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International Usability, Design Guidelines and Effectiveness of a World Wide Web-Based Instructional Program for High School Students in a Cross-Culture Learning Environment

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**International Usability, Design Guidelines and Effectiveness of a World
Wide Web-Based Instructional Program for High school Students in a
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by

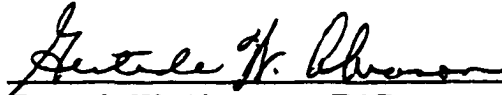
Hajime Hayakawa

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor
of Philosophy

**School of Computer and Information Sciences
Nova Southeastern University**


1999

We hereby certify that this dissertation, submitted by Hajime Hayakawa, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.



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**An Abstract of a Dissertation Submitted to Nova Southeastern University in
Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy**

**International Usability, Design Guidelines and Effectiveness of a
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Hajime Hayakawa

November 1999

The recent growth of the Internet and the World Wide Web (WWW) has resulted in a vast array of on-line courseware and educational Web sites. Unfortunately, as a large percentage of this information is written in English, non-English speakers are unable to access it. Information written in other languages is likewise unavailable to many native English speakers. Therefore, in order to maximize the usefulness of educational material on the Web, it is necessary to design and implement cross-cultural, bilingual or multilingual Web sites and instructional programs.

This study was designed to contribute to the area of bilingual learning on the Web. The researcher developed and evaluated three types of mathematics courseware: an English-only version, a Japanese-only version, and a bilingual version. While both the bilingual and English-only courseware enabled Japanese students with a basic knowledge of English to learn both quadratic equations and mathematical terms in English, the research found that the bilingual version was the most effective courseware for learning both mathematics and English simultaneously. Formative and summative evaluations were conducted in order to improve the program and determine the effectiveness of the bilingual courseware. As the courseware was implemented and evaluated, design guidelines were generated and the issue of courseware usability was explored.

Acknowledgments

People compare life to a journey. There are various kinds of journeys. Some are pleasant meanderings while others have a clear destination. Whichever path one takes, there are always valuable and interesting encounters.

This research was a long, difficult, yet profitable journey; one with a distant destination which sometimes seemed out of sight. Along the way, I met various people who encouraged and supported me.

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Chapter I

Introduction

Problem Statement and Goal

Internet resources have become very useful tools for learning environments in recent years. However, their usefulness is limited by the fact that most information is written in English, as are the majority of instructional programs on the World Wide Web (WWW). In order to derive benefits from these kinds of instructional programs the users must be fluent in English. This is one of the biggest barriers for non-English culture students who wish to use the Internet for their studies. It is also true that non-English Web sites are not easily available to English speaking students. While it might be argued that English is becoming an international language, and therefore should be studied by everyone around the world, we have not yet reached the point where English is universal.

In the United States, there are many students whose native language is not English and who need support in various areas. The National Council of Teachers of Mathematics (NCTM) recognizes this problem. In its position statement (Friedman, 1998) NCTM declares that:

- **Second-language learners should be given appropriate first and second language support while learning mathematics.**

- Teachers, counselors, and other professionals who have expertise should carefully assess the language and mathematics proficiencies of each student in order to make appropriate curricular decisions and recommendations.
- The importance of mathematics and the nature of the mathematics program should be communicated, with appropriate language support, to both students and parents.
- Mathematics teaching, curriculum, and assessment strategies should build on the prior knowledge and experiences of students and on their cultural heritage.

In addition to the need for cross-cultural instructional programs in areas such as mathematics, there are also many situations that require distance education. For example, some subjects such as Advanced Placement (AP) courses are not available because of lack of teachers or an insufficient number of students. Second language is another area in which distance education may be required. Therefore, it is desirable to implement cross-cultural on-line instructional programs; programs which will require some means of translating information from one language and culture to another.

This study focused specifically on the translation of English to Japanese, and Japanese to English, in the area of mathematics distance education via the Internet. There are a number of Japanese/English Machine Translators (MTs) available for use on personal computers, some of which are capable of translating English Web pages into Japanese Web pages immediately (Fujimoto, 1998). Their prices range from \$80 to \$300 (Mikami, Sekine & Ohara, 1997). Although MTs have recently become easily available, the quality

of translation provided is still far below that of a human translator (Nagao & Makino, 1995). MTs might be adequate for merely sending and receiving information. Their current abilities are not, however, adequate for instructional programs that require accurate information and culture-oriented content.

Learning and cognition are fundamentally situated in the learner's environment (Brown, Collins & Dugid, 1989); therefore, merely translating an English instructional program by means of a MT is not optimal for Japanese students. There are many cultural differences between countries in curriculum, icons, color and so on, which must be considered. Nevertheless, most software companies believe that a single design with translated language is usable in any country and very few firms redesign their icons when they export their products (Fernandes, 1995).

Mikami, Sekine and Ohara (1997) researched some tens of companies and organizations which utilize multilingual Web pages and found three basic types of multilingual Web systems (p218):

- Separate pages for different languages on one server (small and mid-sized companies use this type).
- A special Web page on an individual server designed for a special country and language, and managed locally (large companies).
- A single page written in several languages (small companies).

There are many pros and cons for each of these three types of Web pages. It is necessary, therefore, to determine which are most suitable for instructional systems.

In this study the following questions were addressed:

- How are different languages arranged on the screen?
- What kinds of browsers are necessary to display instructional mathematics programs?
- What kinds of fonts and mathematical symbols should be used on the browser?
- What kinds of colors or icons are appropriate for different cultures?
- What kinds of desktop environments and authoring systems are suitable for developing bilingual instructional programs? (Dodd, 1998)
- How can bilingual mathematics instructional programs help students to learn both mathematics and English?

Although there have been some studies conducted on guidelines for designing usable Web pages (Borges, 1996; Nielsen, 1995; Falk, 1997), it is rare to find studies of international instructional programs on the Web, especially for K-12 students. In this study, the author employed developmental problem solving strategies combined with experimental design.

Research Hypothesis

Three types of cross-cultural instructional pages were developed: separate pages for different languages (English-only and Japanese-only pages) and pages written in two languages (bilingual pages). The pages were compared as to their effectiveness in improving skills in English and mathematics. The research hypothesis was that the use of a single page written in both English and Japanese will result in a greater improvement in

Japanese students' understanding of English mathematical terms and their performance in mathematics than the use of separate pages for different languages. The author produced some guidelines for the design through international usability testing.

The students who participated in the study attend Keio Junior High School (Futsubu) in Yokohama, Japan. Some of the evaluators have attended the Keio Academy of New York. Keio University operates a number of schools, including the one in New York, where the problems of bilingual education have become increasingly apparent.

This study grew out of the researcher's observations of the problems with bilingual education encountered by the teachers at the Keio Academy of New York. An experimental on-line courseware authoring system known as CALAT (Computer Aided Learning and Authoring Environment for Tele-education), which was implemented between the Keio schools, provided the essential background for the development of the project.

Background of the Implementation of Bilingual Courseware

Keio Academy of New York is a high school (grades 9 to 12), located in Purchase, New York. The majority of the students are Japanese and nearly all will enter Keio University in Japan after graduation. Students from Keio's many brother and sister schools in Japan will also be attending Keio University (Keio, 1998). One of the biggest challenges facing the teachers at the school derives from this situation: not only must the Academy meet Keio University standards like the other schools in Japan, but it must also foster bilingual and bicultural identities in the students.

In order to maintain the culture unique to Keio University, Japanese teachers are brought in from the brother and sister schools in Japan, including the Futsubu. They stay and teach for three to six years in New York. After finishing their assignments, they go back to Japan and subsequently have little contact with their former students and colleagues. This situation is very wasteful of human resources.

One solution which has been put forward is to utilize the Internet, which is becoming increasingly interactive. Many Web sites and other programs now come equipped with animation, audio, and video. Teachers can offer Internet instruction in real time and groups can conference and collaborate over long distances (Glener, 1996). It was therefore proposed that a pilot tele-education program be established between the Keio Academy of New York and the Keio schools in Japan.

The project the Keio system developed was a joint venture with Nippon Telephone and Telegraph (NTT) which provided remotely separated schools with identical learning environments. NTT invited Keio to join in the summer of 1996. Originally, this project was to end in February in 1997, but it was decided to extend the time period further. The project was finally concluded in April of 1999.

Keio Academy implemented a Web-based distance learning system known as CALAT, which was developed by NTT Information and Communication Systems Laboratories (Nakabayashi, 1995). The project was a cooperative tele-education venture that included all of the Keio schools. Keio utilized computer-assisted instruction system (CAI) programs which are available on the Internet. A Web server was set up in each school.

As Keio teachers communicated via the Internet, they created a number of interesting programs on CALAT, including instructional CAIs provided by the Japanese schools on haiku (Japanese short poems), Heike Monogatari (the Heike story), and Yukichi Fukuzawa (the founder of Keio University). Keio Academy, in turn, provided a CAI on the American presidential election. The material for the CAIs was collected by the teachers at the respective schools. The programming, however, was done by NTT.

The students were trained in Internet browser techniques in their computer classes. Keio employs a student-directed method wherein the students are provided with user-friendly software that allows them to explore by themselves. Therefore, usability testing of CALAT was necessary. The technique worked well. Once CAI programs were implemented, the students had already had experience in the use of the browsers. It was also necessary to train the teachers in the use of the equipment and give them ideas for its possible applications in their classrooms.

The author developed linear equation courseware in English for the CALAT project. Hopefully, with the help of NTT, the prototype will be completed and evaluated by the end of 1999. Meanwhile the researcher independently created the bilingual, quadratic equation courseware which was used for this study.

Until now the Keio Academy of New York has been producing English courseware and the Keio schools in Japan have been producing Japanese courseware. This study has resulted in the creation of bilingual courseware which will benefit students in both Japan and the United States. It also produced some guidelines for designing bilingual courseware.

The programs in this study were used and evaluated at Keio Futsubu, a junior high school located in Kanagawa Prefecture in Japan. The school has 714 students from seventh to ninth grade. Nearly all the students enter the Keio senior high schools. Some students go on to the Keio Academy of New York. There are no academic exchange programs between Keio Futsubu and the Academy, but it is hoped that this study will encourage increased communication between the two schools.

Relevance and Significance

Portability of educational software

There have been a number of studies dealing with the portability of international offline software. For example, Gomes (1996) conducted usability testing of educational software prototypes by using different ethnic users as testers. Based on his study he suggested methodological considerations for further work, including the fact that it is important to collect data from different ethnic user groups when developing software for international users. Romiszowski (1996) investigated the portability of instructional computer software which was developed in Israel and was translated and adapted to local Brazilian needs by the end-user institution. Like Ito and Nakakoji (1996) he mentions that cultural factors have important effects on learners.

Although research projects such as those by Gomes (1996) and Romiszowski (1996) investigate the international portability of off-line CAI software, there are few that discuss the international usability of on-line courseware. This study has added to our knowledge of this aspect of CAI.

Distance education

The term, “netcourse” refers to education that consists of dispersed human and material resources shared via a computer network. A netcourse faculty may include experts from anywhere in the world, who are thereby able to share their time and knowledge with interested learners (Berman & Tinker, 1997). With distance education, it is possible to teach subjects normally unavailable within the parameters of conventional education; subjects such as oceanography, fifth-year French, Spanish, Latin, and college level classes in introductory Japanese, psychology, and criminal justice (Beasley, 1997).

One of the best characteristics of distance education is its ability to adapt to the needs of the individual student. The student who cannot enter a traditional classroom because of illness or any other reason, is able to study and communicate with teachers and fellow students by means of a computer network (Mikovsky, 1997). An example of this is the Virtual High School (VHS) which provides an optimal learning environment for the individual through the Internet (Hammonds, 1998).

At this point in time, the expectations for distance education are great and the supporting Internet technology has been improving (Clark & Else, 1998). The environment which supports various forms of distance education has been improving as well (Ludlow & Duff, 1998). This has resulted in an increase in netcourses. According to a recent annual federal study, 22% of all public schools in the United States are using advanced telecommunications for distance education (Clark & Else, 1998).

With the development of new technology and the educational environment to support it, distance education may soon become as common as speaking on the telephone

(Beasley, 1997). However, there are some physical and psychological barriers separating students and teachers that must be dealt with if distance education is to succeed. There is also the problem of how to coordinate schools linked by distance education programs (Beasley, 1997).

According to a survey conducted by Tiene (1997), it is difficult to keep students fully involved in their classes when they are in an unfamiliar location. There may also be psychological problems. All of the teachers in Tiene's survey agreed that teaching on an interactive television system is somewhat different than regular classroom teaching (Tiene, 1997). However, other studies have garnered different results. For example, in their study on Desk Top Conference (DTC), Baggot and Wright (1997) found that the performance of the students taught at a distance via the DTC link is not significantly different from those taught in the classroom, face-to-face.

While distance education for K-12 students has become increasingly popular, most of the courseware has been limited to one country and to the university level (Aranda & Vigilante, 1995; Grimaldi, 1995; Jordahl, 1995; McCartney, 1996; Seagren & Watwood, 1996; Shoesmith, 1995; Stewart, 1994). It is difficult to find on-line international instructional programs on the high school level between two countries. As the number of distance-learning programs increases and the range of delivery technologies grows, studies that examine and evaluate the impact of such efforts should be conducted more frequently (Zhang, 1998).

Collaboration

Assuming that “computers should support the activities of people” and that “people’s activities are inherently cooperative,” it is clear that groupware is ideal for use by more than one person, often at the same time (Wexelblat, 1993). It will, therefore, become necessary to develop systems that utilize groupware. Two areas in which this is happening today are entertainment and the military. Cable companies are attempting to develop multi-user games and interactive shopping. The military has been trying to develop large scale networked training exercises. Other areas being explored are tele-medicine and networking of tele-robotic systems for space exploration (Durlach & Mavor, 1995). Tele-education is another area likely to become increasingly important.

NCTM is in the process of compiling new standards for the next millennium. The draft includes five principles, one of which, the Equity Principle, states that mathematical instructional programs should promote the learning of mathematics by *all* students including Limited English Proficient (LEP) students. Another of the standards holds that mathematics instructional programs should use communication to foster understanding of mathematics (Lappan, Ferrini-Mundy & Lindquist, 1998). In order to achieve this goal in its fullest sense, it will be necessary to develop international collaboration between all teachers and students of mathematics.

The Keio-NTT project helped to construct an environment of collaboration because the participants were able to communicate and exchange ideas by using Internet functions such as tele-conferencing and e-mail. In order for schools to collaborate internationally, the barrier of language must be overcome. If bilingual courseware should become available, it will be extremely helpful. For example, Keio is currently attempting to

translate science courseware originally created in English by an American teacher. This study has created bilingual mathematics courseware.

Developmental studies

While there have been numerous studies done on computer aided instruction and its effect on math performance (Jolicoeur & Berger, 1988; Randel, Morris, Wetzel and Whitehill, 1992; Szabo & Poohkay, 1996; French, 1997; Rinaldi, 1997), few developmental studies have been done. When Dempsey, Rasmussen and Lucassen (1994) reviewed articles on instructional gaming published over the preceding 12 years, and categorized them into 1) research, 2) theory, 3) reviews, 4) discussion, and 5) development, they found that the majority were discussion articles. Development articles were the least numerous.

Ritchie and Hoffman (1996) estimate that the use of the WWW is increasing at a rate of 6% to 20% per month. The majority of Web sites offer little more than semi-structured information and very few instructional Web sites exist. They suggest creating design criteria for instructional Web sites by using instructional design principles. As a developmental study on mathematics CAI that includes instructional gaming on the Web, this project will contribute valuable information to the field.

Math anxiety and motivation

Very often students become bored with drill and practice sessions. This can lead to poor performance, and failure to succeed is thought by many researchers to be one factor in the development of math anxiety (Relan, 1991). Stewart (1997) also states that interactive Web games can be great motivators within training programs if they are

developed and implemented properly. Since this courseware includes an instructional game, the author evaluated it from the point of view of motivation.

Bilingual environment

Japan is considerably behind the United States in the development of the Internet. One reason is that Japan has a disadvantage in language and culture because the Internet is English-oriented. Developers in Japan are handicapped by such popular Internet programming languages as C++ and Java because these languages don't translate well into Japanese (Leopold, 1996). The Japanese do input a great deal of information to the Internet in Japanese, but do not often contribute information in English. People in other countries must resort to Optical Character Recognition (OCR) and machine translators in order to retrieve information from Japan (Lammers, 1995).

There are few completely bilingual corporations in Japan and most foreign companies in Japan need to communicate in more than one language. In this situation there are naturally some difficulties in the personal computer environment (Boyd, 1998). Such companies attempt to resolve these problems by using different operation systems, applications, and so on. This study therefore, will contribute to cross-cultural communication as it applies to a shared U.S.- Japanese learning environment.

Bilingual education

When teaching English to Limited English Proficient (LEP) students, there are two factors which can increase success: the inclusion of the student's native language in the curriculum and content-based second language instruction – the integration of other academic subjects into the English curriculum. According to Rothstein (1998), successful

English education requires support from the native language. At the beginning of the 20th century, a large influx of immigrant children was taught in English-only public schools. According to a report in 1911, immigrant students who received English-only education demonstrated low achievement. An investigation in 1908 revealed that the retardation rate of immigrant students from non-English-speaking countries was about 60 % higher than that of immigrants from English-speaking-countries (Rothstein, 1998). In another area of study, Laufer and Hardar (1997) found that a "bilingualised" dictionary (an English monolingual dictionary with a translation of the entry), is the most effective of three kinds of dictionaries: monolingual, bilingual, and bilingualised, in the acquisition of new English words.

According to Asimov (1998), integrating English education for non-native speakers with other subjects results in better performance in all areas. Among the students who took an achievement test in Bay Area, San Jose, those who received bilingual education out-scored native English-speaking students in reading, math, language, and spelling (Asimov, 1998). Thus, it is possible to improve English ability through the study of other subjects. Also, English-speaking students in immersion programs, wherein much of the curriculum is taught in the second language, can acquire the other language without sacrificing either English language development or academic achievement (Genesee & Cloud, 1998).

These findings support the inclusion of some primary academic instruction in the student's native language in an English language curriculum as well as language-across-the-curriculum instruction. Basic education in the next millennium will hopefully include

the acquisition of a second and even a third foreign language, as multilingual people will benefit most from the “Information Age” (Genesee & Cloud, 1998). The problem before us is how best to create a multilingual global population for whom the second language is as strong as the first (Rothstein, 1998).

Mathematics education and bilingual education form a close connection. The standards of the NCTM emphasize communication and bilingual educators are recommending cooperative teaching on the part of language and mathematics departments. While it is true that mathematics is an international language in the area of computation, the teaching of mathematics to non-native speakers still requires support from the native language. This problem can best be addressed through a collaborative approach. This study has attempted to answer some of the questions about interaction between bilingual and mathematical education through the design and the evaluation of a bilingual instructional mathematics program.

Speed requirements

The last and one of the most significant points of the project between Keio and NTT was the development of high-speed multimedia courseware. Generally speaking, Web-based courseware is text-oriented because the average speed of a modem is only about 2,880 bps. Szabo and Poohkay (1996) studied the effects of using multimedia in CAI on math performance and attitude toward CAI. They concluded that there are significant effects on math performance and attitude when animation and graphics are used, both of which require high speed. It is probable that in the future, with the development

of faster communication systems, multimedia distance education will become widely available.

Nielsen (1995) outlines guidelines for response time:

- The file format and size should be indicated in parentheses if it takes more than 15 seconds to download the file.
- In order to create the sensation that the user is directly manipulating objects on the screen, 0.1 second response time is required.
- Ordinary response time can be as long as 1.0 seconds.

In order to incorporate these guidelines, the Web pages in this study were designed to be text-based.

Barriers and Issues

CALAT is a Course Management System (CMS) similar to TopClass (formerly WEST) which is used at the State University of New York at Plattsburgh (Graziadei, 1997). CMS is integrated with groupware such as Lotus Notes and communication tools such as e-mail and videoconferencing. Although the first version of CALAT was marketed in 1998, it did not yet have full CMS functions. The second version of CALAT was also developed. NTT is now developing a new course management system with different parameters. While the researcher's experience with CALAT helped in determining what kind of CMS is suitable for building bilingual courseware, it became obvious that the current CMSs, including CALAT, are not flexible enough.

The standards of NCTM emphasize collaboration in studying mathematics. The next issue to be considered is the implementation of collaboration. Groupware is very important in distance education because collaboration results in “(1) problem solving; (2) creativity; and/or (3) discovery” (Knupfer & McLellan, 1993, p.5). While distance learning (DL) technologies have been used for lecture-based courses (Grimaldi, 1995), there has been little research done on the collaborative aspects of distance education. Therefore, how to implement collaborative functions in courseware is a very important issue (Falk, 1997). It is especially difficult to collaborate between two countries because of time differences and language barriers.

Cheng, Lehman & Reynolds (1991) suggest several issues to be considered when planning computer conferencing courses, including: 1) the method of orienting learners to the system; 2) which courses and course contents are suitable for computer-based distance education; and 3) the use of supplementary materials. They recommend that persons involved in computer conferencing courses identify the following: 1) the best instructional strategies; 2) the formats which will best present the course material; 3) the most suitable instructional intervals; 4) the best orientation and motivation techniques; and 5) those learner characteristics which are related to computer-based distance learning. Although the suggestions from Cheng, et al. (1991) are mainly aimed at synchronous teaching-learning situations (computer conferencing courses), which are difficult to implement across different time zones, they helped the researcher improve the design of the instructional program in this study.

The design of the instructional program may also be improved through the use of heuristic evaluation. Levi and Conrad (1996) mention that the developers of the Bureau of Labor Statistics (BLS) homepages gained many insights into designing from heuristic evaluation.

How to conduct heuristic evaluation internationally is another issue. According to Nielsen (1996a), there are three levels of globalization concerns: 1) the computer must be capable of displaying the user's native language, character set, and notation; 2) the user interface and documentation must be translated into the user's native language in a way that is understandable and usable; and 3) the system must match the user's cultural characteristics. The first level is easily achieved and most major computer vendors are considering it. The second and third levels are more difficult to attain. Very few people have addressed these issues systematically.

Besides translation, there are many problems involved in this area, such as time zones, currencies, icons on computer screens, social conventions and so on (Connolly, 1996). Even as usability testing of software is considered, these issues must be taken into account. For example, when a questionnaire is administered, should it first be translated into the native language of the user? In general, the answer would be yes. However there are a great many difficulties arising from the decision to translate which must also be taken into consideration (Hoft, 1996).

When designers fail to deal with a cultural problem, the failure sometimes changes the native culture. Ito and Nakakoji point out that word- processor software, in which a

Western typewriter metaphor was used, changed Japanese writing and formatting styles in Japan (Ito & Nakakoji, 1996).

Another barrier to building internationally usable on-line courseware is the difficulty in maintaining transmission speed between countries. According to Kato (1997), multimedia online-courseware requires at least a 1.5Mbps link for only one user.

The last and biggest barrier and issue is the effect of bilingual education. According to Rothstein (1998), there is pressure from various directions both for and against bilingual education and it is difficult to judge its validity. Occasionally, bilingual education even becomes a political issue. Senator Bob Dole, for example, led an effort to stop the practice of multilingual education (Rothstein, 1998). Rothstein concludes that the best thing that could happen to this debate is the separation of the argument about bilingual education from the political domain. Because so many diverse groups are involved in the controversy, the effects of bilingual education have been difficult to ascertain and remain obscure in even the most recent studies. This study has both contributed to our understanding of this issue, and investigated one aspect of the validity of bilingual education, by evaluating a bilingual instructional program.

This study also addressed the question of how to design bilingual documents on Web pages. In general, languages in bilingual documents are switched by clicking the icon or letters which represent countries. Thus one sees either one language or the other. This may not be the most effective way to deal with bilingual documents in instructional situations. There are a number of other formats already in use in both software and in print, such as the collated, the facing pages, the side-by-side, the stacked and the tumble formats

(del Galdo, 1996). There is also the option of using a stacked format on a Web page to display the second language below the first only when the user requires translation (see Appendix Q for samples of display screen). This has been made possible by the development of Dynamic HTML. The latter method was utilized in this study.

Limitations and Delimitations of the Study

One of the most important limitations in this study was the fact that the client browsers were limited to Microsoft Internet Explorer (version 4.0 and over) and Netscape Communicator (version 4.01 and over), because both Keio and the researcher wished to take advantage of advanced features such as DHTML. This meant that optimal usage of mathematical symbols such as MathML was not possible, as they are not completely available on these browsers under ordinary circumstances.

Network speed was another limitation. When the CALAT program began, Keio was utilizing T1 and ATM connections which enabled the use of multimedia Web pages without delays. However, after the first series of tests were completed, NTT removed the server in New York and the T1 and ATM connections. This study utilized a slower Internet connection which meant that the Web-pages were predominantly text-based rather than multi-media.

A delimitation of this study was the fact that it was confined to an English-Japanese bilingual environment. Bilingual education focusing on this combination of languages is less common than Spanish-English bilingual education in the United States.

However, the results garnered from the study of bilingual English-Japanese courseware should add significantly to our understanding of bilingual education as a whole.

Definition of Terms

This study used the definitions as follows:

ANOVA (ANalysis Of VAriance)

ANOVA, which stands for Analysis of Variance, is a statistical method of testing the differences in mean values of a dependent variable between two or more categories of independent variables (SPSS Inc., 1998).

ASCII

American Standard Code for Information Interchange: A standard digital representation of letters, numbers, and control codes which can be interpreted by most computers (Tripathi, 1998).

Asynchronous Distance Education

Education in which interaction between instructor and student takes place at different times (Tripathi, 1998).

bps

Bits per second: a measurement of data transmission speed (Tripathi, 1998).

Browser

A client program (software) that searches different Internet resources (Enzer, 1999).

CAI

Computer Assisted Instruction: a method of teaching wherein students employ a computer to acquire educational skills (Tripathi, 1998).

CALAT

Computer Aided Learning and Authoring environment for Tele-education: an intelligent CAI system, developed by NTT Information and Communication Systems Laboratories, running on the WWW.

Client

In object-oriented programming, a member of a class or a program that uses a service from another unrelated class or program. It can also be a computer that accesses shared network resources provided by a server on the Internet (Microsoft, 1999b).

Collated format

The collated format is a collection of different language translations of the same document layered one on top of the other (del Galdo & Neilsen, 1996, p. 193).

CSS

CSS, or Cascading Style Sheets, provide Web page designers with several properties at once to all elements on their pages with a particular tag. For example, all H1 headers can be displayed in a particular size, font, and color (Castro, 1999, p.239).

Developmental Problem Solving Strategy

The process of developing new tools or techniques, such as software or a new curriculum, for use in an educational setting.

DHTML

Dynamic Hyper Text Markup Language: a collection of technologies implemented in Internet Explorer 4.0, including such features as dynamic styles, dynamic contents, CSS positioning, and data binding, controlled via a script language such as Javascript, or Visual Basic (Gulbransen & Rawlings, 1997).

Distance Education

Conveying knowledge over distance (Tripathi, 1998).

Distance Learning

Learning over distance (Tripathi, 1998).

Facing pages format

A method used in bilingual documents wherein languages are arranged such that one language appears on even-numbered pages and another language appears on odd-numbered pages (del Galdo & Neilsen, 1996, p. 195).

Formative Evaluation

An evaluation conducted during product development. Based on results of the evaluation, the prototype to be developed is revised, extended or abolished.

Globalization

Globalization, or internationalization, is the process of developing a Web site or program core whose features and code design are based on more than one language or locale (Microsoft, 1999a).

Heuristic evaluation

Heuristic evaluation is a usability engineering method for finding the usability problems in the user interface based on standard usability principles (Nielsen, 1994, p. 26).

HTML4.0

An improved version of HTML containing more text, multimedia, and hyperlink features and providing script and object support, enhanced support for forms, support for in-line frames and framesets, compound document enhancements, and enhanced table support.

HTML 4.0 is more easily accessed on the Web than its predecessors and features improved representation of international characters, text direction, and punctuation of Web-based documents (Microsoft, 1999a).

I18N

Internationalization – There are 18 characters between the start letter “I” and the ending letter “N” of internationalization. Therefore, I18N is used to represent the concept of internationalization.

International inspection

International inspection is a means of improving international usability, by utilizing recognized usability inspection methods to determine whether or not a specific software program is suitable for a specific country or culture.

International user testing

International user testing involves international inspection by real users in the target country who do real tasks with the system without outside assistance.

Intranet

A private network inside a company or organization (Enzer, 1999).

Java

Java is an object-oriented programming language, similar to C++, developed by Sun Microsystems. Java was designed to be downloaded from a Web site and can be run with a Java-compatible Web browser such as Microsoft Internet Explorer or Netscape Navigator. The most common feature of Java on the Internet is the Java applet. Java programs or source code files (.java) are compiled into a format known as bytecode files (.class) which can be executed by a Java interpreter. Many operating systems, such as Windows, Macintosh OS, and UNIX, have Java interpreters and run-time environments known as Java Virtual Machines (Microsoft, 1999a).

JDK

Java Development Kit: a software development package from Sun Microsystems that allows the user to write, test and solve problems with Java applications and applets (Enzer, 1999).

LAN

Local Area Network: a computer network limited to a small defined area, such as a single floor or a building (Enzer, 1999).

Listserv

"Listserv" is a common kind of maillist on the WWW which originated on BITNET. It is a registered trademark of L-Soft International, Inc (Enzer, 1999).

Localization

Localization is the process of adapting a Web site or program to serve the needs of a specific area. (Microsoft, 1999a).

Maillist (or Mailing List)

A (usually automated) system that allows people to send e-mail to one address, which then redistributes the message to others on the maillist (Enzer, 1999).

MANOVA

MANOVA (Multivariate Analysis of Variance) is a multivariate extension of ANOVA (Walker, 1998).

MathML

MathML (Mathematical Markup Language) was developed by W3C. It facilitates the use and re-use of mathematical and scientific content on the Web. MathML is one application of XML (Diaz & Ion, 1998).

Multimedia

A document that utilizes more than one form of communication, such as text, audio, and/or video (Tripathi, 1998).

Object-Oriented Programming

Programming in which the data, and the means of manipulating it, take precedence over procedure. It consists of objects and messages (methods) which are used for communication between the objects (Flanagan, 1997, p. 4).

Plug-in

A small software program that can be used in conjunction with a larger application to increase its usefulness (Microsoft, 1999b).

Server

A server is a computer on a local area network (LAN), or on the Internet or other network, that may control access to the network and respond to commands from its clients (Microsoft, 1999b).

Side-by-side format

A format often used for bilingual documents, and occasionally for trilingual documents, that consists of columns of text in different languages that run side-by-side down the page (del Galdo & Neilsen, 1996, p. 197).

Stacked format

A format in which translated language versions of text are stacked vertically (del Galdo & Neilsen, 1996, p. 198).

Summative Evaluation

An evaluation conducted after the development has been completed, to determine the effectiveness of the products in real situations.

Synchronous Distance Education

Distance education that takes place in real time but in different locations (Tripathi, 1998).

Tumble Format

The tumble format is a bilingual format with two variations. Only one format is displayed at a time (del Galdo & Neilsen, 1996, p. 193).

T-1

A leased-line connection capable of carrying data at 1,544,000 bits-per-second. At maximum theoretical capacity, a T-1 line could move a megabyte in less than 10 seconds, which makes it the fastest speed commonly used to connect networks to the Internet (Enzer, 1999).

Unicode

Unicode is a 16-bit character encoding standard developed by the Unicode Consortium, in which each character is represented by two bytes. It is useful because it allows most written languages of the world to be represented using a single character set (Microsoft, 1999b).

Variance

The variance is an index of variability that demonstrates the dispersion among the measures in a given population (Hoffman, 1998).

WWW (World Wide Web)

All of the resources in “cyberspace” that can be accessed using Gopher, FTP, HTTP, telnet, USENET, WAIS and other search engines; as well as the collective hypertext servers (HTTP servers), which allow users to mix text, graphics, and sound files together (Enzer, 1999).

XML

Extensible Markup Language, XML, is related to HTML and has two important features:

1) it allows the Web page creators to create their own tags according their needs; 2) it completely separates content from formatting through the use of CSS (Castro, 1999, p. 19).

Summary

There are many studies on the portability of stand-alone CAI software. However, it is rare to find substantive work on Web-based instruction between two countries.

Although there are some multilingual home pages, they are not meant to be educational and interactive. The Internet has become more important as an educational resource and has technically improved to the point where it is possible to build multimedia distance education between different countries. We need guidelines to build such a system, in order to overcome the various difficulties involved.

This study developed some guidelines for designing cross-culture Web-based instruction while building a prototype of a bilingual instructional program intended to help Japanese students learn both English and mathematics. It also investigated the effectiveness of bilingual programs for learning both mathematics and English.

Chapter II

Review of the Literature

Introduction

The recent development of the World Wide Web has motivated research on international Web page design. There have also been a number of studies done on the ways in which the Internet can be utilized in learning situations. This study sought to address both of these issues.

Another motivation for this study was the recent development by NTT of a Web-based, intelligent tutorial system (ITS) known as CALAT. The researcher assisted with this project by developing linear equation courseware (originally a stand-alone application) and by testing and evaluating the usability of the courseware created for the CALAT system. In order to accomplish this, it was necessary to review the existing literature. The following are areas in which a comprehensive literature review was considered essential for building usable bilingual courseware:

- **Design of World Wide Web pages**

There have been many studies done on the design of Web pages. The majority of these deal with commercial Web sites, which are not meant

to be used for educational purposes. Therefore, it was necessary to extract those parts which relate to learning situations.

- Design of Web-based courseware

This body of literature concentrates on the teaching and learning aspects of Web pages.

- Design of instructional games

One of the goals of this study was the implementation of an instructional game on the Web which motivates the learner. It was necessary, therefore, to investigate how to build a usable game in a learning environment.

- Authoring tools

It is important to choose developmental tools for Web-based courseware. Bilingual courseware in particular requires appropriate tools.

- Internationalization

The question of internationalization was central to this study.

Design of World Wide Web Pages

There are five important factors to be considered when building Web pages: simplicity, well-adapted interfaces, easy navigation, contents, and evaluation.

Simplicity

Web pages should be simple. They should be succinct and concise (Middleberg, 1996), with simple URLs (Nielsen, 1996). The designer should avoid using unnecessary features and should not: a) over design (Wanliss-Ortebar, 1996); b) employ the latest technology merely for the sake of appearance (Nielsen, 1996; Langa, 1996); or c) use scrolling text, marquees, or constantly running animations (Nielsen, 1996). The researcher developed simple text-based Web pages for this project with the exception of the game itself.

Supporting navigation and a strong sense of structure

In order to allow the user to move easily in any direction on the page, the designer should employ the following criteria: ease of navigation; delineation of the goals and structure of the pages; and location. Web sites should support simple navigation so as to allow users to browse easily (Middleberg, 1996; Wanliss-Ortebar, 1996; Nielsen, 1996). The audience should know where they are, where they have been, and where they can go (Nielsen, 1999). It is also important to clarify the purpose of the page, to get organized, and to prioritize icons and content (Middleberg, 1996; Wanliss-Ortebar, 1996). The goal of the page is to get the audience to take the action the designer wishes them to take (Middleberg, 1996). In order to do so, the use of frames and non-standard link colors should be avoided (Nielsen, 1996).

Well-adapted interface

A Web page should support an well-adapted interface with the audience. One of the key factors is fast response time. Although great graphics are eye-

catching, they make the pages too slow to be usable (Middleberg, 1996).

Therefore, Web page builders should avoid overly large graphics by taking into consideration such factors as file size and the speed of the modem (Langa, 1996).

They should also avoid overly long download times (Nielsen, 1996; Nielsen 1999).

Another factor in designing an effective Web page is good interaction with a variety of audiences, including the handicapped, non-native English speakers, and so on (Middleberg, 1996; Wanliss-Ortebar, 1996). By taking cultural diversity into consideration, the designer avoids unequal access (Langa, 1996).

Nielsen (1996, 1999) suggests that long scrolling pages should be avoided, particularly in the case of navigation pages. Furthermore, links located below the window border are much less likely to be chosen than links displayed at the top. Users need to be able to see all their options at the same time and it is wise to display their choices prominently at the top of the page. Most of the pages developed for this study are completely visible on a full screen without scrolling.

Contents

According to Nielsen, “content is king” (Nielsen, 1999). Good content and attractive displays make the audience wish to return (Middleberg, 1996). As it is desirable to post new and valuable information on a Web page, the designer should avoid using outdated information (Nielsen, 1996) or any content which is available in a hard copy (Langa, 1996).

Evaluation

The designer should evaluate Web pages professionally (Middleberg, 1996) and fix deficient areas before posting them. It is important to avoid untested pages (Langa, 1996). The designer should also avoid creating hard-to-read pages by staying away from inappropriate fonts, orphan pages, and other kinds of incomplete pages (Nielsen, 1996; Langa, 1996).

The designer should also consider how the page looks on the screen. One of the biggest problems designers of math courseware have encountered is the difficulty in displaying math symbols on the Web. Although the WWW Consortium (W3C) is developing Mathematical Markup Language (MathML) (Diaz & Ion, 1998) which can display math symbols easily, widely available browsers such as Netscape Navigator or Microsoft Internet Explorer have not yet fully supported it without the plug-in.

Although the guidelines stated above for designing Web pages are useful, they are rather general. Borges, Morales, and Rodriguez (1996) propose more practical guidelines, which are supported by experimentation. Based on the results of the heuristic evaluation of several university Web pages, the following list of guidelines for designing Web pages was compiled:

- Headers should not take up more than 25% of a letter size page.
- Headers and footers should be clearly separated from the body of the pages.

- Names of links should be concise and provide a hint of the content of the page to which they are linked.
- Explanatory comments to textual links should not be used.
- “Linking-mania” should be avoided.
- Links to existing pages should be verified.
- Linking icons should display a distinctive feature representative of the page to which they are linked.
- Consistency should be maintained when using icons. The same icon should always be used for the same purpose.
- Colors should be selected so that the pages can be clearly displayed and reproduced on black and white displays and printers.
- It is desirable to include the date the page was last modified, the e-mail address of the person who maintains the page, and the URL address of the page in the footer.

Although these guidelines were not specifically intended for Web-based instructional programs, they served as the foundation for the guidelines of this study. With the use of an appropriate Web page editor, most of the criteria listed above may be satisfied. Therefore, choosing a suitable editor was necessary for the successful completion of this study.

Design of Web-Based Courseware

Designing a Web-based education system requires an appropriate learning environment and usable courseware, which is constantly improved by evaluation. Usable courseware incorporates clear goals; easy navigation and high quality content, and, in addition, is easily upgraded.

Clear goals and easy navigation

It is important for students to be able to easily see what and how they learn, and what they gain through the courseware. Both the problem and the goal must therefore be presented in terms the students can understand. In order to accomplish this, the designer should carefully define the educational problems the courseware will address before attempting to create the software (Falk 1997).

The first part of the tutorial should provide a brief, clear-cut definition of the concept to be taught (Bronderick & Caverly, 1994). A Web-based class syllabus is a good medium for this kind of information (Microsoft, 1999). It is also important to allow the students to see what they will gain by completing the lesson. Bronderick and Caverly (1994) suggest that the author of the courseware let students know how the concept being taught will benefit them.

According to Friedman (1996), it is necessary to fully integrate CAI material into the curriculum and teachers should test the students on what they learn through CAI. He also suggests that developers should design CAI material to be superior to both printed material and lectures in transferring factual information.

In order to allow the students to easily see what and how they are learning, the Web pages should explain how the material is organized (Bronderick & Caverly, 1994). Once again, keeping it simple helps the designer organize the information clearly (Falk, 1997).

Updating constantly

Well-designed material is the result of constant updating and careful and fully integrated evaluation, while poorly designed material often results from either non-standardized evaluation or no evaluation whatsoever. Friedman (1996) mentions that there actually are no standards for evaluating CAI programs and so obviously, a great deal of poorly designed Web-based material exists. The designer of Web courseware must, therefore, conduct surveys to get feedback from students (Microsoft, 1999). Falk (1997) suggests that the designer should thoroughly examine the advantages and disadvantages of alternative solutions before making decisions, continually evaluate throughout the development of the software, and make the instructional design an iterative process.

New and high quality content

If, as Nielsen (1999) suggests, good content is essential to successful Web page design, then the content of Web-based courseware is of equally great importance. In order to create new and high quality content, the author should review content-related resources (Falk, 1997) and update material frequently (Friedman, 1996).

Appropriate learning environment

The creation of an appropriate learning environment requires well-implemented feedback from students and suitable hardware. Providing support to students with both synchronous and asynchronous feedback can be accomplished through the use of a) e-mail to stay in better touch with students, b) threaded discussions, and c) online class hours (Microsoft, 1999). Falk (1997) mentions the importance of providing on-line support to students as well as initiating direct person-to-person interaction.

Arranging a suitable hardware environment is another important issue. Friedman (1996) points out ten reasons why Web-based CAI can fail, including: a) insufficient computers available for Web-based material, b) slow response time on the Internet, and c) uncomfortable computer laboratories. Students tend not to concentrate on the content of the program, but rather, on the particular features of the computer itself. Therefore, selecting an appropriate platform for the development of the study is an important and difficult task, particularly in a bilingual environment such the one in which this study was implemented.

Evaluation for improving the courseware

The designer of the courseware should collect information from various sources in order to improve the product. It is important, for example, to collect information from the students' performances after learning. Good courseware provides students with opportunities to retain and apply the knowledge they have learned.

Bronderick and Caverly (1994) suggest that the instructor:

- Provide practice.
- End the tutorial with a reading selection to reinforce the skill.

Another important feature of good courseware is the provision for students to review what they have learned. The designer should provide both a conclusion and exercises for review (Bronderick and Caverly, 1994). The instructor should record lectures and make them available to students (Microsoft, 1999).

Another means of collecting information for the improvement of courseware is through collaborative efforts. The designer may:

- Implement a distribution list or listserv in email (Microsoft, 1999), and
- Organize a team with relevant skills (Falk, 1997).

Courseware designers should choose the best alternatives from all new and possible solutions. Falk (1997) recommends that the designers produce a variety of possible solutions to the educational problem and review new media and new ideas that others have created. This study included a usability test as a formative heuristic evaluation.

Design of Instructional Games

The game as an instructional program

The educational game is a type of instructional program. Stewart (1997) maintains that a game can be an effective instructional tool. A well-designed game focuses on the student's learning and creates an atmosphere in which the student is

free from distractions and other physical and psychological barriers to productive study (Houser & Deloach, 1998). For example, the designer should minimize the use of violence in the game (Alessi & Trollip, 1991). The game should also stimulate students to learn. Instructional computer games are popular in schools and are often used to enhance motivation (Stewart, 1997).

Alessi and Trollip (1991) suggest that an instructional game should clearly state its objectives and purpose. It should:

- Define the objective, including the instructional purpose of the game;
- Relate the scenario to what is being learned.

Computer games also teach rules, expose students to the concept of random events, and increase comfort with the computer (Stewart, 1997). If the designer uses a game as a part of an instructional program, the game should match the tone of the other parts of the program (Stewart, 1997).

Feedback

Web-based instructional games can provide feedback of good quality, which means giving positive, while avoiding negative, feedback. Games should provide positive feedback at every step. For example, Houser and Deloach (1998) suggest that immediate success and gradual introduction of complex problems should be part of any instructional game design. Alessi and Trollip (1991) recommend that the game allow the student some success at every level of difficulty.

Negative feedback should be avoided. Stewart (1997) points out that losing games results in humiliation and lack of motivation. Therefore, interesting feedback should follow correct rather than incorrect performance (Alessi & Trollip, 1991). According to Houser and Deloach (1998), users should be provided appropriate help and constant feedback on their actions. Quick response is also important for the game because it enhances feedback. Web-based games in particular, allow efficient data collection, analysis and reporting (Stewart, 1997), which ensure feedback of good quality.

Motivation

Web-based instructional games provide real-time interaction across a remotely located population (Stewart, 1997), which increases motivation. For best results, the games should provide intrinsic rather than extrinsic motivation, and require some difficulty at each stage. Games that are too easy are not interesting (Stewart, 1997). Alessi and Trollip (1991) recommend making the game challenging, rewarding learning rather than luck, and making the game the motivator, not the reward (Alessi & Trollip, 1991).

Well-defined and interesting content

A good Web-based instructional game is clearly defined, interesting and available at any time. Choosing a good scenario is necessary in order to maintain the student's motivation. Stewart (1997) points out that a Web-based game should incorporate dynamic and changing scenario characteristics in order to make it interesting. According to Alessi and Trollip (1991), the designer should choose a

scenario that will capture the student's attention and use sensory and cognitive curiosity to maintain motivation. They recommend that the game designer pilot the game in a non-computerized way first, to make sure it is stimulating. The instructional game in this study was used for many years in a non-computerized environment and was well accepted (Hayakawa, 1980).

The game should be introduced to the users in a clear and simple fashion. Houser and Deloach (1998) recommend that users should: a) be able to learn how to start using the program quickly and easily, and b) be provided minimal instruction to get started and keep going. According to Alessi and Trollip (1991), games should provide complete directions that allow the students to return to them at any time, and ensure that the students know what to do next. The users should be informed as to what they are supposed to do to succeed (Houser & Deloach, 1998).

Alessi and Trollip (1991) also recommend using a short title page. This is one of the best ways to introduce the game. Also, game scenarios and rules should be presented properly to hold the student's attention and understanding (Stewart, 1997), and should always be available while the game is being played (Alessi & Trollip, 1991). A clear and attainable goal should be set. Furthermore, the game should provide a final message at the end and recognize the winner (Alessi & Trollip, 1991).

Web-based instructional games

Stewart (1997) lists eight basic elements of optimal game design: entertainment, fantasy, non-threatening reality, objectives, rules, opposition, hazards, and outcomes. He discusses how to implement those elements in business applications. He also discusses the advantages of Web-based instructional games.

- They provide asynchronous learning opportunities.
- They allow efficient data collection, analysis, and reporting.
- They provide real-time interaction across a remotely located population.
- They can display dynamic/changing scenario characteristics.

Authoring Tools

Selection of authoring systems

Good selection of authoring systems requires clear criteria and information collection. The selection of the system depends on the kind of instruction suitable for your institution and the price (Phillips, 1998). There are two choices for an authoring system: off-the-shelf component software and integrated packages (Kaplan, 1998). In order to choose systems, the builder should get support from buyers who have used the systems, open discussion lists, and electronic forums (Phillips, 1998).

Simple is better

Complicated systems require complicated procedures. In order to run the courseware, the following extra work is required: setting Web-browser plug-ins

and configuring the system before developing courses (Phillips, 1998). For example, although Macromedia's products, such as Authorware, can be used on-line as well as off-line, setting shockwave Web-browser plug-ins is required. Integrated packages such as Web Course in a Box, WebCT, TopClass and so on, usually include a course management system (CMS). One of the most sophisticated CMSs is supported by Phoenix for Windows (Phillips, 1998). Sometimes, integrated packages are difficult to implement because of complications.

Off-the-shelf components are preferred over integrated packages. Kaplan (1998) recommends off-the-shelf components for the following reasons:

- Off-the-shelf component software is more flexible.
- Off-the-shelf components are cheaper than integrated packages.
- Integrated packages are text based and lack variety.

Furthermore, off-the-shelf components are simple compared with integrated packages. For this study, the researcher had to decide which platform for developing the courseware was preferable: off-the-shelf components or an integrated package such as CALAT.

Interaction requires more sophisticated software

According to Phillips (1998), there are three levels of implementing interaction on Web-based courseware: a) level one interaction is between learner and content, b) level two interaction is between learner and instructor, c) level

three interaction is among other learners. Symposium, TopClass, and Learning Space allow instructors to build richly interactive classrooms (Phillips, 1998), which facilitates all three levels of interactions. TopClass was selected by PC Week as the No. 1 all-around authoring system in 1997 (Phillips, 1998). Kaplan (1998) suggests that Ewigie, Cow, Hypernes or WebBoard can best implement class discussion.

Authoring tools require more complicated computer languages than BASIC in order to undertake complicated tasks such as the second and third levels of interaction. For examples, DHTML and Java, are dynamic languages that allow learners to experience instruction on three levels. Toolbook and QuestNet+ lend themselves to more complicated tasks than does DigitalTrainer, which can provide only the first level of interaction (Phillips, 1998). CALAT virtually accommodates the second level of interaction because it is an intelligent tutorial system that adapts to the learner's response.

FrontPage 98 is the one of the best off-the-shelf authoring tools

FrontPage 98 is recommended as an authoring tool for Web pages. Goodwin and Hammond (1998) evaluated several authoring tools and concluded that the free software, Microsoft FrontPage Express and Netscape Communicator are fine for building the most basic Web pages. After evaluating Microsoft FrontPage 98, SoftQuad HotMetal Pro 4.0, NetObject Fusion 2.02, and Macromedia Dreamweaver 2.0, Goodwin and Hammond (1998) chose FrontPage 98 as the best tool for the money. Phillips (1998) suggests that DigitalTrainer is a good first

level authoring choice. Handouts, assignments, syllabi, articles and so on can be created easily by Netscape Composer (Kaplan, 1998).

The reasons why Goodwin and Hammond recommend FrontPage 98 are as follows:

- FrontPage 98 and Fusion, accomplish the most difficult tasks.
- FrontPage 98 is very low-priced.
- Users of FrontPage 98 and Dreamweaver can test their results on both Microsoft IE and Netscape Navigator.

There are also other kinds of off-the-shelf software which allow the user to prepare presentations and quizzes. PowerPoint, software designed for making presentations, allows for the creation of slides with synchronized audio.

Presentations of course materials made with expandable outliners and frames are neat and uncluttered. Text within courseware may be created using Microsoft Word, Netscape Composer, and FrontPage. Screen Cam, from Lotus, and other software like it, are able to capture screen movements. Test Pilot, created by Malcolm Duncan at Purdue University, can produce quizzes easily and inexpensively (Kaplan, 1998).

CALAT

CALAT (Computer Aided Learning and Authoring environment for Tele-education) is a server-oriented server/client system that includes CAIRNEY (CAI Expert System for New Technology). CAIRNEY is a general-purpose intelligent

CAI platform which has been running on stand-alone personal computers, while CALAT is an intelligent CAI system constructed and distributed on the WWW (Nakabayashi et al., 1995c). In this system CAIRNEY processes are running on the server and CAIRNEY viewers are running on the clients. Figure 1 is the configuration of CALAT which shows how CAIRNEY can be used on the Internet. As an interactive educational system consisting of an Intelligent Tutoring System (ITS) on a server and a multimedia scene viewer on the client, CALAT requires the capability to control what is being presented to the student (Nakabayashi et al., 1995c). A viewer control mechanism, which is an example of a server-oriented server/client mechanism, improves the function of CALAT by increasing the speed of the system response. The simulation environment, which has been incorporated into a later version of CALAT, is implemented by fully exploiting the viewer control mechanism (Nakabayashi et al., 1996).

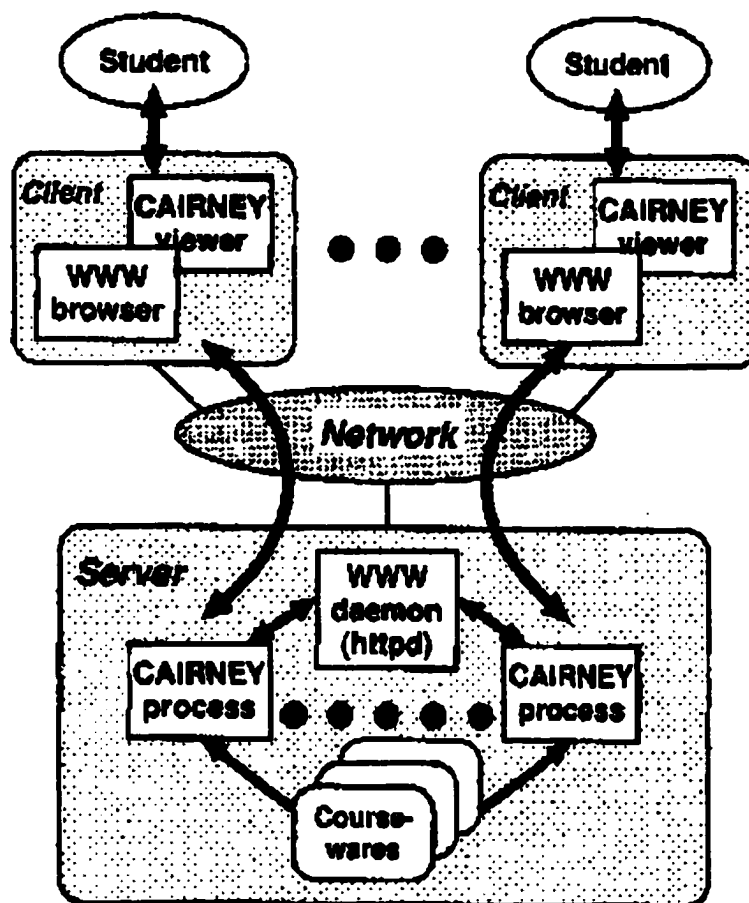


Figure 1. The CALAT configuration: CAI processes run on the WWW server in server/client architecture. Copyright by NTT. Used with permission.

CAIRNEY consists of CAIRNEY-AUTHOR and CAIRNEY-TUTOR (see Figure 2 for the structure of CAIRNEY). CAIRNEY-TUTOR has three components: student status information, general-purpose tutorial expert systems, and courseware. This module, which has been incorporated as part of the CALAT server, facilitates user identification, viewer control, and navigation, which are essential for a Web-based tutorial system that adapts to individual students.

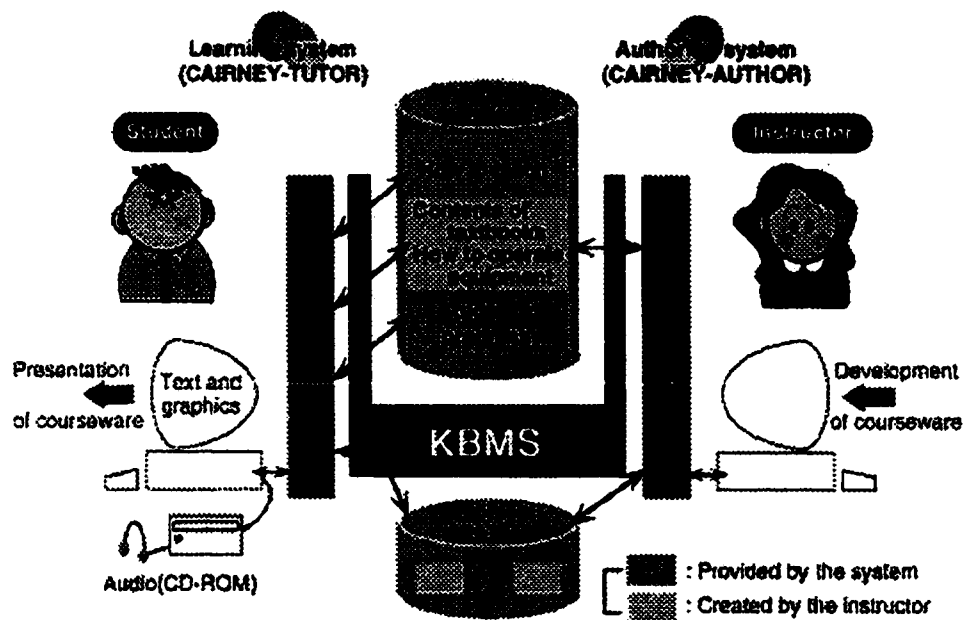


Figure 2. The structure of CAIRNEY: CAIRNEY consists of CAIRNEY-TUTOR and CAIRNEY-AUTHOR. Copyright by NTT. Used with permission.

With CAIRNEY-AUTHOR, the author can create courseware which consists of multimedia explanation scenes, exercises, and a hierarchy of educational goals (Nakabayashi et al., 1995c). In the latest version of CALAT, any HTML data existing on another WWW server can be included as a part of the courseware. For example, an explanation page can be written in any type of HTML, including Java applet and/or multimedia plug-in applications (Nakabayashi et al., 1997). The next generation of CALAT will be able to utilize other CALAT courseware on the WWW (Nakabayashi et al., 1995c).

Because CALAT is a server-oriented system, it requires a high performance server. According Nakabayashi et al., (1998a), the old Sun Workstation (SparcStation5) is not suitable for large audiences of more than 30 clients. It is recommended that the CALAT server should have at least 128MB of memory.

Another consideration in CALAT performance is response time. Although a courseware page consisting of animation and audio data is too large to be transferred over a low speed network, the newer version of CALAT improves its response time.

As an ITS with many modules, CALAT is an individual-adaptive system which requires dynamic and interactive Web pages. The WWW is essentially a passive and static hypertext. In order to build an individual adaptive system, it is desirable to control the information accessible to the student and to adapt to the student's level of understanding. CALAT provides a mechanism for the server to control the viewer on the remote client. An individual adaptation environment requires the student's identification. In CALAT the instructions vary the types of explanations given by dynamically considering the student's level of understanding. The general-purpose tutorial expert system determines the most effective scenario for each student (Nakabayashi et al., 1995c). Therefore, information on each student is essential. Current student information should be available and it should be updated dynamically (Nakabayashi et al., 1995c). By storing such information, the student can resume learning from the point where the previous learning terminated. In order to achieve user identification capability, CALAT requires user names and the courseware name when students log on.

One of the important roles of CALAT is to train workers in the basic operations of NTT. It must provide not only conceptual and theoretical knowledge, but also operational knowledge (Fukuhara et al., 1995). In the first version of

CALAT, learning style was limited to explanation and was exercise-based (Nakabayashi et al., 1996). There was no support for interactive simulation (Nakabayashi et al., 1996). In the newer version, three types of pages, explanation, exercise, and simulation, are available (Nakabayashi et al., 1997).

Another improvement made to CALAT was to allow it to be more easily upgraded. In the beginning, it was difficult to modify, improve or extend the functionality and behavior of CALAT (Nakabayashi et al., 1998b). It was also difficult to implement pages by using the latest technologies such as Java or various interactive plug-in programs, because the GUI module and other modules were highly interdependent. An object-oriented architecture has been employed to design the latest version of CALAT to eliminate these problems (Nakabayashi et al., 1998b).

Internationalization

What is internationalization?

Internationalization (I18N) is the process of enabling a program to run internationally. Because of the diversity of cultures worldwide, this is often difficult to achieve. For example, according to Flanagan (1997), one problem facing internationalization is the observance of local customs and conventions in areas such as date and time formatting. In order for a program to be useful in a foreign setting, displays of dates, times, number, and currency value need to be tailored to the locale.

Demand for internationalization

The recent demand for internationalization has led to an improvement in the tools designed to implement it. Internationalization has become more important in the development of software and the translation of software is increasing.

Although it has been taken for granted that English is the standard language of the Internet, that assumption is changing. It is estimated that the market for text-based language translation is growing (Schaff, 1998). Today about 20% of all computer documentation is translated into 30 languages. The figure will be 60% and in 80 languages by the year 2005 (Cowan, 1998). As the global Internet grows, internationalized programs will become increasingly important (Flanagan, 1997).

Because of the demands of I18N, improved tools or platforms for it are being developed. Java is one of the most suitable programming languages for internationalization tools. According to Flanagan (1997), Java 1.1 provides tools that can deal with I18N problems and has a great advantage over C or C++.

Also, according to Bishop, Brown, and Meltzer (1998), Windows NT5.0 is an excellent platform for developing international software for a number of reasons: a) the use of Windows NT 5.0 prevents the necessity of switching from one localized system to another during development; b) it allows per-user setting of the user-interface language; and c) it is possible to install Chinese, Japanese, and Korean input method editors (IME) to facilitate the entry of text in the appropriate language.

Unicode is a key word for internationalization. Unicode is a character code system that supports the localization of text; that is, the interchange, processing, and display of written texts in diverse languages. Inputting and outputting text should be localized by designing the system to meet local character encoding standards. For this purpose, translation from Unicode to the local code, and from the local code to Unicode, is all that is necessary (Flanagan, 1997). Modern platforms such as Java and Windows NT 5.0 are using the Unicode encoding system. According to Flanagan (1997), Java uses the Unicode encoding for its characters and strings. Bishop et al. (1998) mentions that Windows NT 5.0 includes a Unicode script processor that supports line measurement, display, caret movement, character selection, justification, and line breaking of Unicode plain text and rich text.

Internationalization in the learning environment

In the learning situation, complete localization is not always necessary, especially in learning a second language (L2). Learning and retaining vocabulary properly requires many cognitive activities and the acquisition of information. The more difficult the task of inferring meanings of words, the greater the retention of second language vocabulary: that is, meaning inferred results in higher retention than meaning given (Grace, 1998). It is important, however, to support learners by supplying context and other information. According to Grace (1998), a combination of contextual and definitional approaches is effective. The author also mentions that a “pregnant sentence,” one in which the factors of subject, verb, and function of the target word have a strong relationship to the word to be inferred,

facilitates the correct guessing of a word (Grace, 1998). Mathematics is a type of international language that provides context. Therefore, learning math together with a second language may be effective for the retention of vocabulary. Extra information for each sentence also helps students learn vocabulary. According to Grace (1998), sentence level translation helps students to learn L2 vocabulary. In his study, he implemented sentence level translation in the program.

Barriers to internationalization

Implementing I18N is difficult, time consuming, and expensive. According to Cowan (1998), international rollouts are delayed and revenues are unpredictable. I18N projects take triple the time, and cost triple the amount, than do comparable projects in the United States (Dalton, 1998). Multilingual text is also difficult to implement. Flanagan (1997) points out that: a) it is important when writing a program to ensure that all user-visible text is loaded at runtime rather than hard-coded directly into the program; and b) text representation is one of the most difficult problems of internationalization.

Browsers present another barrier. The current battle between Netscape's Navigator and Microsoft's Internet Explorer is a battle for control of the standards for internationalized computer technology (Adam, Awerbuch,, Slonim, Wegner & Yesha, 1997).

Summary

The beginning of this chapter introduced the current situation regarding the design of Web-based courseware; the main issues being simplicity; usable, well-organized interfaces; content, and evaluation. Much of the literature stresses the limitations placed on courseware design by Internet data transfer speed; the conclusion being that simple pages are better. Furthermore, courseware should be easy to navigate and should clearly indicate what the users are to learn, what they should do, where they are, what they can do, and so on. It is also important for the designers to evaluate the courseware as it is being developed. Both formative evaluations and summative evaluations should be performed.

This study focused on instructional games, which should be developed according to the guidelines mentioned above. In addition, the designers of instructional games should include feedback and a means of motivating the student. Motivation, in particular, is an extremely important element of instructional games. Therefore the researcher conducted a summative evaluation for motivation.

The selection of authoring systems is very important for the developer of Web-based courseware. There are two choices: off-the-shelf component software and integrated packages, such as CALAT, which was also discussed here. Because building bilingual Web pages requires flexible developing tools, the researcher employed off-the-shelf components. Among the most important components is the Web page editor. Microsoft FrontPage 98 is recommended. The CALAT system, an example of an integrated package, was also discussed in detail.

The last, and the most important, topic covered in this chapter, was internationalization. Recent developments in technology, including the Internet, have spurred a trend towards globalization, and the tools for this purpose have been improved. In a learning environment there is an even greater need for true internationalization. Because mere translation is not adequate for the design of cross-cultural Web-based courseware, how context should be integrated into the learning process is a very important issue. This study addressed this problem by demonstrating that teaching math and English together through the use of on-line courseware is an effective educational strategy.

Chapter III

Methodology

Falk (1997) mentions five important steps in designing a course on the World Wide Web: carefully defining the educational problem, developing other Web-based instructional solutions, carefully examining each possible solution, implementing the chosen solution, and evaluating the result. The author followed the steps outlined above.

Research Questions

The primary goal of this study was to determine what kinds of Web-based courseware are suitable for students who wish to learn both English and math and how those pages can be designed and implemented. In the course of this research, three kinds of pages were constructed: English-only pages, bilingual pages and Japanese-only pages. The researcher examined those pages from the standpoint of the students' mastery of English vocabulary and math calculation skills, and their motivation. At the same time, design guidelines for developing bilingual pages were assessed. The main research question addressed in this study was the effectiveness of bilingual pages for learning both English and math.

Resources and Materials

The author conducted goal and task analyses by referring to works by Abramson, and Alessi and Trollip (1991). These books were also helpful during the development of

the prototype of the courseware. There are many other references, including those cited above, which were helpful as resources. Studies by del Galdo and Nielsen (1996) were particularly valuable for international usability.

The instructional program guides the learner in the mastery of quadratic equations and English math terms. The target users were ninth graders who are on a beginning level in English and are native speakers of Japanese. Because this instructional program was designed for use in Japan and in the United States, it had to be consistent with curriculums in both countries. Kelly (1999) suggests a global mathematics curriculum. Should this become a reality, it will be easier to build international instructional programs, which are compatible between countries. The author used textbooks (Smith, Dossey, Keedy and Bittinger, 1992; Trivieri, 1992; Kawaguchi, 1995) from both countries to conduct task analysis.

Alessi and Trollip (1991) identify five major types of computer-based instruction programs: tutorials, drills, simulations, games, and tests. This instructional program consists of two parts: a tutorial and a game. The network speed the author originally intended to use was 1.5Mbps, the speed necessary for the optimal operation of multimedia on-line courseware (Kato, 1997). Unfortunately, this was impossible as the Keio project, which would have accommodated the desired speed, was terminated. As the main purpose of this study was the effect of bilingual pages on learning math and English rather than the effect of speed, the slower speed did not constitute a significant problem. For the summative evaluation, the courseware was tested on the Intranet at Keio Futsubu. Some formative evaluations were carried out on the Internet. Heuristic evaluations were used for

the formative evaluation. The book, *Usability Inspection Methods* (Nielsen & Mack, 1994), was extremely helpful. The “Instructional Materials Motivation Survey” (IMMS), which Dr. Keller (1990) permitted the researcher to use (see Appendix B for the permission to use IMMS), was utilized to evaluate the students’ motivation (see Appendix C for the IMMS).

Microsoft Visual J++ 1.1 and JDK1.2 were the programming tools used to create the game. FrontPage 98 and Dreamweaver were used as HTML editors. Both Japanese and English Windows 95 were used as operation systems.

The computer lab where the summative evaluation was conducted has 50 machines running the Japanese version of Windows 95. All 50 computers are connected to the Web-server where the courseware was installed. The Web browser used for the evaluation was Microsoft Internet Explorer 4.0.

Preliminary Study

The researcher conducted an evaluation of a pencil-and-paper game (see Appendix G for the abstract of the game) which he created for use in the mathematics classroom. As the evaluation indicated that the pencil-and-paper game was well accepted, it was adapted as the basis of the game developed for this study. The stand-alone game was created first (see Appendix H for the calculation game) on Windows 95 with Microsoft Visual C++. Several persons, including two doctoral students from Nova Southeastern University, evaluated the prototype. These preliminary studies provided the foundation for the methodology employed in this research.

Design Process

The design of game portion of the program was based on the preliminary study. While the framework of the Web-based game is similar to that of the stand-alone game, there are a number of differences. The most significant difference is that the Web-based game has less multimedia features than the stand-alone game because multimedia games require a high transfer speed of data.

In order to construct the tutorial, a task analysis was performed. Important concepts of quadratic equations were culled from English and Japanese textbooks. The concepts were written on cards and were organized into a tree structure, which was used to facilitate the programming with FrontPage.

Programming Environment

In order to determine what type of environment was most suitable for programming this particular software, both the Operation System (OS) and the application were taken into consideration. The author used both Japanese and English Windows 95 on one IBM-compatible personal computer. There are a number of ways to switch from one OS to the other by rebooting. One method is to use the unofficial Microsoft program, WinBoot, and automatically switch with the program (Microsoft, 1999c). The other, which Slater (1998) suggested, is by programming the computer to replace the configuration files of one system, such as autoexec.bat and config.sys, with the configuration files of the other system. The first technique is flawed due to the instability of the program; therefore, the researcher used the latter method.

The selection of authoring systems was another issue; the choice was to use an integrated package, such as CALAT, or off-the-shelf component software. The best choice for this project was off-the-shelf component software because it allowed for greater flexibility in the design of the courseware. Had CALAT been used, it would have been necessary to select a primary language for the courseware. Had English been chosen, it would have been difficult to use Japanese in the platform without having to alternate programs a great deal.

There are many Webpage editors such as WebberActive 4.0, SoftQuad HoTMetal Pro, Dreamweaver, FrontPage 98 and so on (Hacker & Young, 1998). Dreamweaver is a popular program, particularly with developers who want their Web pages to be compatible with both Netscape and Microsoft browsers. However, FrontPage 98 (English version) was the best choice because this program has a tree diagram feature, which indicates how each page is structurally related to the others. Tree diagrams are particularly good for expressing task analysis, a necessary element in the design of instructional programs. Although both Dreamweaver and FrontPage 98 were used in the project, FrontPage 98 was employed to a greater degree.

The two most popular Web browsers, Microsoft Internet Explorer and Netscape Communicator, are not entirely compatible in terms of Dynamic Hyper Text Markup Language (DHTML) which was used to implement the appearance and disappearance on each English Webpage of the Japanese translation of the English text. According to Gulbransen and Rawlings (1997), Microsoft supports more features of DHTML than does Netscape Communicator. However, the researcher attempted to make the two browsers

work with this program by using DreamWeaver whose functions are compatible with both (Nakajima & MediaStudio, 1999).

Another programming language used in this study was Java. This instructional program includes game programming, which requires more control over procedures; thus the use of Java Script was contraindicated. Microsoft J++ 1.1 was employed as an Integrated Development Environment (IDE). The Java Development Kit version 1.2 (JDK1.2) was also used because it supports some features not supported by Microsoft J++ 1.1. Therefore, for the purposes of this endeavor, the researcher upgraded Microsoft J++ by installing JDK 1.2. The quizzes in the tutorial were created by using the authoring tool known as Hot Potatoes, which has six modules designed to implement multiple-choice quizzes, fill-in-the-blanks exercises, matching exercises, short-answer exercises, jumbled sentence exercises and crossword puzzles.

In the early developmental stage of this project, the programming environment was English-oriented; that is, English applications were used on English Windows 95. The later programming environment was mixed; English applications were used on Japanese Windows 95 because Japanese characters had to be input and displayed.

Microsoft Internet Explorer 4.0 and Netscape Navigator 4.5 were used as client software because the features of DHTML utilized in this program did not work on other browsers. Although some browsers, such as IBM's Techexplorer Hypermedia Browser, can display math symbols written by MathML, they were not used in this study as client software because they are not as readily available as Internet Explorer or Netscape Navigator.

Evaluation of the program

Evaluators

The researcher asked a computer education specialist, a librarian, a former student of Keio Academy of New York, two Japanese math teachers, and a high school student to conduct formative evaluations of the usability of the program on the Internet. The summative evaluation was carried out by 235 ninth grade students in the researcher's class. All have studied English for two years and have had experience using Internet browsers. They have also had the experience of working with the pencil-and-paper calculation game when they were in the eighth grade.

Formative evaluation

The formative evaluation examined the usability of the program. The researcher asked the evaluators to fill out forms (see Appendix A for the questionnaire) developed by referring to Nielsen's ten usability heuristics (see Appendix I for the list of the heuristics). Some heuristic evaluations consist of four sessions: a pre-evaluation training session, an actual evaluation, a debriefing session to discuss the outcome of the evaluation, and a severity rating session where the evaluators assess the severity of the usability problems (Nielsen, 1994). In this study, an authentic, in-depth, heuristic evaluation was not conducted. An optimal heuristic evaluation requires at least three trained evaluators (Nielsen, 1994). As such help was unavailable, the researcher omitted the training session, the debriefing session, and the severity rating session.

The researcher observed two evaluators (the librarian and the high school student), who had done evaluations of the preliminary study, and applied the usability heuristics as

they tried the program. The other four evaluators filled out questionnaires, designed with usability heuristics in mind, which enabled them to identify usability problems.

Summative evaluation

The 235 students from five homeroom classes were randomly divided into three groups which were assigned to different programs. One group used English-only courseware, one used bilingual courseware, and the third group used Japanese-only courseware. All students were given a pretest and a posttest on both English vocabulary and quadratic equations (see Appendix E and F for the tests). They were also given the IMMS created by Keller (1990), which was translated into Japanese by the researcher. The programs were used on the Intranet on Keio Futsubu's LAN.

The statistical analysis consisted of the Multivariate Analysis of Variance (MANOVA) wherein the dependent variables were the students' performances in English and math, and their motivation; and the independent variable was the type of courseware (English-only, bilingual, and Japanese-only courseware). The Multivariate Analysis of Covariance (MANCOVA) was also used for the performance evaluation. In this case, the dependent variables were the scores of the posttests in English and math and the covariables consisted of the scores on the pretest.

The actual evaluation was conducted as follows:

Five classes (A~E) of 46 to 48 ninth graders were divided in half. For example, Class A (46 students) was divided into two groups A-1 (23 students) and A-2 (23 students). Each subgroup was allotted 75 minutes to use the courseware, 15 minutes for

the performance test, and 45 minutes to fill out the IMMS and the questionnaire. The researcher randomly assigned one of the three programs to the subgroups. The sessions followed the schedule outlined below:

Timetable for the Classes

Table 1

The First Day

Period	Time	Group	Version
1	9:00 – 9:55	3C-1	Japanese
2	10:05 – 10:40	3A-1	Bilingual
3	10:50 – 11:35	3E-1	English
4	11:45 – 12:30	3B-1	Japanese
5	13:10 – 13:55	3D-1	Bilingual
6	14:05 – 15:50		

Note. Group 1 students studied math by using the program after receiving a short explanation of the program. Every student took the pretests one day before this session.

Table 2

The Second Day

Period	Time	Group	Version
1	9:00 -- 9:55	3E-1	English
		3E-2	Bilingual
2	10:05 – 10:40	3D-1	Bilingual
		3D-2	English
3	10:50 – 11:35		
4	11:45 – 12:30	3A-1	Bilingual
		3A-2	Japanese
5	13:10 – 13:55	3B-1	Japanese
		3B-2	English
6	14:05 – 15:50	3C-1	Japanese
		3C-2	Bilingual

Note. Group 1 students continued to study math by using the program for 30 minutes. They then took the performance tests for 15 minutes. Group 2 students studied math by using the program after receiving a short verbal explanation.

Table 3

The Third Day

Period	Time	Group	Version
1	9:00 – 9:55	3C-2	English
2	10:05 – 10:40	3A-2	Japanese
3	10:50 – 11:35	3E-2	Bilingual
4	11:45 – 12:30	3B-2	Bilingual
5	13:10 – 13:55	3D-2	English
6	14:05 – 15:50		

Note. Group 2 students continued to study math by using the program for 30 minutes. They then took the performance tests for 15 minutes. 3C-2 students experienced hardware problems during their class. Therefore, their data was eliminated from this study.

Table 4

The Fourth Day

Period	Time	Group	Version
1	9:00 – 9:55	3E-1	English
		3E-2	Bilingual
2	10:05 – 10:40	3D-1	Bilingual
		3D-2	English
3	10:50 – 11:35		
4	11:45 – 12:30	3A-1	Bilingual
		3A-2	Japanese
5	13:10 – 13:55	3B-1	Japanese
		3B-2	English
6	14:05 – 15:50	3C-1	Japanese
		3C-2	Bilingual

Note. The timetable for the fourth day was the same as for the second day. Both groups filled out the IMMS and the questionnaire.

Method of Analysis

In order to examine the effect of the instructional programs on the performance of English and math, a mixed design, repeated measure, 3 x 2 analysis of variance (ANOVA) was conducted. The analysis included one between-subjects factor (the program;

Japanese-only, bilingual, or English-only) and one within-subjects factor (the tests; pretest and posttest). The analysis was conducted using the SPSS MANOVA procedure. To determine which program was more effective, a multiple comparison Tukey test was performed. The analysis included one dependent variable, difference or gain scores (posttest score – pretest score) and one independent variable, programs. Although these two methods are used quite frequently, the analysis of covariance (ANCOVA) is the preferred method of analysis for pretest-posttest design (Stevens, 1996). Therefore, the researcher also used this method.

In order to analyze motivation and usability, pairwise multivariate tests were conducted by using the SPSSX DISCRIMINANT program (Stevens, 1996, pp199-202). After determining which pairs were significantly different, the SPSSX T-TEST procedure was performed in order to discover which of the items contributed to the multivariate significance in each case.

Actual process

There are two ways in which international usability can be tested. The first is called the “international inspection” or the international usability inspection method (Nielsen & Mack, 1994). The second is the ultimate international usability engineering method, which consists of international user testing involving real users doing real tasks (Nielsen, 1996b). According to Nielsen (1996b), there are four main ways to conduct international user testing: (a) go to the foreign country yourself, (b) run the test remotely, (c) hire a local usability consultant to run the test, or (d) employ local staff. In order to provide an

efficient iterative on-line course it is necessary to evaluate usability repeatedly. Dringus (1995) recommends heuristic evaluation for that purpose.

The researcher used the first and second methods. The process was as follows:

1. An investigation of several on-line instructional program sites and cross-cultural sites on the Web was conducted.
2. An English instructional program prototype was designed and then improved through the use of a heuristic evaluation (Nielsen, 1994).
3. The instructional program was implemented on Keio's server based on step two. A formative evaluation was conducted to improve the Japanese and bilingual prototypes (Stewart, 1994).
 - Native English speakers and bilingual students, some of whom are familiar with usability testing, evaluated the instructional program (international inspection).
 - The instructional program was translated into Japanese by the author. The Japanese and bilingual versions of the program were then evaluated by Japanese teachers (international inspection).
 - Based on the evaluations, the design of the instructional program was improved.
4. A summative evaluation was conducted by Japanese ninth grade students who used the three instructional programs (English-only courseware, bilingual courseware and

Japanese-only courseware) and subsequently evaluated them by filling out a translated questionnaire (international user testing).

Reliability and Validity

The English performance test was created using vocabulary from the courseware. The researcher, an experienced teacher of mathematics who has written many tests on quadratic equations, created the math test. Therefore, the content validity might be considered to be high. The Kuder-Richardson formula 21(KR-21) was used to calculate the reliability of the tests whose items were scored dichotomously. The formula is as follows:

$$\text{Reliability (KR-21)} = \frac{(K)(SD^2) - \bar{X}(K - \bar{X})}{(SD^2)(K - 1)}$$

where

K = the number of items in the test

SD = the standard deviation of the scores

\bar{X} = the mean of the scores

Table 4 shows the actual internal reliability of both the math and the English tests. The average reliability between the pretest and the posttest in math was .82 and the average reliability of the pretest and the posttest in English was .77.

Table 5

Reliability of the Tests

	English Pretest	English Posttest	Math Pretest	Math Posttest
<i>K</i>	20	20	12	12
\bar{X}	2.067961	5.57767	1.830097	7.412621
<i>SD</i>	2.340574	4.336041	3.224187	2.826639
KR-21	0.696366	0.827442	0.928145	0.704005

Keller (1990) reported that based on Cronbach's alpha measure, the reliability estimates of the IMMS were as follows:

Attention: .89 Confidence: .90 Total Scale: .96

Relevance: .81 Satisfaction: .92

In a validation study, differences in two sets of instructional materials with respect to format, content and other features affected the differences in scores on the IMMS. The researcher calculated Cronbach's alpha measure of the translated version of IMMS by using the following formula:

$$\alpha = \frac{(K)((SD^2) - \sum (SD_i^2))}{(K - 1)(SD^2)}$$

where

K = the number of items

SD = the standard deviation of the scores

$\sum SD_i^2$ = the sum of the variance for each item

Table 6

Cronbach's Alpha Measure of Translated IMMS Score

	Attention	Confidence	Relevance	Satisfaction	Total
K	12	9	9	6	36
SD^2	77.03532	40.38414	34.55064	29.05611	474.2808
$\sum SD_j^2$	19.05355	14.27336	12.90614	9.28573	55.51879
α	0.821089	0.72738	0.704764	0.816505	0.908168

Although the reliability of the translated IMMS scales is lower than that of the originals, all the scores are above .70 which is acceptable for reliability. The reliability of the usability questionnaire was .071, which is Cronbach's coefficient alpha.

Summary

This study investigated what kind of bilingual courseware is suitable for Japanese students of basic level English and how to build it. The researcher developed three kinds of Web-based courseware: English-only, bilingual and Japanese-only courseware, through an iterative design process. Developing bilingual courseware requires appropriate operation systems and application software. In this study, both English and Japanese Windows 95 were used. FrontPage and Dreamweaver were employed as applications for the tutorial parts of the courseware, and Microsoft J++ was used to program the game. A heuristic formative evaluation was conducted. Three analyses were conducted for the English and math performance evaluations: 1) repeated measure 3x2 analysis of variance, 2) the Tukey test on the gain scores (posttest - pretest), and the multivariate analysis of

covariance. Test problems created by the researcher were used to evaluate performance. The motivational instrument was the IMMS, which was translated by the researcher with permission from Dr. John Keller, the creator of the survey. The development and evaluation processes were conducted according to the time schedule shown in Tables 1-4. Finally, the validity and reliability of the instruments were tested.

Chapter IV

Results

Data Analysis

Formative Evaluation

Formative evaluations were conducted by four adults (an American librarian, two Japanese math teachers, and an American computer education specialist), and two students (a bilingual Japanese graduate of Keio Academy and a dual-national bilingual international secondary school student).

The American librarian works at an international school in Japan. Her undergraduate major was English and her graduate degree was in library and information science. She has been assisting the researcher by proofreading both this paper and the English version of the program. While proofreading the game, she observed several usability problems:

1. She was not familiar with navigation buttons marked “up” rather than “back.”
2. Although most Web page links are blue, those in the program were black.
3. One of the hints in the exercise part of the program was confusing.

Points one and two have not been altered. The color of the links and the designation on the navigation button come from the FrontPage template. Therefore, changing them might create errors and confusion. The third problem was corrected. The librarian also suggested

that the researcher create more attractive pages with animation and graphics.

Consequently, animation was added to the title page and graphics were added to the road maps

The first Japanese math teacher (math teacher A) has been teaching at a junior high school for more than 20 years. Using the Japanese translation of the evaluation form (see Appendix A for the form), and working through Netscape Navigator, he evaluated both the Japanese and the bilingual versions of the program. His overall reaction to the programs was favorable. However, he did point out the following usability problems:

Japanese version:

1. The explanation of the rules of the game should be translated into Japanese.
2. The rules should clearly state that only integers and fractions such as "2/3" are permitted as answers.
3. A character in the popup window, which indicates the checkpoint, was missing.
4. The directions for the road map were ambiguous.

Bilingual version:

1. Some of the Japanese text overlapped the English text on the first page of the rally.
2. The explanations of the rules found in the popup windows were missing certain words.

Each of these problems was corrected immediately. On the evaluation form, teacher A assigned a grade of two (good) to four of the ten questions, and a grade of one (excellent) to each of the remaining six questions.

Math teacher B also teaches at a junior high school. For the purposes of this evaluation he used Internet Explorer 4.0. When evaluating the bilingual version of the game he found the following usability problems:

1. There should be more frequent confirmation of correct answers.
2. Although he did what he thought was required to play the game correctly, he received no message confirming his success.
3. In his opinion, there should be more detailed messages at the end of the game, in addition to the total score, informing the user how and why the score was reduced.

Unfortunately, as teacher B returned his evaluation form late, the problems listed above were not corrected. Teacher B's answers to the questions on the evaluation form were similar to those of teacher A with the exception of two unanswered items on his form.

The computer education specialist recently earned a doctoral degree in computer education. When she evaluated the English version, she found the following usability problems:

1. There were Japanese characters in the "Math Terms" section.
2. The navigation buttons were inconsistent.

The first problem was fixed; however, the navigation buttons were difficult to change as FrontPage provides them as a default. The only alternative would have been to reprogram so as to create new buttons. As a result, this problem has not yet been resolved. The evaluator felt that the overall page looked “great.”

The next evaluator was a bilingual freshman at Keio University who had studied AP-Calculus while at Keio Academy in New York. He evaluated the English version. However, despite his familiarity with the English language, he was unable to answer all of the questions on the evaluation form due to the technical terminology. The evaluator did not find any usability problems. He did mention, however, that while this program is suitable for students like himself, who are good at math, it might not be appropriate for students who are either novices or not particularly good at math.

The sixth evaluator was a bilingual ninth grader who had not yet studied factoring or quadratic equations. He evaluated the stand-alone game in the preliminary study. As the student played the game, the researcher observed his actions. Although familiar with computer games, he had difficulty using the navigation buttons in the tutorial parts of the program. There are two kinds of navigation buttons. The first, the “next” button, is used to link to pages on the same structural level as the current page. The other button is used to jump one level below the current page in the tree diagram. When the user needs more information about what he is learning, he must click this button. It was necessary to explain to the evaluator how to navigate using the buttons. He also had some trouble with content at one point, as he had not yet studied factoring. He continued on and had no problem with the rest of the program.

During the summative evaluation, the Keio students who used the program also found some usability problems, most of which were found in the formative evaluations. Problems that were not uncovered in the formative evaluations were as follows:

1. There were two mathematical errors: $(x+3)^2$ should be $(x+6)^2$ and $x^2 - x + 12$ should be $x^2 - x - 12$.
2. When students used the English version of the game on a Japanese Windows 95 platform, the math symbols \pm and 2 were displayed incorrectly on the screen.
3. One of the links in the Japanese version was occasionally broken.

With the exception of the broken link, for which the cause is unknown, the problems detailed above were corrected.

Summative Evaluation

The students' performances on the pretests and posttests in mathematics and English were compared and the bilingual version was found to be the best of the three programs for the acquisition of English mathematical terms. There was, however, no significant difference in students' performances in mathematics regardless of which of the three programs they used. The detailed data is shown in Tables 7 to 11.

Table 7

Mean Scores (Standard Deviation) of Pre-test, Post-test, and Gain Scores in English Performance

Program (No. of data)	pretest	posttest	difference
Japanese (70)	2.186 (2.235)	4.700 (3.887)	2.5143 (2.9179)
Bilingual (70)	1.900 (2.247)	7.600 (4.695)	5.7000 (4.1296)
English (66)	2.121 (2.563)	4.364 (3.623)	2.2424 (2.6080)
Total (206)	2.068 (2.341)	5.578 (4.336)	3.5097 (3.6409)

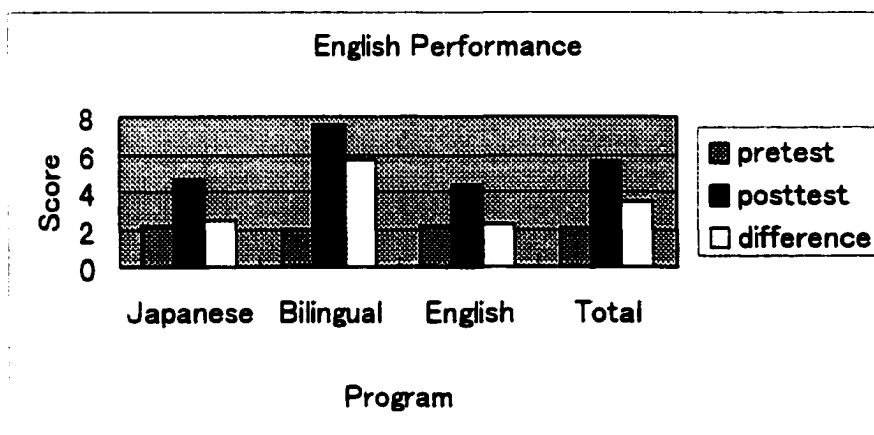


Figure 3. The mean English scores for the pretest and the posttest for the Japanese, bilingual, and English programs.

The significant interaction revealed by the MANOVA procedure ($F=5.47, p<.005$) indicates that the method of instruction (the Japanese, the bilingual or the English version) had an effect on the students' performances on the English posttest (see Table 7 for cell means; see Table 8 for the MANOVA results).

Table 8

MANOVA Summary Table for English Tests and Methods

Source of Variation	DF	SS	MS	F
Between-Subjects				
Methods	2	185.03	92.52	5.47*
Error (Between)	203	3433.54	16.91	
Within-Subject				
Tests	1	1250.41	1250.41	230.10**
Methods X Tests	2	255.59	127.79	23.52**
Error (Within)	203	1103.15	5.43	

* $p < .005$, ** $p < .001$

After the means of the gain scores (posttest-pretest) for all three versions were calculated, the Tukey test was used to determine which of the contrasts of the means were significant. The results of the test demonstrated that there was a significant difference between the bilingual version and two other programs at the .05 level (see Appendix L for the printout of the Tukey test of English performance). There was no significant difference between the English version and the Japanese version. Therefore, of the three programs utilized in this study, the bilingual version was the most effective for teaching English mathematics terminology.

Table 9

Mean Math Scores (Standard Deviation) for Pretest, Posttest, and Differences Between the Three Programs.

Program (No. of data)	pretest	posttest	difference
Japanese (70)	1.886 (3.352)	7.929 (2.463)	6.0429 (3.1551)
Bilingual (70)	1.429 (2.831)	6.843 (3.183)	5.4143 (3.2325)
English (66)	2.197 (3.470)	7.470 (2.713)	5.2727 (3.3029)
Total (206)	1.830 (3.224)	7.413 (2.827)	5.5825 (3.2310)

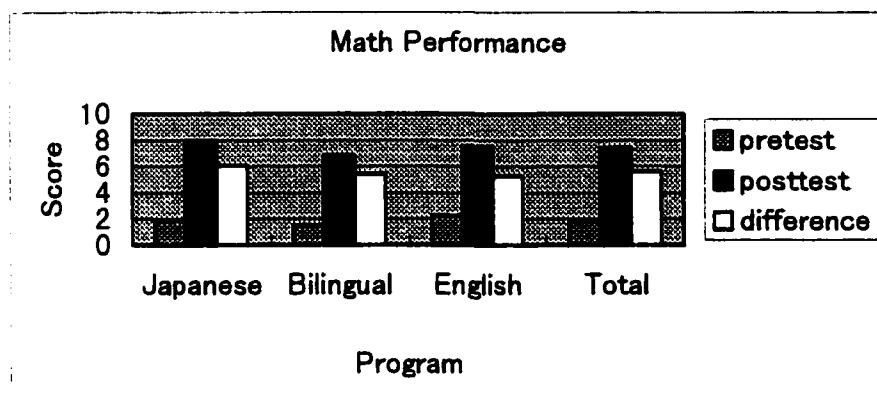


Figure 4. The average math scores for the pretest and the posttest for the Japanese, bilingual, and English programs.

All three programs significantly improved the students' performances in both math and English at the .001 level (see Tables 8 and 10 for the MANOVA results). However, the repeated measures analysis indicated that the version of the program had no effect ($F=1.93$, $p < .148$) on the performances in math (see Table 9 for cell means; see Table 10 for MANOVA results). The results of the Tukey test on the gain scores also showed that

there was no significant difference among the programs at the .05 level (see Appendix M for the printout of the Tukey test of math performance).

Table 10

MANOVA Summary Table for Math Tests and Methods.

Source of Variation	DF	SS	MS	F
Between-Subjects				
Methods	2	50.38	25.19	1.93
Error (Between)	203	2648.55	13.05	
Within-Subject				
Tests	1	3200.71	3200.71	613.85*
Methods X Tests	2	11.57	5.79	1.11
Error (Within)	203	1058.47	5.21	

* $p < .001$

The results of the MANCOVA procedure for the two dependent variables (the math and English posttests) and the two covariates (the math and English pretests) confirmed these findings. Once again, there was no significant difference between the students' math performance scores for the three versions while the bilingual program was determined to be the best among the three for teaching English math terminology (see Appendix N for the printout of the MANCOVA). The adjusted means of the performances in math and English are shown in Table 11.

Table 11

Adjusted Means (Observed Means) of Performances in Math and English

	Japanese	Bilingual	English
English	4.57858 (4.70000)	7.77073 (7.60000)	4.31433 (4.36364)
Math	7.87877 (7.92857)	7.02155 (6.84286)	7.34081 (7.46970)

The Instructional Materials Motivation Survey (IMMS), developed by Dr. John Keller of Florida State University, was used to compare student motivation for the three programs. The IMMS investigates motivation based on the ARCS Model (Keller, 1987a, 1987b) which consists of four measures (attention, confidence, relevance, and satisfaction). The four measures are scored from one (low motivation), to five (high motivation). The IMMS was translated into Japanese by the researcher.

Table 12

Mean Scores (Standard Deviation) for IMMS

Program (No. of data)	Attention	Confidence	Relevance	Satisfaction
Japanese (70)	2.799 (.627)	3.035 (.637)	2.643 (.558)	2.724 (.821)
Bilingual (64)	2.311 (.769)	2.637 (.774)	2.554 (.688)	2.349 (.904)
English (66)	2.505 (.734)	2.677 (.658)	2.591 (.642)	2.399 (.844)
Total (200)	2.546 (.735)	2.789 (.710)	2.597 (.627)	2.497 (.868)

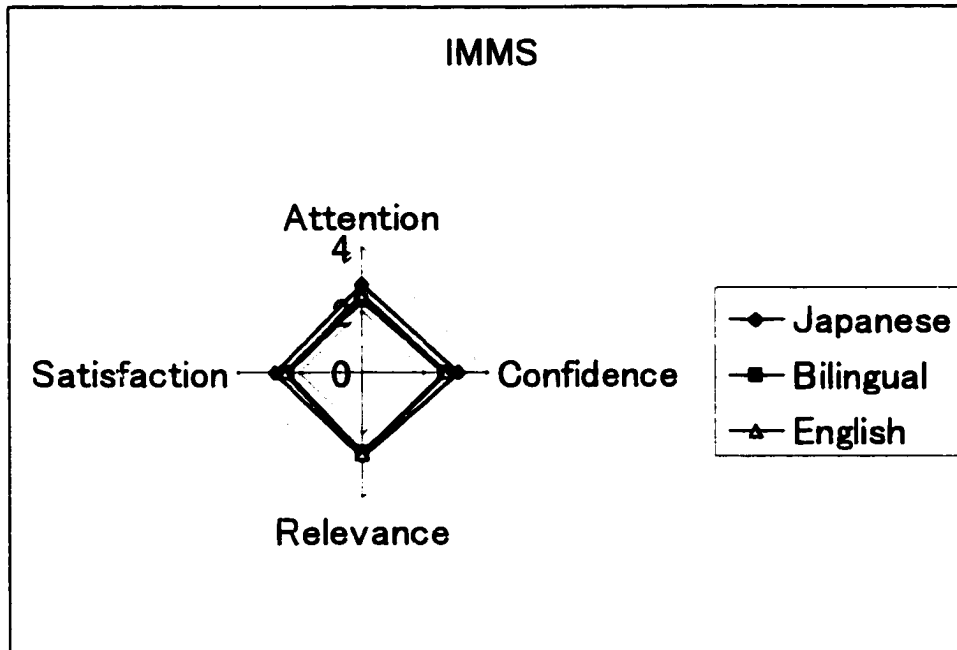


Figure 5. The average IMMS scores for attention, confidence, relevance and satisfaction in the three programs.

Pairwise multivariate tests were conducted using the SPSSX DISCRIMINANT program (Stevens, 1996, pp199-202) to perform multiple comparisons among the three versions (see Appendix O for pairwise multivariate tests). There was a significant difference between the Japanese program and the other programs at the .01 level but no significant difference between the bilingual and the English programs. There was a significant difference between the Japanese version and the bilingual version in both attention and confidence at the .01 level, and in satisfaction at the .05 level, but no significant difference in relevance between the two programs. There was a significant difference between the Japanese version and the English version in confidence at the .01 level, significant differences between them in attention and satisfaction at the .05 level, and no significant differences in relevance (see Table 12 for the average IMMS scores; see Table 13 for the t-values of the comparisons).

Table 13

t-values Between Japanese Version and Other Versions.

Pairwise comparison	Attention	Confidence	Relevance	Satisfaction
Japanese vs. Bilingual	4.01**	3.26**	.83	2.52*
Japanese vs. English	2.51*	3.23**	.50	2.28*

* $p < 0.05$, ** $p < 0.01$

Table 14

Mean Scores (Standard Deviations) on Usability Questionnaire for Ten Items in the Three Programs

Questionnaire items	Japanese	Bilingual	English
1. Does this program keep you informed about what is going on?	3.346 (1.064)	3.698 (1.059)	3.558 (.854)
2. Is the information in this program expressed in natural rather than technical terms?	2.846 (.978)	3.326 (1.149)	3.070 (1.055)
3. Do you have control and freedom?	2.404 (1.071)	2.628 (1.291)	2.860 (1.187)
4. Is this program consistent? Does it hold to internal standards?	2.558 (.958)	2.674 (.919)	2.721 (.854)
5. Is this program proof against errors?	2.635 (.929)	2.372 (1.047)	2.465 (1.099)
6. Does user have to memorize information in order to use this program or are the instructions clear and accessible?	2.346 (1.136)	2.930 (1.387)	3.047 (1.362)
7. Does this program cater to both novice and experienced users?	2.500 (1.163)	2.512 (1.077)	2.581 (.879)
8. Does this program have an aesthetic and minimalist design?	2.269 (.992)	2.186 (1.052)	2.465 (1.008)
9. Are this program's error messages understandable?	3.058 (1.145)	3.419 (1.159)	3.488 (1.055)
10. Are this program's help and documentation necessary?	2.885 (1.263)	3.140 (1.167)	3.721 (1.202)

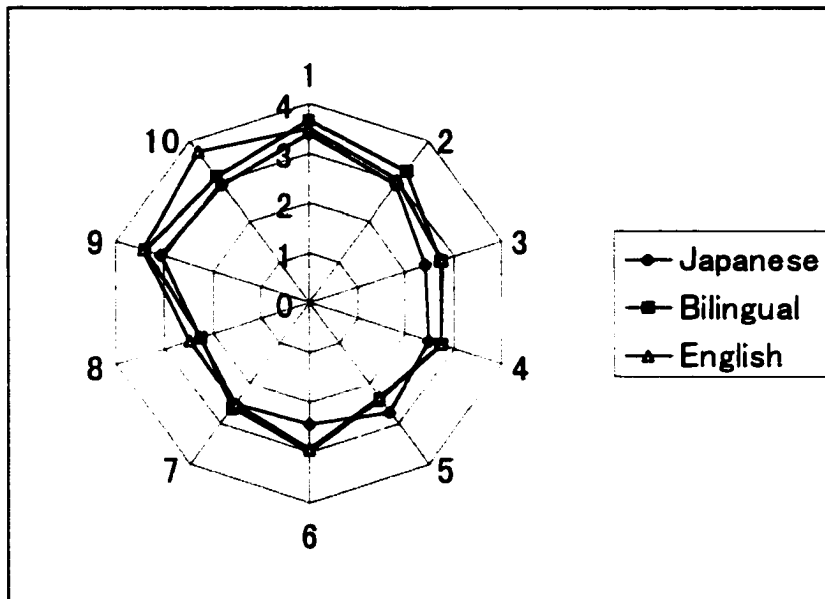


Figure 6. The average usability scores for the three programs as recorded on the questionnaire.

To evaluate the usability of this program, students were asked to fill out questionnaires (see Appendix A for the questionnaire) scored from 1 (good usability) to 5 (poor usability). The results are shown in Table 14. The results of the pairwise multivariate test indicate that there were no significant differences between any of the pairs (program versions). F statistics and significance between the pairs are in Table 15.

Table 15

Pairwise Test on Usability Questionnaire for Ten Items in the Three Programs

Pair of groups	Value of F	Significance
Japanese vs. Bilingual	1.2639	.2579
Japanese vs. English	1.6182	.1086
Bilingual vs. English	.8777	.5559

Note. Each F statistic has 10 and 126 degrees of freedom.

The results of the t-test for each item indicate that there were some significant differences between the mean scores for the three versions.

- In item 2, the contrast between the Japanese and the bilingual versions was significant at the .05 level ($p < .030$).
- In item 6, the contrast between the Japanese and the bilingual versions was significant at the .05 level ($p < .026$). The contrast between the Japanese and the English versions was significant at the .01 level ($p < .007$).
- In item 10, the contrast between the Japanese and the English versions was significant at the .01 level ($p < .001$) and the contrast between the bilingual version and the English version was also significant at the .05 level ($p < .025$).

Comments about the Japanese version were roughly divided into three types: favorable comments, comments which pointed out problems and comments which suggested improvements to the program (see Appendix R for translations of the student's comments). Some students said that quadratic equations could be effectively learned by using this program. Their comments indicated that the program was not only easy to understand but helped the student to learn quadratic equations in an entertaining atmosphere. A number of students said that they enjoyed using computers in class. Others said that they had not expected to gain knowledge so effortlessly. There were also a couple of comments that indicated the students' interest in the calculation rally.

Some students wanted more detailed explanations of the contents and the operations of the program. Other students mentioned problems which made it difficult to

understand the contents of the program. There were a couple of comments that suggested that there should be a greater number of exercises.

One student pointed out that there was a gap between the easy and difficult sections of the game, saying that the latter part of the rally was especially difficult. Others suggested that the order of presentation was important. There were comments pointing out that students who are not accustomed to using personal computers might be at a disadvantage. Based on the comments about the program, it appears that the Japanese version was generally well accepted.

Comments about the bilingual versions were similar to those for the Japanese version. A number of comments focused on the screen display. Other students made comments about the well-explained content. The class seemed to be interesting for the students. There were some students who indicated that they enjoy using computers in the classroom. Some students liked the calculation rally itself. There were students who said that the program was worth doing even though there were a few problems.

The students encountered problems with the operational aspects of the program. As with the Japanese version there were some comments that the program was difficult to use. There were also students who complained about the button link. There was dissatisfaction with the level of feedback, and were some problems with the layout of the pages. In particular, students pointed out difficulties with the display of Japanese text. There were students who felt that the English was a barrier to learning quadratic equations. As with the Japanese version, there were students who pointed out problems with the questionnaire itself.

There were negative comments regarding the interest level of the program. There were students who thought that an ordinary class would be better. Some students noted that the problems in the calculation rally suddenly became more difficult. There were students who thought that it would have been better to use more multimedia rather than text-based explanations. While there were comments suggesting that there were too many explanatory notes, some felt that the explanations were incomplete. There were also students who said that the class time was inadequate. Finally, there were students who pointed out the necessity of some learning preparation before studying with the computer.

There were more negative comments about the English version than there were about the other two versions. Overall, the students felt that it was difficult. Some students suggested that more explanations be given. The additional problem of learning mathematics through the English language seems to have made the students feel that this program is difficult to use. There were also a few students who claimed that learning English and mathematics at the same time was difficult. There were a number of students who were dissatisfied with the English version and who preferred the ordinary class. It was easier for the students to learn math in Japanese.

There were mixed reflections on this program. One student wrote: "I have enjoyed the program. Although it was difficult, I could understand it because I studied with great effort." Another student said that while the English was difficult, he was able to enjoy the program. Finally, although they were in the minority, there were some favorable comments on the English version (see Appendix R for translations of the student's comments).

Findings

Formative Evaluation

The overall evaluation was favorable, but minor usability problems were found. Although some of them were fixed, others were difficult to change because they originated with the Web editor's templates. The evaluation was mainly carried out with the use of the questionnaire and its translated version. This questionnaire needs improvement because some of the questions are difficult to answer.

Summative Evaluation

All three versions were evaluated in terms of the students' learning of English mathematical terms as demonstrated by their performances on the English test. Of the three, the bilingual version was the most effective for teaching English mathematics terminology. No statistically significant difference was found on the performance measure for mathematics when the three programs were compared. Therefore, the bilingual version is the best version of the program for learning both mathematics and English mathematics terminology.

When motivation measures of the three programs were compared through the use of the IMMS, the Japanese version scored highest. There were no significant differences in motivation between the bilingual and English versions.

There were no significant differences among the three in terms of usability except that the Japanese version was better for its help function and clear explanations of the tutorial. The students' comments support these findings. They seem to have liked the programs in the following order: 1. The Japanese version, 2. The bilingual version, and 3.

The English version. They had difficulty learning mathematics with the English only program and required extra help in order to properly play the game.

Summary

The formative evaluation was conducted by six people whose overall impressions were favorable. There were no serious usability problems found. Although some minor problems were fixed, other problems, which were caused by the Web editor's templates, were too difficult to fix.

The summative evaluation was performed by 235 Japanese junior high school students who had learned factoring and square roots. They were divided into 10 groups and randomly assigned into three treatment groups: the Japanese version, the bilingual version and the English version. They took pretests and posttests in math and English terminology. After an approximately one hour computer class session, they filled out the IMMS and the questionnaire for usability testing. The groups using the bilingual program showed significantly better English test scores when compared with those of other groups. There were no significant differences among the groups' performances in mathematics. Based on the results of the IMMS, in terms of motivation, the Japanese version was judged to have performed better than the others. Although the Japanese version seemed to be slightly better than the others for usability, there was no statistically significant difference among the three programs.

Chapter V

Conclusion, Implications, Recommendations and Summary

Conclusion

This study focused on the development of a bilingual cross-culture Web-based instructional program intended to help Japanese students learn both English and mathematics. During the design process, six basic research questions were addressed:

1. How should different languages be arranged on the screen?
2. What kinds of browsers are necessary to display instructional mathematics programs?
3. What kinds of colors or icons are appropriate for different cultures?
4. What kinds of desktop environments and authoring systems are suitable for developing bilingual instructional programs?
5. How effective are bilingual pages for teaching both English and mathematics?
6. What are the guidelines for building a bilingual instructional program?

Of these six, the last two are of greatest importance.

Arrangement of languages

The bilingual program utilized a stacked document format. The translated text (Japanese) was hidden so that the users would not feel that the screen was cluttered. This was obviously a good choice as some students felt that there was too much information on the screen with only one language displayed. One problem with this method is the difficulty in arranging the two languages in the correct locations on the page so neither obscures the other when both are displayed. In some places in this program, the Japanese text overlapped the English text.

Browsers

As was mentioned in Chapter III, the target browsers were Microsoft Internet Explorer (above ver. 4.0) and Netscape Navigator (above ver. 4.0) because of their popularity and the ready availability of DHTML. There were some difficulties with the proper display of mathematical symbols such as the square root, " $\sqrt{\quad}$." Fortunately, only a few mathematical symbols were used in the study. As MathML becomes more easily available on the browsers, such problems will disappear.

Colors and icons

Choosing colors and icons that would be culturally acceptable to both speakers of English and speakers of Japanese presented a challenge. Microsoft provides templates for FrontPage, including one with a school theme. Although Microsoft does offer a Japanese version of this template, the two are virtually identical. Some students liked the resulting pages which featured an apple icon. One of the formative evaluators pointed out that while the apple symbolizes school in the United States, there is no connection between apples

and school in Japan. Ideally, the Japanese version of the program should use icons which represent school in the Japanese culture. Using a blackboard as a symbol, for example, would have been better as it is recognized by both cultures. Templates have many advantages, including the ability to create consistent pages with ease. Unfortunately, they do not allow for much flexibility.

Desktop environments and authoring systems for bilingual instructional programs

The program was originally developed in an English language environment using the American version of FrontPage in Windows 95. It was later exported to a Japanese language environment. This method of developing bilingual software is preferable to doing it in reverse because English characters are easily displayed in Japanese Windows 95. Although the English version was edited in Japanese Windows 95, it was later implemented in English Windows 95 because English and Japanese fonts are different. For example, the Japanese character “²” (superscript 2) is assigned a different English character. Therefore the English pages had to be tested in English Windows 95. Microsoft Internet Explorer 5.0 makes this situation easier to deal with because it enables the user to input and display Japanese characters in English Windows 95.

There are both positive and negative aspects to utilizing FrontPage for projects such as this. On the positive side, FrontPage provides a navigation view that allows easy reconfiguration of the Web page tree structure as well as various theme templates that enable the user to create consistent pages. On the negative side, FrontPage is inflexible. If the user inputs HTML source codes that are not compatible with FrontPage, they are automatically erased. FrontPage also has some features in its templates that do not

conform to common usage. For example, one of the formative evaluators pointed out that the default navigation buttons and link buttons in FrontPage are unusual. Web page designers might prefer to insert their own buttons or change buttons in order to make the page more usable. One way to modify the inflexibility of FrontPage is to use it first to build structured and consistent pages, and then fix or change the pages with the use of other editors such as Dreamweaver.

Effectiveness of the bilingual instructional program

The bilingual instructional program was proved to be effective for learning both English and mathematics. The results of the mathematics test indicated that learning mathematics with the bilingual program, as opposed to the Japanese program, did not put the students to any disadvantage while the students who used the bilingual program scored highest on the English test. Thus, embedding the English mathematics terminology in the mathematical content, i.e., teaching language in context, resulted in a good performance in both subject areas. What is more, when the students' answer sheets were examined, it was discovered that even the Japanese-only program helped students to acquire English mathematics terms by encouraging them to use their knowledge of mathematics to guess the meanings of the English terms on the test. However, the English-only program was not as effective for teaching English mathematical terms, even with the use of an English-Japanese dictionary, because mathematics terms are not usually the first definitions given in a dictionary.

In regard to motivation and usability, it is difficult to build a bilingual program of good quality because the students prefer their native language. It is also true that arranging

one language on the screen is easier than arranging two. The last problem, that of unifying two different cultures on one Web page, is perhaps the most difficult to overcome.

Guidelines

The general guidelines for building Web pages were discussed in Chapters II and III. However, this study has generated some guidelines specifically for bilingual courseware. There are three areas to be considered: translation, supporting tools, and choice of tools.

This study has shown that students require more time to learn when using bilingual rather than monolingual courseware (the Japanese version) and that bilingual pages require more space. In other words, bilingual pages should be extremely simple and the text should be as brief as possible.

- Split up long information into multiple pages by using hypertext (Nielsen, 1997).
- One page should not contain too many words.
- Write no more than 50% of what might be written as hardcopy (Nielsen, 1997).

It is not necessary to translate all the text on a page. In this particular program, only certain elements of the pages were translated. Furthermore, it is necessary to present some of the text, particularly that which is essential to the operation of the program, in the users' native language. For example, the "help" function, the explanations of the

program's operations, and the rules of the game, should all be written in detail in the users' native language.

The Java programming source codes should not include the text to be translated. Otherwise, each time the programmer changes the translation, the source codes must be recompiled. Finally, the evaluation instruments should be well translated.

Use every possible means available to support students as they learn the material. Multimedia is particularly useful in motivating K-12 students. Many students wanted to see more animation and graphics in the program. Content readiness is also important for bilingual pages. Some students preferred to learn the mathematics content in their native language before studying the English vocabulary.

Effective usage of HTML is another key point in building better courseware. Extended HTML should be used as follows:

- To create consistent attractive pages by using CSS (Hacker, 1998).
- To create more dynamic and interactive pages by using DHTML (Hacker, 1998).

Using HTML tags or gif files to display mathematics symbols is better than using local language symbol codes. Some of the problems in the bilingual program came from the symbol codes which display symbols differently on different operation systems.

Choosing suitable tools for building bilingual courseware is also very important. There are three kinds of program languages on the Web: HTML, Javascript, and Java. The programmer should choose the language that is most suitable for his program. Recent Java

Development Kits (JDK) include features essential for internationalization. Taking advantage of such features will result in better bilingual courseware. Choosing the correct HTML editor is also important (Hacker, 1998).

As was stated earlier, the use of FrontPage's template and navigation tools simplified the task of building the pages at the cost of flexibility. In this study the emphasis was placed on the effectiveness of learning mathematics and English simultaneously rather than on usability and motivation. Therefore, some usability was sacrificed. In order to build more usable pages, some parts of the template, such as navigation buttons, should not be used. However, foregoing the use of the FrontPage server extensions would have made its many useful features unavailable.

In this study, the researcher used machine translators (MTs). Although MTs alone are insufficient for building usable bilingual courseware, they proved useful as supplementary tools. The English to Japanese translator is better than the Japanese to English translator because the subject is usually omitted in the Japanese language. In terms of MT use, building the English pages first and then translating them into Japanese is better than the reverse.

Implications

A number of Japanese graduates from the Keio Academy in New York have said that after being taught an English mathematics curriculum for a long time, even very simple Japanese mathematics terminology can later become a barrier to the successful study of mathematics at Keio University. This is also true for foreign students who are

studying in Japan. For those students the program developed in this study will be a valuable resource. The reverse is also true. In the United States, there are many Japanese immigrants and students who were taught mathematics in Japanese when they were young. For them, English mathematical terms are completely new and difficult to understand. Ginbayashi and Ginbayashi (1999) mention that Japanese often cannot find the definitions of the most basic English mathematics terms which are usually taught in elementary and middle schools. In most countries these terms are studied at compulsory schools, are internalized at an early age, and become a matter of common sense. It is unusual to find explanations of such terms as they are unnecessary for the local residents.

One anticipated short-term benefit of the development of this courseware will be improvement in both the English vocabulary and mathematics calculation skills of the students involved in the study. Because the study of language is best accomplished through context, the students who master the mathematical content may at the same time increase their understanding of the English mathematics terminology. Those students who already understand the concepts may still derive benefits from this courseware, as it may help them learn English and improve their retention of English vocabulary. The reverse might also be true. Students who do not do well in mathematics but do well in English may be motivated by this kind of interdisciplinary courseware.

By answering some of the questions about interaction between language and mathematics education, this study, as a long-term benefit, will contribute to the field of interdisciplinary education. Furthermore, the bilingual courseware in this study has the potential to serve a larger population than most educational software, as students from

more than one country can utilize it. This will help promote an international collaborative learning environment.

The last and most important implication of this study is the promise of the internationalization of educational resources which will be shared, via the Internet, not only within one country, but all over the world. In the business world many sites are multilingual and thus available internationally, but most educational resources are written in only one language and reflect the curriculum of only one country. At this point in time many of them are written in English. Therefore, most Japanese K-12 students cannot benefit from these materials. The researcher hopes that this study will promote the sharing of educational resources internationally and motivate Japanese students to learn practical English.

Recommendations for Further Studies

The requirements for bilingual courseware should be investigated in greater detail than has previously been the case. Which sections of the courseware text should be translated, and in which areas of a learning environment globalization should be applied, are both issues to be addressed. Although this study did not employ an integrated system such as CALAT to build bilingual courseware, the use of an integrated system in this context should be investigated further. At the beginning of the study, CALAT was scheduled to be used to build the instructional programs. The reasons why it was not used were as follows:

- The CALAT server at Keio Futsubu is Netscape. Netscape servers are not compatible with Internet Explorer, which was the only browser available in the computer room at the time. Netscape was later installed.
- CALAT requires high-speed transmission technology, such as the Asynchronous Transfer Mode (ATM), for optimal usage. After the Keio-NTT project was finished, that speed was no longer available.
- For this study, 48 computers required access to the server at the same time. The CALAT server might have slowed down, as it requires a large memory capacity.
- The quiz building tools available on CALAT are fully integrated with the other modules in CALAT and cannot be used independently without making extensive alterations to the program.

Although it was not used for this project, there are several advantages to using CALAT. For example, had CALAT been used, there would not have been as many navigation problems as were encountered in this study. The courseware would necessarily have been more adaptable to the needs of the students because CALAT is an intelligent tutorial system.

The following aspects of the tools and instruments for developing bilingual courseware should also be studied and improved:

- The reliability and validity of translated evaluation instruments.

- The usability of mathematics courseware developed after the standardization of MathML.
- The uses of Windows NT 5.0 or other international operation systems.
- Multimedia courseware.

The material included in this study was not particularly culture-oriented. Studies with more culture-oriented materials should be initiated. If problem solving rather than calculation skills had been chosen as the subject of the study, the courseware would have been more culture-oriented.

This study tested one type of bilingual documentation arrangement for Web pages. There are, however, other alternatives that should be investigated. Document arrangement is very important, because it is difficult to arrange other languages together with a native language.

There are three levels of implementing interaction on Web-based courseware: a) level one interaction between learner and content, b) level two interaction between learner and instructor, and c) level three interaction among other learners. In this study, only the level one interaction was implemented. Future studies should investigate the other levels of interaction.

Collaborative learning is especially important in educational courseware and should also be investigated. The original calculation rally was a pencil-and-paper game which allowed teams of students to compete with each other. Thus, there was collaborative learning among team members. In this computer game however, teams were not organized.

A comparison of collaborative learning with individual learning and how to implement collaboration in bilingual courseware are both issues that should be studied in the future.

In this study the bilingual courseware was mainly written in English and was only partially translated. Therefore, the students were required to have some knowledge of English. The program could also have been written mainly in Japanese and partially translated into English for students who have less knowledge of English. This kind of courseware might be more suitable for Japanese students. The bilingual program generated less motivation for attention, confidence, and satisfaction as compared with the Japanese program. One of the reasons might have been that the bilingual program is English-oriented. Further research should investigate this point. Also, in order to improve motivation, the courseware should have had links to English language Web sites related to quadratic equations to allow the students to apply their knowledge of English.

The last, and one of the most important recommendations generated by this study, is improvement of evaluation. The formative heuristic evaluation for this study should have been conducted more thoroughly. For example, severity ratings could have been conducted after locating usability problems. Because the students were already familiar with the game, they didn't have too much difficulty playing it. A person with no previous experience with the game might not have understood it as readily. In that case, more usable game programming would have been required.

The evaluation process could also have been improved by changing the types of questions on the tests. The achievement tests for both the mathematics and the English mathematics terms were constructed response problems. It would have been better to

make them multiple choice problems so that the correct and incorrect answers would have been more clearly defined.

The IMMS was originally written in English and targeted evaluators older than the junior high school students who were the summative evaluators in this study. The validity and reliability of the translated IMMS should be improved. Determining precisely how to do that will require further research.

Post Study

In this study the instructional computer program was not compared with face-to-face teaching because it is rare to find a situation wherein bilingual instruction is given in a mathematics class. However, a post study was conducted in an attempt to answer two of the research questions generated by the original study:

- Does the courseware developed in this study motivate the students more than an ordinary face-to-face class?
- Can the students retain English mathematics terms without any further English instruction?

Three months after the courseware study was conducted, the students were taught quadratic equations in Japanese with the use of a Japanese mathematics textbook. After teaching the material for more than three hours in total, the same performance tests and IMMS survey were administered. As the data below indicates, a great deal of the English terminology originally acquired was forgotten in three months time (see Table 16).

Table 16

Mean English Scores on Pretest and Two Posttests

	Pretest	Posttest 1	Posttest 2
Japanese	2.118	4.662	4.235
Bilingual	1.9	7.6	4.857
English	2.154	4.4	4.646

Note. Posttest 1 is the posttest given immediately after the computer instruction and Posttest 2 is the posttest administered three months later.

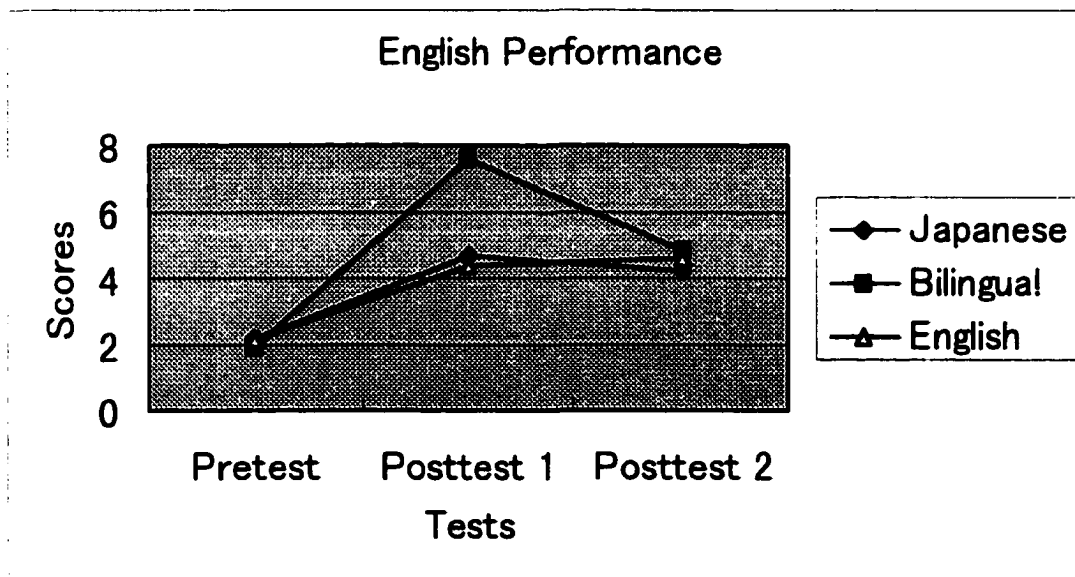


Figure 7. Average English scores for the pretest and the two posttests.

Many of the English mathematics terms, which the students acquired by using the bilingual program, were forgotten three months later. Nevertheless, they still remembered more English terminology than did the students in the other two groups, although not at a significant level. The students who used the Japanese or the English program maintained the same level of retention documented in the first posttest. It is possible that learning

English within the context of the mathematics lesson helped them maintain that level of retention. As regards the students' performance in mathematics, there was no significant difference between the three programs (see Table 17).

Table 17

Mean Mathematics Scores on Pretest and Two Posttests

	Pretest	Posttest 1	Posttest 2
Japanese	1.941	7.985	9.853
Bilingual	1.429	6.843	9.686
English	2.215	7.508	9.815

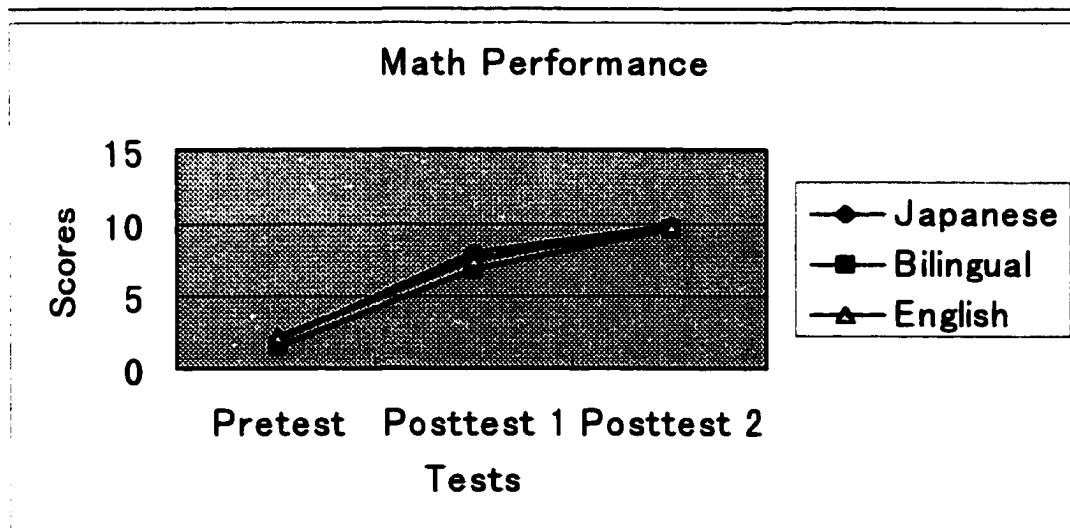


Figure 8. Mean mathematics scores for the pretest and the posttests.

A multivariate matched pairs analysis (Stevens, 1996, p.469-472) was conducted in order to compare computer and face-to-face instruction in terms of the IMMS (see Table 18). There were significant differences between them at the .01 level in confidence, relevance, and satisfaction. While the computer programs were superior to face-to-face

instruction for relevance and satisfaction, the face-to-face instruction scored better than the computer programs for confidence. The reason why the face-to-face instruction is better for confidence might be that the students had some additional exposure to the subject three months after the original computer tutorial sessions.

Table 18

Mean Differences between Face-to-Face Instruction and Computer Instruction on IMMS

	Mean difference (Face-to-face) – (Computer)	Standard deviation
Attention	.007	.649
Confidence	.393*	.771
Relevance	-.213*	.684
Satisfaction	-.370*	.864
Total	-.014	.500

* $p < 0.01$

The data generated by the second posttest indicates that teaching English mathematics terminology within the context of mathematics instruction may help maintain the retention of those terms, and that computer instruction may be a better motivator than an ordinary face-to-face class. Further research should be conducted to verify these results.

Attention should also be paid to the question of how to improve the reliability of the translated IMMS. In the original study the students complained that the first, literal, translation of the IMMS was written in “strange” Japanese. The IMMS was then altered,

by omitting some subjects of sentences, to make it read more like natural Japanese. The expectation was that the new version of the IMMS would have a higher reliability. That expectation, however, was not supported by the data (see Table 19).

Table 19

Cronbach's Coefficient Alphas of the First and the New Version of the Translated IMMS

	Attention	Confidence	Relevance	Satisfaction	Total
The first version (n=203)	0.821089	0.72738	0.704764	0.816505	0.908168
The new version (n=216)	0.741773	0.687148	0.62684	0.774755	0.854298

There are possibly many reasons why the newer version had a lower reliability. One of them may be the fact that English is a more precise language than Japanese is. Further research is required in this area.

Summary

Although the Internet has become very useful resource for K-12 education, students whose native language is not English cannot fully utilize its power because the Internet is English-oriented. In the United States, there are many students whose first language is not English and who need support in various areas. The National Council of Teachers of Mathematics recognizes this problem and has made an effort to improve mathematics education for second language students. Although many bilingual pages exist

on the Internet, very few address K-12 bilingual education. In this study, a bilingual Web-based instructional program designed to teach both English and mathematics, was implemented in the Keio school system and the effectiveness and usability of the bilingual program were explored.

The Keio high school system includes a number of brother and sister schools. Among them, the Keio Academy of New York has had the most extensive problems with bilingual education. One of the primary motivations for this study was the situation at the Keio Academy. The CALAT project developed by Keio and NTT provided remotely separated schools with identical learning environments, and created opportunities to investigate and solve these problems.

This study has addressed a number of interesting points. Although there have been a number of studies dealing with the internationalization of offline software, few have been done on the international usability of on-line courseware. Furthermore, while distance education for K-12 students has become increasingly popular, most of the courseware has been limited to individual countries (mainly English-speaking countries) and to the university level. It is difficult to find on-line international instructional programs at the high school level. While there have been numerous studies done on CAI and its effect on mathematics performance, few developmental studies have been done. This study has also contributed valuable information on the development of mathematics CAI that includes instructional gaming on the Web. The last and most significant point of this study was to support the theory that the inclusion of some primary academic instruction (in this case,

mathematics) in the student's native language in a second language program as well as language-across-the-curriculum instruction is more effective than monolingual instruction.

There are some issues and barriers to success in building effective bilingual instructional programs. Choosing suitable authoring tools is always a problem. Although many good course management systems such as TopClass, CALAT and so on are available, it is not always true that those systems are also suitable for building bilingual programs. The existence of many languages is another issue to be considered. Although collaboration is one of the most important and difficult factors in studying mathematics, language barriers present an additional problem.

According to Nielsen (1996a), there are three levels of globalization concerns. Merely displaying the user's native language, character set, and notation (the first level) is not enough. For example, time zones, currencies, icons on computer screens, social conventions and so on should be considered as well as translation. The process of translation itself creates additional difficulties. When the pages are designed, which languages should be used first? Which parts of the text should be translated for the purpose of learning the language? How should the original text and the translated language be arranged on the screen? Those questions should be answered before designing bilingual pages.

In order to build the Web-based bilingual instructional program, the researcher examined many current articles regarding the design of Web-based courseware; the main issues being simplicity; usable, well-organized interfaces; content, and evaluation. Much of the literature stressed the limitations placed on courseware design by Internet data transfer

speed. Because of this limitation, the courseware in this study was designed to be mainly text-based rather than a full implementation of multimedia. This study also attempted to implement a game that would motivate students' learning. Therefore, a summative evaluation for motivation was conducted.

The selection of authoring systems is very important for the developer of Web-based courseware. The researcher chose off-the-shelf component software instead of an integrated package, such as CALAT because of its flexibility. Microsoft FrontPage 98 and Dreamweaver were used as Web page editors.

The processes through which this study was developed are as follows. Based on the pencil-and-paper game developed previously by the author, the calculation rally was built, using C++, as a stand-alone program. This game was analyzed through the use of heuristic evaluation. The game sections of this study were then implemented with Microsoft J++. The tutorial parts of the program were developed by performing a task analysis of quadratic equations while referring to both Japanese and American textbooks, creating problems on note cards and arranging those cards as a tree structure. The tree structure was used to construct the Web pages on Microsoft FrontPage. At first English-only pages were implemented. Next, bilingual pages were constructed by using DHTML. After completing the bilingual pages, Japanese-only pages were implemented. When the English-only pages were created, the English Windows 95 was used as the OS. The other two pages were constructed on the Japanese Windows 95. After completing the three kinds of pages, a heuristic formative evaluation was conducted. After fixing minor problems that were uncovered in the formative evaluations, summative evaluations were

conducted. The formative evaluations were conducted by four adults and two students: an American librarian, two Japanese mathematics teachers, a computer education specialist, a former Keio Academy student, and a international high school student. The summative evaluators were 235 ninth grade students whose native language is Japanese and who are on a beginner's level in English. The summative evaluation examined the students' performances in English and mathematics, and their motivation levels.

Although most of the usability problems found by the formative evaluations were minor and easily fixed, one proved rather difficult. There are two kinds of navigation buttons: one is for linking the current page to other pages on the same level in the tree structure and the other takes the user one level below the current page. The users were confused as to which buttons should be pressed next. The summative evaluation indicated that the bilingual program was the best for acquisition of English mathematical terms and that there was no significant difference among the three kinds of programs for performance in mathematics. Although there were no significant differences among the programs in regard to motivation and usability, the Japanese-only program seems to have a slightly higher level of motivation and usability than the other two. On the whole, the bilingual program was the most effective for learning both English and mathematics.

In the future, problem-solving courseware should be promoted rather than programs that concentrate on acquisition of skill. This kind of program will require more in-depth consideration of international usability. What kinds of developmental tools are suitable for creating bilingual programs is another issue to be addressed. Although off-the-shelf component software was used in this study, an integrated program like CALAT

should be considered as a viable alternative. The original pencil-and-paper game focused on collaborative learning. However, in this study, this aspect of bilingual education was omitted and emphasis was placed on the performance differences between the programs. However, collaborative learning is important in educational courseware and should also be investigated. The effect of mathematical knowledge on the retention of English mathematical terms and the reliability of the translated evaluation instrument were discussed in the post study. Further research is required in these areas.

Appendix A
Questionnaires

Please put an "x" or a written answer next to each question and write comments, if any, about this program in the space provided at the end of this form.

About the user

1. Grade _____

2. Gender

_____Male _____Female

3. Modem speed

() bps

4. Are you familiar with Internet browsers?

Yes No

1 _____ 2 _____ 3 _____ 4 _____ 5 _____

5. Which browser did you use for this program?

_____Netscape _____Internet Explorer. Version ()

About This Program

1. Does this program keep you informed about what is going on?

always never
1 _____ 2 _____ 3 _____ 4 _____ 5 _____

2. Is the information in this program expressed in natural rather than technical terms?

natural and logical sometimes uses technical terms uses technical terms
1 _____ 2 _____ 3 _____ 4 _____ 5 _____

3. Do you have control and freedom?

able to exit, undo or redo whenever you want no control or freedom
1 _____ 2 _____ 3 _____ 4 _____ 5 _____

4. Is this program consistent? Does it hold to internal standards?

consistent and predictable some confusion unpredictable interface
 1 _____ 2 _____ 3 _____ 4 _____ 5

5. Is this program proof against errors?

errors prevented occasional errors many errors
 1 _____ 2 _____ 3 _____ 4 _____ 5

6. Does the user have to memorize information in order to use this program or are the instructions clear and accessible?

instructions clear and accessible need to memorize
 1 _____ 2 _____ 3 _____ 4 _____ 5

7. Does this program cater to both novice and experienced users?

suitable for both difficult for novice users awkward for experienced users
 1 _____ 2 _____ 3 _____ 4 _____ 5

8. Does this program have an aesthetic and minimalist design?

simple and aesthetic some information is irrelevant much irrelevant information
 1 _____ 2 _____ 3 _____ 4 _____ 5

9. Are this program's error messages understandable?

understandable difficult to understand error messages
 1 _____ 2 _____ 3 _____ 4 _____ 5

10. Are this program's help and documentation necessary?

unnecessary difficult to use the system without help and documentation
 1 _____ 2 _____ 3 _____ 4 _____ 5

Comments

各問について“x”マークをつけるか、隣に回答を書き込むかしてください。また、この用紙の終わりのスペースに何でもよいですからコメントを書いてください。

あなた自身について

1. 学年または年齢 _____

2. 性別

3. モデムのスピード

_____ 男 _____ 女

() bps

4. インターネットブラウザを使うのに慣れていますか？

はい

いいえ

1 _____ 2 _____ 3 _____ 4 _____ 5 _____

5. このプログラムを見るのにどちらのブラウザを使いましたか？

_____ Netscape _____ Internet Explorer バージョン()

このプログラムについて

1. このプログラムはあなたに今何が起きているのかを伝えていますか？

いつも伝えている

ぜんぜん伝えていない

1 _____ 2 _____ 3 _____ 4 _____ 5 _____

2. このプログラムの情報は技術用語より、日常の用語を使っていますか？

日常語を使う

時々技術用語を使う

技術用語を使う

1 _____ 2 _____ 3 _____ 4 _____ 5 _____

3. 自由にいろいろな操作ができますか？

好きな時終了したり、やり直したりできる

自由な操作が不能

1 _____ 2 _____ 3 _____ 4 _____ 5 _____

4. このプログラムは一貫性がありますか？内部的な標準を持っていますか？

一貫性があり予測可能

少し混乱している

予測不能な画面表示

1 _____ 2 _____ 3 _____ 4 _____ 5 _____

5. このプログラムは誤動作予防措置がしてありますか？

予防措置がある

時々誤動作がある

多くの誤動作がある

1 _____ 2 _____ 3 _____ 4 _____ 5 _____

Appendix B

Permission to Use IMMS

送信者: John Keller <jkeller@mailier.fsu.edu>

宛先: Hajime Hayakawa <hajime@kf.keio.ac.jp>

件名: Re: IMMS

日時: 1999年4月23日 11:57

Dear Hajime,

It is nice to hear from you and that you continue to be interested in the topic of motivation. I am happy to give you permission to use the IMMS with your students, and to translate it. However, there are several matters to consider in doing the translation to insure fidelity with the original concepts and reliability. Have you already designed a process for doing the translation? Would you be interested in collaborating on it and trying to publish the results in Japan. I can not, of course, speak or write Japanese, but I could assist you with designing the translation process and the activities to establish reliability. Please do not consider it to be an obligation to say yes. If you prefer to simply do your own translation and use the instrument in your study without the additional trouble of making it a formalized translation process, it is perfectly okay with me.

It occurs to me that I should check with my colleague, Professor Katsuaki Suzuki, to see if he knows whether someone has already done a translation. He and I began a project to translate the Course Interest Survey, which is similar instrument but for use in a classroom setting, but we didn't finish the project. He was at Tohoku Gakuin University in Sendai, but he is transitioning to a professorship at a new university in the Iwate region. His email address is: ksuzuki@soft.iwate-pu.ac.jp.

I have the good fortune to be coming to Japan for a few days in June. I haven't been there for three years and I am really looking forward to it.

Best wishes,

John Keller

We are all mortal until the first kiss or the second glass of wine.

--Eduardo Galeano

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Florida State University, Tallahassee, FL 32306
Phone: 850-644-8790 Fax: 850-644-8776

Home Office: John Keller Associates

6439 Count Turf Trail

Tallahassee, FL 32308-1911

Phone: 850-906-9986, Fax: 850-906-9989

Appendix C

IMMS

IMMS
Instructional Materials Motivation Survey

John M. Keller
Florida State University
307 Stone Building
Tallahassee, Florida 32306-3030

COPYRIGHTED MATERIAL

Contact author for permission and scoring
Information before using.

INSTRUCTIONS

1. There are 36 statements in this questionnaire. Please think about each statement in relation to the instructional materials you have just studied, and indicate how true it is. Give the answer that truly applies to you, and not what you would like to be true, or what you think others want to hear.
2. Think about each statement by itself and indicate how true it is. Do not be influenced by your answers to other statements.
3. Record your responses on the answer sheet that is provided, and follow any additional instructions that may be provided in regard to the answer sheet that is being used with this survey. Thank you.

1 (or A) = Not true

2 (or B) = Slightly true

3 (or C) = Moderately true

4 (or D) = Mostly true

5 (or E) = Very true

1. When I first looked at this lesson, I had the impression that it would be easy for me.
2. There was something interesting at the beginning of this lesson that got my attention.
3. This material was more difficult to understand than I would like for it to be.
4. After reading the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.
5. Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.
6. It is clear to me how the content of this material is related to things I already know.
7. Many of the pages had so much information that it was hard to pick out and remember the important points.
8. These materials are eye-catching.
9. There were stories, pictures, or examples that showed me how this material could be important to some people.
10. Completing this lesson successfully was important to me.
11. The quality of the writing helped to hold my attention.
12. This lesson is so abstract that it was hard to keep my attention on it.
13. As I worked on this lesson, I was confident that I could learn the content.
14. I enjoyed this lesson so much that I would like to know more about this topic.
15. The pages of this lesson look dry and unappealing.
16. The content of this material is relevant to my interests.
17. The way the information is arranged on the pages helped keep my attention.
18. There are explanations or examples of how people use the knowledge in this lesson.

- 1 (or A) = Not true
- 2 (or B) = Slightly true
- 3 (or C) = Moderately true
- 4 (or D) = Mostly true
- 5 (or E) = Very true

- 19. The exercises in this lesson were too difficult.
- 20. This lesson has things that stimulated my curiosity.
- 21. I really enjoyed studying this lesson.
- 22. The amount of repetition in this lesson caused me to get bored sometimes.
- 23. The content and style of writing in this lesson convey the impression that its content is worth knowing.
- 24. I learned some things that were surprising or unexpected.
- 25. After working on this lesson for awhile, I was confident that I would be able to pass a test on it.
- 26. This lesson was not relevant to my needs because I already knew most of it.
- 27. The wording of feedback after the exercises, or of other comments in this lesson, helped me feel rewarded for my effort.
- 28. The variety of reading passages, exercises, illustrations, etc. helped keep my attention on the lesson.
- 29. The style of writing is boring.
- 30. I could relate the content of this lesson to things I have seen, done, or thought about in my own life.
- 31. There are so many words on each page that it is irritating.
- 32. It felt good to successfully complete this lesson.
- 33. The content of this lesson will be useful to me.
- 34. I could not really understand quite a bit of the material in this lesson.
- 35. The good organization of the content helped me be confident that I would learn this material.
- 36. It was a pleasure to work on such a well-designed lesson.

IMMS**Instructional Materials Motivation Survey**

教材動機づけ調査

John M. Keller
Florida State University
307 Stone Building
Tallahassee, Florida 32306-3030

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著作権で保護された資料

Contact author for permission and scoring
information before using (translated by

Hajime Hayakawa).

使う前に、許可と採点情報のために筆者に連絡してください。(翻訳者 早川肇)

- 1 (または A) = あてはまらない
- 2 (または B) = 少しあてはまる
- 3 (または C) = 半分あてはまる
- 4 (または D) = ほぼあてはまる
- 5 (または E) = あてはまる

1. 最初にこのレッスンを見た時、それが容易であるという印象を持った。
2. このレッスンの最初に、注目と興味をひく何かがあった。
3. 予想した以上に、この教材は理解しにくかった。
4. 最初の画面をみた後に、このレッスンから学ぶべき事柄を知っていると思った。
5. このレッスンの練習を完了することにより達成感が得られた。
6. この教材の内容と、すでに知っている事とがどのように関連しているかがはっきりしている。
7. 殆どのページにおいて、非常に多くの情報が詰まっていたので、重要なポイントを選び出し、覚えることが困難であった。
8. この教材は注意を引く。
9. この教材がある人々にとっていかに重要でありうるかを示唆する物語、絵、または例があった。
10. このレッスンを首尾よく完成することは私にとって重要であると感じた。
11. 記述の質は、注意を引きつけるのに役立っていた。
12. このレッスンは非常に抽象的なので、注意を集中することが困難であった。
13. このレッスンに取り組んだ時、その内容を習得する事ができると思った。
14. このレッスンを非常に楽しめたので、このトピックについてもっと知りたいと思った。
15. このレッスンのページは、無味乾燥で、魅力がない。
16. この教材の内容は私の興味にあっている。
17. ページの情報の配備のされ方は、注意を集中するのに役立っていた。
18. このレッスンの知識を、どのように使うかの説明または例がある。

- 1 (または A) = あてはまらない
- 2 (または B) = 少しあてはまる
- 3 (または C) = 半分あてはまる
- 4 (または D) = ほぼあてはまる
- 5 (または E) = あてはまる

19. このレッスンの練習は難しすぎた。
20. このレッスンは、好奇心を刺激するものを持っている。
21. このレッスンを勉強するのを本当に楽しんだ。
22. このレッスンは繰り返しが多く、時々退屈させた。
23. このレッスンに書かれている内容とスタイルは、その内容を知る価値があるという感じを伝えている。
24. 新鮮な驚きを持って、思いがけないいくつかのことを学んだ。
25. しばらくこのレッスンに取り組んだ後、学んだ事柄についてのテストに合格できることを確信できた。
26. 学ぶべきことのほとんどを既に知っていたので、このレッスンの必要性を感じなかった。
27. 練習の後の受け答え、また、このレッスンの他のコメントの表現は、努力が報われいると感じる助けになった。
28. 文章、練習、説明などの多様性は、レッスンに注意を集中するのに役立っていた。
29. 文章のスタイルは退屈である。
30. このレッスンの内容を、今まで見たり、したり、または考えたりした事と関係づけることができた。
31. 個々のページに非常に多くの単語が使われているので、いらいらする。
32. このレッスンを首尾よく完了すると気持ちが良い。
33. このレッスンの内容は有益である。
34. このレッスンの教材のかなりの部分が理解できなかった。
35. 内容のアレンジがいいので、この教材を学習できていることを確信できた。
36. このようによくデザインされたレッスンに取り組むことは楽しみであった。

Appendix D
Manual for IMMS

Manual for the *Instructional Materials Motivation Survey (IMMS)*

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Purpose

The Instructional Materials Motivation Survey is intended to be a situational measure of students' motivational reactions to instructional materials. It was designed in accordance with the theoretical foundation represented by the ARCS Model (Keller, 1987a, 1987b). This theory is derived from the current literature on human motivation; hence, many of the items in the IMMS are similar in intent (but not in wording) to items in established measures of psychological constructs such as need for achievement, locus of control, and self-efficacy, to mention three examples.

Results

Reliability estimates based on Cronbach's alpha measure were obtained for each subscale and the total scale. They were:

Attention:	.89	Confidence:	.90	Total Scale:	.96
Relevance:	.81	Satisfaction:	.92		

In a validation study, differences in two sets of instructional materials with respect to format, content, and other features affecting motivation were reflected in the differences in scores on the IMMS.

Note:

Additional information concerning the development of this survey and the results of the validation study will be included in the next draft of this document.

References

- Keller, J. M. (1987). Strategies for stimulating the motivation to learn. Performance & Instruction,(8), 1-7.
- Keller, J. M. (1987). The systematic process of motivational design. Performance & Instruction,(9), 1-8.

¹Department of Educational Research, Occasional Paper, April 1990 (draft).

IMMS SCORING GUIDE

Instructions: The response scale ranges from 1 to 5. This means that the minimum score on the 36 item survey is 36, and the maximum is 180 with a midpoint of 108. The minimums, maximums, and midpoints for each subscale vary because they do not all have the same number of items.

An alternate scoring method is to find the average score for each subscale and the total scale instead of using sums. For each respondent, divide the total score on a given scale by the number of items in that scale. This converts the totals into a score ranging from 1 to 5 and makes it easier to compare performance on each of the subscales.

There are no norms for the survey. As it is a situation specific measure, there is no expectation of a normal distribution of responses. As data become available from a variety of applications of the scales, descriptive statistical information will be published.

Scores are determined by summing the responses for each subscale and the total scale. Please note that the items marked *reverse* are stated in a negative manner. The responses have to be reversed before they can be added into the response total. That is, for these items, 5 = 1, 4 = 2, 3 = 3, 2 = 4, and 1 = 5.

<p>Attention Items</p> <p>2 15 (reverse) 24</p> <p>8 17 28</p> <p>11 20 29 (reverse)</p> <p>12 (reverse) 22 (reverse) 31 (reverse)</p>	<p>Confidence Items</p> <p>1 13 35</p> <p>3 (reverse) 19 (reverse)</p> <p>4 25</p> <p>7 (reverse) 34 (reverse)</p>
<p>Relevance Items</p> <p>6 18 33</p> <p>9 23</p> <p>10 26 (reverse)</p> <p>16 30</p>	<p>Satisfaction Items</p> <p>5 32</p> <p>14 36</p> <p>21</p> <p>27</p>

Appendix E

English Test

3年 組 番氏名 _____ 1999年6月16日

次の文章の下線の部分に当てはまる日本語の言葉を括弧の中に記入しなさい。

1. The solutions of an equation are all values that make it true. ()
2. $ax^2+bx+c=0$ is a quadratic equation. ()
3. $ax^2+bx+c=0$ is the standard form of a quadratic equation. ()
4. Solve $x^2-5x+6=0$. ()
5. What two numbers have a product of 6? ()
6. Factor x^2-5x+6 . ()
7. $ab=0$ is equivalent to ($a=0$ or $b=0$). ()
8. $4x^2+12x-7=0$: Multiplying both sides by $1/4$. ()
9. $x(x-1)=20$: Multiplying out the left side. ()
10. $0.1x^2+0.5x-1.4=0$: Make the coefficients integers. ()
11. The square roots of 16 are -4 and +4. ()
12. The definition of a square root. ()
13. The trinomial x^2+2x+1 is the square of a binomial. ()
14. Complete the square for x^2+6x . ()
15. x^2+6x+9 is a trinomial square, which is equal to $(x+3)^2$. ()
16. $x^2-2x-5=0$: Adding 5 to the both sides. ()
17. $x^2+3x-7/4=0$: Move the constant term $7/4$ to the right. ()
18. -5 is a negative number. ()
19. -5 is an integer. ()
20. The sum of 4 and 5 is 9. ()

Appendix F**Math Test**

3年 ____組 ____番 氏名 _____ 日付：1999年 6月 16日

次の方程式を解きなさい。

1. $(2x+1)(2x-3)=0$

2. $(x+3)(x-4)=0$

3. $(2x-1)x=0$

4. $x(-x+2)=0$

5. $x^2 - 16=0$

6. $x^2 - 2x - 15=0$

7. $x^2 - 5x + 6 = 0$

8. $x^2 + 2x - 3=0$

9. $x^2 + 2x - 4=0$

10. $x^2+10x+10=0$

11. $x^2 - 16x + 3=0$

12. $x^2 - 8x + 1=0$

Class ___ **ID** ___ **Name** _____

Solve the following equations.

1. $(2x+1)(2x-3)=0$

2. $(x+3)(x-4)=0$

3. $(2x-1)x=0$

4. $x(-x+2)=0$

5. $x^2 - 16=0$

6. $x^2 - 2x - 15=0$

7. $x^2 - 5x + 6 = 0$

8. $x^2 + 2x - 3=0$

9. $x^2 + 2x - 4=0$

10. $x^2+10x+10=0$

11. $x^2 - 16x + 3=0$

12. $x^2 - 8x + 1=0$

Appendix G

Abstract of the Calculation Road Race (Hayakawa, 1980)

CALCULATION ROAD RACE

- A Game to Help in Problem Solving and Group Learning -

1. Objectives of the game

The two main objectives are as follows:

- 1) Drill and practice are sometimes boring, but they are necessary in many cases, especially in calculation. The game makes the drill of calculation more interesting.
- 2) Since students have to cooperate with each other in this game, they will learn how important cooperation is.

2. Content

- 1) A brief explanation of this game:

For this game two sheets of paper are necessary. One sheet will be used for about 120 calculation problems. The other sheet called the ROAD MAP gives instruction concerning the order in which the problems are to be solved.

Participants begin by solving the problem which the ROAD MAP shows as START. Then the player follows the ROAD MAP instructions and proceeds to the point marked GOAL. On the way there are several CHECK POINTs each one of which gives the solution for the next CHECK POINT. The players will be able to find the solution to these problems in advance, but will not know where the next CHECK POINT is.

If the player solves the problems following the ROAD MAP instructions, he will discover the CHECK POINTs and go on to reach the GOAL.

- 2) In the classroom

1. Formation of teams - Each team has 6 or 7 members.
2. Group learning - Each team learns as a group.
3. Pairs in each team - Each team divides itself into pairs to make the best combinations.
4. Playing the game - Pairs compete against each other.
5. Discussion - Each team discusses the results of the game as a group.

3. Conclusion

This game has been well received since I developed it 4 years ago. I have observed that the students have a lot of fun finding the CHECK POINTs and proceeding on to the GOAL. For this there is much cooperation among the students. Teachers who observed my class said that they had not seen such an exciting class before. As can be seen from the above, the game serves not only as an aid to drills in calculation, but also as a group learning experience.

1. $(+8) + (+12)$	2. $(-7) + (-5)$	3. $(+9) + (-8)$	4. $(-7.3) + (+2.6)$
5. $(+5) + (-8)$	6. START	7. $(-7) + (-2)$	8. $(-1) + (+3)$
9. $(+6) - (-1)$	10. $(+7) + (-3)$	11. $(-3) + (-2)$	12. $(+7) + (-8)$
13. $(-2) + (-4)$	14. $(+8) + (+5)$	15. $(-2) + (+2)$	16. $(-8) + (-5)$

Before starting this game, be sure to read the following rules!

1. First of all, in order to start, the problems to the right, left, above and below the box marked **START**, must be solved.
2. Next - following the **ROAD MAP**, you must proceed to the next box.

EXAMPLE:

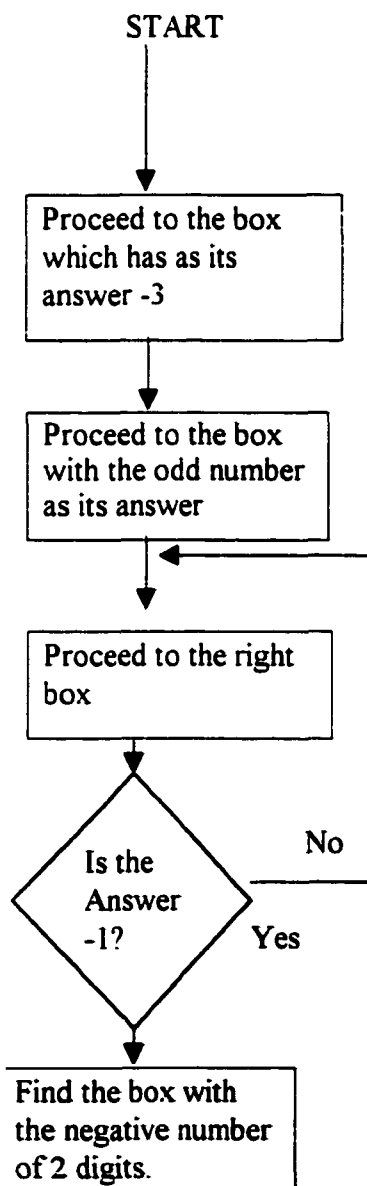
Start: (begin at the point marked, **START**.) - Following the **ROAD MAP**, find the box which has as its answer, -3. To do this, you must solve the problems the right and left and above and below the **START** box. (In this case you proceed to box #5) → next, find the box with the odd number as its answer, and proceed to it, (in this case, you go to box # 9 which has the odd number 7 as its answer) →Next, keep on going right until you find the box which has as its answer -1., and stop at the box (in this case, you have to proceed to box # 12). Next, find the box with the negative number of 2 digits. This is the **GOAL!** (in this case, the **GOAL** is box # 16)

Proceed in this manner, and you should be able to make your **TRIP** without much difficulty. The accurate road description is on the bottom of this page.

Accurate road description

START 6. → (-3) 5. → $(+7)$ 9. → (-1) 12. → (-13) 16.=**GOAL**

ROAD MAP



Appendix H

Unpublished Paper on the Calculation Road Race (Stand-Alone Game)

Calculation Race

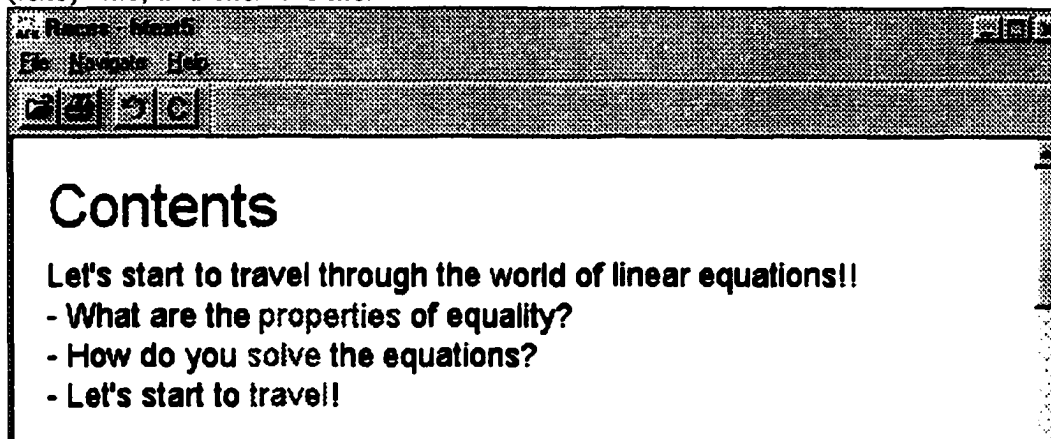
This courseware is under construction, so several parts are still missing. The only parts completed are game parts. After completing the courseware you can use it to teach linear equations. Right now you can use it to enhance your students' calculation ability. The intended audience is age 13-15.

Getting up and running

This software requires the following:

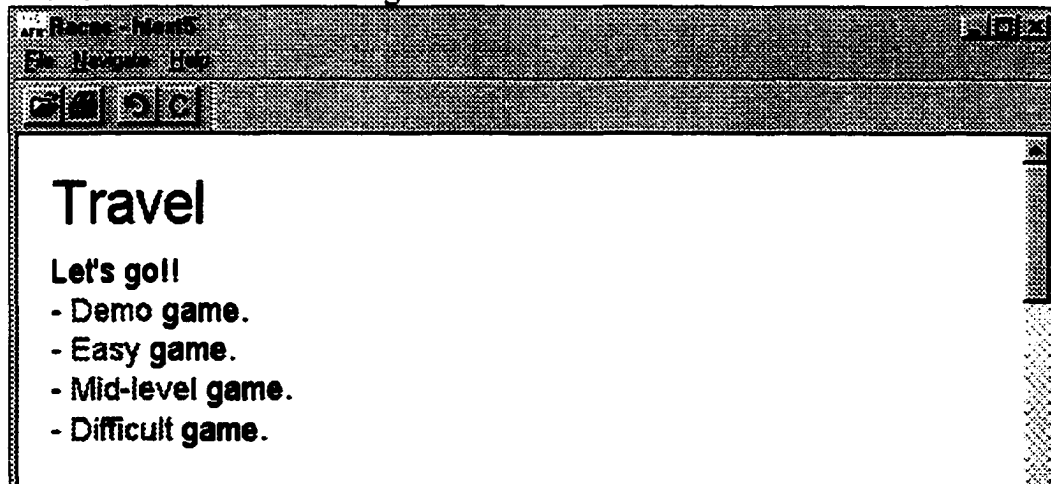
1. IBM compatible machine: 33 MHz 486DX or faster, 8MB of RAM
2. Operation system: MS-DOS 5.0 or higher, Windows 95.
3. Display: SuperVGA (640 x 480, 256 colors).
4. MPC-compliant sound device
5. Mouse and hard drive.

In order to install the program you should make a new folder, and copy all files on the 3 disks. After copying you can click the Start button to explore. Find the "Races (.exe)" file, and click the file.



After running the program, you should open the file "Races (.htf)" by clicking "File" on the top of the program menu then click "travel".

The next menu is the following:



The games I have completed are the Demo Game and the Easy Game. To start the games you can click on the menu.

Objectives of the game

The two main objectives are as follows:

1. Drill and practice are sometimes boring, but they are necessary in many cases, especially in calculation. The game makes the drill of calculation more interesting.
2. Since students have to cooperate with each other in this game, they will learn how important cooperation is.

Brief explanation and usage of the game

A brief explanation of this game

For this game two dialog windows are necessary. One window will be used for calculation problems. The other window called the ROAD MAP gives instructions concerning the order in which the problems are to be solved. Problems should be solved in sequence. To see the ROAD MAP, click any place on the MAP.

Participants begin by solving the problem which the ROAD MAP shows as START. Then the players follow the ROAD MAP instructions and proceed to the point marked GOAL. On the way there are several CHECK POINTs, each one of which may give the solution for the next CHECK POINT. The players will be able to find the solution to these problems in advance, but will not know where the next CHECK POINT is. If the players solve the problems in sequence following the ROAD MAP instructions, they will discover the CHECK POINTs and go on to reach the GOAL.

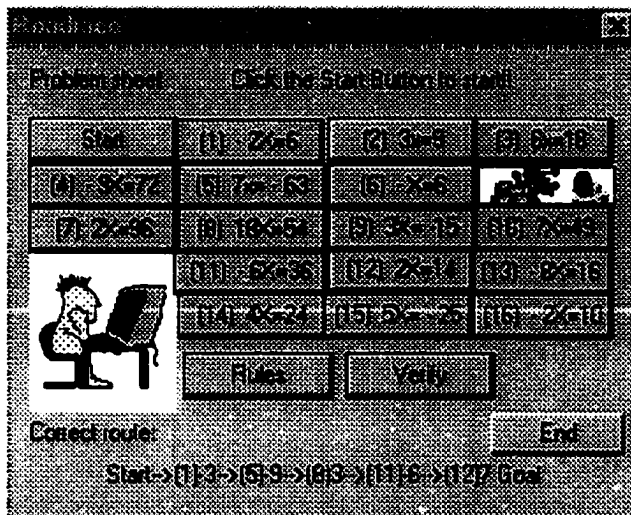
In the classroom

This game can be used for individual students, but it is good for group learning. To use this game in group learning:

1. Formation of teams - Each team has 6 or 7 members.
2. Group learning - Each team learns as a group.
3. Pairs in each team - Each team divides itself into pairs to make the best combinations.
4. Playing the game - Pairs compete against each other. Discussion - Each team discusses

the results of the game as a group.

The explanation of the game



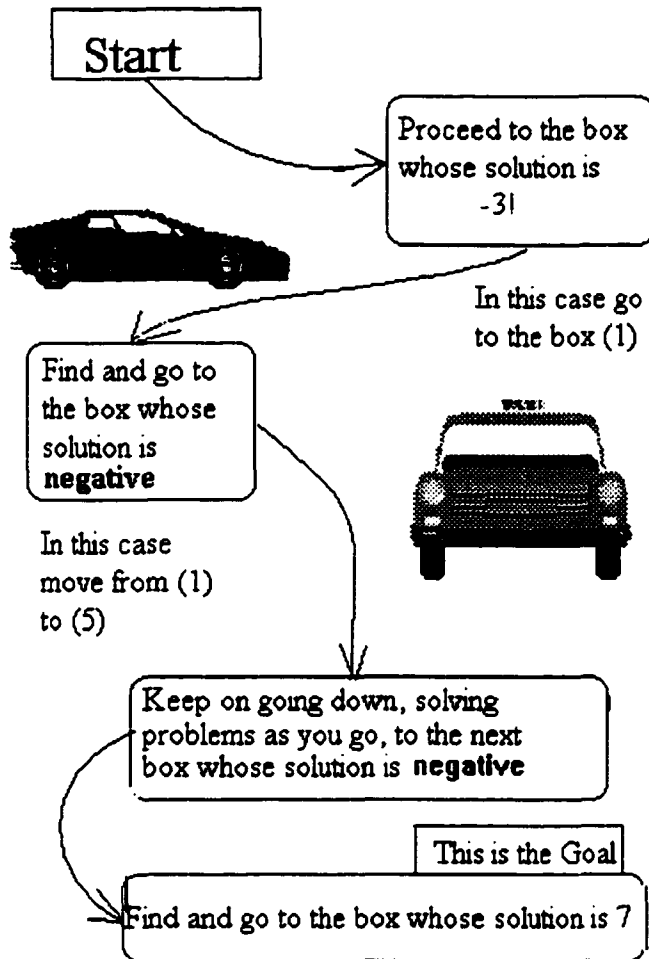
Before starting this game, be sure to read the following rules:

1. First of all, in order to start you must click the START button.
2. After each problem refer to the ROAD MAP by clicking on it.
3. You cannot proceed diagonally.
4. You can click the VERIFY button to see if your answer is correct or not, but you lose one point to do this.
5. You also lose a point if you answer incorrectly.
6. You have to solve every problem on the path to the goal.

When you click problem buttons, the dialog windows will pop up so that you can input your answers. After inputting answers, sometimes you can get feedback depending on whether the answers are correct or not. Many times you can not get feedback. If you want to know if your answer is correct or not, you have to click the Verify button which deducts one point from your score. There are hidden checkpoints which you have to pass by giving the correct answers. If you don't pass the points, you cannot reach the goal even if you accidentally click the goal box and give a correct answer. When you reach the goal box correctly, you receive your score.

The following is an example of the road map and its explanation.

Road Map



The explanation of the road map

1. Begin at the point marked, Start.
2. Following the road map, find the box which has as its answer, -3. To do this, you must solve either the problem below or the problem to the right of the Start box (in this case, you proceed to box [1]).
3. Next, find the box with a negative number as its answer, and proceed to it (in this case, you go to box [5]) which has the negative number, -9, as its answer).
4. Next, keep on going down, solving problems as you go until you find the box which has as its answer a negative number, and stop at the box, (in this case, you have to proceed to box [11]).
5. Next, find the box with 7 as its answer. This is the goal (in this case, the goal is box [12]).

Appendix I

List of Heuristics (Nielsen, 1994)

Ten Usability Heuristics

Visibility of system status

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

Match between system and the real world

The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

User control and freedom

Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

Consistency and standards

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

Error prevention

Even better than good error messages is a careful design which prevents a problem from occurring in the first place.

Recognition rather than recall

Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

Flexibility and efficiency of use

Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

Aesthetic and minimalist design

Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

Help users recognize, diagnose, and recover from errors

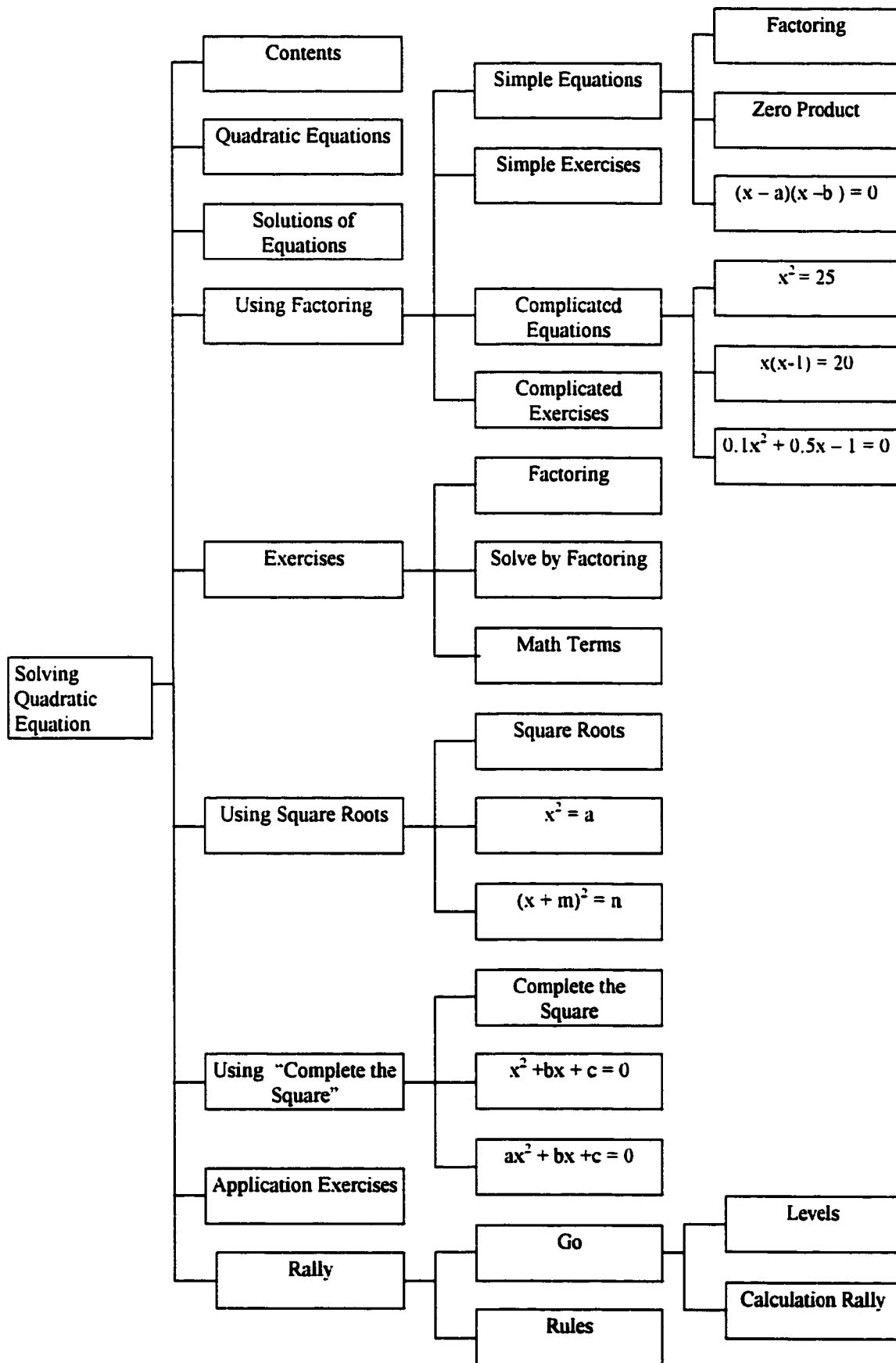
Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

Help and documentation

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

Appendix J

Tree Structure of the Courseware



Appendix K
IRB Approvals

From: Maxine Cohen <cohenm@scis.acast.nova.edu>
To: <hajime@kf.keio.ac.jp>
Subject: IRB approvals (fwd)
Date: 1999 年 6 月 16 日 1:02

Hajime,
Here's the original note.

Maxine S. Cohen
Associate Professor
School of Computer and Information Sciences
Nova Southeastern University
phone: 954 262 2072
fax: 954 262 3915
cohenm@scis.nova.edu

----- Forwarded message -----
Date: Mon, 14 Jun 1999 21:59:35 -0400
From: Dr. Maxine Cohen <cohenm@scis.acast.nova.edu>
To: hajime@kf.keio.ac.jp
Cc: abramson@scis.acast.nova.edu, Maxine S. Cohen <cohenm@scis.acast.nova.edu>
Subject: IRB approvals

Hajime,
This note is to approve your research under the Exempt Category.

Sorry for the delay.

Exempt means your research does not need a full review, but is none the less logged as research under SCIS.

Maxine S. Cohen
Associate Professor
School of Computer and Information Sciences
Nova Southeastern University
Fort Lauderdale, FL
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web page: <http://www.scis.nova.edu/~cohenm>

Appendix L

Printout of the Tukey Test of English Performance

Printout of the Tukey test of English performance

On the printout below from SPSS, Grp 1 is the Japanese version, Grp 2 is the bilingual version, and Grp 3 is the English version. ENGDIFF is the difference between the pretest and the posttest.

17 Sep 99 SPSS for Unix, Release 6.1 (Solaris 2.3)
 Page 1
 01:40:19 NOVA SOUTHEASTERN UNIVERSITY SUN SPARC Solaris 2.3

For Solaris 2.3 NOVA SOUTHEASTERN UNIVERSITY SPSS ID 300301

1 0 DATA LIST FREE/PROGRAM PRETEST POSTTEST
 2 0 LIST

210 0 END DATA

211 0 COMPUTE ENGDIFF=POSTTEST-PRETEST
 212 0 ONEWAY ENGDIFF BY PROGRAM(1,3) /
 213 0 RANGES TUKEY /
 214 0 STATISTICS ALL.

----- O N E W A Y -----

Variable ENGDIFF
 By Variable PROGRAM

Analysis of Variance

Source	D. F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	511.1737	255.5868	23.5163	.0000
Within Groups	203	2206.3069	10.8685		
Total	205	2717.4806			

Group	Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum
Grp 1	70	2.5143	2.9179	.3488	-2.0000	10.0000
Grp 2	70	5.7000	4.1296	.4936	-2.0000	15.0000
Grp 3	66	2.2424	2.6080	.3210	-1.0000	8.0000
Total	206	3.5097	3.6409	.2537	-2.0000	15.0000
Fixed Effects Model			3.2967	.2297		
Random Effects Model				1.1145		
Random Effects Model - estimate of between component variance						3.565

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
7.3598	2	203	.001

- - - - - O N E W A Y - - - - -

Variable ENGDIFF
By Variable PROGRAM

Multiple Range Tests: Tukey-HSD test with significance level .05

The difference between two means is significant if
 $MEAN(J) - MEAN(I) \geq 2.3311 * RANGE * \sqrt{1/N(I) + 1/N(J)}$
 with the following value(s) for RANGE: 3.35

(*) Indicates significant differences which are shown in the lower triangle

Mean	PROGRAM	
2.2424	Grp 3	
2.5143	Grp 1	
5.7000	Grp 2	* *

G G G
r r r
p p p
3 1 2

Appendix M

Printout of the Tukey Test of Math Performance

Printout of Tukey test of math performance

In the printout below from SPSS, Grp 1 is the Japanese version, Grp 2 is the bilingual version, and Grp 3 is the English version. MATHDIFF is the difference between the pretest and the posttest.

17 Sep 99 SPSS for Unix, Release 6.1 (Solaris 2.3)
 Page 1
 01:41:59 NOVA SOUTHEASTERN UNIVERSITY SUN SPARC Solaris 2.3

For Solaris 2.3 NOVA SOUTHEASTERN UNIVERSITY SPSS ID 300301

1 0 DATA LIST FREE/PROGRAM PRETEST POSTTEST
 2 0 LIST

210 0 END DATA

Preceding task required .10 seconds CPU time; .10 seconds elapsed.

211 0 COMPUTE MATHDIFF=POSTTEST-PRETEST
 212 0 ONEWAY MATHDIFF BY PROGRAM(1,3) /
 213 0 RANGES TUKEY /
 214 0 STATISTICS ALL.

----- O N E W A Y -----

Variable MATHDIFF
 By Variable PROGRAM

Analysis of Variance

Source	D. F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	23.1490	11.5745	1.1099	.3316
Within Groups	203	2116.9481	10.4283		
Total	205	2140.0971			

Group	Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum
Grp 1	70	6.0429	3.1551	.3771	-2.0000	10.0000
Grp 2	70	5.4143	3.2325	.3864	-2.0000	10.0000
Grp 3	66	5.2727	3.3029	.4066	-2.0000	10.0000
Total	206	5.5825	3.2310	.2251	-2.0000	10.0000
		Fixed Effects Model	3.2293	.2250		
		Random Effects Model		.2371		

Random Effects Model - estimate of between component variance 1.67E-02

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.4740	2	203	.623
- - - - - O N E W A Y - - - - -			

Variable MATHDIFF
By Variable PROGRAM

Multiple Range Tests: Tukey-HSD test with significance level .05

The difference between two means is significant if
 $MEAN(J) - MEAN(I) \geq 2.2835 * RANGE * \sqrt{1/N(I) + 1/N(J)}$
 with the following value(s) for RANGE: 3.35

- No two groups are significantly different at the .050 level

Appendix N

Printout of MANCOVA

Printout of MANCOVA

17 Sep 99 SPSS for Unix, Release 6.1 (Solaris 2.3)
 Page 1
 18:45:50 NOVA SOUTHEASTERN UNIVERSITY SUN SPARC Solaris 2.3

For Solaris 2.3 NOVA SOUTHEASTERN UNIVERSITY SPSS ID 300301

1 0 DATA LIST FREE/PROGRAM PREENG PREMATH ENG MATH
 2 0 LIST

PROGRAM PREENG PREMATH ENG MATH

Number of cases read: 206 Number of cases listed: 206
 210 0 END DATA

211 0 MANOVA PREENG, PREMATH, ENG, MATH BY PROGRAM(1,3)
 212 0 /ANALYSIS=ENG, MATH WITH PREENG, PREMATH
 213 0 /PRINT=PMEANS
 214 0 /DESIGN
 215 0 /ANALYSIS=ENG, MATH
 216 0 /DESIGN PREENG+PREMATH, PROGRAM, PREENG BY PROGRAM + PREMATH BY PROGRAM
 217 0 /ANALYSIS=PREENG, PREMATH

***** Analysis of Variance -- Design 1*****

Order of Variables for Analysis

Variates Covariates

ENG PREENG
 MATH PREMATH

2 Dependent Variables
 2 Covariates

EFFECT .. WITHIN CELLS Regression

Multivariate Tests of Significance (S = 2, M = -1/2, N = 99)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.53645	36.83686	4.00	402.00	.000
Hotellings	.86943	43.25407	4.00	398.00	.000
Wilks	.51005	40.02102	4.00	400.00	.000
Roys	.42774				

Note.. F statistic for WILKS' Lambda is exact.

EFFECT .. WITHIN CELLS Regression (Cont.)

Univariate F-tests with (2,201) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ENG	1212.72341	2204.04932	606.36171	10.96542	55.29763	.000
MATH	389.16225	1207.19143	194.58112	6.00593	32.39818	.000

Regression analysis for WITHIN CELLS error term

--- Individual Univariate .9500 confidence intervals

Dependent variable .. ENG

COVARIATE	B	Beta	Std. Err.	t-Value	Sig. of t
PREENG	1.0462453487	.5647580812	.10325	10.13337	.000
PREMATH	.0148459037	-.0110390946	.07521	-.19740	.844

Dependent variable .. MATH

COVARIATE	B	Beta	Std. Err.	t-Value	Sig. of t
PREENG	.2952858095	.2445088290	.07641	3.86443	.000
PREMATH	.3152712438	.3596120458	.05566	5.66428	.000

***** Analysis of Variance -- Design 1*****

EFFECT .. PROGRAM

Multivariate Tests of Significance (S = 2, M = -1/2, N = 99)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.20468	11.45792	4.00	402.00	.000
Hotellings	.25238	12.55600	4.00	398.00	.000
Wilks	.79708	12.00835	4.00	400.00	.000
Roys	.19570				

 EFFECT .. PROGRAM (Cont.)

Univariate F-tests with (2,201) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ENG	507.21147	2204.04932	253.60574	10.9654223	12777	.000
MATH	26.16440	1207.19143	13.08220	6.00593	2.17822	.116

Adjusted and Estimated Means

Variable .. ENG

Factor	Code	Obs. Mean	Adj. Mean	Est. Mean
PROGRAM	1	4.70000	4.57858	4.70000
PROGRAM	2	7.60000	7.77073	7.60000
PROGRAM	3	4.36364	4.31433	4.36364

Adjusted and Estimated Means (Cont.)

Variable .. MATH

Factor	Code	Obs. Mean	Adj. Mean	Est. Mean.
PROGRAM	1	7.92857	7.87877	7.92857
PROGRAM	2	6.84286	7.02155	6.84286
PROGRAM	3	7.46970	7.34081	7.46970

***** Analysis of Variance -- Design 2*****

Order of Variables for Analysis

Variates Covariates

ENG
 MATH

2 Dependent Variables
 0 Covariates

EFFECT .. PREENG BY PROGRAM + PREMATH BY PROGRAM

Multivariate Tests of Significance (S = 2, M = 1/2, N = 97)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.02205	.54898	8.00	394.00	.819
Hotellings	.02235	.54490	8.00	390.00	.822
Wilks	.97804	.54695	8.00	392.00	.821
Roys	.01646				

Note.. F statistic for WILKS' Lambda is exact.

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18:45:51 NOVA SOUTHEASTERN UNIVERSITY SUN SPARC Solaris 2.3

*** Analysis of Variance -- Design 3 ***

Order of Variables for Analysis

Variates Covariates

PREENG

PREMATH

2 Dependent Variables

0 Covariates

*** Analysis of Variance -- Design 3 ***

EFFECT .. PROGRAM

Multivariate Tests of Significance (S = 2, M = -1/2, N = 100)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.01085	.55347	4.00	406.00	.697
Hotellings	.01095	.54999	4.00	402.00	.699
Wilks	.98916	.55174	4.00	404.00	.698
Roys	.00983				

Note.. F statistic for WILKS' Lambda is exact.

EFFECT .. PROGRAM (Cont.)

Univariate F-tests with (2,203) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
PREENG	3.13253	1119.91602	1.56626	5.51683	.28391	.753
PREMATH	20.38543	2110.66797	10.19272	10.39738	.98032	.377

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 18:45:51 NOVA SOUTHEASTERN UNIVERSITY SUN SPARC Solaris 2.3

Preceding task required .49 seconds CPU time; .49 seconds elapsed.

```

218 0 INCLUDE ANCOVAS2.SPS
219 0
220 0 *****
221 0 * MACRO NAME: ANCOVAS2.SPS *
222 0 * *
223 0 * README FILE: ANCOVA.RM *
224 0 * *
225 0 * SPSS REQUIREMENTS: Release 4.0 or above *
226 0 * Advanced Statistics Module *
227 0 * *
228 0 * AUTHOR: David Nichols (nichols@spss.com) *
229 0 * *
230 0 * LAST UPDATED: 06/12/96 *
231 0 *****
232 0
233 0 preserve
234 0 set printback=off mprint=off

```

Preceding task required .03 seconds CPU time; .03 seconds elapsed.

REPORT problem requires 3052 bytes of memory to store specifications for this task.

Adjusted Means		
Group	Adjusted Mean	Standard Error
1	4.577627	.3959610
2	7.769768	.3969414
3	4.313369	.4084699

Scheffe Pairwise Comparisons

Standard Adjusted Mean		Adjusted Mean	Sig.	Mean Difference	Error of Difference
1	vs.	2	**	-3.192141	.561044
1	vs.	3		.264258	.568747
2	vs.	3	**	3.456398	.570876

REPORT problem required an additional 1152 bytes of memory.

Preceding task required .02 seconds CPU time; .02 seconds elapsed.

File ac_tmpl.sav

Created: 17 SEP 99 18:45:51 - 5 variables and 206 cases

389 command lines read.

0 errors detected.

0 warnings issued.

1 seconds CPU time.

2 seconds elapsed time.

End of job.

Appendix O

Pairwise Multivariate Tests for the IMMS

Pairwise multivariate tests for the IMMS

In the printout below from SPSS, GP 1 is the Japanese version, GP 2 is the bilingual version, and GP 3 is the English version. Y1 is Attention, Y2 is Confidence, Y3 is Relevance, and Y4 is Satisfaction.

10 Oct 99 SPSS for Unix, Release 6.1 (Solaris 2.3)
 Page 1
 09:05:46 NOVA SOUTHEASTERN UNIVERSITY SUN SPARC Solaris 2.3

For Solaris 2.3 NOVA SOUTHEASTERN UNIVERSITY SPSS ID 300301

1 0 DATA LIST FREE/GP Y1 Y2 Y3 Y4
 2 0 LIST

Number of cases read: 200 Number of cases listed: 200

204 0 END DATA
 205 0 MANOVA Y1 TO Y4 BY GP(1,3) /
 206 0 PRINT=CELLINFO(MEANS) HOMOGENEITY(COCHRAN, BOXM) /

```

-----
                CELL NUMBER
                1   2   3
Variable
  GP           1   2   3
  
```

Cell Means and Standard Deviations

Variable .. Y1

FACTOR	CODE	Mean	Std. Dev.	N
GP	1	2.799	.627	70
GP	2	2.311	.769	64
GP	3	2.505	.734	66
For entire sample		2.546	.735	200

Variable .. Y2

FACTOR	CODE	Mean	Std. Dev.	N
GP	1	3.035	.634	70
GP	2	2.637	.774	64
GP	3	2.677	.658	66
For entire sample		2.789	.710	200

Variable .. Y3

FACTOR	CODE	Mean	Std. Dev.	N
GP	1	2.643	.558	70
GP	2	2.554	.688	64
GP	3	2.591	.642	66
For entire sample		2.597	.627	200

Variable .. Y4

FACTOR	CODE	Mean	Std. Dev.	N
GP	1	2.724	.821	70
GP	2	2.349	.904	64
GP	3	2.399	.844	66
For entire sample		2.497	.868	200

***** Analysis of Variance -- Design 1 *****

EFFECT .. GP

Multivariate Tests of Significance (S = 2, M = 1/2, N = 96)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.13611	3.55986	8.00	390.00	.001
Hotellings	.15424	3.72113	8.00	386.00	.000
Wilks	.86522	3.64091	8.00	388.00	.000
Roys	.12554				

Note.. F statistic for WILKS' Lambda is exact.

EFFECT .. GP (Cont.)

Univariate F-tests with (2,197) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
Y1	8.11300	99.41130	4.	.50463	8.03863	.000
Y2	6.54037	93.64228	3.27019	.475346	.87966	.001
Y3	.26897	78.08751	.13449	.39638	.33928	.713
Y4	5.63760	144.24907	2.81880	.73223	3.84961	.023

207 0 DISCRIMINANT GROUPS=GP(1,3)/
 208 0 VARIABLES=Y1 TO Y4 /
 209 0 METHOD=WILKS/FIN=0/FOUT=0/
 210 0 STATISTICS=FPAIR/

----- DISCRIMINANT ANALYSIS -----

10 Oct 99 SPSS for Unix, Release 6.1 (Solaris 2.3)
 F statistics and significances between pairs of groups after step 4
 Each F statistic has 4 and 194 degrees of freedom.

	Group	1	2
Group			
2		6.4356	
		.0001	
3		3.7857	.9149
		.0055	.4563

Summary Table

Step	Action	Vars	Wilks'		
Entered	Removed	in	Lambda	Sig.	Label
1	Y1	1	.92455	.0004	
2	Y3	2	.89880	.0003	
3	Y2	3	.87219	.0002	
4	Y4	4	.86522	.0004	

Preceding task required .24 seconds CPU time; .24 seconds elapsed.

211 0 T-TEST GROUPS=GP(1,2)/
 212 0 VARIABLES=Y1 TO Y4/

Variable	Number of Cases	Mean	SD	SE of Mean
Y1				
GP 1	70	2.7988	.627	.075
GP 2	64	2.3112	.769	.096

Mean Difference = .4876

Levene's Test for Equality of Variances: F= 4.469 P= .036

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	4.04	132	.000	.121	(.249, .727)
Unequal	4.00	121.71	.000	.122	(.246, .729)

Variable	Number of Cases	Mean	SD	SE of Mean
Y2				
GP 1	70	3.0349	.634	.076
GP 2	64	2.6372	.774	.097

Mean Difference = .3978

Levene's Test for Equality of Variances: F= 3.367 P= .069

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	3.26	132	.001	.122	(.157, .639)
Unequal	3.24	122.06	.002	.123	(.154, .641)

Variable	Number of Cases	Mean	SD	SE of Mean
Y3				
GP 1	70	2.6429	.558	.067
GP 2	64	2.5538	.688	.086

Mean Difference = .0890

Levene's Test for Equality of Variances: F= 2.930 P= .089

t-test for Equality of Means					95%
Variiances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	.83	132	.410	.108	(-.124, .302)
Unequal	.82	121.43	.415	.109	(-.126, .305)

Variable	Number of Cases	Mean	SD	SE of Mean
Y4				
GP 1	70	2.7238	.821	.098
GP 2	64	2.3490	.904	.113

Mean Difference = .3749

Levene's Test for Equality of Variances: F= 1.561 P= .214

t-test for Equality of Means					95%
Variiances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	2.52	132	.013	.149	(.080, .670)
Unequal	2.50	127.59	.014	.150	(.079, .671)

213 0 T-TEST GROUPS=GP(1,3)/

214 0 VARIABLES=Y1 TO Y4 /

t-tests for Independent Samples of GP

Variable	Number of Cases	Mean	SD	SE of Mean
Y1				
GP 1	70	2.7988	.627	.075
GP 3	66	2.5051	.734	.090

Mean Difference = .2938

Levene's Test for Equality of Variances: F= 1.021 P= .314

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	2.51	134	.013	.117	(.063, .525)
Unequal	2.50	128.05	.014	.117	(.062, .526)

Variable	Number of Cases	Mean	SD	SE of Mean
Y2				
GP 1	70	3.0349	.634	.076
GP 3	66	2.6768	.658	.081

Mean Difference = .3582

Levene's Test for Equality of Variances: F= .082 P= .775

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	3.23	134	.002	.111	(.139, .577)
Unequal	3.23	132.77	.002	.111	(.139, .578)

Variable	Number of Cases	Mean	SD	SE of Mean
Y3				
GP 1	70	2.6429	.558	.067
GP 3	66	2.5909	.642	.079

Mean Difference = .0519

Levene's Test for Equality of Variances: F= .683 P= .410

t-test for Equality of Means					95%
Variiances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	.50	134	.615	.103	(-.152, .256)
Unequal	.50	128.96	.616	.103	(-.153, .256)

Variable	Number of Cases	Mean	SD	SE of Mean
Y4				
GP 1	70	2.7238	.821	.098
GP 3	66	2.3990	.844	.104

Mean Difference = .3248

Levene's Test for Equality of Variances: F= .164 P= .686

t-test for Equality of Means					95%
Variiances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	2.28	134	.024	.143	(.042, .607)
Unequal	2.27	133.00	.025	.143	(.042, .607)

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09:05:47 NOVA SOUTHEASTERN UNIVERSITY SUN SPARC Solaris 2.3

Preceding task required .04 seconds CPU time; .05 seconds elapsed.

215 0

214 command lines read.
0 errors detected.
0 warnings issued.
1 seconds CPU time.
1 seconds elapsed time.
End of job.

Appendix P

Printout of Pairwise Multivariate Tests for Usability

:

Pairwise multivariate tests for usability

In the printout below from SPSS, GP 1 is the Japanese version, GP 2 is the bilingual version, and GP 3 is the English version. Y1 is item 1, Y2 is item 2, Y3 is item 3, and so on.

_11 Oct 99 SPSS for Unix, Release 6.1 (Solaris 2.3)

Page 1

05:08:43 NOVA SOUTHEASTERN UNIVERSITY SUN SPARC Solaris 2.3

For Solaris 2.3 NOVA SOUTHEASTERN UNIVERSITY SPSS ID 300301

1 0 DATA LIST FREE/GP Y1 Y2 Y3 Y4 Y5 Y6 Y7 Y8 Y9 Y10
2 0 LIST

142 0 END DATA

143 0 MANOVA Y1 TO Y10 BY GP(1,3) /
144 0 PRINT=CELLINFO(MEANS) HOMOGENEITY(COCHRAN, BOXM) /

***** Analysis of Variance -- Design 1 *****

EFFECT .. GP

Multivariate Tests of Significance (S = 2, M = 3 1/2, N = 62)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.18075	1.26177	20.00	254.00	.205
Hotellings	.20088	1.25548	20.00	250.00	.210
Wilks	.82660	1.25868	20.00	252.00	.208
Roys	.11896				

Preceding task required .58 seconds CPU time; 1.41 seconds elapsed.

145 0 DISCRIMINANT GROUPS=GP(1,3) /
146 0 VARIABLES=Y1 TO Y10 /
147 0 METHOD=WILKS/FIN=0/FOUT=0 /
148 0 STATISTICS=FPAIR /

F statistics and significances between pairs of groups after step 10
Each F statistic has 10 and 126 degrees of freedom.

Group	1	2
2	1.2639 .2579	
3	1.6182 .1086	.8777 .5559

149 0 T-TEST GROUPS=GP(1,2)/
 150 0 VARIABLES=Y1 TO Y10/
 t-tests for Independent Samples of GP

Variable	Number of Cases	Mean	SD	SE of Mean
Y2				
GP 1	52	2.8462	.978	.136
GP 2	43	3.3256	1.149	.175

Mean Difference = -.4794

Levene's Test for Equality of Variances: F= 2.235 P= .138

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-2.20	93	.030	.218	(-.913, -.046)
Unequal	-2.16	82.89	.033	.222	(-.920, -.039)

Variable	Number of Cases	Mean	SD	SE of Mean
Y6				
GP 1	52	2.3462	1.136	.157
GP 2	43	2.9302	1.387	.212

Mean Difference = -.5841

Levene's Test for Equality of Variances: F= 4.535 P= .036

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-2.26	93	.026	.259	(-1.098, -.070)
Unequal	-2.21	80.98	.030	.264	(-1.109, -.059)

151 0 T-TEST GROUPS=GP(1,3)/
 152 0 VARIABLES=Y1 TO Y10 /

t-tests for Independent Samples of GP

Variable	Number of Cases	Mean	SD	SE of Mean
Y6				
GP 1	52	2.3482	1.136	.157
GP 3	43	3.0465	1.362	.208

Mean Difference = -.7004

Levene's Test for Equality of Variances: F= 2.173 P= .144

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-2.73	93	.007	.256	(-1.209, -.192)
Unequal	-2.69	81.89	.009	.261	(-1.219, -.182)

Variable	Number of Cases	Mean	SD	SE of Mean
Y10				
GP 1	52	2.8846	1.263	.175
GP 3	43	3.7209	1.202	.183

Mean Difference = -.8363

Levene's Test for Equality of Variances: F= .054 P= .817

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-3.28	93	.001	.255	(-1.342, -.331)
Unequal	-3.30	91.14	.001	.253	(-1.340, -.333)

153 0 T-TEST GROUPS=GP(2,3)/
 154 0 VARIABLES=Y1 TO Y10 /
 155 0

t-tests for Independent Samples of GP

Variable	Number of Cases	Mean	SD	SE of Mean
Y10				
GP 2	43	3.1395	1.167	.178
GP 3	43	3.7209	1.202	.183

Mean Difference = - .5814

Levene's Test for Equality of Variances: F= .259 P= .612

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-2.28	84	.025	.255	(-1.089, -.073)
Unequal	-2.28	83.93	.025	.255	(-1.089, -.073)

Appendix Q

Raw Data

1	4	5	1	9	2.67	2.44	2.89	2.50	2.64	1	2	2	4	3	4	3	3	2	2	2	3	4	30
1	3	6	2	10	2.92	3.67	3.22	3.67	3.31														
1	8	17	0	6	3.08	3.22	3.44	3.67	3.31	2	1	1	3	3	3	3	3	2	2	3	3	3	28
1	3	8	2	10	3	3.78	2.22	3.5	3.08	2	2	1	1	2	1	1	1	1	1	1	1	2	13
1	3	3	1	9	2.00	2.67	2.22	1.83	2.19	5	1	2	4	3	2	3	3	3	3	4	5	5	35
1	1	4	0	10	2.42	2.78	2.89	3.67	2.83	1	1	1	3	2	3	3	4	4	3	2	4	4	32
1	8	18	5	12	2.92	3.00	2.22	2.83	2.75	4	0	1	3	3	2	3	4	2	4	1	3	4	29
1	0	0	0	9	2.67	2.89	2.67	2.5	2.69														
1	0	4	0	7	3.25	4.00	2.78	3.50	3.36														
1	4	7	12	12	3.5	3.67	2.67	3	3.25	4	3	2	4	4	3	1	3	1	4	1	4	2	27
1	0	4	0	6	3.58	3.67	2.89	3.67	3.44	3	0	2	3	3	2	2	1	1	2	2	3	2	21
1	3	8	0	3	3	2.56	3	2.83	2.86														
1	4	7	1	6	2.67	3.33	2.44	2.00	2.67	3	1	1	4	3	4	3	3	2	4	3	3	2	31
1	0	5	0	3	2.17	1.89	2	1.5	1.94	4	1	1	4	4	2	2	4	1	2	4	4	3	30
1	1	8	0	7	2.25	2.78	2.00	2.00	2.28	4	0	1	5	2	2	5	3	2	5	4	1	5	34
1	3	13	0	9	3.33	2.89	3	2.83	3.06	4	2	1	3	3	2	3	3	2	2	2	3	2	25
1	1	1	0	8	3	3.44	2.78	2.83	3.03														
1	0	5	0	9	2.83	3	1.89	2	2.5	4	2	1	5	5	4	3	3	4	4	1	5	5	39
1	6	10	0	9	3.75	3.78	2.56	2.83	3.31														
1	10	14	9	12	3.83	4.67	3.44	4.5	4.06	1	3	1	1	2	1	2	1	1	1	1	1	1	12
1	0	1	0	9	2.5	3.11	2.11	2.17	2.5	5	2	1	3	2	2	2	3	1	3	2	3	2	23
1	6	7	0	10	1.92	3.11	2.78	2.5	2.53	1	2	1	2	2	3	2	4	1	5	3	3	1	26
1	5	3	0	9	3.25	3.11	3.89	3	3.33	3	2	2	3	1	1	3	3	2	3	2	3	2	23
1	1	3	10	9	2.92	3.44	3.33	3.5	3.25														
1	2	1	1	10	3.17	3.89	3.56	3.67	3.53	2	1	1	2	2	3	2	2	2	2	1	2	1	19
1	0	0	1	11	3.25	2.67	2.44	3.33	2.92	3	2	1	5	3	3	3	3	3	3	3	2	1	29
1	0	0	0	5	3.67	3.44	3.56	4.33	3.69														
1	0	1	0	1	1.92	2.33	1.67	1.83	1.94	4	1	1	3	4	1	3	3	1	1	2	3	2	23
1	5	4	0	10	2.92	3.44	2.56	3.67	3.08	2	3	1	3	2	2	2	3	3	2	2	2	3	24
1	1	3	0	10	2.92	3.22	3.33	5	3.44	4	3	1	4	2	2	2	2	2	2	2	2	2	22
1	2	7	0	7	2.33	2.11	1.67	1	1.89	4	2	2	4	3	3	3	2	3	2	3	3	4	30
1	5	8	4	10	3	3.56	2.89	3.33	3.17	3	2	1	3	1	1	2	2	1	1	2	2	2	17
1	0	1	8	7	3.58	2.67	2.11	1.83	2.69	3	1	1	3	3	3	3	3	3	3	3	3	2	29
1	1	1	0	10	2.83	3	2.89	2.67	2.86														
1	4	3	9	11	2.5	3.33	2.33	2	2.58	3	2	2	3	3	3	3	3	3	3	3	3	3	30
1	3	5	0	2	3	2.89	2.89	3.17	2.97	3	1	2	3	3	3	3	3	3	1	2	3	3	27
1	5	5	0	8	2.42	3.44	2.44	3.17	2.81														
1	1	3	1	8	3.17	3	3	3.17	3.08	3	1	1	5	2	2	2	2	2	1	1	3	3	23
1	4	3	0	8	3.17	3.11	3.11	3.33	3.17	3	2	2	4	1	4	1	4	5	1	1	2	1	24
2	0	5	5	10	3.83	3.44	3.67	4.67	3.83														
2	1	8	0	7	1.33	1.78	2.78	1.50	1.83														
2	0	3	0	4	1.33	2.22	1.89	1.67	1.75	2	1	2	4	4	2	2	4	5	4	4	3	4	36
2	1	5	1	6	1.75	2.33	2.22	2.00	2.06	3	0	1	5	5	3	3	3	1	3	3	3	3	32
2	0	1	0	4	1.50	1.44	2.11	1.67	1.67														
2	2	8	2	2	2.33	1.56	1.78	3.00	2.11	1	0	2	4	3	4	3	4	3	1	3	3	4	32

2	6	7	12	12	1.75	4.33	1.78	1.83	2.42	5	3	2	5	5	4	5	4	4	4	2	5	1	39
2	3	14	0	7	1.83	4.11	2.00	3.17	2.67	1	3	2	3	2	1	3	3	3	4	2	4	2	27
2	3	2	0	9	3.42	2.78	3.00	3.00	3.08	3	1	1	3	4	3	3	3	4	2	2	3	4	31
2	9	18	10	11	3.58	3.67	3.56	3.33	3.56	2	0	1	2	3	1	1	3	5	2	1	3	1	22
2	5	15	1	8	2.00	2.89	2.44	3.17	2.53	2	1	1	3	4	3	3	2	2	4	1	5	3	30
2	0	4	0	6	4.00	3.78	4.22	3.67	3.94														
2	3	16	3	9	2.25	2.44	1.67	1.33	2.00														
2	0	4	0	7	1.00	1.22	1.44	1.00	1.17														
2	2	12	3	10	1.92	3.00	2.44	2.00	2.33														
2	2	6	0	0	2.17	3.22	3.44	2.00	2.72														
2	1	0	0	7	1.83	1.89	1.89	1.67	1.83	1	1	1	2	1	5	2	3	4	4	1	3	5	30
2	3	10	2	7	2.00	2.56	2.33	2.00	2.22	5	1	1	5	4	3	2	1	4	2	2	3	1	27
2	1	4	0	8	3.00	2.56	2.22	2.67	2.64	3	0	1	4	2	3	3	2	1	1	2	4	4	26
2	0	0	0	0																			
2	2	3	0	8	2.25	2.33	2.78	2.17	2.39	1	1	1	3	3	2	3	1	4	3	1	2	5	27
2	0	9	0	0	2.75	1.78	2.33	1.67	2.22														
2	0	1	0	5	1.08	1.00	1.44	1.50	1.22														
2	0	6	0	9	2.08	2.56	2.78	3.83	2.67														
2	2	6	0	10	2.92	2.78	3.22	3.67	3.08	1	2	1	4	3	1	3	2	4	3	4	3	5	32
2	5	10	0	6	1.33	1.33	1.78	1.00	1.39	3	0	1	3	3	4	3	2	4	3	2	5	4	33
2	2	1	0	1	1.58	1.11	2.22	2.17	1.72	3	2	2	4	4	3	2	2	3	3	2	3	4	30
2	0	1	0	4	2.42	2.22	3.00	2.33	2.50														
2	0	3	0	4	2.67	2.11	2.89	2.17	2.50	5	0	2	5	5	5	2	1	2	4	2	3	3	32
2	11	10	10	12	1.67	4.11	2.11	1.83	2.42	1	1	2	3	1	2	4	2	4	3	2	3	3	27
2	1	8	0	10	1.33	1.44	2.33	1.67	1.67	4	2	1	5	5	1	1	3	4	1	1	5	4	30
2	1	4	1	5	2.17	3.22	2.11	3.17	2.58														
2	4	9	7	12	3.17	3.00	2.78	2.50	2.92	4	1	2	3	2	4	2	2	2	3	2	3	3	26
2	1	7	2	10	2.58	3.00	2.33	2.83	2.67	5	1	1	4	4	2	2	4	1	2	1	5	3	28
2	5	13	0	7	2.42	2.89	3.11	3.33	2.86	2	0	1	3	3	4	2	3	4	3	3	3	5	33
2	3	5	0	8	1.08	1.67	1.56	1.00	1.33	3	2	1	4	4	3	4	2	5	4	4	5	4	39
2	1	7	0	6	2.67	2.89	2.78	3.83	2.94														
2	5	3	0	7																			
2	0	4	0	1	1.58	1.78	1.78	1.17	1.61	2	0	1	4	3	1	2	3	1	1	4	5	1	25
2	2	2	9	10	2.92	3.44	3.78	3.00	3.28														
2	0	6	0	5	3.33	3.56	3.56	3.67	3.50														
2	0	5	0	9	3.33	3.00	4.22	3.83	3.56														
2	1	5	0	7	1.83	2.56	2.22	1.50	2.06														
2	1	5	3	9	1.42	1.89	1.44	1.00	1.47														
2	0	13	0	9	3.00	3.22	3.22	3.00	3.11	3	3	2	3	2	4	2	4	1	3	2	4	2	27
2	1	5	1	10	2.25	3.11	2.11	2.67	2.5	1	2	1	4	5	1	3	2	3	1	3	5	3	30
2	3	12	2	7	3.17	2.89	3.22	2.83	3.06	5	1	2	1	1	1	1	1	2	2	1	3	14	
2	5	17	5	8	2.08	2.56	2.67	2.17	2.36	1	0	1	5	5	1	3	3	2	2	1	3	2	27
2	3	16	0	4	3.42	3.33	3	3	3.22	2	0	1	3	3	2	2	3	4	3	2	3	3	28
2	5	13	0	9	2.08	3.33	3.11	3.83	2.94	5	0	1	5	5	5	5	5	5	3	5	5	3	46
2	4	6	1	3	4.17	2.67	3.78	3	3.5	4	1	1	3	3	1	2	2	4	2	3	1	2	23

3	9	14	9	11	2.00	3.89	2.89	2.17	2.72	3	3	1	2	2	1	1	2	1	4	3	1	1	18
3	1	2	9	12	1.00	1.44	2.33	1.67	1.56	2	3	1	5	5	4	2	2	5	3	5	3	5	39
3	2	4	0	10	3.00	3.22	2.78	3.17	3.03	2	2	1	3	3	2	2	3	2	3	3	4	3	28
3	0	0	1	1	2.08	2.22	2.78	3.50	2.53														
3	0	8	0	6	3.17	2.67	2.67	3.00	2.89	2	2	2	3	2	5	3	3	2	3	1	5	3	30
3	1	1	7	8	1.17	3.33	1.89	1.00	1.86	5	3	2	5	3	3	3	3	1	3	3	4	4	32
3	2	2	5	9	2.67	2.44	3.00	2.50	2.67	3	2	2	3	3	3	3	2	3	4	2	3	5	31
3	1	0	0	6	2.67	2.44	2.33	2.33	2.47														
3	0	3	9	8	2.33	2.44	2.22	2.67	2.39	1	2	1	4	4	1	2	2	5	3	2	2	5	30
3	4	7	0	8	1.83	2.56	2.11	1.00	1.94	2	2	1	5	5	4	2	2	4	3	1	5	5	36
3	6	11	1	10	2.33	4.11	2.44	1.83	2.72	2	2	2	3	3	2	2	2	4	2	2	5	2	27
3	0	0	1	9	2.00	2.44	2.56	2.83	2.39														
3	0	2	1	5	2.75	2.44	2.00	1.67	2.31	1	2	1	4	2	4	3	4	4	4	2	3	3	33
3	7	7	7	10	3.25	3.22	2.78	3.00	3.08	5	1	1	3	3	3	3	2	2	1	2	3	3	25
3	3	5	1	9	2.67	3.67	2.78	2.33	2.89														
3	4	3	1	7	2.67	2.78	3.67	3.00	3.00	2	1	1	3	5	3	3	2	3	3	3	4	5	34
3					2.08	3.89	2.33	1.17	2.44	3	3	1	4	3	4	3	3	3	3	2	3	4	32
3	5	8	0	10	3.33	3.00	3.78	3.50	3.39														
3	1	5	0	8	3.08	2.56	3.00	2.17	2.78	3	1	1	4	3	1	3	1	5	3	1	3	5	29
3	5	4	1	5	3.75	2.67	2.11	2.67	2.89	2	2	1	3	3	1	2	1	4	3	3	3	4	27
3	4	3	3	9	2.17	2.33	1.89	1.83	2.08	5	2	1	3	3	4	3	2	5	3	2	4	5	34
3	0	4	10	11	1.42	1.56	1.44	1.17	1.42														
3	0	1	1	6	3.00	2.44	2.89	1.67	2.61	4	0	1	5	5	4	3	3	4	4	4	5	5	42
3	0	1	0	3	2.42	3.11	2.22	1.67	2.42	2	1	2	3	4	2	3	2	4	3	2	3	4	30
3	0	1	2	7	2.25	2.78	1.78	2.67	2.33	1	1	1	4	3	4	3	2	5	2	2	4	3	32
3	1	2	0	2	5.00	3.33	4.44	5.00	4.44	3	1	1	3	3	1	2	2	3	1	2	3	4	24
3	1	0	0	9	1.17	3.89	1.22	1.33	1.89	3	3	2	3	3	3	3	3	1	1	3	3	1	24
3	2	1	2	7	2.17	2.33	2.56	3.00	2.44	1	2	1	3	2	2	5	3	2	1	2	2	4	26
3	0	0	0	8	3.00	2.89	2.11	1.67	2.53	3	1	2	3	1	3	3	1	3	2	2	3	5	26
3	1	0	0	8	2.17	2.44	2.22	3.17	2.42	3	2	1	3	1	3	3	3	3	3	3	5	5	32
3	2	1	0	10	1.75	2.44	2.56	2.67	2.28														
3	8	7	0	9	2.83	3.33	2.67	3.33	3.00	3	2	2	3	3	3	3	3	2	2	3	5	3	30
3	5	9	0	9	2.67	1.67	2.22	2.50	2.28	1	2	2	3	4	1	2	3	2	2	2	3	4	26
3	3	6	0	10	1.00	1.44	1.44	1.00	1.22	2	3	2	3	3	3	3	3	3	3	2	5	3	31
3	2	6	0	6	3.17	3.78	3.11	3.33	3.33														
3	0	0	0	9	3.08	2.44	3.00	2.83	2.86														
3	1	2	0	9	2.50	2.56	2.89	2.33	2.58	1	2	1	4	4	4	3	2	4	3	3	4	4	35
3	2	2	0	10	2.75	2.33	3.22	4.00	2.97														
3	3	4	0	9	2.50	2.78	2.33	2.33	2.50	2	1	1	4	3	4	3	2	3	2	3	4	3	31
3	13	15	11	10	1.33	2.11	1.33	1.83	1.61														
3	0	1	0	4	2.75	2.89	2.11	1.67	2.44	1	2	2	2	2	1	2	1	1	3	2	2	5	21

Appendix R

Translations of Comments Made by Ninth Grade Japanese Students in the Summative Evaluations

**Translation of comments made by ninth grade Japanese students
in the summative evaluation**

The Japanese version

Favorable comments:

- I think that it is a good program.

- I think that it is very good program because I was able to understand quadratic equations just by running this program.

- I felt that it was a fairly interesting program. It was very easy to understand and use this program.

- There is nothing bad to say about this program.

- It was very easy to understand.

- I think that I have increased my knowledge.

- I could understand well.

- It was easy to understand quadratic equations.

- I wish many other classes would allow the use of personal computers because it is fun.

- Because I like computers, I was glad to take this class.

- I think that it is fairly good to be able to use computers in class.

- I was delighted to study with the computer.

- Practicing on the computer was fun.

- In the class where the personal computers were used, I was unexpectedly able to easily understand the materials.
- During the pre-test I didn't understand the subject at all, but I was able to understand it after taking this class. That surprised me.
- I skipped the tutorial so I could go straight to the calculation rally.
- The calculation rally was fun.

The comments which indicated problems:

- The program should have more detailed explanations, including more examples and notifications.
- There was a lack of explanation.
- I wanted to have more explanations of how to solve quadratic equations.
- It was difficult to operate the program freely.
- The wording was ambiguous.
- It was difficult.
- It was concise, but I couldn't grasp the structure of the game.
- Solving many problems on worksheets at my desk is more effective than solving multiple-choice problems on the computer.
- There are too few exercises in this program.

- You had better consider the quality of the questionnaire as well as the quality of the program.
- Make the questionnaire simple.

Suggestions for improvements to the program:

- It would be better if students could learn quadratic equations first and then use the computer.
- It was good for me to learn the simple equations and then move on to more complicated ones.
- It takes quite a bit of time.
- Because I do not use a personal computer daily, I had trouble understanding and operating it.

Bilingual version.

Favorable comments:

- This program is suitable for learning English and quadratic equations.
- It was good that the text was displayed in both languages.
- The light background makes the screen easy to see.
- Although it was the first time I had learned quadratic equations, the contents were so easy and well-explained that a beginner such as myself could easily understand them.
- The contents were easy to understand due to the good explanation.

- It was fun because I haven't had much experience learning mathematics using a computer.
- I like classes where I can use computers.
- This was the first time I had used a program like this. It was fun.
- The calculation rally was interesting.
- I want more calculation rallies to be included in other classes because they are interesting.
- I tried to master "completing the square" but the hurdle was placed fairly high.
- It was difficult but I am glad that I have gained some knowledge.
- It was very difficult, but after being able to understand and solve the problems, I was glad because I felt a sense of achievement
- There were a few points that I couldn't understand but nevertheless, this form of studying is interesting.
- Using a computer in class was fun but I couldn't completely understand the contents.

The comments which indicated problems:

- It was quite easy to understand the contents but the operation was difficult.
- There were some small problems with regard to operation.
- I became lost because there were many links to various places. I wish that only the "NEXT" buttons were linked.

- The operation was incomprehensible. For example, I couldn't find out which buttons would take me to the problem exercises.
- I wanted feedback after I finished solving all the questions in the exercises.
- It was difficult to find out whether the answers were right or wrong after solving problems.
- I liked the way the program was structured with the exercises appearing after the tutorial.
- I would prefer fill-in answers rather than multiple choice exercises.
- The positioning of the Japanese text made it incomprehensible.
- I was uncomfortable reading the page because the Japanese text covered parts of the English sentences.
- The title of the page shifted from the center.
- There is little rationale for studying mathematics and English on the Internet.
- The English was difficult.
- The questionnaire was not comprehensive compared with the program itself.

Negative comments:

- I didn't have a fun time.
- I wasn't interested in it as much as I expected I would be.
- I want this program to be changed because it wasn't interesting.

- It was too disordered and unpleasant.
- I haven't learned much from this program because I played with the computer.
- It was impossible to understand because I am not good at computers. An ordinary class is better for me.
- It is easier to learn quadratic equations with the textbook rather than with a computer.

Suggestions to improve the program:

- This calculation rally became quite difficult.
- I didn't understand the HIGH section (the upper course) well because I have not studied quadratic formulas.
- I think that the programmer should have used more pictures because the pages were filled with text.
- A little illustration would help make the program more attractive.
- I would prefer more animation on the pages which I found boring.

There were also comments suggesting that there were too many explanatory notes.

- The explanations were too long.
- I thought that it was quite interesting as a mathematics lesson but I felt that there were rather too many explanations.
- The explanations of the rules were insufficient.

- Help was required.
- There was a lack of explanations in the calculation rally.
- I think that the program would be interesting if there were enough time.
- I wish I could have had a little more time to spend in this class.
- I could only solve the “EASY” section of the calculation rally because the time had run out.
- There was no time to study “completing the square.”
- I wanted to use this program after receiving more explanations.
- Because it was new for me to both learn quadratic equations and to study them in English, I couldn’t understand the contents at all.
- I didn’t know how to start the class with a computer by myself without any preparation. I want to use this program after studying the subject in an ordinary class.

The English version

Favorable comments:

- It is good to learn with a computer once a while.
- I had a fun time in the class which utilized computers.
- I thought that I wanted to study again this way.
- From now on, the school should schedule more classes like this.

- This was the first time I studied quadratic equations in this format, therefore I received a fresh sensation.
- I think that to practice calculation in the calculation rally format was very interesting.
- This was the first time I studied quadratic equations in this format; therefore I received a fresh sensation.
- I have enjoyed the program. Although it was difficult, I could understand it because I studied with great effort.
- It was good. Although the English was difficult and I didn't understand it well, with perseverance I was gradually able to understand it.
- I didn't understand it very well but I enjoyed the feeling of the game.
- I couldn't understand the rules of the game but I gradually came to understand how to solve the problems in the game as I advanced step by step.
- Although I had a hard time reading the text in the program because of the English, I was finally able to understand it.
- I could understand quite well but it was difficult.
- Because I had to examine the words one by one, I had a hard time. But at the same time, I quite enjoyed this program.

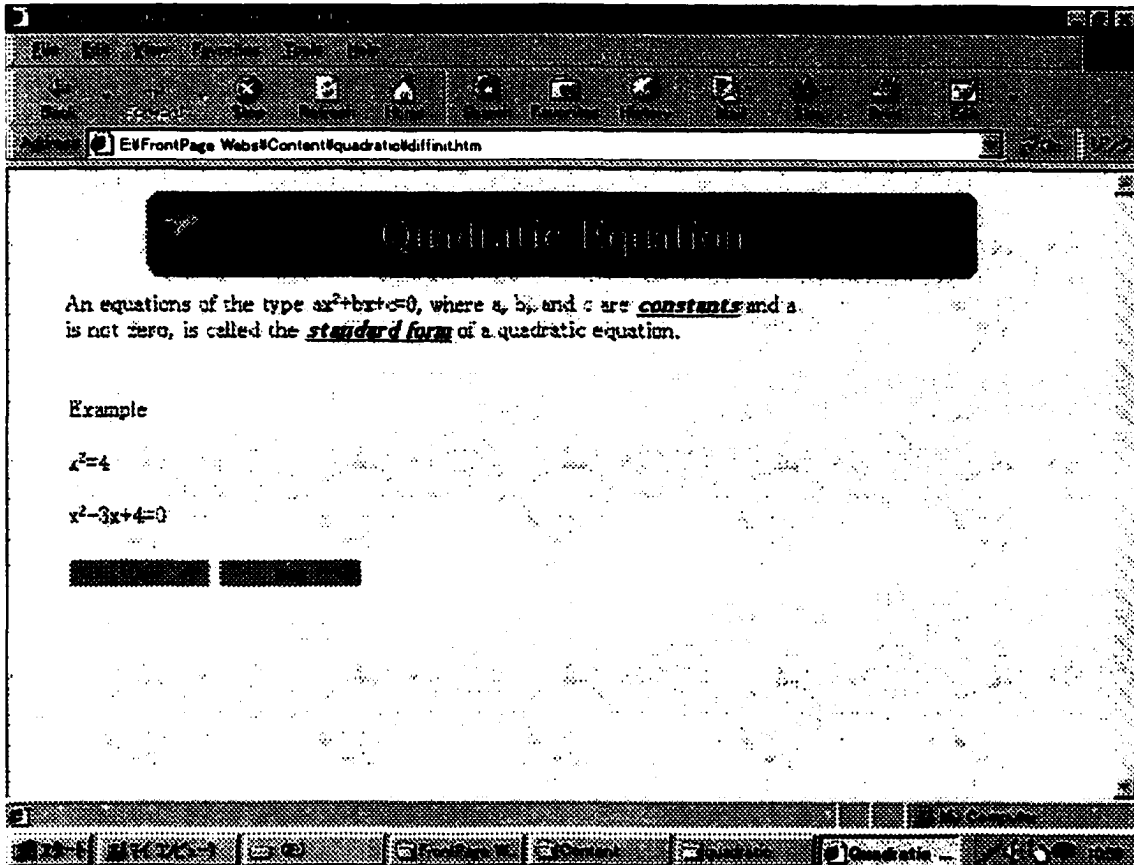
Negative comments:

- It was too difficult.

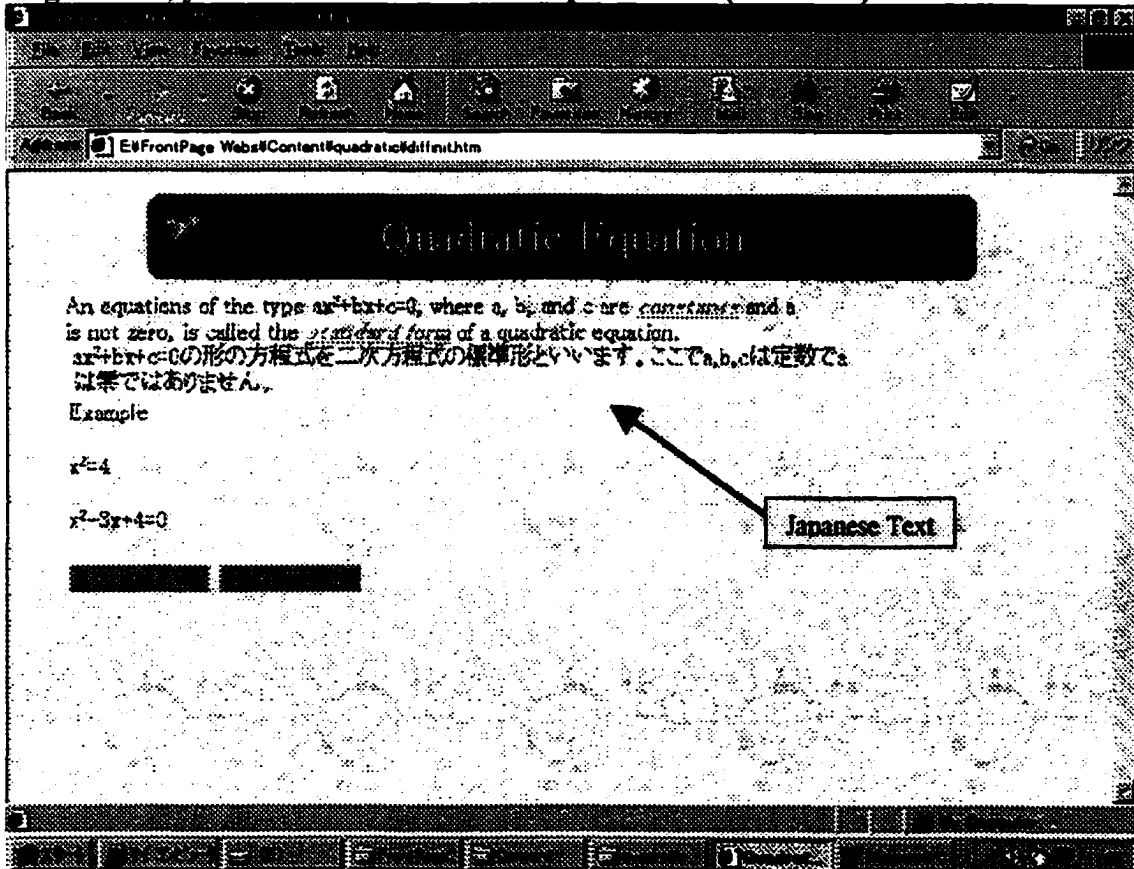
- I wish this program were a little simpler.
- I could not understand the meaning of the problems. There was no sense of how each item related to the others.
- Explanations with only numbers and letters are impossible to understand.
- There was a lack of explanations for the rules of the game.
- Rather than use this program, I would like to study math in an ordinary classroom in Japanese.
- It was tough even to read the rules of the game because it is written in English.
- It was difficult to understand because the entire text was written in English.
- It was fun, but there were many places where the explanations were difficult and I didn't understand the English well.
- The class had ended as soon as I learned the rules of the game. I wish the rules were written in Japanese.
- It isn't good for me to study two subjects at the same time because I cannot concentrate on them.
- English is difficult for me, so this math class was too tough.
- I couldn't understand why it was necessary to use a computer in this class.
- I think that it would be easier for me to receive my explanations on the blackboard in Japanese.

- It was easy to use but difficult to understand.
- The calculation rally was simple and easy to play but it was difficult to study the lesson without the bilingual version.
- It was difficult. The Japanese version was easier to understand.
- It is easier for me to understand when the explanations are in Japanese.

Appendix S
Samples of the Screen



The screen above is written in English only, but if you place your mouse over the English text, you can see the translated Japanese text (see below).



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