disapproval of the offline, noncomputer nature of the frame treatment.

Table 3
Students’ Ranking (Sorting) of Activities in Terms of Time Occupied by the Activity and Helpfulness of the Activity

(The rankings are from 1 to 9, with 1 indicating the most frequent or most helpful activity. The p-value was obtained by independent samples t-test. (Caution: since the rank orders are not independent within groups, the p-values should not be used to assess relative significance of the items. However, rank orders between groups are independent, so each p-value can be used to assess significant difference between groups on an individual item).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time occupied by activity</th>
<th>Helpfulness of activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean rank control</td>
<td>Mean rank exprmt p =</td>
</tr>
<tr>
<td>browsing or looking at other web pages</td>
<td>6.375</td>
<td>6.611</td>
</tr>
<tr>
<td>reading material and information</td>
<td>2.250</td>
<td>3.000</td>
</tr>
<tr>
<td>taking notes or writing out notes</td>
<td>5.812</td>
<td>2.833</td>
</tr>
<tr>
<td>typing information into your web page</td>
<td>2.500</td>
<td>5.444</td>
</tr>
<tr>
<td>editing or changing your web page</td>
<td>4.625</td>
<td>5.611</td>
</tr>
<tr>
<td>discussing the information for the web page</td>
<td>6.000</td>
<td>4.056</td>
</tr>
<tr>
<td>discussing or asking how to make a web page</td>
<td>5.438</td>
<td>7.556</td>
</tr>
<tr>
<td>thinking about information for the web page</td>
<td>4.688</td>
<td>3.111</td>
</tr>
<tr>
<td>thinking about other things or taking a break</td>
<td>7.750</td>
<td>6.778</td>
</tr>
</tbody>
</table>
All the pairs mentioned their interest in having more time to add additional features or layout elements to their pages. (Recall that several pairs did not get an opportunity to submit a page at all). It is interesting to note that the group that had more time to add features (the control group) scored lower on the aesthetic scale. The authors see this as reinforcement of the general motivation, as evidence that subjects do need additional structure in their authoring tasks to relate layout and composition to page content, and consequently to support appropriate learning objectives.

**DISCUSSION**

These results augment previous research findings that students in an open, social learning environment work differently with curricular content in the presence or absence of a multipurpose frame. However, the implications from these findings are largely related to the content and nature of the presentations used and therefore may not be completely generalizable. Nevertheless, the results of this pilot study offer conditional support of previous research on hypermedia in education.

The fact that the experimental group copied more of its content literally from the text sources should not be surprising given the evidence of superior familiarity with that material. When subjects needed to make a comparison or evaluative statement, the experimental group, being more familiar with the text sources, were more likely to find an appropriate statement in the text sources than to have to generate a new one. This would not be indicative of superior knowledge restructuring by the control group; they simply may have “made up” more statements, without regard to the literal facts at their disposal.

The superior improvement of the experimental group in the multiple-choice test is consistent with the interpretation previously offered. Using the teacher’s unit test ensured that the performance measured was based on the existing curricular objectives, that is, the literal recall of facts. It also means that this test did not measure higher level interpretations of the text, nor direct evidence of constructive activity. The fact that the instruction style (in step 4) was lecture, allowed the control of any overtly socially constructive component within the experimental treatments (steps 7-8). The instructional style was not adjusted to match the theory behind the treatments, in order to avoid confounding any effects of the treatments. Thus, a benefit for the proposed new devices (i.e. the frames) was established in terms of traditional instructional objectives. With this start, follow-up studies might examine
the effect of closely related (participatory, constructive) instructional styles; and focus on other (high-level, constructive) outcomes.

The lower initial scores for the experimental group on the performance test does raise some concern, since one could contend that the experimental group simply had more “room” for improvement. However, it seems unlikely that this could account for the entire result, since the experimental group eventually exceeded the performance of the control group. This result is much more compelling than if the control group had started with the lower average score. As the results now stand, the experimental group had to “overtake” and “pass” the control scores.

These data suggest that the experimental group attended studiously to the source text material as opposed to the control group, which had a more lively, interactive experience centered on their web page layouts. Superficially, the more interactive experience may appear to be a better socially constructive setting; it was not a simple matter of a physically dynamic environment being better. The quality of the conversations and type of information under discussion were also important. More thoughtful exchanges may demand a more quiet, controlled environment.

The frames given to the experimental group were paper-based. The use of paper-based frames was earlier presented as having pedagogical rationale and eliminating confounding factors of computer use from the treatment. However, it did produce a negative attitude toward the activity of using the frame—since it delayed access to the computers. A reasonable follow-up would introduce additional factors into the experiment, allowing the students prepare their frame content on the computer screen.

A three-group experiment could compare a paper-based multi-purpose frame in one treatment group, with an HTML editor in a second treatment, and an authoring software such as AlivE (Ward & Tiessen, 1997), eWeb (Zhao, 1998) or WebCT (Goldberg, 1998) in a third group. Frames could be included as part of the computer activity in the second and/or third groups. In any case, students would be encouraged to complete their frames on the screen instead of on paper. This will almost certainly effect which elements of the task receive attention by the students, creating alternative possible sequencing of activities, or merging activities such as completing the frames and creating the web pages. Most programs make no distinction between filling in a template and creating the web page itself. Care must be taken, since this study indicates that structuring the activities affects how attentive students are to source materials.
CONCLUSIONS

The environment at the school offered an interesting challenge; how to make the students’ experience more effective in terms of curricular relevance, without eliminating the administrative and motivational advantages of the open constructivist environment fostered by the school. The method explored was an obvious one; the emphasis on what was perceived to be interfering with productive work was reduced (i.e., the document formatting activity), and supplemented with a simple structuring activity (i.e., filling in frames). It is not claimed that these particular frames are best, or even appropriate to the topic. In fact, the enigmatic nature of the multipurpose frame was itself an interesting point; it should not be difficult to come up with an improvement.

The study demonstrated that the additional structure provided by the frames was beneficial. The experimental subjects demonstrated superior knowledge after the treatment, and must have rethought or reorganized the basic textbook material as they reviewed it. This is supported by the informal reports and interview data.

The implicit assumption is that the reorganization of the content in its physical form (i.e., on the web page) is related to a restructuring of the student’s knowledge of that content. If the frames provide benefit in this re-structuring, it should be possible to use them to mold student activities and make them more effective.

This is related to the type of goal-free environment often espoused by constructivists, which is intended to ensure the student is engaged in setting their own learning objectives. The notion of goal-free is seldom employed in a total literal sense; there is always a general area of interest, even when there is no specific evaluation that can be employed. That is, it is still possible to “waste time.” The observations here suggest even very general goals (e.g., “find out something about banking”) may be jeopardized by the intricate tasks which are meant to provide extrinsic motivation and structure, in this case the authoring and publishing of web pages. Students that were occupied with learning about the formatting features of HTML authoring, were distracted from their unit topic of instruction.

Since the frame structuring device has a positive impact, one might imagine that more and more specific frames for the activity should provide more and more specific outcomes. A general question is: can we develop a model which prescribes the correct amount and/or type of structure, depending on how specific the learning goals? This is not far removed from the general problem of Instructional Design (ID), although ID models tend
to set the granularity of interaction outcomes at a particular level, such as individual concepts, procedures or skills. This study suggests the possibility of developing a scale of “goal granularity,” ranging from goal-free activity through to fully specified outcomes, with prescriptions (or at least simple techniques) that could be applied at various increments along the scale. This would be a substantial change from the view of goal-oriented versus goal-free as a dichotomy in educational practice.

The frame technique has practical application as well. It is a simple, reproducible method for increasing the value of the students’ time in the activity. Furthermore, the technique is not topic-specific. The kind of activity used in this study can be applied to any topic area. An additional benefit is that the computer skills are separated from the topic expertise. In fact, the entire template activity can be applied by any classroom teacher, without knowledge of computers or the Internet. Once the designs are completed, the computer skills may be provided by a resource specialist (as in our environment), other student peers, or by some other means. The learning benefit in actually performing the web page design using templates is accrued, whether or not the computer authoring is itself a success. This can provide a means for teachers who are resource poor (in terms of equipment or skills) to use computer-oriented activities as motivation for these curricular projects.

**FUTURE DIRECTIONS**

The activity assigned to the students was not particularly oriented to producing visible results of higher order thinking. In investigating the effect of the frame technique, other mechanisms that would foster knowledge restructuring (such as test items that would prompt such activity) were avoided, since they could have confounded the effect attributed to the frame technique used. In the future, different types of objectives (such as critical or creative achievement by students) should be investigated.

It is an assumption that the textual interpretation measured the highest level of interpretation achieved. However, if the instructions only elicit literal statements, students may be producing other ideas or thoughts, and simply rejecting them as relevant to their web pages. In this case, the interpretations would not be available for the investigators to measure. This is one motivation for a dynamic protocol, using verbal and keyboard activities captured by way of video for analysis. Mann (1997) has constructed a video analysis suite for this type of investigation which will be used in the future. This will also help relate specific components of the frame (step size, frame
protocol, etc.) to specific events which illustrate learning and/or achievement. For example, the students may refer to parts of the frame or elements of the web page in a struggle to integrate some concepts into their presentation. Studying the pattern of such events should allow progress towards a broader research agenda: to be able to prescribe specific frame constructs for specific settings and learning goals.

The test instrument was based on literal content of the textbook, with only a few items requiring inferences from the text. When the acquisition of literal facts is the goal of the instructional unit, an open environment may not be appropriate. A conventional view (although not shared by these authors) might prescribe an open “constructive” environment for promoting creative or thinking skills objectives, and independent study for factual learning goals. In other words, the best preparation for improved performance on a factual test may be to spend more time reading the textbook. Again, a dynamic protocol would better establish the relationship between the students’ activity, their level of text analysis, and its effect on performance at the factual or literal versus other levels.

Finally, if the theoretical framework is useful, we must investigate other elements of the frame concept represented in the literature, such as distribution of emphasis and step size, as well as different types and arrangement of zones.

References


