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Articles

CALL FOR PAPERS

Special Issue on Health Promotion, Media and Education

The Canadian Journal of Educational Communication, a peer reviewed publication, welcomes submissions for an upcoming special issue on Health Promotion, Media and Education. Submissions may take the form of literature reviews, description of approaches or procedures, descriptions of new applications, theoretical discussions or research reports. Within the context of media and health promotion, topics may include but are not limited to: tobacco use prevention, nutrition, active living, childhood obesity, reproductive health, and injury prevention.

The guest editor for this issue is Delailah Khan, B.Sc.N, B.A., a public health nurse.

The goal of the CJEC is to improve “instruction or practice through the use of media and technology”.

Please consult the last pages of this issue for submission guidelines.

Please submit manuscripts no later than September 30, 2001. The target publication date is April, 2002.

Web Design for Instruction: Research-Based Guidelines

Bonnie Skaalid

"Web Design for Instruction" is a web site that introduces novice web designers to some of the principles involved in design and navigation of instructional web sites. This article discusses the process involved in designing the site, the lessons leamed while developing it, and some recommendations for further research. It also includes a list of research-based guidelines derived from the literature in the areas of screen design, multimedia, human-computer interface design, and usability testing.

« Web design for Instruction » est un site web qui initie les apprentis créateurs de sites web aux principes qui sous-tendent la conception et la navigation sur les sites web destinés à l'apprentissage. Cet article traite du processus utilisé dans la conception d'un site, des enseignements tirés de l'élaboration de tels sites, et de certaines recommandations pour la poursuite des recherches. Il comporte également une liste des principes tirés des études déjà effectuées en matière de conception de formats d'images, de création d'interfaces être humain-ordinateur et de tests d'utilisation.

Canadian Journal of Educational Communication, Vol. 27, No. 3, Pages 139-155

The Project

"Web Design for Instruction" is a web site that introduces people without a background in graphic design to some of the principles involved in design and navigation of instructional web sites. The site was developed as part of a Master's project in Educational Technology and contains the following topics: design theory, research-based recommendations about site design, page design, and multimedia: a section with links to teacher resources; a summary of research-based guidelines for the design of instructional web sites as well as recommendations from a survey of practicing web designers. This web site can be found at http://www.usask.ca/education/coursework/skaalid/.

Why this Site was Developed

This web site was developed as a learning resource to provide access to information about designing instructional web sites. Although there are many resources available on the web for beginning web designers, searches of the web have not found many online resources that discuss research-based findings about screen design and usability. There are books and articles available on these topics, but these are scattered and difficult to find. I have never located a web site that addresses either the theoretical concepts of graphic design or gestalt perception. Finally, although many sites give recommendations concerning web design, few are based on explicit research (Boling, Bichelmeyer, Squire and Kirkley, 1997). My objective was to design a resource that pulled together all the relevant information needed to design an effective instructional site.

The Process

I examined two different models for the information design process. One model is taken from the book *Interactivity by Design* (Kristof & Satran, 1995) while the other model comes from *Web Navigation: Designing the User Experience* (Fleming, 1998).

Comparison of the Two Models

Fleming's model is considered a development cycle for web sites and consists of 6 phases:

Phase 1: Information gathering - *This phase consists of collecting background information such as resources available, goals for the site and the target audience. (corresponds to Part I : Information Design in the other model)*

In this project, the resources were collected for the most part during an independent study project on design. While maintaining and revamping a large, complex web site for the College of Education, I collected information about web design, navigation, and usability. The final objective of this project was to summarize and present all the information painstakingly gathered in order to make it available to others also involved in web design. I also felt that teachers might find this information useful, since many of them were in the process of developing sites to present information, or having students develop sites to publish their knowledge about a topic.

Phase 2: Strategy *- The focus is on defining an approach through brainstorming and problem-solving, identifying any problems which may occur during development.*

This element was minimal in the project. Various potential problems were discussed at the preliminary oral conference which were considered throughout development. One problem which was discussed and still needs to be considered regularly is the problem of broken links. Broken links occur when pages of information are moved or deleted from another site. If a site contains links to these missing or deleted pages, then the user will be given an error message to that effect. Strategies for dealing with this problem include trying to make a web site as self-contained as possible, and using special link-checking software which informs the web designer when a link is broken. At that time, the designer can choose to remove the link or find a substitute link which illustrates the same concept.

Phase 3: Prototyping *- In this phase, the designer creates a rough plan for the site and considers navigational issues. Prototypes may include paper mockups, storyboards, hypercard stacks or rough web sites. (corresponds to Part 2 & 3 in the other model)*

During this phase, the top level navigation pages were designed in order to test usability and navigation. With my limited art skills, it was just as easy for me to use Claris Home Page to design the pages as it was to design storyboards or paper mockups! At the same time, colors, fonts and grid layouts were developed to create a certain "look and feel" for the site. A number of prototype navigation designs were produced and tested using formative evaluation. After several iterations and some new menu categories, a final navigation scheme was adopted (Figure 1, next page) which seemed to be logical and less confusing to use.

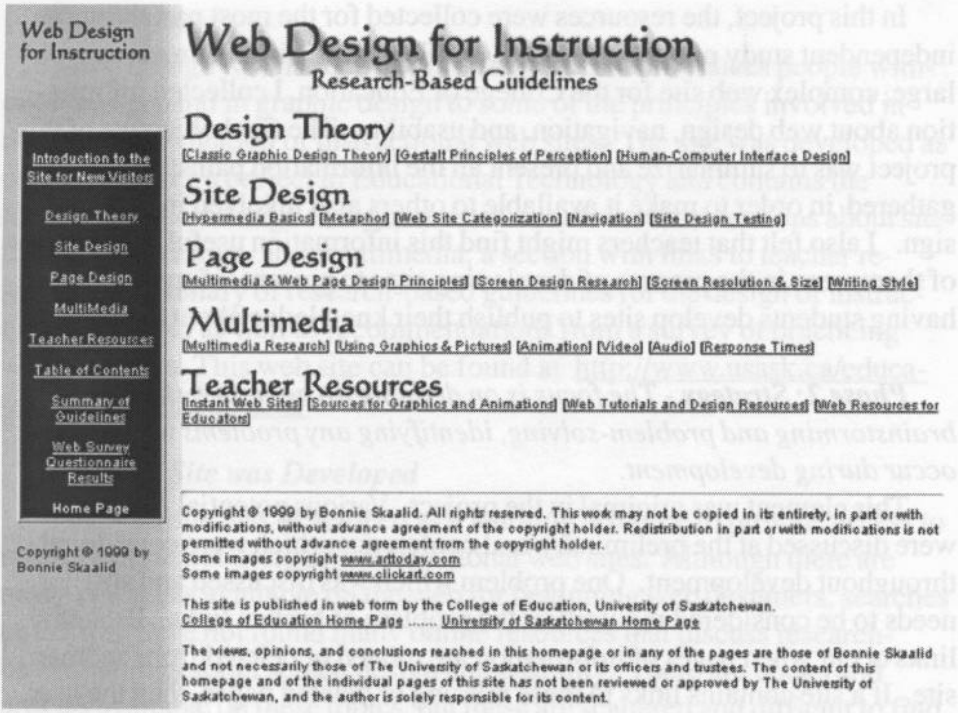

Figure 1.

Phase 4: Implementation *- Use the results from the formative evaluation (phase 3) to build the site.*

In this case, prototyping and implementation were often happening at the same time. Once the look and feel was finalized, it was just a matter of cutting and pasting the existing text onto template pages in order to complete the site.

Phase 5 & 6: Launch, Maintenance & Growth *- Launch is the period just before and after the web site goes online during which extensive testing is carried out to ensure consistency, compatibility and stability. Launch is also the time when the site is advertised or linked so that people can find it. Maintenance and growth addresses the need to keep the site current and accurate and to ensure that all links still work.*

Pages were uploaded and tested throughout the implementation period so there was not a single significant testing period during the launch. In order to ensure that people could find the site, a link was created from the College of Education **Student Produced Resources** section to this site. As well, the site was submitted to a number of search engines for cataloguing.

Resources are still added to the site if they are found to be relevant, and

links are checked once a month to ensure they are still working. If a link has expired, it will be removed from the site. Periodic site revisions are also a necessary evil in web site design to ensure people come back to a site more than once.

Design Considerations

The site was designed with multiple pathways through the data depending on the user's background and interests. Navigation was completely within the user's control at all times. The preliminary Theory section was included to scaffold web designers without a background in graphic design, gestalt theory, or human-computer interface theory. The sections on Site Design, Page Design, and Multimedia were designed to present based guidelines that might be used to design more effective instructional web sites. The Teacher Resource section was designed as a jumping-off point for the actual design of web sites. To this end, the section is filled with links to page templates, web creation tutorials, resources for web design such as graphics, sounds and video, and links to other exemplary educational sites.

The site was designed in a hierarchical manner with the top level navigation page designed to allow access to almost every page in the site. This gives new users an overview of the entire site when they first enter while also giving repeat users quick access to any section. The home page also contains three links not found on any other pages. One link leads to an orientation page for new users which discusses what the site was designed to do, as well as what it will not do. The orientation page also provides a key for any symbols used as well as an in-depth discussion about each one of the topics in the site. A second link leads to a special summary page which gives an overview of all the research findings for users who just want the final results. A third link discusses the findings from a survey of web designers.

Web Navigation, Fleming (1998) poses a number of questions which users of learning sites will often ask. One of Fleming's questions that I felt was important to address was: "How do I know what you say is true?" Many tutorials on web design give advice about the way things should look, or the way navigation should work, but few actually provide information about the reasons supporting that advice. Advice may appear to have the same credibility whether it is given by a person who has been designing for two weeks, or by Jakob Nielsen PhD., a Sun Systems engineer who has conducted years of usability tests to determine effective navigation strategies. This web site was designed to show that information was based on research data, not just the "folk" wisdom which is prevalent on the web.

Therefore, in this site, you can pursue links back to the original documents or web pages where the research is discussed.

As much as possible, the research recommendations listed in the site were modelled within the site. Graphics were only used when they were needed for explanation of a concept. Navigation elements were located at the side for ease of use and repeated at the bottom. Colored borders and boxes were used to enhance the page and create balance but were limited to the non-text areas so that readability of the text was never affected. Navigation labels were text-based to ensure the pages loaded very quickly. Page location was indicated inside the navigation boxes by changing the current page to a different color and eliminating its link. Feedback was provided inside the bottom navigation box by changing the color of visited links so that users would know which links they had already seen. (Figure 2)

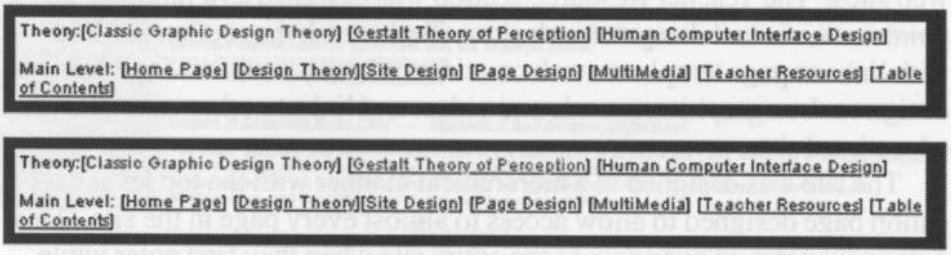

Figure 2

Summary of Research-Based Guidelines

This summary lists the research recommendations found within each of the research-based sections of the web site. In many cases, the research recommendations are in the author's own words. Although all of these guidelines are based on research, not all the research was conducted specifically for the web. Some of the guidelines come from studies of Computer Assisted Instruction (CAI) or multimedia.

Design Theory

Guidelines from human-computer interface design research:

1. Recognize Diversity

• make your main navigation area fast loading for repeat users

• provide a detailed explanation of your topics, symbols, and navigation options for new users (FAQ or introduction page)

• provide a text index for quick access to all pages of the site

• ensure your pages are readable in many formats, to accommodate

users who are blind or deaf, users with old versions of browsers, lynx users, users on slow modems or those with graphics turned off

2. Strive for consistency in:
menus
help screens
color
layout
capitalization
fonts
sequences of actions

3. Offer informative feedback · rollover buttons, sounds when clicked.

4. Build in error prevention in online forms.

5. Give users control as much as possible.

6. Reduce short term memory load by providing menus, buttons or icons. If you use icons, make sure you have a section which explains what they mean. Make things obvious by using constraints grayed out items in menus for options not available in that page.

7. Make use of web conventions such as underlined links, color change in links for visited pages, common terminology.

8. Provide a conceptual model of your site using a site map or an index. (Shneidetman, 1998; Norman, 1988)

Site Design

Guidelines for Hypertext Creation

1. Know users and their tasks.

2. Ensure that meaningful structure comes first.

3. Apply diverse skills (by including information specialists, content specialists and technologists on the project team).

4. Respect chunking. Organize information into chunks that deal with one topic, theme or idea.

5. Show interrelationships (by using links to related articles).

6. Ensure simplicity in traversal. Design the link structure so that navigation is simple and consistent throughout the system.

7. Design each screen carefully, providing on-screen prompts such as icons or menus. (Shneiderman, 1998)

Guidelines for Metaphor:

l.A useful metaphor will help users navigate your site. Good examples of metaphor include shopping sites based on the idea of paper catalogs and the hypercard card index that looked just like a Rolodex. (Davis & Merritt,

1998, Bielenberg, 1993)

Guidelines for Web Site Categorization:

1. Boling, Bichelmeyer, Squire and Kirkley (1997) identified seven profiles for web sites based on a matrix of high information, high motivation to low information, low motivation. A quick summary of their profiles are as follows:

Profile 1: No Expectations - very low need to motivate users or deliver content - e.g. personal home pages

Profile 2: All Motivation - high need to motivate users to view site - e.g. promotional commercial sites

Profile 3: All Content - high need to deliver content where site may be the only provider of this information or users are highly motivated to use site already- e.g. search engines or research results

Profile 4: High Motivation - a need to provide some content along with motivating factors, at same time users must be able to distinguish between content and glitz

Profile 5: High Content - need for content outweighs the need for high motivational factors but an attractive site is necessary - e.g. government agencies, universities

Profile 6: Mixed Elements & Profile 7: Great Expectations - "in both these profiles the need to deliver specific content and the need to motivate users to a specific response are highly interdependent and interrelated" - e.g. commercial catalogue sites, sites devoted to charitable or political causes, or educational sites

Guidelines for Navigation:

Structure

1. Hierarchical menus are useful for straightforward searching tasks, but the additional clarification available from embedded, contextual menus will aid complex search tasks. Therefore, designing menus to be more verbose, or adding information in the form of textual indexes with clarification will help users to be more successful in finding what they are looking for (Lai & Waugh, 1995; Lynch & Horton, 1997).

Orientation

1. It is very important to include site information on every page of a site. It is also essential to include links to the local home page on every page to accommodate users who jump into your site. Links to other pages in a sequence are also useful.

2. Categorization of information into menus is a very difficult process as well as one which needs careful attention. Menu items need to be unique, non-overlapping and familiar. It is better, when designing a structure, to have breadth over depth (fewer long menus as opposed to many shorter menus).

3. Orienting devices such as textual indexes, guided tours or overview diagrams are useful to keep users from becoming disoriented in a site.

4. Navigation information is easiest to use if located in a similar location on every page of a site. This helps because the user knows where things are located from page to page. (Balasubramanian, 1993; Instone, 1997; Lynch & Horton, 1997; Nielsen, Nov. 1997; Rosenfeld, 1997; Shneidetman, 1998; Spool, 1998)

Guidelines from Usability Research (Jakob Nielsen)

1. Most users don't read, they scan for information.

2. The author's personality makes a site more attractive.

3. Web users are impatient, they don't want to be slowed down by cool features or self-promotion.

4. Search capability is very important.

5. Download factors are critical.

is almost always annoying.

7. Frames are disliked.

8. Wild backgrounds disrupt reading.

9. Although more users are scrolling (pages no longer than 3 screens are recommended), many still don't go beyond the first screen.

10. Image maps are more usable now, especially if they are broken up into smaller sections that load more quickly than one large graphic.

11. Users want sites to work and are no longer tolerant of those that don't.

(Nielsen, Dec. 1997).

Page Design

Guidelines for Multimedia and Web Page Design

1. Keep the design principles of simplicity, consistency, clarity, balance, harmony & unity in mind when designing web sites (Schwier, & Misanchuk, 1993; Anglin, Towers & Levie, 1996; Norman, 1988; Mullet, & Sano, 1995).

Guidelines for Screen Design

1. ***Grid:*** Use a grid to design pages. Map out where your navigation elements will be located and be consistent from page to page with this layout (Lynch & Horton, 1997)

2. ***Screen Density:*** Although results concerning screen density are conflicting, it appears from recent research that screens with too much white space are confusing (Hooper & Hannafin, 1986; Morrison, Ross, Schultz, & O'Dell, 1989; Ross, Morrison, &Schultz 1994; Spool, 1998).

3. ***Fonts:*** If possible, use fonts designed for the web such as Georgia or Verdana since they are easier to read - use ragged right justification on the screen as it is easier to read (Misanchuk, Schwier, & Boling, 2000).

4. ***Buttons, boxes and menus:*** Buttons, radio buttons, check boxes and menus should look like something you would normally press, click, put x's in, or pull down. HTML includes special routines which draw radio buttons, check boxes, and pull down menus for you. The design of buttons is a bit trickier, since you have to draw your own graphic and make it look like a button (bevelled edges give the 3D effect which makes a graphic look like something you would press). Give the user some feedback that execution is occurring after a button is pressed. This was much harder in the past, but with the addition of Javascript to the newer web browsers, icons will flash or change color when pressed, giving the user the sense that something may happen (Shneidetman, 1998; Norman, 1988).

5. ***Use of Icons:***

- represent the object or action in a familiar and recognizable manner
- limit the number of different icons
- make the icon stand out from its background
- consider three dimensional icons; they are eye-catching but also can be distracting
- ensure that a single selected icon is clearly visible when surrounded by unselected icons
- make each icon distinctive from every other icon
- ensure the harmoniousness of each icon as a member of a family of

icons

(Horton, 1994; Shneiderman, 1998)

*6. **Use of color:***

- design conservatively, possibly starting with black and white, and consider older or color-blind users
- do not make color the only way to discriminate between choices
- use color to add reality
- use color to discriminate between elements of a visual
- use color to focus attention on relevant cues
- use colors to code and link logically related elements
- be consistent in general color choices throughout materials
- use colors such as highly saturated red and violet to attract attention and to create an emotional response
- use highly saturated colors for materials intended for young children
- consider commonly accepted color meanings i.e. red and yellow are warm, green and blue are cool, red means stop, green means go, etc.
- when producing materials for persons from varied cultures consider the meanings they attribute to colors

(Misanchuk, Schwier, & Boling, 2000; Murch, 1995; Pett, & Wilson, 1996)

Guidelines for Screen Resolution and Size

1. Design for the smallest standard screen which is:
   - Macintosh size (Macintosh screen area is smaller than Wintel machines) 595 pixels wide by 295 pixels high
   - 14 inch monitor (640 x 480 pixel area)
   - ***256*** colors
2. Start your design in black and white to ensure readability for persons with color deficiency.
3. Include ALT tags on all image files to ensure that people using text-only browsers or special readers (i.e. blind or sight deficient users) are still able to access the information provided in your pages.

(Misanchuk, Schwier, & Boling, 2000; Lynch & Horton, 1997)

Guidelines for Writing Style

1. Users like summaries and the inverted pyramid style used by journal- where the most important information is presented first in an article.
2. Users appreciate headings which help them to scan and locate the information they are interested in.
3. Users do not appreciate flowery or "marketese" writing and want

web pages to be concise.

4. Simple and informal writing is preferred over formal writing style. (Morkes, & Nielsen, (1997)

MultiMedia

Guidelines for Multimedia

1. Be careful that you don't overload your communication processing channels by sending information in more than one way at the same time (listening to words and trying to read text at the same time causes interference) (Moore, Burton, & Myers, 1996).

2. Guidelines for using graphics and pictures

- illustrated visuals used in the context of learning to read are not very helpful

- illustrated visuals that contain text-redundant information can facilitate learning

- illustrated visuals that are not text-redundant neither help nor hinder learning

- illustration variables (cueing) such as size, page position, style, color, and degree of realism may direct attention but may not act as a significant aid in learning

- there is a curvilinear relationship between the degree of realism in illustrations and the subsequent learning that takes place (Anglin, Towers, and Levie, 1996)

- visuals that complement the text information being presented increase the likelihood for retention of that information, but visuals which are not related to the text have no effect on retention. When bandwidth is a problem, gratuitous visuals would seem to be unecessary in page design (Misanchuk, Schwier, & Boling, 2000)

3. Guidelines for using animation

Appropriate uses for animation include:

- showing continuity in transitions - proving the Pythagorean theorem by animating the movement of various squares and triangles as they move around to demonstrate that two areas are the same size

- indicating dimensionality in transitions - animated arrows pointing left and right can indicate movement forward and back, zooming boxes can indicate one screen was enlarged from another

- illustrating change over time - showing population change by fading from one density map to the next over time

- multiplexing the display - showing more than one piece of information in the same location i.e., buttons which change color when the

mouse rolls over them, help labels which appear when the cursor is on top, menus which pull down when you hold the mouse down

- enriching graphical representations - animated icons can give a better understanding of the function of the icon - i.e. an eraser icon which erases pixels to explain its function

Do not use animations that continue endlessly - they irritate users - **Never** use the Blink command

(Nielsen, Dec. 1995, Nielsen, Dec. 1997)

Guidelines for video, sound and response time

1. Due to restrictions in bandwidth, video is not recommended. If used:

- include information about its size so that users can decide whether or not they want to wait (Nielsen, Dec. 1995)

- never incorporate the automatic downloading of a video into the loading of a page

2. If audio is incorporated in your site, make sure it is the highest quality you can produce (Reeves, & Nass, 1996)

- audio can be used to give help or directions without obscuring the screen

3. Currently, the minimum goal for response times should be to get pages to users in no more than ten seconds, since that's the limit of people's ability to keep their attention focused while waiting.... speed must be the overriding design criterion. To keep page sizes small, graphics should be kept to a minimum and multimedia effects should only be used when they truly add to the user's understanding of the information (Nielsen, Mar. 1997)

Recommendations

The section on guidelines identified a myriad of elements to consider in web design. Although I think all these guidelines should be considered in web design, after reading the recommendations from my intensive interviews and the web survey questionnaires, as well as reflecting on my experience with designing web sites, I have chosen to highlight several guidelines that I feel are the most important when designing a site.

1. Carry out formative evaluation designed to elicit ideas about zation very early, before much time and effort is expended on aesthetic considerations. It is very important that you have a final version of your main categories very early on in site design. If you have to move blocks of pages from category to category, this will necessitate a large amount of relinking (which introduces the likelihood of misplaced links). User testing to determine problems in terminology and misunderstandings about navigation must be done very early on.

2. Although page creation programs are very good, they all have their limitations. Ensure that you are somewhat familiar with HTML coding so you can look at source code and understand what is going on. Some activities can only be done by writing HTML code.

3. It is important to consider users who may be handicapped, or who use Lynx browsers, or who surf with graphics turned off.

4. Make sure that you test your web site often to ensure that links are working. Online programs like Netmechanic can go through your site and report back on links that aren't working.

5. Since download time is such a critical factor for many users, use the minimalist approach to design. Do not use graphics or animations unless there is a pedagogical reason for their use.

Research Questions

With the exception of usability studies, most of the research-based guidelines identified in this project were not web-based but were derived from studies of instructional software and multimedia. Although studies of usability have provided valuable insights into the navigational design of a web site, many other questions specific to web design remain to be answered. In the process of collecting the guidelines and developing my own web sites, the following questions emerged as ones for which I would like to see research carried out.

1. What are the elements which should be present in an instructional site? Is there a certain way in which sites should be designed when used for instruction? Are there differences in the way a site should be structured for younger versus older learners?

2. What about the traditional design issues of line length, page density, and choice of fonts? Are there optimal choices for these elements in terms of making web instruction more effective?

3. Which multi-media modes can be combined and which should be avoided in combination with each other in order to optimize learning?

4. What are the elements which combine to make the most effective instructional web site? For example: Is interactivity the most important element in effective web instruction? What about aesthetics? Inclusion of graphics, videos, and sound?

5. What about the use of metaphor? Does it help or hinder when navigating a web site?

Any studies addressing these research questions must consider the context within which the research takes place. It is meaningless to discuss elements such as optimal font size, for example, without also discussing screen resolution, font color or type, what brand of computer is used, what

age group is tested and a myriad of other factors which impinge upon the outcome. Similarly, identification of factors which lead to successful web instruction should consider the learning contexts, the preferences and characteristics of individual learners, and the nature of the learning tasks when studies are devised.

Conclusion

Web design is a very exciting process to be involved with - you can create a site that is interesting and visually stimulating as well as reflective of your own creativity. At the same time, it is necessary to temper creativity with the knowledge of what an effective, pedagogically sound web site needs to look like. My hope is that this site is a small beginning towards accumulating that knowledge.

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A "High-Wired" Balancing Act: Technological Change and Public Education in Canada (1)

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This paper explores the impact of new technologies on public education. It looks specifically at Bill Gates' prediction that new technologies will "alter the focus of education from the institution to the individual." Such a change, the authors suggest, would significantly restrict the "public" element of public education. It would erode society's ability to spread the costs of education among all its citizens. It would further dilute the responsibilities of private interests for training and retraining their employees as they retool to retain and/or increase market share. These changes, it is suggested, further the interests of mobile capital in the globalized economy rather than the needs of students in their classrooms or communities.

Ce travail étudie l'effet des nouvelles technologies sur l'éducation publique. De façon plus précise, il porte sur la prédiction de Bill Gates, selon laquelle les nouvelles technologies vont "modifier le centre de l'éducation, qui va passer des institutions à la personne". L'auteur laisse croire qu'un tel changement limitera de façon sensible la dimension "publique" de l'éducation publique. Il diluera encore davantage les responsabilités des intérêts privés en matière de formation et de perfectionnement de leurs employés, au fur et à mesure qu'ils se réoutillent, dans le but de conserver leur marché et/ou d'augmenter leur part de marché. Ces changements, laisse-t-on entendre, favorisent les intérêts du capital mobile au sein de l'économie globale, plutôt que les besoins des élèves dans leurs classes ou au sein de leurs communautés.

(1)This is an edited and updated version of Moll, Marita and Heather-Jane Robertson. (1997). wash from the technological wave; Critical perspectives on the impact of information technology on public education," a paper presented at Memorial University, St. John's, Newfoundland, June 12 (unpublished).

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Propelled by the media, politicians, and promoters of new technologies, the agenda to connect everything in sight to the Internet, including toasters, Coke machines and computer notebook-toting students seems unstoppable. In his book, *The Road Ahead*, Microsoft mogul Bill Gates provides an excellent example of the technological optimism that dominates our culture:

> I've already said I am an optimist, and I am optimistic about the impact of new technology. It will enhance leisure time and enrich culture by expanding the distribution of information. It will help relieve pressures on urban areas by enabling individuals to work from home or remote-site offices. It will relieve pressure on natural resources because increasing numbers of products will be able to take the form of bits rather than of manufactured goods. It will give us more control over our lives and allow experiences and products to be custom tailored to our interests. Citizens of the information society will enjoy new opportunities for productivity, leaming and entertainment. Countries that move boldly and in concert with each other will enjoy economic rewards. Whole new markets will emerge, and a myriad of new opportunities for employment will be created (1995, p. 250).

Tuming to education, Gates offers a rainbow vision of the use of computers in the classroom, jumping from vignette to vignette as to how individual classrooms have used the Internet to invigorate, motivate, excite (presumably) bored students and energize (presumably) tired teachers. There is no research offered to support the inference that computers in classrooms create happier, healthier, and smarter students. Gates surfs over the idea that there are major costs involved in creating techno-centric classrooms, costs that are both financial and social. "Whatever problems direct access to information may cause, the benefits it will bring will more than compensate" (1995, p. 204), he assures us. Pausing to remember that Gates the futurist and Gates the public relations frontman for Microsoft are one and the same, it should be noted that electronic delivery of educational services is a key Microsoft business strategy. The potential benefits to Microsoft are substantial if we confuse the prediction with the propaganda.

Gates' educational vision implies that, "All you have to do is click" to arrive at the educational outcome of your choice; furthermore, it will be just

as easy to "undo" when things begin to go wrong. "Frankly, I'm not too concerned about the world whiling away its hours on the information highway," Gates writes. "At worst, 1 expect, it will be like playing video games or gambling. Support groups will convene to help abusers who want to modify their behaviour" (1995, p. 264). Presumably, these opportunities, too, will be accessed through the Microsoft network.

The easy promises of power brokers like Gates carry much weight in a society seeking instant answers to complex social problems. This paper explores the solutions proposed by Gates and other techno-promoters to the "problem" of schools. It considers Gates' contention that, "The [information] highway will alter the focus of education from the institution to the individual. The ultimate goal will be changed from getting a diploma to enjoying lifelong leaming." Paradoxically, technology is the shift, while at the same time it makes the shift possible (1995, p. 204). What are the resulting costs to the individual and to society? Who will benefit? Or, in the words of technology critic Neil Postman, "What is the problem to which this is the solution? And whose problem is it?" (1997).

The Internet - "Cause Célébre" of the 1990's

The Internet was certainly the centrepiece of technological change at the end of the 20th Century. Developed with public funds in the 1960's as an experimental network to support research and development (Rheingold, 1993), it was rapidly privatized in the 1990's as its commercial value became apparent (McChesney, 1999). Where commercialism was once shunned as contrary to network "ethics," commercial interests are now embraced enthusiastically. The Internet is suddenly the hot advertising medium of the new millennium. Its interactive features seem tailor-made to entice, cajole and manipulate well beyond the boundaries of the traditional advertising spaces, ready to plug directly into the persona1 data stream of a new generation of consumers.

The shift was a well-planned exercise in convergence. The United States Telecommunications Act of 1996 offered a new legal framework and more opportunities for mega-media-merger-mania. Many media watchers foresaw the consequences. Canadian media activist Jesse Hirsh wamed, "The Internet will consume all media until it becomes the information superhighway media monopoly brought to you by AT&T. The Internet is the ultimate red herring, the dazzling distraction that abducts our attention while power plays with totality" (Hirsh, 1996). Gates, however, has sured the public that they have no cause for worry. The deals, he wrote, are

"just background noise; they keep rumbling along whether or not anyone is listening" (1995, p. 248). Gates was certainly rumbling along, aggressively acquiring rights to valuable digital content. "Bill Gates said to himself, 'As long as 1 own the information highway, 1 might as well own the trucks on it, too' " mused Claudio De Polo, president of the Fratelli Alinari Archive, a collection of 15 million historic photos (as quoted in Clark, 1996). Gates' privately owned Corbis Corporation had just bought up the rights to 500,000 digital images, representing a treasure of historic and cultural imagery.

Seeking to add digital school buses to his fleet, Gates keeps his eye on worldwide developments in the electronic delivery of educational services. "It's very exciting to see what's going on here in Canada in a number of areas... SchoolNet... is the leading program in the world in terms of letting kids get out and use computers," observed Gates (as quoted in Industry Canada, 1996, p.23) while in Ottawa on his Windows '95 tour. His comments on SchoolNet, the Industry Canada on-line service for schools, were featured in the Liberal "Red Book," a policy strategy document produced by the Liberal party whenever an election is underway. Such a prominent supporter makes excellent political collateral.Provinces are following closely behind. New Brunswick formed a partnership with Microsoft Canada to set up an interactive "virtual campus" using Microsoft On-line Institute (MOLI), an "interactive leaming and information resource" accessible on the Internet through the Microsoft Network. "It virtually tums a computer into a world-class campus" boasted a press release from the New Brunswick Department of Economie Development and Tourism ("New Brunswick company offers courses," 1997). On this virtual campus, everyone from kindergarten pupils to corporate employees can take courses from anywhere, at any time, 24 hours per day. Microsoft's technical experts have been contracted to train New Brunswick content providers on the use of Microsoft software. Microsoft will charge the province for running the network; students will be charged a fee for courses they take.

Former New Brunswick Premier Frank McKenna hoped this would enable the province to develop courses for export to countries around the world, with New Brunswick seizing the opportunity to become a "world-class" educational cal1 centre. Whether McKenna's dream materializes or not, clearly Gates has managed to export his dream to both politicians and marketers. It is easy to imagine an educational future centring around the customized delivery of homogenized services. "McSoft" education could do it all for the new generation of plugged-in leamers.

Assisted by politicians and promoted by powerful information technology industries, the future of education has become inextricably bound to the Internet, this "dazzling distraction." It has assumed a central role in education reform agendas around the world. Between 1994 and 1996, Japan declared its intention to install 900,000 network-equipped PCs in schools by the year 2000; Germany announced a three-year "Schools on the Network" project; Denmark vowed to put all schools on-line by the year 2000; Finland established an "Education, training and research in the information society" strategy; and the UK initiated a "Superhighway in education" plan ("Europe Union," 1996). The demands of globalization - deregulation to enable free trade - help explain this unprecedented convergence in educational planning. Canadian govemments have either bought in or caved in, depending on who is describing the appetites of globalization. "The role of govemment is to reduce the impediments that reduce competitiveness and thus add value," trade minister Sergio Marchi told an education marketing conference (Robertson, 1998, pp. 12-13). The origins of the current deregulation mania in the communications industry should not be lost to Canadians. In his 1989 analysis of the effects of corporate growth on American public policy, U.S. communications expert Herbert Schiller noted that "in tracing the main lines and identifying the key players in the deregulation of American communications, one point needs special emphasis. What began as a [U.S.] domestic restructuring for interna1 economic reasons has had global impact" (Schiller, 1989, p. 113).

Towards Deregulation

In January 1994, U.S. vice-president Al Gore issued a "challenge" to industry leaders to connect all American schools, hospitals and libraries to the information highway by the year 2000. Yet this speech was not about schools, hospitals or libraries. It was about competition between the telephone and cable industries and about the Clinton administration's intention to "clear from the road the wreckage of outdated regulations and allow a free-flowing traffic of ideas and commerce for the benefit of all Americans" (White House, 1994). Bill Gates couldn't have said it better. American-based communications and information industries dreamed of an ever-widening dissemination of their products through an information highway as ubiquitous as the television set, but now ready to take orders for everything from blue chip stocks to running shoes. The strategically-placed challenge satisfied the political requirement for the appearance of public benefit, but the objective was clearly the deregulation of the communications industry to strengthen the position of U.S.-based interests in glo-

balized markets, not the improvement of education.

At the same time, Industry Canada's Science Promotion Directorate launched its SchoolNet program to provide Canadian students and teachers with "exciting electronic services that would develop and stimulate the skills needed in the knowledge society" (Industry Canada, 1996, p. 22). Since very few schools had even heard of such electronic services at that time, let alone tried to connect to them, the first task for SchoolNet was to promote electronic connections in Canadian elementary and secondary schools. As it did in the U.S., the education initiative helped to divert Canadians from the critical examination of public interest issues. There was little debate about the possible loss of sovereignty imbedded in the deregulation demands of the communications industry, and little concern that Canadians might forfeit any ability to manage their communications environment - the key strategic resource of the 21st century. (2)

Government public relations machines went into overdrive pushing the impending communications revolution into the classroom. The rhetoric mixed the carrot with the stick. "The contest for markets in the 21st Century is being fought right now in the classrooms of the world!" said Industry Minister John Manley promoting the need to have more technology in the classroom (as quoted in ITAC, 1994). The federal Information Highway Advisory Council (IHAC), a blue ribbon policy advisory pane1 appointed by Industry Canada, claimed that using the new technologies in the classroom would result in an immediate reduction in the high school drop-out rate and subsequent savings in the order of $26 billion by the year 2000 (IHAC, 1995). No supporting information was offered to back up this astonishing statement. A recommendation from Phase II of the IHAC process strongly endorsed full Internet access for all schools and identified the private sector as a key player in realizing that goal (IHAC, 1997, p. 52). Should the private sector be relied upon to provide fundamental resources for a supposedly publicly funded institution? Such discussions would have to find other fora. This parade was carefully shrink-wrapped and rain-proofed well before being placed on public review.

Globalization causes (or creates an excuse for) "disintermediation," a post-modern coinage that means political power gravitates rapidly to either global or local entities. Intermediate levels of government, bureaucraties, and corporations scramble to redefine themselves or face forced restructur-

For a more in-depth discussion of the connection between telecommunications deregulation and policy objective to connect all schools to the Internet see: Moll, Marita. (1996). "Supporting or subverting the public interest: A critical look at the agenda to connect all schools, hospitals and libraries to the information highway." Paper presented to the meeting of INET 96 (The Internet Society), Montreal, June 1996. Available at: http://www.iif.hu/inet 96/e3/e3 3.htm.

ing. Nation-states themselves become "intermediate" governments, as their traditional powers are subsumed by organizations at the super-govemment level or encoded in trade agreements. The federal govemment may be seeking to "re-mission" itself by carving out a national role in education, whether the provinces object or not.

Provincial govemments are caught in a different part of the globalization vice. Traditional sources of tax revenues slip away as mobile capital roams the world looking for the cheapest labour markets. The need to control "out of control" spending justifies massive centralization efforts. As Michael Apple points out, technology makes "the middle" both untenable and redundant because it offers "new forms of control, [it enables] the process of deskilling, the separation of conception from execution, [processes which] are not limited to factories and offices" (1995, p.127). It may be no coincidence that New Brunswick, determined to become both the cal1 centre capital of North America and a leader in the electronic delivery of education, was also the first province in Canada to abolish school boards altogether.

The Road to Education Reform

Education shifts when power shifts. Howard Besser identifies several predictable stages when educational services are redefined to meet the needs of new power structures. First reports are produced by expert panels, usually by a blue ribbon team of business leaders, in which ski11 deficiencies are articulated and international comparisons are seized upon, often presented in misleading ways. The media obliges by indulging in a feeding frenzy of "schools are failing" stories (Besser, 1993, pp. 50-61). This is a well-wom (and well-documented) path followed both in Canada and in the United States. Among the consequences of what David Berliner and Bruce Biddle cal1 "the manufactured crisis" is a decrease in the power of public education as measured by public and political support (Berliner, 1995).

The high-tech corporate sector which stands to gain the power schools lose, has been among the most active critics of the quality of public education and the validity of education's goals. (3) Their solutions to the "problem" of schools are both technocratic and technology-rich. Central fiats, central control, and central reform are key strategies that fit seamlessly into globalization. In all provinces, such initiatives are underway. New Brunswick abolished school boards, placing educational decision-making

(3) See "Visioning education in the information economy" by Alison Taylor for a description of Canadian corporate alliances impacting on education and "Canadian classrooms on the information highway: Making the connections" by Marita Mol1 for a specific discussion of high tech alliances in the connecting classrooms agenda. Both essays appear in Moll, Marita (ed.). Tech High: Globalization and the Future of Canadian Education. Ottawa: Canadian Centre for Policy Alternatives, 1997.

directly in the hands of government officials. Alberta reduced the number of rural school boards from 144 to 60, the number of trustees from 1500 to 500, and county governance of education was abolished. Ontario reduced the number of school boards from 129 to 66 and the number of trustees from 1,900 to 700. The Ministers of Education from Manitoba, Saskatchewan, Alberta, British Columbia, Yukon Territories and the Northwest Territories entered into an agreement to collaborate in designing a Western protocol for mathematics, science and language arts curricula. The Council of Ministers of Education (CMEC) initiated a project to harmonize program protocols across the country - beginning with a Pan-Canadian science education protocol. All of these initiatives support and are supported by the new technologies being proposed for the classroom. Eventually, centrally developed curricula could be pushed out to any desktop in the country on a just-in-time, pay-as-you-go basis. This might sound far-fetched from a policy perspective, but the technology will soon be in place to make it possible. And the technological imperative, "because it can be done, it should be done," is a well-worn path in North American culture.

The second step on the way to reform is induced educational deterioration. Canadians may criticize their schools, but at the same time they hold them, and the traditions they embody, in general respect. To gain enough political support for the public to accept substantial change in schools is difficult as long as the public remains satisfied with schools as they are. To move from the "schools are failing" rhetoric to the felt reality of systemic crisis, the system must be starved to the point where it can no longer deliver on its stated goals and objectives.

Such a process has been underway for several years. Educational funding cuts in Canada in 1996-97 removed a further $928 million or 2.9 percent from a system already squeezed at all levels (Canadian Teachers' Federation, 1996 A, p. 1). The Ontario government sought to save $150 million with its recent reorganization proposals. According to the British Columbia Teachers' Federation, per student spending on elementary/secondary education in B.C. declined by $427 or 7 per cent between 1990/91 and 1996/97, while enrolment increased by 16 per cent, the number of special needs students increased by 60 per cent, and ESL students increased by 128 per cent (McLintock, 1997, p. A4). In its analysis of staffing and class size issues, the British Columbia Teachers' Federation found that the student/educator ratio had increased in the 1990's, while teacher librarian services had declined, despite the role teacher librarians play in teaching students to use information technology. Between 1993 and 1997, Alberta cut $224 million from the education budget and spending decreased by $466 per student, according to Alberta Education's 1995/96 Annual Report

(as cited in "Election '97," 1997, p. 1). At the same time, the "Alberta Teachers' Association *Report on Education in Alberta, 1996,* indicates that 63.5 percent of teachers have fewer resources to help children than they did three years ago. Teachers in Alberta schools are finding it harder to obtain the resources they need to help children. Guidance counsellors, reading specialists, teacher-librarians and teachers' assistants have become endangered species. Fully 78 percent of teachers report a decrease in assistance for students with special needs" ("Election '97," 1997, p. 1).

The Atlantic Provinces Education Foundation (APEF) noted that student/teacher ratios and class size had increased for almost all Atlantic provinces since 1989/90 (APEF, 1996). School boards were finding it increasingly difficult to maintain high levels of services. Cutbacks in government funding had placed schools, particularly the poorest schools and school boards, in an extremely vulnerable position.

Amidst all this, the physical infrastructure was also deteriorating. *Canadian Schoolhouse in the Red,* a 1993 national study of Canadian school facilities reported that two out of three school buildings had exceeded their predicted useful life. Fifty-three per cent of these were built in the 1950's and early 60's fourteen percent were built before 1950, and certainly not with the needs of the "Information Age" in mind.

It is hardly surprising that a national poll conducted for the Canadian Teachers' Federation in April 1998 found that Canadians identified underfunding as the greatest problem faced by schools (Vector, 1998). This did not deter them from expecting more from their schools, however. As a result, demoralized teachers, driven in contradictory directions by centrally mandated policies, know that the gap between what is expected of them and what is possible is widening every day. In this climate of shrinking resources and growing expectations, the addition of the current technological imperative has become "one more way not to be good enough" writes Alberta teacher and educational researcher Jean Claude Couture (1998, p. 150). The power known as orofessional self-esteem gradually ebbs away.

Following the Money

Despite alleged financial "crises," every province has made a considerable amount of money available for new technology. Globe and Mail reporter Andrew Tausz reported that "Alberta [despite massive funding cuts]...will invest $45-million in classroom technology. Ontario doubled its funding to $40-million for a program that matches private-sector invest-

(4) For more information on provincial technology plans see: Council of Ministers of Education Canada. (1996, July). The Use and Teaching of Information Technologies at the Elementarv and Secondary Levels. Summarv of Questionnaire Responses. and "Technology plans — An update on recent initiatives," CEA Newsletter, (Canadian Education Association), March 1997.

ments in public school technology. New Brunswick recently completed a three-year, $23-million initiative to link every public school in the province to the Internet" (Tausz, 1996, p. C6).(4) These figures are only suggestive. There is no record of how much has already been spent on technology, nor have there been any studies to determine the impact of these technology expenditures on students, teachers, or the already strained resources of schools. There has been minimal teacher education, or curriculum preparation for the massive changes envisioned by government and industry. The CMEC has suggested that the idea of lending laptops to teachers to work on during weekends is a promising "professional development" strategy (CMEC, 1997).

Between 1994 and 1997, through Industry Canada and its SchoolNet program, the Federal government spent between $25-35 million to develop services that promote and support the use of technology in education. The February 1998 federal budget allocated $205 million over three years to expand and extend SchoolNet and its companion Community Access Program (CAP) (Finance Canada, 1998). In June 1998, Prime Minister Jean Chrétien announced his government's intention "to have a computer for every Canadian class in every school by the end of the year 2000, a target that will require 250,000 computers to be donated by governments and the private sector (Chrétien, 1998).

The $13 million invested in the Telelearning Research Network which connects 125 researchers in 28 universities has attracted corporations such as Apple, IBM and Microsoft who pay $20,000 each for the privilege of being close to the starting gate when these publicly-funded experiments move into the product development and marketing stages. Some of the $78.5 million of public funds granted to Phase II (1995-1999) of the industry-led and managed CANARIE Inc. (Canadian Network for the Advancement of Research, Industry and Education) has also been targeted to educational products. A CANARIE newsletter announced that a newly formed Education Steering Committee would be working "as a catalyst and facilitator to bring together various government representatives and institutional stakeholders to develop a pan-Canadian strategy for integrating technology into the educational system" (Harasim, 1997, p. 7). The Committee, chaired by Telelearning leader Linda Harasim, is also working on a private sector- led initiative called Oui.Can.Leam. Such convergence of thinking between a leading spokesperson in the Canadian educational academic community, the govemment of Canada and the interests of the information technology industry, so well articulated by Bill Gates, is truly a sign that times are indeed "a-changing," as Bob Dylan wamed in the '60's.

The public appears to have some other education spending priorities.

Surveys show that computers rank well behind teacher upgrading and smaller class sizes (Canadian Teachers' Federation, 1996, p. 6), when Canadians are asked where money for education should be spent. A referendum in a North Vancouver school district which sought a small property tax hike to fund the updating of computer hardware and software was defeated by a 58 percent majority (Schaefer, 1997, p. A6). At its 1996 Annual Meeting, the Canadian Home and School and Parent-Teacher Federation passed an emergency resolution urging all education stakeholders to support the continued role of music and fine arts education as a fundamental part of public schooling, programs which have suffered particularly heavy cuts in the recent budget squeeze. A January 1997 Angus Reid poll showed that two-thirds of Albertans thought the public education system was working well but was under-funded. Forty-four per cent of those polled feared that recent changes to education could lead to a two-tiered system ("Majority of Albertans," 1997, p. 1).

All this means that the current agenda for education reform is quite evidently not driven by a populist agenda, and it is not driven by educators. The powering up of schools is not driven by a need to spend excess money. This leaves two options: it is occurring because it serves students' interests or because it serves a political/economic agenda despite students' interests.

Where's the Benefit?

Ask most teachers and parents why schools have been told to "embrace technology," and they will respond with either or both of these rationales: using computers improves student achievement and/or using computers is the route to (or synonymous with) computer literacy, which will prepare students for the workforce of the future. Both these statements are closer to urban myths than fact. Their passage into conventional wisdom, despite much evidence to the contrary, serves the mythmakers very nicely.

Defying the myths, many researchers and media critics continue to point to the scant evidence that the new technologies will deliver the "more effective, more efficient" education promised. Numerous analysts and researchers point to the absence of independent research indicating a strong cor-relation between the use of technological tools and the improvement of learning (Moll, 1998; Robertson, 1998). Larry Cuban concluded that "the research evidence on [the overall effect of technology on student learning] was ambiguous and unhelpful in determining policy" (1990, p. 205). Stephen Kerr, "one of the few [educational] researchers who examines seriously the deep-set beliefs of both technophiles and technophobes" (Cuban, 1990, p. 209), pointed out that there was no proof that using

technology in the classroom increased achievement (Kerr, 1991, p. 114). U.S. researcher Thomas Becker reviewed evaluative studies on the integrated learning systems in which many schools had invested heavily and found that the research had been of poor quality and moderate effects had been typically overstated (Becket-, 1992). "No long-ter-m supporting empirical or qualitative evidence shows that technology has made schools and teachers more effective or significantly positively affected the lives of their students," write Muffoletto and Knupfer (1993, p. 2). In 1999, educational researcher Thomas L. Russell compiled a database of findings related to the effective use of technology, chiefly in the field of distance learning, as compared to alternative methods or techniques of teaching. Three hundred and fifty-five research reports, summaries, and papers are cited in which no significance difference was reported between the variables compared. (Russell, 1999). ". . . these no significant difference studies provide substantial evidence that technology does not denigrate instruction," says Russell. (1999, p.xiii).

Finally, Thomas Fleming, professor of educational history at the University of Victoria and teacher researcher Helen Raptis, after an extensive analysis of research in educational technology, concluded that "what is actually known about the effects of educationai technology on the cognitive development of students appears remarkably small. Because SO few publications in this area of research have explored cognitive effects in empirical ways, there is almost no scientific basis for discussion, beyond the findings of a handful of papers. In fact, apart from their panacea effects as 'gateways to new worlds of learning,' or marginal claims about improving student learning, no strong or coherent argument for educational technology's use in schooling may be found in the literature of recent years (Fleming, 2000)."

The incompatibility of the more effective/more efficient rationales is pointed out in the research done by well-known American researcher Henry Becker. Becker concludes that exemplary classrooms using computers reduced class sizes to 20 and incurred additional costs amounting to about $1,000 per pupil per year in extra personnel and support costs. Hardware and maintenance costs were about $500 per pupil per year (Becker, 1994). Accounting for the exchange rate, Canadians are looking at more then $2,000 per pupil per year. Fleming and Raptis note "it is interesting to observe that the high acquisition costs of new technologies — and the remarkably short periods they remain state-of-the-art — is not justified within the literature on the basis that they may yield significant labour-cost

For more information outlining potential costs see: Froese-Germain, Bernie. (1998). "Taking another look at education and technology (Part 4): The 'computers in schools' express - all aboard?" Ottawa, ON: Canadian Teachers' Federation. Available at: http://www.ctf-fce.ca/e/what/restech/ART&PAP2.htm

savings, by making instruction more efficient, or by reducing the time it takes for students to complete programs of study (2000)." So far it seems quite clear that the benefits are, as yet, quite undetermined, but the information technology industry knows the true costs better than anyone. A recent advertisement for Compaq Computers claims that 85 percent of the money spent on technology is spent post-purchase. Computer "intensification" can never be a cost saving proposition unless education ceases to be conceived of and delivered in traditional ways.

The Cult of Individualisation

The ideology of individualism moves in tandem with the culture of progress through technological innovation. Note the growth of the "personal" computer, "persona1 productivity software," and entertainment technology that allows persona1 viewing, listening and singing along. Now technology can be used to shift the emphasis from the collective experience and benefit characteristic of schools to individual experiences and benefits. There are many who, for various reasons, concur with Gates' suggestion that education must be more tailored to the needs of the individual (1995, p. 204). "The central organizing principle we need for education in our future is mass customization: a unique education curriculum, a unique set of educational tools, and perhaps even a unique set of educators for each and every student," says futurist Richard Worzel(1996, p. 5). "Computers will permit a degree of individualization - personalized coaching or tutoring - which in the past was available only to the rich. Al1 students may receive a curriculum tailored to their needs, leaming style, pace and profile of master-y . . ." predicts Howard Gardner, well known for his work on multiple intelligences (2000). In a less altruistic vein, Trimark Investment Management Inc. wams that, "In the year 2014, they say it will cost over $65,000 for an undergraduate degree (1996)." The advertisement urges Globe and Mail readers to start their persona1 "Legacy for Leaming" fund right away. After all, if leaming is "personal," why would costs not be "personalized"? Unfortunately, the emphasis on the "individual" and "personal" appears to be eroding our commitment to the social and collective responsibilities for education. Recent examples of this in public policy at the federal level have been (personal) Millennium scholarships and (personal) RESP's as a response to the under-funding of post-secondary education.

Who will have the most choice and the most benefit in this new educational supermarket? Those with the greatest (personal) resources, of course. The information highway will indeed provide new services for those who

can afford them, but on-line education in which students can take any course, at any time, from any location, could be much more restrictive for the majority of citizens than the current education delivery mechanisms. As traditional ways of delivering education begin to disappear or become too expensive, a "plug and play," "pay as you go" modular education system could replace the current system in which society shares the costs and the benefits, in which individual and collective interests are balanced through democratically elected decision-makers. In the year 2014, technology pushes education to "you":

> What is it you want to learn from Microsoft software?
> What is it you want your children to learn?
> Here it is, right at your fingertips. All you have to do is click (Microsoft, 1997).

Offloading responsibility for education from society to the individual appears to be part of the plan for education in the new millennium. In this brave new world, those seeking enhanced educational services will find many options available to them, at a price. Those who cannot afford this price will become the new underclass in the jungle of the information age. "All you have to do is pay" is a more honest conclusion to the Microsoft mantra.

Buyer, beware!

(1) For a more in-depth discussion of the connection between telecommunications deregulation and policy objective to connect all schools to the Internet see: Moll, Marita. (1996). "Supporting or subverting the public interest: A critical look at the agenda to connect all schools, hospitals and libraries to the information highway." Paper presented to the meeting of INET 96 (The Internet Society), Montreal, June 1996. Available at: http://www.iif.hu/inet _96/e3/e3_3.htm.

(2) See "Visioning education in the information economy" by Alison Taylor for a description of Canadian corporate alliances impacting on education and "Canadian classrooms on the information highway: Making the connections" by Marita Moll for a specific discussion of high tech alliances in the connecting classrooms agenda. Both essays appear in Moll, Marita (ed.). Tech High: Globalization and the Future of Canadian Education. Ottawa: Canadian Centre for Policy Alternatives, 1997.

(3) For more information on provincial technology plans see: Council of

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La Latent Semantic Analysis et Le Macro-Professeur : Exemple d'intégration de l'intelligence artificielle à un système de tutorat intelligent

Julien Mercier
Monique Brodeur

This article describes the technique of Latent Semantic Analysis (LSA), an artificial intelligence algorithm that can be integrated into intelligent tutoring systems (ITS). LSA is a technique that extracts some semantic properties of a text, using mathematical and statistical operations. The technique uses huge amounts of digitized text, integrated in a semantic space that acts as a knowledge base. LSA is used to compare words or texts with respect to their semantic content. The algorithm is first described. Then, the nature of a semantic space and the method to build one is made explicit, starting from an example (a semantic space on the topic of psychology, in French). Finally, an example of a recent ITS using LSA is described; it consists of a system to support the teaching of summarizing skills, named Le Macro-Professeur, which is available on the Web.

Cet article décrit la Latent Semantic Analysis (LSA), un algorithme d'intelligence artificielle pouvant être intégré à des systèmes informatiques de tutorat intelligent. La LSA est une technique qui extrait certaines propriétés sémantiques d'un texte par des opérations mathématiques et statistiques. Elle évolue à partir dune grande quantité de texte numérisé et intégré dans un espace sémantique qui fait figure de base de connaissances. La LSA sert à comparer des mots ou des textes entre eux quant à leur contenu sémantique. L'algorithme est d'abord décrit. Ensuite, la nature d'un espace sémantique et la méthode menant à sa création sont exposées, en menant comme exemple un espace sémantique

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de langue française portant sur la psychologie. Enfin, un exemple de système de tutorat intelligent récent utilisant la LSA est apporté ; il s'agit d'un système de support à l'enseignement des stratégies de rédaction d'un résumé, Le Macro-Professeur, qui est disponible sur le Web .

La Latent Semantic Analysis (LSA)

Dans une perspective large, le domaine de l'intelligence artificielle vise notamment à recréer artificiellement, au moyen de l'informatique, les processus inhérents à l'intelligence humaine. Par conséquent, l'intelligence artificielle peut être utilisée pour développer des systèmes de tutorat hautement spécifiques destinés à favoriser l'apprentissage. Par exemple, des chercheurs de l'université McGill ont développé un système de tutorat pour I'apprentissage des statistiques au troisième cycle universitaire (Frederiksen & Donin, 1999). D'autres projets d'envergure ont trait à l'entraînement de mécanicien en avionique ou à l'entraînement au diagnostic médical (Lillehaug & Lajoie, 1998). La section suivante présente quelques généralités et l'aspect mécanique de la *Latent Semantic Analysis*.

Généralités

La *Latent Semantic Analysis* (Landauer & Dumais, 1996, 1997) est un nouveau type d'intelligence artificielle qui tire l'information d'un texte par des opérations mathématiques et statistiques complexes (Landauer, Foltz, & Laham, 1998). Les connaissances ou informations que ce système tire des textes qui lui sont soumis sont représentées dans un espace sémantique ou *semantic space.* Selon plusieurs auteurs (Burgess, Livesay, & Lund, 1998; Landauer & Dumais, 1997 ; Landauer, Laham, Rehder, & Schreiner, 1997), cet espace sémantique reproduit artificiellement, à maints égards, le modèle connexionniste de représentation des connaissances élaboré par Kintsch (1998) : le modèle de construction-intégration. De plus, l'utilisation de la LSA est tout indiquée pour les recherches considérant le *textbase,* c'est-à-dire les propositions dont un texte est composé (Foltz, 1996). Selon Perfetti (1998), la LSA fait partie de ces outils qui représentent le *nec plus ultra* pour des applications au niveau de la recherche quantitative portant sur les productions écrites.

Aspect mécanique

Les deux principaux aspects de cette technique de LSA seront explicités ici. D'abord, la mécanique mathématique et statistique sous-jacente à la LSA sera développée. Ensuite, l'espace sémantique, qui est le résultat de cette

(1) L'adresse intemet est la suivante : http://lsa.colorado.edu/Macro-Professeur/

mécanique, sera décrit puisque c'est de ses qualités que dépend l'efficacité de la LSA.

Mécanique mathematlque utilisée par la LSA

La mécanique centrale à la LSA est basée d'une part sur l'analyse statistique descriptive des mots contenus dans les textes et, d'autre part, sur l'analyse factorielle de ces statistiques. Elle est basée sur le postulat qu'il existe une structure « latente » sous-jacente à l'utilisation des mots à travers l'ensemble des écrits. Le système considère l'apparition de chaque mot dans son contexte, généralement au niveau de la phrase ou du paragraphe dont il est issu. Limitons-nous pour l'instant à un mot, point de départ des deux étapes principales opérées par la LSA.

Première étape: analyse statistique descriptive. Le système considère et compile toutes les phrases ou plus généralement tous les paragraphes au sein desquels ce mot apparaît. On obtient donc une liste de tous les contextes dont ce mot fait partie. À ce niveau, on peut concevoir la signification du mot comme la moyenne de tous les contextes où il a été retrouvé. À un niveau plus mathématique, on représente le résultat de cette première opération dans une matrice, dans laquelle les rangées représentent tous les mots des textes et les colonnes représentent tous les contextes (lignes ou paragraphes) dans lesquels apparaissent les mots. Dans cette matrice, chaque case contient la fréquence d'occurrence d'un mot dans chaque contexte.

Deuxième étape : analyse factorielle. Par la suite, une deuxième opération intervient, qui témoigne de l'importance de chaque mot dans chaque contexte. Comme on considère chaque contexte où un mot apparaît et que ces différents contextes forment des contraintes mutuelles, cette opération imite le principe de satisfaction de contraintes du modèle de construction-intégration (Landauer, Laham, Rehder, & Schreiner, 1997). C'est une forme d'analyse factorielle *(singular value decomposition* ou *SVD)* qui mène à la réduction des dimensions à laquelle il sera fait allusion plus loin. Cette analyse factorielle conduit à l'élaboration d'une matrice qui fait état de l'estimation très juste de la fréquence à laquelle apparaîtrait un mot dans chaque contexte dans le cas où l'on considérerait une infinité d'occurrence de ce contexte. Ici, la signification d'un mot est basée sur l'ensemble des contextes où le mot apparaît, sur l'ensemble des contextes où ce mot pourrait apparaître comme synonyme, et sur l'importance de ce mot dans les contextes considérés. Cette réduction des dimensions augmente considérablement la puissance de la technique. Par exemple, elle permet de mettre les synonymes en évidence. En somme, la nature de cette signification sémantique n'est pas logique. Elle est

en fait basée sur des relations de similarité contextuelle entre les mots. C'est donc dire que cette signification est construite à partir des autres mots et contextes de la matrice, à l'image du processus associatif décrit dans le modèle de construction-intégration. C'est pourquoi il est important de réduire les dimensions de la matrice afin de conserver les facteurs qui caractérisent de façon prépondérante l'ensemble des mots utilisés. Ces facteurs sont en quelque sorte des continuums qui représentent chacun une dimension de la matrice. En termes plus mathématiques, le sens d'un mot est déterminé par sa position sur chacun des continuums retenus. Par extension, la signification d'un paragraphe ou d'un passage entier est établie selon les mêmes mécanismes. Elle est constituée des moyennes des vecteurs sémantiques des mots que le paragraphe ou le passage contient, indépendamment de l'ordre des mots (Landauer, Laham, Rehder, & Schreiner, 1997). Les mots et les contextes ainsi que les facteurs qui les caractérisent forment ce que l'on appelle un espace sémantique, qui symbolise artificiellement le savoir qu'une personne retirerait de la lecture des textes traités par la machine, suggérant l'analogie avec le *situation mode1* de Kinstch (1998).

Par ces opérations mathématiques, la LSA permet l'analyse des informations sémantiques issues des contextes dans lesquels apparaissent les mots. Cette analyse est le point de départ de plusieurs actions essentiellement comparatives portant sur les productions écrites de sujets humains, tels que des élèves et des étudiants de tous les cycles, du primaire à l'université. D'abord, elle permet d'évaluer le résumé d'un texte par comparaison avec le texte original et d'obtenir de la rétroaction sur les particularités de ce résumé. C'est d'ailleurs ce principe qui est mis à profit dans le logiciel présenté en exemple. Elle permet de plus d'évaluer le degré de convergence de plusieurs travaux sur un même sujet. Elle permet aussi de cerner à partir d'un ensemble imposant de connaissances les éléments-clés à retenir sur un sujet particulier. Ces comparaisons s'opèrent sur les vecteurs associés à chaque texte ou partie de texte. Il est à noter que ces opérations ne peuvent être réalisées que sur des textes faisant appel au même espace sémantique. Les caractéristiques d'un espace sémantique, les considérations nécessaires à son élaboration ainsi que ses principales fonctions seront exposées maintenant.

L'espace sémantique

Un espace sémantique est caractérisé principalement par l'ensemble des mots qu'il contient. L'ensemble du vocabulaire contenu dans les textes auxquels le système a eu accès lors de la construction de l'espace sémantique par les mécanismes décrits précédemment détermine la teneur des liens, des dimensions et des informations que l'on pourra retirer des analyses. Ainsi, le système construit des « connaissances » liées au vocabulaire et aux contextes

émanant des textes qu'on lui soumet. On peut donc choisir de lui faire absorber le contenu d'un domaine particulier comme la biologie (McNamara, Kintsch, Songer, & Kintsch, 1996) ou la psychologie (Mercier, 1999, site web) selon le sujet des écrits que l'on intègre dans le système. On peut aussi considérer les écrits plus usuels et quotidiens tels que ceux que l'on retrouve dans les forums de discussion sur l'Internet. Toutefois, le choix des textes se doit d'être réalisé judicieusement selon le matériel utilisé à travers les analyses. Comme la méthode est basée essentiellement sur le vocabulaire et ses relations avec le contexte, il doit y avoir un lien étroit entre le sujet des textes contenus dans l'espace sémantique et le sujet des textes produits par les humains. Les publications récentes au sujet de la LSA (Foltz, 1996 ; Landauer, Foltz, & Laham, (1998) ; Rehder et al., 1998) suggèrent qu'idéalement, on devrait retrouver dans l'espace sémantique l'ensemble des mots utilisés par les humains dans leurs textes.

Comme la LSA a recours aux statistiques, l'élaboration d'un espace sémantique de qualité nécessite une grande quantité de textes. De façon analogue à la taille de l'échantillon garant de sa représentativité de la population, l'augmentation de la quantité de contextes où l'on retrouve un mot favorise l'élaboration d'une signification juste de ce mot. De plus, l'étendue du vocabulaire de l'espace sémantique est tributaire de la quantité de textes traitée. Les espaces sémantiques construits jusqu'à maintenant renferment de 8300 mots à quelques centaines de millions de mots pour un vocabulaire de 30119 à 92000 mots. L'examen des espaces sémantiques réalisés antérieurement suggère d'autres précautions qui seront énoncées ici, bien qu'elles n'aient pas encore fait l'objet d'expérimentations empiriques avec la LSA.

Il semble que les textes doivent favoriser l'extraction de l'information contextuelle. À cet égard, les livres spécialisés dans un domaine semblent être tout indiqués. En effet, les mots qu'ils renferment font partie intégrante d'un discours organisé conformément aux connaissances des auteurs sur un sujet. De plus, les mots utilisés dans l'exposé des idées sont soigneusement choisis par l'auteur soucieux d'être bien compris. Enfin, la ressemblance de la LSA avec le modèle connexionniste suggère que la qualité de l'espace sémantique, et conséquemment de ses applications, dépend de la qualité de ce qui est traité, à l'image de la qualité d'un apprentissage qui est tributaire de la qualité du contenu abordé.

Le fait que certains mots revêtent un sens particulier selon le domaine auquel ils réferent suggère que les textes traités lors de l'élaboration de l'espace sémantique devraient être spécifiques au domaine des textes analysés. Selon cette considération intuitive, les textes devraient être tirés d'un même corpus de connaissances relativement spécifique, tel qu'une science particulière. Il est toutefois possible que des impératifs très pragmatiques viennent

influencer le choix des textes ; le rassemblement d'une telle quantité de matériel requiert un investissement considérable de moyens. Pour limiter les ressources nécessaires, les chercheurs ont avantage à limiter l'importance des textes traités. En effet, les sources disponibles de documents en langage-machine (ASCII) sont l'Internet et les CD-roms encyclopédiques qui demandent une recherche et un traitement permettant de colliger un corpus de textes. L'alternative consiste à numériser des textes sur papier, ce processus nécessitant des ressources considérables. De plus, les capacités limitées du système informatique imposent de réduire les dimensions de l'espace sémantique. Selon ces observations, la portée réduite des espaces sémantiques existants serait due non pas à des précautions quant à l'efficacité de la technique de LSA mais bien à des contraintes externes de nature pragmatique.

Préalablement au travail du premier auteur, il n'y avait pas d'espace sémantique de langue française disponible. Le site Web de la LSA (http:// mis sur pied par des chercheurs de l'Université du Colorado à Boulder est essentiellement anglophone. Il comporte plusieurs applications de la LSA ainsi que des sources d'informations concernant la théorie et les techniques sur lesquelles la LSA est fondée. Mis à part le matériel anglophone, le site ne contenait qu'un espace sémantique trilingue regroupant des articles de magazines européens rédigés en français, en anglais et en allemand. Un autre projet en développement porte sur les débats parlementaires bilingues du parlement canadien. Comme le logiciel présenté dans cet article est réalisé avec des textes académiques de niveau universitaire en langue française, l'élaboration d'un espace sémantique approprié est de rigueur. La qualité de cet espace sémantique est déterminante puisque la qualité de la rétroaction fournie par le logiciel dépendent exclusivement de ses propriétés. En effet, c'est au sein de celui-ci que les comparaisons sémantiques sont opérées.

Exemple d'espace sémantique

Cette section comporte deux parties. D'abord, les principales caractéristiques de l'espace sémantique sont exposées. Ensuite, un exemple d'analyse est proposé, afin d'illustrer la teneur et les limites des résultats obtenus par les différentes analyses avec la LSA.

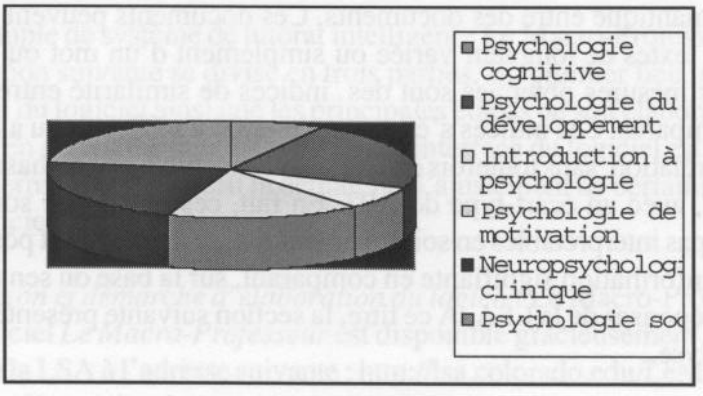
Principales caractéristiques de l'espace sémantique

Cette section comporte des informations sur la nature de l'espace sémantique, sur son élaboration ainsi que sur sa principale fonction. L'espace sémantique présenté dans cette recherche est disponible à la communauté de chercheurs intéressés par des investigations en langue française réalisées avec la LSA, à l'adresse électronique http://lsa.colorado.edu/. Il a pour nom *Psychology_French*.

Nature de l'espace sémantique Psychology_French

L'espace sémantique *Psychology_French* est constitué de 6 livres récents utilisés comme références dans plusieurs cours de première année du programme de baccalauréat spécialisé en psychologie. Les livres font le survol de plusieurs champs disciplinaires de la psychologie : psychologie générale, psychologie cognitive, psychologie sociale, neuropsychologie clinique, psychologie du développement et psychologie de la motivation. La figure suivante offre un aperçu de la proportion occupée par chaque champ de la psychologie au sein de l'espace sémantique.

Figure 1. Proportion occupée par chaque champ de la psychologie au sein de



l'espace sémantique

Élaboration de Psychology_French

Les 6 livres ont été numérisés entièrement, à l'exception des graphiques et des figures. Trois critères principaux ont influencé le choix de numériser des livres plutôt que de l'utilisation de CD-roms ou de textes disponibles en ligne sur Internet. Premièrement, une très grande quantité de livres francophones est disponible. Ensuite, le contenu d'un livre est clairement identifié, notamment par ses descripteurs. Enfin, l'utilisation d'un volume dans le cadre d'un cours universitaire est un indicateur du niveau académique de son contenu. Les résultats de nos recherches sur Internet ou dans les répertoires de CD-Roms n'ont pas répondu à ces trois critères.

Comme le logiciel de reconnaissance de caractères utilisé lors de la numérisation des livres (*Omnipage Limited Edition*) a un taux d'efficacité variant de 30 à 96%, les textes numérisés ont été corrigés à l'aide du correcteur orthographique de *Microsoft Word 95*. Le document *Word* qui a servi de base à la méthode mathématique de la LSA afin de créer l'espace sémantique comporte 2295 pages à interligne simple, soit près de 12 MB de texte. L'espace

sémantique obtenu à partir des livres numérisés comporte un vocabulaire de 41741 mots utilisés dans les champs de la psychologie considérés. À titre de comparaison, *Le Petit Larousse* 1998 contient 59 000 noms communs.

La dimension du contexte a été fixée au paragraphe. Le nombre optimal des dimensions de l'espace sémantique a été fixé à 300. Ce nombre optimal de dimensions permet à la LSA de simuler le jugement humain sur la signification des mots donnant lieu à des résultats de l'ordre de quatre fois la précision d'un espace sémantique sans réduction des dimensions (site web de la LSA).

Fonction d'un espace sémantique

Les analyses menées avec la LSA permettent essentiellement la comparaison sémantique entre des documents. Ces documents peuvent prendre la forme de textes de longueur variée ou simplement d'un mot ou groupe de mots. Les mesures obtenues sont des indices de similarité entre les documents comparés. Ces indices s'étendent de -1.OO à 1.OO, un peu à la manière d'une corrélation, sans toutefois en être une. Deux mots pris au hasard obtiennent 0.02, avec un écart-type de 0.03. En fait, ces indices ne sont, pour le moment, pas interprétables en soi de par leur nature même. Il est possible d'en tirer une information signifiante en comparant, sur la base du sens commun, diverses réponses de la LSA. À ce titre, la section suivante présente un exemple d'analyse.

Exemple d'analyse

Le tableau suivant présente le résultat d'une analyse permettant de comparer plusieurs mots entre eux. Il s'agit de l'application *Matrix Comparison,* que l'on retrouve sur le site Web de la LSA, utilisée avec l'espace sémantique *Psychology_French.*

Tableau 1. Résultat d'une comparaison au sein de l'espace sémantique

	psychanalyse	psycho. développement	béhaviorisme	psycho. sociale
Freud	0.62	0.12	0.04	0.05
Piaget	0.03	0.47	0.07	0.03
Pavlov	0.08	-0.01	0.19	0.07
Vallerand	-0.02	-0.02	0.01	0.02

Pour cette analyse, quatre grands noms de la psychologie ont été entrés, accompagnés des domaines de la psychologie auxquels ils ont

significativement contribué. Freud obtient la meilleure association avec psychanalyse (0.62). Piaget obtient la meilleure cote auprès de la psychologie du développement (0.47), tandis que Pavlov arrive premier au niveau du béhaviorisme (0.19). Enfin, Vallerand n'est pas associé avec la psychologie sociale, contrairement à la réalité. Il est possible d'expliquer ceci en référant aux caractéristiques des mots employés. En effet, les mots psychologie et sociale sont utilisés dans bon nombre de contextes et indépendamment de surcroît, sans doute sans lien précis avec les citations du professeur Vallerand.

En définitive, il est important de garder à l'esprit la nature statistique de la LSA. À cet égard, on peut penser que les analyses opérées à partir de documents plus longs, tels que ceux utilisés dans la présente étude, sont moins sujettes aux aberrations découlant d'une analyse opérées sur un ou deux mots.

Exemple de système de tutorat intelligent : Le Macro-Professeur

La section suivante se divise en trois parties. En premier lieu, une brève description du logiciel ainsi que les principales étapes de son élaboration sont exposées. En deuxième lieu, un aperçu de l'interface du logiciel est présenté. Enfin, la dernière partie décrit la démarche d'ajustement de certains paramètres du logiciel.

Description et démarche d'élaboration du logiciel Le Macro-Professeur

Le logiciel *Le Macro-Professeur* est disponible gracieusement sur le site Internet de la LSA à l'adresse suivante : http://lsa.colorado.edu/LeMacro-Professeur/. *Le Macro-Professeur* oriente l'utilisateur vers la production d'un résumé comportant l'information essentielle (2) d'un texte tout en satisfaisant une contrainte de longueur du résumé. Sa mécanique fait appel *à* la *Latent Semantic Analysis*. L'espace sémantique, décrit précédemment, constitue la base de connaissances permettant au logiciel d'évaluer les résumés de textes prédéterminés et de fournir de la rétroaction à l'utilisateur. L'interface par lequel l'utilisateur prend contact avec les stimuli et la rétroaction du logiciel est composé de pages HTML. Le logiciel ne requiert donc pour son utilisation qu'une plateforme *PC* ou *Mac* munie du logiciel de navigation *Microsoft Internet Explorer* 5 ainsi que d'un accès à Internet. Le logiciel *Microsoft Virtual Machine* est téléchargé automatiquement et gratuitement lors de l'utilisation du logiciel s'il n'est pas déjà présent dans l'ordinateur. Les étapes suivantes ont été nécessaires à la réalisation du *Macro-Profeseur*.

D'abord, tous les messages de rétroaction de la version anglaise ont été traduits en français. Il s'agit d'une traduction libre de l'auteur principal. Ces messages ont ensuite été intégrés à l'interface du logiciel afin de remplacer les

(2) La détermination de l'information essentielle a un texte est discutée ultérieurement.

messages originaux en anglais. Il est à noter que cette procédure ne requiert nullement de dispositions particulières comme dans le cas de la validation transculturelle d'un questionnaire. Il s'agit de faire en sorte que les messages de rétroaction du logiciel soient compréhensibles par l'utilisateur francophone. Comme les processus de compréhension en lecture de même que l'habileté de résumer sont des mécanismes cognitifs qui n'impliquent pas à prime abord de composantes culturelles, le logiciel présenté dans cette étude est destiné à toute personne qui maîtrise le français écrit.

Deuxièmement, trois textes servant d'exercices, choisis en raison de leur intérêt général, ont été intégrés au logiciel. Les textes sont présentés en ordre croissant de difficulté, sur la base d'une expérimentation sommaire. Ces trois textes sont tirés de trois des six livres ayant servi à l'élaboration de l'espace sémantique, afin d'assurer la plus grande correspondance entre les textes à traiter par le logiciel et l'espace sémantique. Les titres des textes sont les suivants: *L'expérience des études collégiales et universitaires, Le modèle de l'intelligence artificielle (IA)* et *L'amour.*

Le Macro-Professeur est développé en vue d'un usage très spécifique : aider les étudiants de niveau universitaire à développer leur habileté à résumer des textes de vulgarisation scientifique. En raison des limites reliées à l'intelligence artificielle à laquelle il fait appel, le logiciel propose présentement du matériel orienté vers les sciences humaines.

L' interface du logiciel

L'interface du logiciel *Le Macro-Professeur* est à plusieurs égards comparable au matériel courant disponible sur l'Internet. En fait, l'environnement interactif du logiciel est composé de fenêtres de saisie pour le texte et de boutons d'action proposant les différentes options. Ces éléments, de même que la rétroaction, sont intégrés et présentés dans une succession de pages web spécifiques au logiciel et organisées autour de la mécanique sous-jacente au logiciel, la LSA. Cette approche permet un interface attrayant, avec logos et motifs d'arrière-plan, que de brèves instructions fournies sur la page d'accueil permettent de rendre convivial.

La page d'accueil du logiciel est élaborée en vue d'une utilisation autonome, notamment en raison de son accessibilité via Internet. Ceci afin que quiconque entre en contact avec le site, soit par hasard ou en y étant référé, puisse y évoluer avec succès sans instructions supplémentaires. Après une brève description de la nature d'un résumé et l'énumération des stratégies de production d'un bon résumé (3), la page contient les instructions détaillées au niveau de l'utilisation du logiciel. Enfin, cette page se termine par des informations concernant l'utilisation de la rétroaction fournie par *Le Macro-Professeur.*

En plus de la page d'introduction et de pages connexes proposant des informations supplémentaires, l'interface du logiciel est composé d'une fenêtre de saisie permettant à l'utilisateur de taper son résumé au moyen du clavier de l'ordinateur. De plus, cette fenêtre indique la longueur idéale du résumé à produire. Cette longueur idéale est d'environ 7.6 % de la longueur du texte original, ce qui contribue à rendre le niveau de difficulté des exercices proposés plutôt élevé. Mis à part la rédaction du résumé réalisée au moyen du clavier, l'interaction avec le logiciel se fait au moyen de la souris. L'utilisateur l'utilise pour cliquer sur les hyperliens afin d'obtenir plus d'information. Il doit aussi cliquer sur les différents boutons d'action qui proposent les choix d'action possibles en fonction de la progression de l'utilisateur dans la tâche à réaliser. Après la rédaction du résumé, Le Macro-Professeur propose notamment de sauvegarder le résumé produit et d'en vérifier l'orthographe ou de fournir la rétroaction sur ce résumé.

La page de rétroaction comporte une partie graphique suivie d'une partie verbale. On y retrouve un indicateur de la longueur du résumé, représenté par la bande verticale. Si l'extrémité de cette bande se situe entre les deux lignes vers le milieu de l'indicateur, la longueur du résumé est adéquate, (tel que symbolisé par la couleur verte de l'indicateur.) Si l'extrémité de la bande se situe en deçà ou au-delà des limites, l'indicateur passe au rouge et signifie que le résumé est trop court ou trop long. En soi, un résumé ne peut être trop court, sauf si sa longueur ne permet pas de couvrir adéquatement l'information principale du texte à résumer. À cet égard, les limites inférieures sont calibrées de façon à ce qu'un résumé très court oriente la rétroaction à l'effet que le contenu du texte n'est pas couvert possiblement en raison de sa brièveté. Les bandes horizontales indiquent la quantité d'information contenue dans le résumé. Chaque bande correspond à une section du texte à résumer et est identifiée par le titre de la section. La ligne noire verticale représente le seuil à atteindre (4) pour chaque section. Ce seuil symbolise la quantité minimale d'information que chaque section du résumé doit contenir pour représenter l'information principale du texte.

En complément, la page de rétroaction comporte certains commentaires verbaux. Ces commentaires fournissent des hyperliens et des boutons d'action adaptés à la qualité du résumé de l'usager, de même que des renseignements complémentaires aux graphiques. Il traitent de la qualité du résumé et proposent des stratégies afin de l'améliorer.

Quand son résumé rencontre les normes de longueur et de contenu, le logiciel lui offre de vérifier si deux ou plusieurs phrases du résumé contiennent la même information (redondance) ou si chaque phrase est bel et bien en

(3) Ces stratégies sont énoncées d'après Brown et Day (1983).

(4) La méthode de détermination de ce seuil est discutée plus loin.

lien avec le sujet du texte (pertinence).

Enfin, de par la relative simplicité de l'environnement du logiciel, les possibilités d'amélioration sont nombreuses. Il est possible d'intégrer une quantité infinie de textes servant d'exercices de difficulté variée afin d'adapter Le *Macro-Professeur* à toute la clientèle estudiantine, du primaire au doctorat. Il est aussi possible d'élargir les domaines couverts par les exercices, de la chimie à la musicologie, moyennant la création de l'espace sémantique approprié.

Ajustement des paramètres du logiciel

Cette section décrit deux principaux paramètres du logiciel. Le premier paramètre est le seuil d'importance du contenu. Le deuxième paramètre est la longueur du résumé à produire. La section se termine par l'appréciation du degré de difficulté du logiciel.

Démarche automatisée d'identifcation du contenu le plus important d' un text.

Au sein de cette méthode, le jugement humain n'intervient jamais dans la détermination du contenu important du texte à résumer. Les étapes mathématiques qui suivent décrivent l'essentiel de cette démarche.

1. Diviser le texte en sections S 1.. . Sn.
2. Pour chaque section Si du texte, la diviser en phrases sl, s2, . . . sm.
3. Opérer les comparaisons C 1 = cos(s1,Si), C2 = cos (s2,Si), . . . Cm = cos (sm, Si).
4. Choisir la phrase sj telle que cos(sj,Si) = max(C1.. . Cm).
5. Prendre les n phrases obtenues et les réunir pour former un résumé.
6. Seuil i = cos(résumé, Si).

En somme, le système décompose le texte original en sections selon les sous-titres. Ensuite, il identifie les phrases composant chaque section. Il produit un indice de similarité sémantique entre chaque phrase et la section d'où est tirée la phrase. Il choisit ensuite la phrase qui affiche la plus grande similarité avec sa section. On joint ces phrases les plus représentatives de leur section pour obtenir un «résumé typique». La dernière étape sert à déterminer le seuil à atteindre pour chaque section du texte à résumer, c'est-à-dire le contenu minimal qui doit être présent dans le résumé de l'utilisateur du *Professeur.*

Cette démarche est déterminante pour l'efficacité du logiciel. En effet, la

mécanique du Macro-Professeur oriente l'utilisateur vers la production d'un résumé dont le degré de similarité sémantique avec le texte original excède celui du contenu déterminé par la présente démarche. C'est en quelque sorte un seuil qui détermine artificiellement la proportion du texte à résumer qui constitue sa macrostructure. Plus ce seuil est élevé, plus petite est la portion du texte qui renferme sa macrostructure. Par conséquent, la partie du texte original à négliger dans le résumé prend de l'ampleur. Il est possible qu'un seuil plus élevé favorise l'utilisation de stratégies de haut niveau dans l'élaboration du résumé.

La contrainte de longueur du résumé à produire

La contrainte de longueur est fixée empiriquement dans le cadre de cette étude à environ 7.6% de la longueur du texte original. Par exemple, le sujet qui choisit le texte portant sur l'intelligence artificielle (2392 mots) doit produire un résumé comportant entre 250 et 300 mots.

Degré de difficulté du logiciel

Le seuil symbolisant le contenu minimal que le résumé doit contenir ainsi que la contrainte de longueur du résumé constituent les deux paramètres permettant de faire varier la difficulté de la tâche. Le seuil déterminé par la méthode décrite précédemment impose de ne retenir que l'information la plus importante du texte à résumer. La contrainte de longueur, quant à elle, impose la formulation concise et précise du contenu important du texte à résumer. L'ajustement actuel de ces paramètres, l'un automatiquement et l'autre empiriquement, font de la tâche proposée par *Le Macro-Professeur* un défi exigeant pour les étudiants universitaires, qui met à l'épreuve leurs capacités de compréhension en lecture.

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Inventeering A Problem-Solving Approach to Teaching Technology Grades l-8 2000, by Bob Comey and Norm Dale, Trifolium Books Inc. Toronto, Canada, 132 pages ISBN 1-55244-014-l

Reviewed by Paul Laing

Bob Comey worked as a wood patternmaker for The Steel Company of Canada before obtaining a teaching certificate. He taught for both the Wellington Board of Education and the Peel Board of Education. Bob is now a part time instructor at OISE/UT in the Initial Certification Program for Technological Studies. Norm Dale worked as a construction electrician for ten years before becoming a teacher. He ended his career as Consultant for Technological Education for the York Board of Education. Both authors are now retired.

Inventeering opens with a statement of the authors' assumptions that many elementary teachers need assistance in meeting the technology requirements of the new Ontario Curriculum since they lack training and skills in the area of technology. The authors are aware of crowding of curriculum and demands on teachers' time for implementing new things. This legitimate concern is met by the fact that they take some time to show how technology can enhance and support the teaching and learning in other curriculum areas.

Section one of the book provides an overview of Design as a Process and some of the considerations in teaching process. Sections two through five provide needed information on tools, materials, and safety. The safety aspect is appropriately and well emphasized in Bob and Norm's book. While experienced science and technology teachers will be familiar with this area, the target audience (general teachers incorporating and teaching technology for the first time) will welcome information in the area of safety. Section six briefly, and with effective diagrams, explains the use of a number of tools and construction techniques. Throughout the book the line drawings used as illustrations are both clear and serve well as aids in understanding the text.

In section eight, the authors review simple machines including levers, wheel and axles, and gears and cams. Section nine follows with a brief discussion of energy and control systems. Basic electricity and hydraulics are covered. At this point, in this easily read and understandable book, the teacher has enough background information to work with students in the design and making of some simple devices fulfilling the teaching of technology requirement.

A most welcome section is nine, which provides a number of approaches to assessment of student progress in the technology area. The range varies from checklists to detailed rubrics for evaluating both the product and the process. Included are methods for evaluating a student's participation and contributions to the group's effort and product. This section ends the first half of the book, which provides background information, theory and rationale for teaching technology and the approaches suggested.

The remainder of the book provides specific challenges for students in technology grouped by grade level and matched to areas of the Ontario curriculum. The authors provide activities with clear directions and diagrams that help explain the steps and techniques. Clearly, the authors took into account the needs of children, as the activities for younger grades are more teacher directed and those for older children allow for more creativity as children gain knowledge of tools, materials and construction techniques. However, the activities are not so rigid that teachers cannot improvise and modify according to their strengths and those of their students. Included are sample letters to send to parents to help collect materials needed. Throughout *Inventeering*, safety is emphasized, as is the fact that there may be more than one solution to a problem.

At the end of the book several Internet resources are provided as well as a three page list of books containing ideas on making things. An additional four page list of books useful in the classroom is included. *Inventeering* is a book that would be a good addition to any school's or any teacher's professional library collection.

Reviewer
Paul Laing is a vice-principal with the Greater Essex County District School Board, Windsor Ontario.

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