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ABSTRACT

This paper reports on a research study which investigated how the implementation of a "strategy redundancy" device, which consisted of the instructor's use of five teaching strategies and their mirroring in five of the features of the webware package, affected the participants' learning outcomes. Participants were eight inservice K-12 teachers and three undergraduate college students involved in a graduate-level course, which followed a traditional classroom-based format but was supported by a webware package developed by the instructor. Qualitative and quantitative data were collected from the following sources: (1) narratives; (2) tabular materials; (3) notes; and (4) testimonials. A causal relationship was found between the "strategy redundancy" device and the course's effectiveness in helping teachers learn to use Internet tools and author six Web projects for use in K-12 education. Three appendices contain a student feedback form; project evaluation criteria; and summaries of course final projects. A table contains the mean quality of the course final projects; and three figures illustrate "strategy redundancy" and learning outcomes, the multiple sources of data, and the Internet tools used in the course. (Contains 35 references.) (DLS)

"STRATEGY REDUNDANCY" AND ITS IMPACT ON THE EFFECTIVENESS OF TECHNOLOGY-ENHANCED INSTRUCTION: A CASE STUDY

ABSTRACT

In this study, eight teachers and three college students involved in a graduate-level Internet course developed skill in using Internet tools and authoring webware materials. The course followed a traditional classroom-based format but was supported by a webware package developed by the instructor (http://www.sover.net/~m1casa/503). A case study research methodology was utilized to investigate how the implementation of a "strategy redundancy" device, which consisted of the instructor's use of five teaching strategies and their mirroring in five of the features of the webware package, affected the participants' learning outcomes. Qualitative and quantitative data were collected from seven sources. A causal relationship was found between the "strategy redundancy" device and the effectiveness of the course in helping teachers learn the use of Internet tools and author six basic Web projects for use in K-12 education.

Dans cette étude, huit enseignants et trois étudiants universitaires inscrits dans un cours supérieur sur l'Internet apprirent à se servir des outils Internet et créer des matériaux web. Le cours suivit un format traditionnel d'enseignment présentiel mais fut supplementé par un paquet webware créé par l'instructeur (http://www.sover.net/~m1casa/503). Une méthodologie de recherche type étude de cas fut mise en place pour élucider comment l'utilisation d'une technique de "redoublement de stratégie", qui consista en l'usage par l'instructeur de cinq stratégies d'enseignment et leur miroitement dans cinq des traits du paquet webware, affecta les résultats d'apprentissage des participants. On collectionna des données quantitatives et qualitatives à partir de sept sources différentes. Une relation de causualité s'avéra entre la technique de "redoublement de stratégie" et l'effectivité du cours pour aider les participants à maîtriser les outils Internet et développer six projects WWW pour utilisation dans l'enseignment élémentaire et secondaire.

Keywords: Strategy Redundancy, Teaching Effectiveness, Webware Development, Participatory Design, Teacher Education,

"STRATEGY REDUNDANCY" AND ITS IMPACT ON THE EFFECTIVENESS OF TECHNOLOGY-ENHANCED INSTRUCTION: A CASE STUDY

INTRODUCTION

Research on the effectiveness of technology-enhanced instruction has concentrated on either the users' teaching/learning processes (Mitra, 1994; Simpson, 1994) or the design of the tools used in that kind of instruction (Chadwick, 1992; Livergood, 1993). Research hasn't, however, addressed the ways in which both teaching/learning processes and tools may work in combination. No inquiries have been conducted to learn, for instance, about the effects of using selected teaching strategies in a given course and embedding them in the design of the courseware created for that course. A main reason for this void is that until very recently, instructors have rarely been able to create and/or customize the technology tools they use in their courses --mainly because of their lack of technological knowledge, time, and funds.

In an effort to contribute to this unexplored avenue of research, this article reports results of a study which investigated the impact of using a "strategy redundancy" device on the effectiveness of a course designed and taught by the author: *RE 503 - Internet for Teachers* (thereof *RE 503*). More exactly, the study investigated the effects of such a device, which consisted of the coupling of selected teaching strategies to be used in the course with selected features of a supporting webware package, on the participants' attainment of the course objectives. The objectives included: 1) learning the use of major Internet tools for communication, information research, and site evaluation; and 2) authoring basic educational WWW projects for use in K-12 education.

COURSE DESCRIPTION

Participants and Tasks

Eight inservice K-12 teachers and three college students participated in *RE 503*, a three-credit, graduate-level course taught by the researcher at Institution X. Of the eight teachers, two worked in early childhood education, four in middle school, one in high school, and another at a middle school as a library media specialist. The three college students were 1st year undergraduates (a peculiarity of Institution X is that it encourages its students, even freshmen, to take specialized courses).

All the teachers in the course knew how to use basic computing tools, such as word-processing and spreadsheets programs. The three college students knew how to use e-mail programs, Internet browser, and graphic tools prior to the course.

The class met once a week for three hours, at the Institution X Language Laboratory, from February 28 to May 29, 1996. The students were assigned readings for each class. They were also given, over the fourteen weeks of the course, seven homework assignments and a final project.

Teaching Materials

The course main teaching material was a webware package developed by the instructor (Borrás, 1996). The package was used in conjunction with a textbook (Cotton, 1996) which served as a source of supplemental readings.

The design of the webware package adheres to some important WWW site design rules (Butler, 1995; Lynch, 1996; Levine, 1996; King, 1996). Those rules included: 1) use of relatively small graphics to speed page load; 2) efficient use of links so that documents within the package can be reached in no more than five clicks; 3) frequent updating of the content with significant additions to maintain students' interest in accessing the materials regularly; and 4) effective layout of the materials to ensure their usability both in on-line and in paper formats.

The package consists of some six hundred textual and graphical files organized around six "nodes." The "Home" node constitutes the main entrance

to the package. The "Info" node features information about the instructor and the course content, objectives, and evaluation tools procedures. The "Schedule" node gives access to the topics and assignments treated in the course. The "Readings" node features a list of required and suggested readings for the course, various links to electronic books and articles, and an entry point to all the sites linked to the package. The "Projects" node provides access to the six Web projects developed by the participants in the course. Finally, the "People" node contains information about the participants' professional background, teaching philosophy, and expectations about the instructional possibilities of the Internet.

THE "STRATEGY REDUNDANCY" DEVICE

In designing *RE 503*, the researcher drew on the conceptual framework provided by Fleming's (1981) five categories of characteristics of effective instructional presentations. Such categories include the "referential" (teaching of meaning variations in languages representation); the "informational" (delivery of content in a rationed and ordered manner); the "relational" (provision of opportunities to share/acquire learning information); the "demand" (encouragement of plural ways of thinking about and applying information); and the "image-of-the-other" (embodiment of learner's knowledge, abilities, and needs into the learning design).

Fleming's framework aims at attaining a "humanistic technology" (1981: 33) and includes principles derived from the behavioral as well as from the cognitive sciences (Fleming & Levie: 1993). Because of its broadness, Fleming's framework can encompass new insights both within and beyond instructional design (Neuman, 1993), and provide an efficient tool for gathering, analyzing and describing a large number of general findings in related areas.

Expanding Fleming's framework, the researcher selected a number of teaching strategies to be used in the *RE 503* course and, for each one of the

strategies, a mirroring feature to be embedded in the accompanying webware package. Such strategies and features, which are shown in Figure 1, exemplify of what this researcher has defined as the "strategy redundancy" device.

— Insert Figure 1 here (*RE 503*: "Strategy Redundancy" and Learning Outcomes) —

The device was then put to test to investigate its contribution to the effectiveness of the *RE 503* course.

METHODOLOGY

The study featured the characteristics of qualitative research, including inductive data analysis, emergent design, and protagonism of subjects in interpreting outcomes (Borg & Gall, 1989). More specifically, the study was guided by the tenets and procedures of the case study method, as described by Yin (1992, 1993, 1994) and Bromley (1986). The method was selected because it can empower the researcher to test relationships between processes and outcomes and to develop findings-based generalizations (Yin, 1992).

In keeping with the principle of triangulation and to address the potential problems of *construct validity* and *reliability*, the study followed Yin's (1994) three principles of data collection. That included the use of multiple sources of evidence; the development of a case study database (notes, documents, tabular materials, narratives); and the development of a chain of evidence through reports which make sufficient citation to the relevant portions of the case study database.

Data Sources

Figure 2 shows the various sources of data upon which relied the study and the acronyms by which the sources are designated when referred in these pages. Participants responses to these sources are, when quoted here, presented using fictitious initials.

—— Place Figure 2 here (*RE 503*: Study Multiple Sources of Data) ——

The "Narratives" source consisted of the summaries that the teachers wrote, for the seventh assignment of the course, about their experiences using the Internet tools they had practiced during the first six weeks of the course. The source also included the summary of the participants' evaluations of the course which, as mandated in Institution X, was written by the Student Educational Policy Committee (SEPC) representative. The third component of the source comprised the evaluations of the teachers' final projects by K-12 users. Data from this latter source were collected through the use of evaluation forms developed by the teachers.

The "Tabular Materials" source included the scores and comments on the effectiveness of the course provided by the teachers using the *Student Feedback Form* (see Appendix A). The source equally included the instructor's ratings of the teachers' final projects, according to the components of the *Project Evaluation Criteria* instrument ((see Appendix B).

The "Notes" source encompassed the instructor's in-class observations and the instructor's reflections upon her e-mail correspondence with the students.

The "Testimonials" source comprised the e-mail messages sent to the instructor by students in the course and by visitors, and borrowers, of the webware package. Data from this source were used to either provide context to the remaining data provided by the students or to weigh the external impact of the course.

Because the study was primarily intended for assessing the effectiveness of the course for teacher training, data from specific sources, such as the feedback on the course and reflections on Internet tools learning, were restricted to the ones provided by the eight teachers and not by the three college undergraduates.

The qualitative sources of data of the study were intended to generate interesting variables through the implication of participants in the interpretation of the results. The intent reflects the researcher shared view with Borg and Gall (1989), on how "Quantitative researchers with behavioristic orientations often overlook the fact that much can be learned from human subjects by asking for their perceptions." (p. 386).

The quantitative sources of data of the study, on the other hand, were equally incorporated because of their value as a supporting source of evidence. The incorporation represents the researcher's agreement with Yin's recommendation (1992) that "... case studies can and should still include quantitative data... where relevant." (p. 124).

Collection Techniques

Data from the above sources were gathered, using observation, document analysis, and quantitative data tabulation techniques. The researcher conducted over seventy-four hours of in- and out-of-class informal observations throughout the fourteen weeks of the course. The researcher also examined the various materials created by the participants in the course, including homework assignments, Web projects, and projects evaluation summaries. The researcher complemented her observations and materials analysis with the tabulation of the data yielded by the *Student Feedback Form* and the *Project Evaluation Criteria* tools.

A thorough examination of the collected data provided the evidence for the study findings. Such findings were graphically portrayed by the researcher, acknowledging with Bromley (1986) the advantages in representing case-studies in diagrams to secure a systematic view of "interrelated factors and conditions giving raise to a variety of possible observable effects." (p. 145).

To ensure the credibility of the findings and the validity of the study (Guba, 1981), a final draft of the article was submitted to two peer reviewers and two participants in the course. The peer reviewers examined the

methodology and the interpretation of the findings, whereas the course participants checked the accuracy of the data. Both reviewers and participants endorsed the study through their highly positive comments.

RESULTS

The analysis of data revealed the causal relationship between the "strategy redundancy" device implemented in the course and the participants' learning outcomes. Both the learning outcomes and the ways they were affected by the "strategy redundancy" device are discussed next.

1. Learning Outcomes

1.1. Learning of Internet Tools.

The course was effective in helping teachers achieve the first of its objectives: learn the use of the Internet tools for communication, information research, and site evaluation. Teachers gained skill in using the Internet tools addressed in the course (see Figure 3) through the readings and the six assignments they accomplished during the first six weeks of the course.

—— Place Figure 3 here (Internet Tools Addressed in *RE 503*) ---

The fact that all the teachers completed the course assignments proved that the objective was basically reached. Moreover, the teachers' reflections of their learning of the Internet tools (IT) in the seventh assignment indicated that they felt confident about their basic mastery of the tools, and that their expectations about their use in the future were high.

1.2. Authoring of Web Basic Projects.

RE 503 turned out to be equally effective in helping students accomplish the second objective of the course: to author basic Web projects for use in K-12

education. All in all, the students produced six Web projects (see Appendix C) which were measured for the quality of their content, design, and documentation, following the *Project Evaluation Criteria* tool. Data yielded by those measurements revealed the high quality of the projects (see Table 1).

--- Place Table 1 here (Course Final Projects: Mean Quality) ---

The projects were further evaluated by the authors themselves, following the "Projects: Field Testing Guidelines," provided by the instructor. Drawing on those directions, the teachers in the course had three to five target users working with their projects, asked the users to fill in the evaluation forms they had developed, and reported the findings about achievement, navigation, and attitudes yielded by the forms and/or their direct observations.

The above sources provide a strong evidence of the overall effectiveness of the course. Agreement about such effectiveness was also expressed by the students in both the *Students Feedback Form*, and the SEPC *Course Evaluation Summary*.

Answers to question 4 of the form indicated that all the teachers agreed upon recommending the course to other teachers based on the fulfillment of the course objectives. The percentages of agreement about the ability of the course to fulfill each of the specified objectives were as follows: 1) learning of Internet basics (100%); 2) development of site evaluation skills (100%); 3) learning of basic Web authoring with HTML (100%); 3) self-paced learning (85%); and 4) task-based learning (90%).

Let us examine next the ways in which the "strategy redundancy" device was responsible for those learning outcomes.

2." Strategy Redundancy" Effects

As shown in the above Figure 1, the "strategy redundancy" device implemented in the *RE 503* course included the five teaching strategies which were used

systematically throughout the course, and the five matching design features of the supporting webware package.

The study various sources of the data showed evidence of how each pair of strategy and webware feature affected the learning outcomes of the participants in the course.

2.1. Provide Effective Guidance/Simplicity of Structure and Ease of Navigation.

The first teaching strategy, "provide effective guidance," was aimed at reducing the "perceived complexity" of the course innovative subject matter. Agreeing with Rogers (1983) that "the complexity of an innovation, as perceived by members of a social system, is negatively related to its rate of adoption." (p. 239), guidance to minimize the apparent difficulty of the course was provided in three ways. The first way consisted on addressing the contents of the course within two well-defined phases, one dealing with Internet cognitive tools (weeks 1-7), and the other concerned with web authoring (weeks 8-14). The summary that the teachers wrote in assignment 7 served as the symbolic closure of the first of the two phases, giving them a sense of accomplishment and raising their expectations about what they were going to learn next:

> B: "I look forward to the next phase of our class." (IT)
> D: "I'm looking forward to the experience of creating a home page document..." (IT)
>
> K: "I am looking forward to HTML learning." (IT)

The second way of providing guidance was through the staging of the development of the Web final projects into four strategic steps. Steps 1 and 2 were completed during the first phase of the course: step 1 (writing project's outline and storyboard) was scheduled for weeks 3 and 4 of the course, while step 2 (writing the evaluation forms) was accomplished in week 6. Steps 3 and 4 (creating HTML files for projects, and field-testing projects) were accomplished during the second phase of the course. This procedure was aimed at helping students realize that designing sensible content and evaluation

procedures for their projects was as important as learning the technical skills required for putting those projects on the WWW.

A third modality of guidance consisted on the use of templates to reduce the HTML learning curve. Students could use the eight HTML templates developed by the instructor to create the suggested components of their projects (Home, Information, Links, Activities, Activities' Answers, and Evaluation Form). According to teachers' answers to question 2 of the *Students Feedback Form*, the instructor's templates ranked first among the preferred HTML-Related Sites categories. Corroborating this finding, data from question 3 of the same form indicated that 90% of the teachers found the templates "very effective" for their learning of HTML.

The "guidance" strategy translated into the "simplicity of structure" and the "ease of navigation" features of the webware package. As said previously, the webware contents were organized into six major nodes, and documents within the package were linked in a way that they could be reached in no more than five clicks. According to their answers to question 1 of the *Students Feedback Form*, 100% of the teachers agreed upon the "excellence" of the webware structure and navigation easiness. Further agreement upon those webware features was found in the open comments expressed by the teachers in the feedback form,

> " I think the home page was most effective in presenting the course and made it accessible at all times." (SFC)

and in the e-mail messages sent to the researcher by scholars from various institutions who visited the webware site:

> Ravitz, J. L.: "In fact, I think your page is the nicest example of on-line course materials that I have seen,... The design is just great." (EM, 4/7/96)

> Lake, D.: "I would like to also say that I continue to be in awe of your pedagogical design as well as your visual design." (EM, 6/27/96)

Dyer, W.: "I was reading through your 503 course and I have to say that this is one impressive work! I like all of it: the content and the layout." (EM, 8/6/96)

Crawford, C: "I appreciate your class' web page for 503 Internet for Teachers. Specifically, I am interested in your evaluation plan and instruments for the class." (EM, 8/22/96)

Welch, T.: " I love the course design, projects, etc...It is a very thorough work." (EM, 8/30/96)

2.2. Tailor Content to Students' Needs/Originality of Webware Materials.

The second teaching strategy implemented in the course, "tailoring of information to students' needs," implied the adjustment of the scope and depth of the course contents to the academic and professional profiles of the teachers in the course. Keeping in mind those profiles, three content areas, K-12 education, Internet tools, and Web authoring, were covered in depth to help teachers achieve the course objectives.

Evidence of the impact of this feature is provided by the data yielded by question 2 of the *Student Feedback Form*. The question sought to find out which were, according to the teachers, the most useful sources of information found in the three categories of sites linked to the course webware, "K-12 Education-Related Sites," "Internet-Related Sites," and "HTML-Related Sites." According to the teachers' answers, "AskERIC Home Page," "Classroom Connect" and "Armadillo's K-12 WWW Resources" rated first among the sites of the "K-12 Education-Related Sites" category. The top two sites for the "Internet-Related Sites" category included "Gopher Jewels" and the "OII Feedback Form for Educational Sites." Finally, the most popular sites and files within the "HTML-Related Sites" category were the instructor's HTML Templates, the "Realm of Graphics," and the student "HTML lessons."

These findings seem to indicate that the teachers valued the sources of information that had been tailored to them and that were useful for the tasks at hand. The selected K-12 sites could provide them with ideas for the topics of

their projects. The selected Internet-related sites gave them the source and the tool for their evaluation task. And the selected HTML sites gave them the templates and the tools they needed to shape their projects.

The "tailoring" teaching strategy went hand in hand with the tailoring of the materials found in the course webware. Agreeing with King (1996) that what makes a great web site is the originality of its content, the bulk of the web-based readings were written by the instructor. To visually emphasize their preeminence, the instructor's readings were laid out at the top of the web pages and were followed by links to sites with supplemental readings.

Teachers' appreciation of the webware materials was evidenced in various ways. First, through the answers to question 1 of the *Students Feedback Form* which revealed the teachers' unanimous agreement about the "excellence" of the webware content. Next, through the teachers' comparison of the textbook and webware qualities:

> " many didn't like the second part of the text. All felt that the course-home page was a superior text and could be downloaded as a hard copy of great value." (CES)

And finally, through the fact that all teachers printed and collected the webware files:

> Instructor: "Students seem lured by the materials... It is kind of unanimous reaction, to turn on the computer, and to watch and print the weekly addition of content (IO, 3/13/96)

2. 3. Promote Intensive Practice through Meaningful Tasks/Purposefulness of WWW Projects.

The third teaching strategy put to use in the course consisted in the promotion of intensive practice through the use of meaningful tasks. This strategy is grounded on the tenets of situated learning theory for which the essence of learning is the result of sharing purposeful, patterned tasks (Roschelle, 1992; Young, 1993). As revealed by the data, it was the meaningfulness of the Internet assignments and web final projects what mainly contributed to the

students' accomplishment of the course objectives. Students understood the purpose of the tasks,

> "[the class] recognized the value of the 7 assignments." (CES)

and they felt proud of their success in spite of the intensity of the demands,

> B: "It is difficult to think that all we have learned has taken place in 7 sessions!" (IT)

or, rather, because of that intensity,

> " It was an incredible amount of work; we didn't, as individuals think we could do it and are so satisfied that we did accomplished it all." (CES)

The "intensive practice" strategy translated into the purpose-building inclusion of the final Web projects developed by the teachers into the course webware. The possibility of developing projects that could be displayed on the web and used later in the classroom was the thread that channeled teachers working efforts. Similar to the proven effects of collaboratively writing for a remote audience (Cohen & Riel, 1989), the development of projects for on-line display contextualized the students' efforts and resulted in superior work and deeper learning. The projects constituted a source of joyful learning experience for some of the students,

> " This course was both challenging and rewarding. I learned more than I thought possible in a semester, accomplished more in our project than I thought possible, and enjoyed doing it." (SFC)

and, certainly, a source of pride for all of them:

> " We all hope that the... projects can find a place in the web where we can share them with colleagues and friends." (CES)

2. 4. Foster In-class Collaborations/Variety of On-line Collaborative Opportunities.

The fourth teaching strategy practiced in the course dealt with the fostering of working collaborations of two kinds, one among the teachers themselves, and the other among the teachers and the three college undergraduates. Encouragement of such collaborations was based on the proven efficacy of

collaborative learning techniques (Sharan, 1990), and on the assumption that technology projects that foster cooperation among groups having different skills, professions, and status may be an effective learning approach (Clement, 1992; Silva & Breuleux, 1994).

Teachers worked collaboratively for either exchanging the e-mail information required by the assignments or developing their final projects. Collaboration with the college undergraduates adopted three forms. One, provision of some technical help to the teachers; two, participation in one of the teachers' projects; and three, production of materials for the course webware --including three HTML files about HTML "basics," "images," and "structures," and the Common Gateway Interface (CGI) scripts for the webware feedback and activities forms.

As expressed in the final *Course Evaluation Summary*, teachers basically attributed their success to the teamwork,

> "Everyone seemed to feel that they entered the course as novices... we didn't, as individuals, think we could do it and are so satisfied that we did accomplish it all." (CES)

and emphasized the value of collaborating with the college undergraduates:

> " The teachers greatly appreciated working with the institution X students --their skills, help, and perspectives. It seemed a strong match -- their templates and projects to aid the teachers' projects." (CES)

The "collaborations" teaching strategy found its counterpart in the opportunities for collaborating in cyberspace that the webware provided to the teachers. Already in the first assignment of the course, the teachers expressed their views about the instructional possibilities of the Internet. Those views revealed the teachers' agreement upon the potential value of the Internet as an information resource as well as a means to bring teachers and students closer, to develop critical thinking, and to favor cultural exchanges.

As the course progressed, and particularly at its conclusion, teachers figured out more concrete ways to materialize those values:

B: " I am very interested in creating a Home Page for the Early Childhood Center this fall. I have ideas galore spinning around in my head for it. You have made the seemingly impossible, entirely feasible!" (EM, 6/7/96)

By featuring the appropriate links and tools to facilitate the access to and the dissemination of resources, the webware materials helped teachers envision greater opportunities for professional support and growth.

2.5. Implicate Learner in Design of Learning Environment/Teacher-Learner Co-authored Webware.

The final teaching strategy implemented in the course dealt with the development of a teacher-learner co-designed learning environment. The adoption of such strategy drew on the tenets of constructivist (Bodner, 1986; Perkins, 1991; Jonassen, 1991) and participatory design (Silva and Breuleux, 1994) learning theories.

Drawing on the principles of constructivist theory seemed all the more appropriate since the subjects were adult learners. Because of their pedagogical expertise, and thus extended prior knowledge, teachers in the course were expected to fulfill the prerequisites for advanced knowledge acquisition: problem solving, interest, autonomy, and cooperation (Jonassen, 1991).

Adhering to the participatory design approach also seemed pertinent. As part of the qualitative research tradition (Kirk & Miller, 1986), the approach created the appropriate conditions for the case study investigation. Or as Silva and Breuleux (1994) would put it, the approach "has the potential to create a setting where opportunities for the researcher to share in and understand the concerns and perspectives of the participants become possible." (p. 102).

Students participated in the design of the learning environment mainly in four ways. First, through the on-line information resources they brought to the class related to the assignments. Second, through the e-mail comments they

sent to the instructor which, like the one below, lead her to rethink some initial decisions regarding the scope and/or design of the webware materials:

> H: "I would like to have a reference booklet I could use about what we are learning in class... I am finding it difficult not to have guidelines to follow in writing. Please advice!" (EM, 3/10/96)

Third, through the extension of the learning environment outside the classroom with initiatives such as the one of the teacher in the course who had an independent student at her high school taking the course on-line and participating in the development of her final project. Such an initiative was very successful; as indicated by the independent student's signed comments:

> " Although I am not one of your students, there was a lot to be learned through your site and other links. The basic set-up of your page(s) is great and easy to use. I learned a lot!" (SFC)

And fourth, through the working choices made by some of the students in the course. Choices like the one made by the college undergraduate who decided to develop the set of CGIs included in the webware so that he could, in the process, learn the programming language he was interested in.

All these forms of participation being supported by the instructor, they resulted in the students' willingness to work hard,

> " I.B.'s high expectations and enthusiasm and support inspired us to work beyond our abilities." (CES)

and to learn more about a field they had uncovered,

> " Many felt this course kindled an interest in pursuing more courses in technology." (CES)

The co-authoring of the webware materials mirrored the co-design of the learning environment. Teachers' participation in the authoring of the webware materials consisted in the development and evaluation of pedagogical projects suitable for use in K-12 education. The projects which, as said above, were evaluated by the instructor against the criteria of the *Projects Evaluation Form*, were additionally field-tested by the teachers with potential target users.

To do the field-testing, the teachers drew on the instructor's "Webware Projects: Field-Testing Guidelines." Following those guidelines, the teachers had three to five target users working with their projects, asked the users to fill in the evaluation forms they had developed, and reported the findings, about achievement, navigation and attitudes, yielded by the forms and/or direct observations.

Teachers conducted their field-testing in a very professional manner. The authors of project 1, followed a naturalistic observation procedure since their target users were pre-literate:

> D & B: "At the outset we planned to assess our project through the following criteria: children's ability to identify and claim their artwork; children's reactions to and discussions of the activities; and children's responses to questions posed by the teachers." (UEP)

The authors of project 4 pointed out the praising comments made by their evaluators,

> F & J: "From the three evaluation forms collected from the students, it can be concluded that the most appreciated was the graphical and organizational aspect of the project as well as the design of activities... all students would recommend this lesson to be used." (UEP)

but they equally reported their critiques, and the changes they made to their project following those critiques:

> F & J: "The main criticism by the students was towards the length of the initial instructions. Even though for the majority of the students they were easy to understand, it was not a stimulating start for the lesson." (UEP)

The authors of project 6 tested it with a variety of users, including two 4th grade students, five 8th grade students, two 5th grade teachers, a 3rd grade teacher, a resource aide, and a parent. Through the input of these users, the authors gain insight about where to fit project in their school curriculum,

> 3rd grade teacher: "...This connects to the third grade Social Studies which is studying our community." (UEP)

or the abilities potentiated by such project,

> 4th grader: "It was fun to learn about our hometown. It improves our research abilities." (UEP)

Implementation/inclusion of the above strategies and webware features contributed to the creation of an environment which provided the researcher with an opportunity to show in action the role that new technologies may have in shaping and promoting effective collaborative learning.

SUMMARY AND CONCLUSIONS

This study revealed the effectiveness of a "strategy redundancy' device used in a graduate-level Internet course in helping participants learn the use of major Internet tools and author basic educational WWW projects.

Because of its qualitative nature, the study allowed the researcher to inductively approach a variety of data sources for investigating the causal relationship between the components of the "strategy redundancy" device, teaching strategies and webware features, and the course outcomes.

The teaching strategies included: 1) provision of effective guidance, 2) tailoring of contents to students' needs; 3) promotion of intensive practice through meaningful tasks; 4) fostering of in-class collaborations; and 5) teacher-learner co-design of the learning environment. The webware features, on the other hand, included: 1) simplicity of structure and ease of navigation; 2) originality of webware materials; 3) purposefulness of Web projects; 4) variety of on-line collaborative opportunities; and 5) teacher-learner co-authored webware materials.

Results of the investigation indicated that the teaching strategies coupled with the features of the on-line materials were responsible for the effectiveness of the course.

The innovative nature of the study and, particularly, its population place some limitations on the conclusions that can be drawn from this study. The

small class size, the differences in professional background and computer literacy between the educators and the college students created an atypical course. However, this same atypicality also made possible to investigate the effectiveness of the course teaching strategies and on-line materials in a way that would not have been possible at this time in many standard full-sized courses. With this in mind, it is reasonable to conclude that:

> The effectiveness of teacher-delivered instruction supplemented by on-line materials highly depends upon the implementation of a given set of teaching strategies and the use of materials whose features mirror those strategies.

This conclusion may provide an answer to Hannafin's question about the possibility for the ISD [Instructional Systems Design] field to assume a significant role in conceptualizing more inclusive learning environments in the future (1992). The ISD field will be instrumental in the validation of case-based learning environments which, as the one portrayed here, feature instructional materials whose specific characteristics are tailored after specific teaching strategies, and those, in turn, after specific learning needs.

Providing on-line materials to support classroom-based education in the way described here has potentially significant educational benefits. However, these benefits require substantial investment of time and effort on the part of the instructor. Starting from nothing, it took the instructor an average of five hours to prepare each one-hour lecture. This included creating the lecture materials, creating/selecting the graphic materials, searching and gathering the supplemental readings, sketching assignments, putting lecture materials and assignments into HTML or PostScript files and uploading the files to the server.

Such an investment in human resources might be considered as counterproductive, at a moment when gains in education seem to be measured by the "cost-savings" rather than by the "quality" of the teaching/learning experiences. And yet the investment can be the most valuable instrument for insuring the extensively effective use of instructional technology. Because, as

Fleming (1993) observes, "The more deeply structural changes to teaching and learning... will only be possible when institutions recognize that time and energy are needed to develop them..." (p. 323). If practitioners are expected to use technology tools creatively, they should be given the time and the means to learn, develop, and disseminate new approaches to the delivery of instruction.

RECOMMENDATIONS AND IMPLICATIONS

In light of the findings of this study, the following recommendations are in order. First, the study should be replicated with a different and bigger population. Second, studies in the field should consider the investigation of the combined impact of teaching strategies and features of alternative delivery tools such as multimedia. Third, more studies should be implemented to investigate the potential of participatory design as a means to effectively introduce the use of instructional technologies. And fourth, more research as the one proposed here would help to truly assess the educational impact of technology. Particularly, because, as Reeves observes: "It would seem that we stand a better chance of having a positive influence on educational practice if we engage in developmental research situated in schools with real problems." (1995: p. 3).

By interrelating teaching strategies and technology tools through the "strategy redundancy" device, this study shows a way to bridge the gap between the constructivist and instructivist camps (Alessi, 1996). If it is true that learning may be a constructive process, it is equally true that expository instruction may still be a decisive mean to foster such construction.

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APPENDIX A. Student Feedback Form

The information you provide in this form will help the instructor to evaluate the effectiveness of the course "RE 503 Internet for Teachers."

1. Rate these aspects of the on-line materials used in "RE 503":

   Quality of Content:

   Instrumentality in Course Objectives Achievement:

   Appropriateness of Links:

   Organizational Layout:

   Ease of Navigation:

2. Type the names of the nine WWW sites (three per category) linked to the on-line materials of "RE 503" which were the most useful for your learning.

   K-12 Education-Related Sites

   Internet-Related Sites

   HTML-Related Sites

3. How effective were the instructor's templates for your learning of HTML?

4. Would you recommend the course "RE 503" to other K-12 teachers? Yes or No? If yes, maybe your recommendation is based on one of the following reasons:

   It promotes the learning of Internet basics.

   It promotes the development of site evaluation skills.

   It facilitates the learning of basic Web authoring with HTML.

   It offers self-paced learning.

   It encourages task-based learning.

5. Additional comments are welcome:

APPENDIX B. Project Evaluation Criteria

Criteria	**Points**
Instructional Quality	*Maximum: 40*
Content matches objectives	
Information is organized/linked pertinently	
Active/collaborative student participation is facilitated	
Narrative is clear, coherent and motivational	
Design & Technical Quality	*Maximum: 50*
HTML templates are used effectively	
Links are operative	
Orienting information about content and navigation is provided	
Graphics/colors/fonts are used appropriately	
Text is free of spelling and grammatical errors	
User Documentation	*Maximum: 10*
Relationship to curricular area is stated	
Rationale is explained	
Objectives are specified	
Implementation procedures are described	
Assessment tools are provided	
	Total:

APPENDIX C. Course Final Projects: Summaries

Internet for Young Children (http://www.sover.net/~milcasa/503/pro1home.html)

Subjects: Computer Technology, Art and Language
Grade Level: ages 3-5
Number of participants: 7

Designed for the 3-5-year olds, this program addresses the following issues: 1) children's ability to recognize their work and photos on the computer screen; 2) children's active participation in the creation of e-mail messages; and 3) children's understanding of the Internet communication processes.

(AMHS) English Department Home Page (http://www.sover.net/~milcasa/503/pro2home.html)

Subject: English Department Curriculum
Grade Levels: 7-12
Number of participants: approximately 280 AMHS students

This project was conceived as an on-line alternative to the paper text Program of Studies of English at Arlington Memorial High School (AMHS). The project provides information about the activities, projects and staff of the English Department, links to related web resources, and feedback tools.

Spanish Proficiency Exercises (http://www.sover.net/~milcasa/503/pro3home.html)

Subject: Spanish Language Learning
Grade Levels: Grades: 6-12
Number of participants: 30

This project consist of ten activities which give 8th graders an opportunity to reinforce their vocabulary and to become familiar with situations which might be found on a Spanish proficiency test (The New York State Regents Exam).

Avez-vous compris? (http://www.sover.net/~milcasa/503/pro4one.html)

Subject: Reading and Writing in French.
Grade Levels: Beginning and Intermediate French.
Number of participants: 5

This project allows Intermediate students of French to practice their reading comprehension skills. The project requires users to read a series of WWW documents organized into four categories: "La culture," "Les régions et les villes," "L' histoire," and "La politique." Drawing on the documents, users have to answer a number of questions which can be submitted electronically.

Biographical Searches (http://www.sover.net/~milcasa/503/pro5one.html)

Subjects: English, Mathematics, Science, and Social Studies
Grade Level: 7th
Number of participants: approximately 90

The project aims at providing 7th graders with the basics of Internet access and retrieval of information through two activities.. The first activity deals with the obtention of information about famous people using search engines, The second activity draws on web-based movie reviews and games.

Greetings from Vermont (http://www.sover.net/~milcasa/503/pro6home.html)

Subjects: Computer Literacy, Language Arts, Science, and Social Studies
Grade Level: 4-8
Number of participants: approximately 200

This project aims at developing 4th to 8th graders' ability to select and share Internet information about their community. Drawing upon selected Web resources, students collect information on the local weather and answer questions about Vermont monthly events, historical sites, and famous people.

TABLE 1. Course Final Projects: Mean Quality

Number of Projects = 6	Possible Scores	M	SD
Instructional Quality	*(0-40)*	36.33	6.02
Design & Technical Quality	*(0-50)*	46.67	1.80
User Documentation	*(0-10)*	8.83	1.21
Overall Quality	*(0-100)*	91.83	8.30

FIGURE 1. *RE 503:* "Strategy Redundancy" and Learning Outcomes

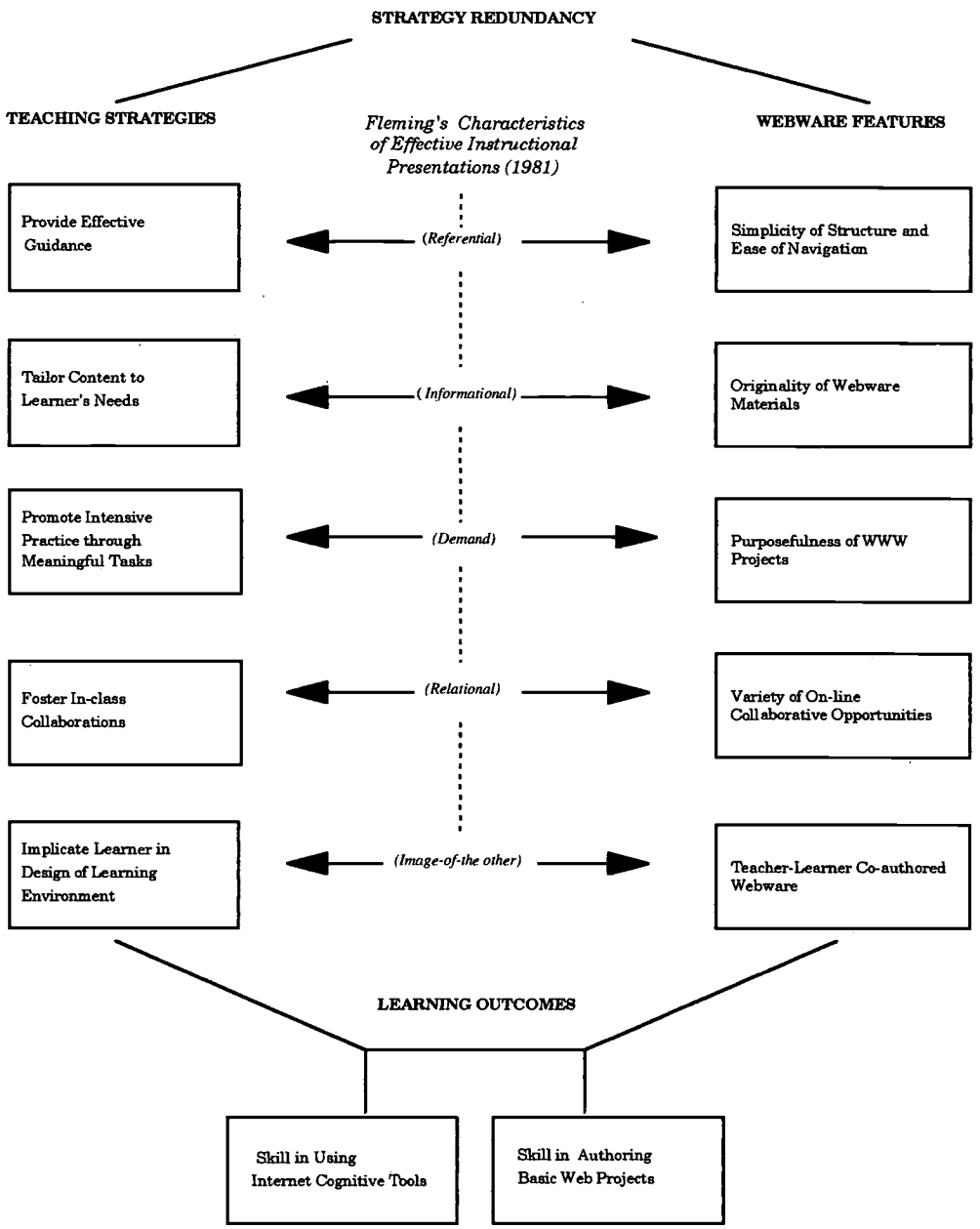

FIGURE 2. *RE 503*: Study Multiple Sources of Data

Narratives	• teachers' reflections on their learning of the Internet tools (IT)
	• final SEPC Course Evaluation Summary (CES)
	• students' reports of users' evaluations of the course projects (UEP)
Tabular Materials	• students' feedback on the course (SFC)
	• instructor's evaluation of the course projects
Notes	• instructor's in- and out-of-class observations (IO)
Testimonials	• e-mail messages from course participants and non-participants (EM)

FIGURE 3. Internet Tools Addressed in *RE 503*

Communication Tools	• Electronic mail	*Eudora* (client program))
		Listserv (mailing lists)
	• Videoconferencing	*CUSeeMe* (client program)
Information-Searching Tools	• Gopher	*TurboGopher* (client program)
		Veronica (search engine)
	• FTP	*Fetch* (client program)
		Archie (anonymous FTP database)
Communication & Information- Searching Tools	• WWW browsers	*Netscape* (client program)
		Lycos. Yahoo, etc. (search engines)
		Usenet/Newsgroups (computer-based-discussions and messages)
	• Telnet	*NCSA Telnet* (client program)
		IRC (multi-user chat system)

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