The Effectiveness of Online Interactive Tutorial
versus Online Help and Printed Manual in
Project GeoSim’s User Assistance System

by

James M. A. Begole

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APPROVED:

Dr. Clifford A. Shaffer, Chairman

Dr. Robert C. Williges

Dr. John M. Carroll

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(ABSTRACT)

The aim of Project GeoSim is to develop simulation based introductory geography education software. To maximize the educational benefit of the software, Project GeoSim has developed three user assistance and training methods: Online Help, Printed Manual, and Online Interactive Tutorial.

Using a population dynamics simulation called IntlPop as the test-bed, an experiment was conducted comparing the three training methods against each other and against no training at all to find the method from which users complete laboratory exercises most quickly and with the greatest accuracy. Twenty-four participants were randomly assigned to one of four treatments: the three user assistance methods and a control that received no training. Following training, the participants answered nine questions using IntlPop.

The control received no training and therefore spent the least time with training material. Of the other training methods, analysis detected no significant difference regarding the time spent with training material. Participants that received training from the online interactive tutorial completed tasks more quickly than those that received no training. However, no significant difference in speed of performance was detected between the online help and printed manual and either the control or online interactive tutorial. Additionally, analysis indicated no significant difference in accuracy of responses among the four treatments. Nor were there any significant differences with respect to subjective satisfaction.
ACKNOWLEDGEMENTS

In addition to her support and encouragement, my wife, Florence, deserves credit for scheduling the sessions of the experiment. This research would not have been possible without her effective management of me and her skill in dealing with the participants of this study. I offer her my most sincere gratitude.

I extend my thanks to my advisor, Dr. Cliff Shaffer, who not only suggested this project but also helped explore the questions raised in conducting such an experiment. I especially appreciate the sharing of his interest and capability in the many subdisciplines of computer science.

I also want to thank Dr. H. Rex Hartson for his assistance in developing the focus of the study. I thank Dr. Robert C. Williges for his assistance during the experiment, providing laboratory facilities and the help of the Human-Computer Interaction Laboratory group.

For her personal instruction on statistical methods and analysis, I owe a great debt of gratitude to Shanthi Sethuraman. I also thank my colleague, Michael L. Talbert, for helping me design the experiment, as well as his consistently stimulating discussions of matters not related to computing. I also want to thank all of the past and present members of Project GeoSim for their work on this excellent software.
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Chapter 1

Introduction

1.1 Project GeoSim

Project GeoSim is a multidisciplinary effort involving members of the Departments of Geography and Computer Science at Virginia Tech to develop computer-aided instruction (CAI) modules for teaching introductory geography to first year college students [11]. Project GeoSim instruction modules typically consist of a multimedia tutorial of background information about the geography concepts involved in the lesson and a simulation program that allows students to apply, experiment with, and enhance the knowledge they have gained.

So that the software may be used by the widest possible audience, it needs to run on a variety of computer platforms. Another goal of Project GeoSim is to have simple and consistent user interfaces for each module developed [5]. For these reasons, the project has developed a library of graphics and interface routines with which to develop the simulation modules. The Project GeoSim Graphical User Interface (GUI) [11] incorporates direct manipulation in the hope of providing short bridges over Norman’s gulfs of execution and evaluation [29]. The interface library has been ported to three major computer platforms: MS-DOS version 3.3 and higher, Macintosh System 7 and UNIX workstations running X-Windows. Applications written using this library are portable, requiring little or no revision to the source code.
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Figure 1.1: A sample screen of IntlPop, a population demographics simulation program.

1.1.1 HumPop and IntlPop

The first Project GeoSim module to be completed consists of a demographics tutorial, Human Population (HumPop), and a demographics simulation program, International Population (IntlPop). These were first used at Virginia Tech in the Spring of 1993 [11]. HumPop introduces a student to ideas and terminology of population studies. The simulation program, IntlPop, lets students examine factors that affect population growth and decline (Figure 1.1). A student may work the simulation on any country or region of the world (based on 1990 political borders).

Members of Project GeoSim carried out formative evaluation of both the multimedia geography tutorial and the simulation program to find weak points in the interfaces. The method of these formative evaluations was informal: observe students using the software; spot and record the circumstances of critical incidents as well as less critical difficulties with the interface; and interview the students about possible changes to the interface.

These evaluations were carried out by asking a student to use the software to answer the same laboratory exercise questions that were assigned in courses using HumPop and IntlPop. Two graduate assistants of Project GeoSim observed the participant. I joined Project GeoSim at this stage of the development of IntlPop and was an observer in
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several of these sessions. If the student was seen to be having trouble completing a question of the exercise, an observer would stop the student and ask about the difficulty he or she was experiencing. I implemented the improvements to IntIPop discovered and recommended during these evaluations.

1.2 User Assistance

Beyond the attention placed on user interface design for Project GeoSim modules, we wanted to include some training, since, as Schneiderman claims, “All users of interactive computer systems require some training” [45, p. 440]. Project GeoSim software was developed to be distributed and used outside of Virginia Tech. Since the developers cannot train all instructors and users of the software, we must distribute some form of instruction.

Users of Project GeoSim software are generally inexperienced computer users. Typically, these students will use a module only once or a few times. Such inexperienced users require assistance to learn the details of a system [52, 21].

Bannon found that when users have a question about a system, they generally prefer to consult other people rather than look in a manual or other source of information [4]. Granda, Halstead-Nussloch and Winters surveyed users about their use of various information sources. Their responses showed that “the best online and human sources are used at about the same rate, 70% of the time; but, humans are rated more effective at 80% versus 60% for online sources” [21].

Unfortunately, of the people involved in a geography course that includes Project GeoSim software, presumably only the instructor will have used the software previously. Typically, instructors will assign Project GeoSim modules as a laboratory outside regular class meetings. In that case, the instructor is not likely to be present, so students cannot ask for assistance when they have difficulty. We therefore need to supply some form of self-instruction material with the distribution of Project GeoSim software.
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1.2.1 User Training

Despite all efforts to develop interfaces that are easy to use by everyone, some aspects of an application’s interface may be misunderstood by some users. Should testing indicate that a particular interface element is non-intuitive, there may be no cost-effective alternative to its inclusion. In these cases training is required to teach users how to use the interface.

Perkins, Blatt, Workman and Ehrlich argue that if one-trial learning can reduce or eliminate errors, then the program should not be changed [38]. They report an example where a new scrolling mechanism was almost impossible for users to discover due to the lack of any visible indication that it existed. To display the full width of a page at the highest resolution available on the display, no scroll bar or other artifact was displayed.

To scroll, the user moves the pen to the edge of the tablet. This causes a hand to appear on the edge of the image. A touch down on the tablet and a sliding motion then causes the image to scroll, which is similar to moving paper on a desk.

No change was made to the scrolling mechanism over three iterations of design. However, the description of scrolling was changed in the tutorial until tests of the final program/tutorial combination detected no scrolling errors.

This is not to suggest that all interface problems may be solved with training. It is through trying to develop training for poor interface elements that their inadequacy may become apparent. The training required may be complicated and therefore go unused [38]. Additionally, Brockman claims that good documentation points out the problems in a bad design, since poorly designed controls are difficult to teach [7, p. 48].

1.3 Purpose of this Study

**Project GeoSim** modules aim to teach principles of geography. The users’ focus should be on learning Geography, not the instructional software. Presumably, users prefer a human instructor, but such would diminish one advantage of computer-aided instruction, that of
CHAPTER 1. INTRODUCTION

freeing instructors from some instruction. Therefore, we have devoted effort to discovering the method that provides users with the most effective training.

1.3.1 Three Assistance Methods

This study compares three software training and assistance methods: online help screens, printed manual, and an online interactive tutorial. While there is research directly comparing online versus printed documentation, no study has compared interactive tutorials to online help and printed manuals.

Each method’s design and implementation for IntelPop is described in Chapter 2. Research into the issues related to these three methods is discussed later in this chapter.

This study was designed to compare the three training methods, along with a control group, and find the method from which users complete given tasks most quickly and with the greatest accuracy. Time to complete the training was also compared.

Hypothesis I hypothesized that: Users of IntelPop that are provided with an online interactive tutorial will complete tasks in less time and with greater accuracy than users provided with (1) a printed manual, (2) an online manual or (3) no training.

I approached the evaluation of these methods as a summative evaluation of each method’s usability.

1.3.2 Measurable Human Factors

Schneiderman identifies five measurable human-factors goals to determine the usability of a system [45, pp. 15-18].

1. Time to learn
2. Speed of performance
3. Rate of errors by users
4. Retention over time
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5. Subjective satisfaction

This study investigates numbers 1, 2, 3 and 5. Since users of Project GeoSim modules are expected to use a module only once or a few times [5], we are not concerned with their ability to retain knowledge of how to use a module.

Besides their use as evaluation measures, the four human factors investigated are important to Project GeoSim for the following reasons.

Time to learn: Despite efforts to present a simple user interface to the students, they must spend some time learning to use the features of each module. We hope to provide users with the training method that will most quickly teach them what they need to use the simulation modules. The goal is that users will be able to quickly learn the software so that they may focus their learning experience on geography.

Speed of performance: Our software is not used in a business environment where productivity is important. Presumably, students should spend as much time with the modules as they require to understand the geography concepts involved. Nevertheless, given that students have limited instructional time, the more quickly they can complete tasks, the more geography questions they may investigate. Therefore, there is some advantage to providing a training method that enables users to perform tasks quickly.

Rate of errors by users: In addition to its relevance as a usability measure, error rate is especially important in an educational setting. No matter how capable the software is of exploring important geography questions, if students are not able to find the correct answers with the software, then it has failed as an education tool.

Some geography issues addressed by Project GeoSim modules, such as population growth and decline and migration patterns, are complex. The simulation programs provide students with the means to adjust simulation factors in realistic and complex ways. Because of the subtle and complex interactions of simulation factors, a student may reach a false
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conclusion to a question with the software.

While we hope to reduce the probability of errors by providing usable interfaces to the simulations, if the elements of the interface are not used correctly, incorrect results will always be possible.

**Subjective satisfaction:** In providing students with the means to investigate geography issues, such as population growth and decline, **Project GeoSim** hopes to engage students’ interest in the subject. Interacting with the software to manipulate population growth curves and cohort pyramids should be more interesting and instructive than simply seeing a few representative graphs in a text book. We hope to improve students’ satisfaction with their learning experience.

Being unable to use software correctly can be extremely frustrating. Therefore, we seek to provide students with the training method that most thoroughly teaches them to use the software effectively.

1.4 Relevant Research

Many researchers have explored issues related to the use of online and printed documentation. However, online interactive tutorials have not received as much attention, perhaps due to the relative difficulty of implementation. The remainder of this chapter reviews the research relevant to this study.

1.4.1 Online Help

Online Help is that information about a program that may be reached either from within the program itself or from a system that is available to the user from the same terminal on which the program is accessed [7, 25]. We felt that putting the training and assistance online would have the following advantages:
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1.4.1.1 Online Material is Always Available

Online manuals and help systems have at least one clear advantage over print media: online media are always available when the user needs them. This is especially true of multi-user systems that often include only one set of manuals to be shared among the several users. Organizations generally keep the printed documents in a central location so that users may find them. However, it seems likely that few users bother seeking out the material if the same information is available from where they sit.

We imagine this to be the case at many locations that use Project GeoSim software, which is freely available on the Internet via ftp, gopher and World Wide Web (Mosaic) at geosim.cs.vt.edu. While the manual is included in two printable formats, Postscript and plain ASCII text, we do not expect that instructors print and distribute manuals to every student. This suspicion is encouraged by noting that even the instructors that use Project GeoSim software here at Virginia Tech do not give each student a copy of a program's user's manual.

Granda, Halstead-Nussloch and Winters found users considered human sources of information more effective than online sources. Nevertheless, users consulted online sources of information at the same rate as they consulted human sources [21]. This is because online sources are available whenever the system is available and, therefore, whenever the user confronts a problem with the system. However, human and printed sources may not be available when needed. Price claims that when faced with a problem, users will not bother locating a manual, let alone search the manual for an answer [40].

1.4.1.2 Online Information can be Quickly Updated

Since software usually evolves and changes, program documentation needs to be updated to include changes and enhancements of the latest version of the software. When software is distributed with online documentation, version upgrades may include corrections and updates to the program documentation. In contrast, when printed documentation is included
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with software updates, users should discard obsolete versions of the material.

Furthermore, information sources inevitably contain errors. Such errors are more easily correctable in online versions than in paper versions. Once a correction is made in an online source, it is correct for all future access of that source. Correcting an error in a printed manual requires both making the correction and reprinting the manual.

1.4.1.3  Online Material can be Made Context-Sensitive

A Context-Sensitive help system provides information based on the state of the program when a user requests help [30]. This is only possible if the help system understands the application program’s states. Printed manuals are incapable of this.

1.4.1.4  Online Material is Inexpensive to Publish

Software developers may save publishing costs by creating online documents. The trend today is to move away from printed documentation by initially creating documentation online or converting existing printed text to online systems. Horton [25] claims that the cost of doing so is small if the documents are:

- Stored electronically in word-processing files – or better still, in a database
- Naturally divided into independent screen-sized chunks
- Consistent in style and presentation
- Clearly and simply organized

However, documents containing graphics of many colors, fine detail, or extremely large size can be costly to put online.

1.4.1.5  Online Material is as Easy to Read as Print

Research has shown that there is no difference in the ability of people to read and comprehend text presented on a computer screen versus that printed on paper [36]. Oborne and Holton explain the differences seen in some studies comparing online versus print by
CHAPTER 1. INTRODUCTION

pointing out that, aside from the difference of medium (electronic vs. paper), the presentation of the medium is different [36]. Online text is displayed on a screen in a fixed position, whereas users of printed material may conveniently position it to optimize distance, posture and lighting.

In their study, Oborne and Holton presented printed material in the same manner as electronic by fixing the distance and visual angle, character height, and lighting conditions. They found no difference between online and print in the time to read a passage of text nor in the comprehension of the text as determined by a test. They also found no difference with the respect to the polarity of the displayed text (that is, dark characters on a light background versus light characters on a dark background). They contend that studies that have found a disadvantage of screen displays did not consider factors affecting reading speed and comprehension such as distance, posture, viewing angle and lighting.

1.4.2 Content and Writing Style of Online Help

Content and writing style influence the effectiveness of online help text. Cherry and Jackson carried out a study comparing the usability of two versions of online help [14]. They revised portions of an existing online help system and compared user performance and preference of the two versions. Their guidelines for the revision are listed below. While there was no significant difference in the quality of work, “participants who used the revised version made 40 percent fewer help requests and viewed 45 percent fewer help screens than those who used the original version.” Additionally, the participants strongly preferred the revised version. While this study compared online help systems, it is likely that similar results hold for printed manuals.

- **Content**
  - Adding detailed information for inexperienced users
  - Adding explanations for terms, prompts, or task steps
  - Removing trivial, repetitive, and irrelevant information
  - Making the help text specific to a situation rather than trying to use the same text for many similar situations
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Table 1.1: Mager’s results of comparing the original VAX/VMS help system to the revised version.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Original Online Help</th>
<th>Modified Online Help</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total task completion time in minutes</td>
<td>75.6</td>
<td>52.0</td>
</tr>
<tr>
<td>Percent commands with errors</td>
<td>37.9%</td>
<td>17.9%</td>
</tr>
<tr>
<td>Number of references to manuals</td>
<td>11.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Questions asked of consultant</td>
<td>6.4</td>
<td>2.0</td>
</tr>
<tr>
<td>Total number of Helps used</td>
<td>22.4</td>
<td>60.8</td>
</tr>
<tr>
<td>Number commands used per min.</td>
<td>0.99</td>
<td>1.95</td>
</tr>
<tr>
<td>Total number of commands used</td>
<td>70.8</td>
<td>98.5</td>
</tr>
</tbody>
</table>

- Writing style
  - Making sentences terse
  - Giving instructions in step-by-step fashion
  - Naming a task followed by the instructions for performing the task (for example, To delete a field, type the character d . . .)

- Presentation of the text
  - Highlighting important information
  - Reformating some paragraphs into lists and tables
  - Providing a quick reference before giving a full explanation.

Magers also found that a revised online help system in a VAX/VMS environment was more effective than the original (see Table 1.1) [31].

1.4.3 Printed Manual

While it may have been infeasible to put software documentation online in the early days of computing, it is now commonplace. Yet the shelves of computer users tilt and sway
CHAPTER 1. INTRODUCTION

with their burden of printed documentation. Researchers have investigated the advantages and disadvantages of printed material.

1.4.3.1 Users Do Better with Print

Although there is no inherent advantage to reading text on paper versus reading text online [36], research has shown that users of printed manuals do better than users of online documents. Here at Virginia Tech, Ray A. Reaux studied two groups of interface evaluators: one using printed copies of Smith and Mosier user interface guidelines and another using an online copy of the same guidelines. The group using the printed manuals did better than the group using the online system [42].

In addition to the medium of help information (online vs. printed manual) Cohill and Williges studied the effects of the initiation of help (computer vs. human) and selection of help topics (computer vs. human) [15, 16, 52]. They found that the optimum combination of the three factors for computer novices was that in which the user initiates and selects the help topic in a printed manual.

In the Granda, Halstead-Nussloch and Winters survey, respondents said that they considered human sources of information to be most effective, printed documentation next and online sources last [21].

Users of paper manuals performed tasks faster than users of online manuals in a study done by Weldon, Mills, Koved and Schneiderman [51]. The members of the treatment groups completed the tasks with approximately equal accuracy. The study also compared tree structured organization versus linear structure. They hypothesized that the tree structure would be an advantage for the online versions of a technical reference and that the linear format would be an advantage for the printed manual. However, they found no effect with regard to organization of the material.
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1.4.3.2 Why Users Prefer Print

Since it has been shown that people can read and understand online material as well as printed material, it is important to explore the factors that give print material an advantage.

Presentation: While it is important to know that there is no inherent difference in people’s ability to read and understand text from a screen versus text on paper, printed material is not normally presented in the manner of Oborne and Holton’s study [36]. In that study, characters were printed to be the same height and weight as characters on a display screen, lines were the same width; Oborne and Holton took pains to ensure that the only difference in the characters of the two media was a slight difference in interline spacing.

Navigation: Other studies point out that the browsing capability of printed manuals generally surpasses that of online systems [42, 15, 40]. The spatial nature of printed books allows faster navigation of contents. Users may keep their place in a book with their fingers or other markers that are not available in the electronic medium. Therefore, users of printed manuals are more able to quickly find the information they seek.

Context Preservation: Additionally, the context of the problem for which the user seeks assistance may be lost while accessing online information systems. In Cohill and Williges’ study the editor screen was overwritten by the online help [15]. Therefore users of online help were not able to refer to the program while reading the help. Users with printed manuals, had no such limitation.

Speed: Access speed has also been cited as contributing to the disadvantage of online systems [40]. The character based terminals from which subjects worked in Cohill and Williges’ study received text at 9600 baud. Therefore, Cohill says, it took longer to display a page of text on screen than to turn a page in the printed manual, possibly discouraging users of online help [15].
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Resolution: In 1981, Price attributed the ability to include multiple fonts and illustrations as an advantage of print medium over online material. Today’s graphical operating environments, such as the Macintosh, Microsoft Windows and X-Window environments, provide many fonts and graphics. Nevertheless, it is still true that the superior character resolution of printed material eases reading. Most laser printers provide a resolution of at least 300 dots per inch, with 600 dots per inch becoming increasingly popular. A typeset and printed book may provide even greater resolution, as much as 2,500 dots per inch [25, p. 26]. However, many video displays today provide approximately 100 dots per inch of screen resolution (1024x768 pixels on a 14-inch display) or less.

1.4.3.3 Online and Print satisfy different needs

Comparisons of online versus printed help systems imply that developers may want to adapt only one of these media to deliver information about their system. However, users are more likely use both, depending on their needs. Price points out the complimentary nature of printed and online material [40].

The two media answer different needs and sometimes address different audiences. Online documentation is used by people who need rapid access to the few facts that will enable them to perform a specific task. Offline documentation may be read cover-to-cover by individuals considering acquisition of a system, those who are about to use a system for the first time, or those who wish to review a system’s capabilities.

1.4.4 Online Interactive Tutorial

Houghton identifies the most difficult problem facing a new user as that of “simply getting started” [27]. He suggests that new users be provided with a step-by-step tutorial that shows the system’s capabilities and allows the user to practice with the system. Unfortunately, as Carroll points out, new users do not like to read training material[8, p. 8].
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Table 1.2: Moll and Fischbacher's results comparing online tutorial and help systems.

<table>
<thead>
<tr>
<th>Assistance Method</th>
<th>Reaches Goal</th>
<th>Reaches Goal in a roundabout fashion</th>
<th>Changes Goal</th>
<th>No Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online Tutor</td>
<td>73 %</td>
<td>9 %</td>
<td>14 %</td>
<td>4 %</td>
</tr>
<tr>
<td>Context-Specific</td>
<td>30 %</td>
<td>7 %</td>
<td>17 %</td>
<td>46 %</td>
</tr>
<tr>
<td>Online Help</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Most students using Project GeoSim software have some experience with computers and of the point-and-click style GUI employed by IntIPop. However, they may have no idea as to the capabilities and use of IntIPop. A simple demonstration of the capabilities of a software application is often enough to give users an idea of where to start. Users require training, however, to learn how to start.

1.4.4.1 Effectiveness of Tutorials

Perkins, Blatt, Workman and Ehrlich compared task completion times between subjects trained to use software with an online interactive tutorial and subjects with no training. Users of the tutorial took an average of 10 minutes, while those that received no training took 28.9 minutes [38].

Additionally, Moll and Fischbacher compared an online interactive tutorial with a context-specific online help system. In a tool-and-die making system, they found that while users of the online help system reached their goal only 30 percent of the time, tutorial users reached their goal 73 percent of the time (Table 1.2). They attribute this effect to the fact that the online help system was completely passive, requiring the user to initiate help. In contrast, the tutorial was both passive and active, initiating dialogs 56 percent of the time versus the users' 44 percent.

1.4.4.2 Online Tutorials vs. Printed Instruction

While users do not consider online tutorials as effective as a human instructor, they do consider them better than a printed instructional manual. In evaluating the Talking Tutor
CHAPTER 1. INTRODUCTION

'n' Trainer (TNT), Nakatani, Egan, Ruedisueli and Hawley asked subjects to rate (on a 0-5 scale) five methods of instruction: a human tutor, a well-written instructional manual, the Talking Tutor 'n' Trainer, a small class with an instructor, and learning by "playing around." There was no significant difference between a human tutor ($\bar{X} = 3.36$), TNT ($\bar{X} = 2.84$), a small class ($\bar{X} = 2.88$) and "playing around" ($\bar{X} = 2.46$). However, TNT was rated reliably higher than the instructional manual ($\bar{X} = 2.04$) [34].

1.4.4.3 Advantages of Online Tutorial

Al-Awar, Chapanis and Ford [2] identified the following as advantages of an online interactive tutorial versus an instructor and printed instruction:

- The user does not have to keep shifting his attention between the terminal and an instruction booklet or between the terminal and an instructor.

- By focusing his attention on the terminal itself the user continually practices the very skills he needs to use it.

- Since there need be no other person present while the user goes through the tutorial, he can avoid the embarrassment that people feel when they make mistakes.

Additionally, most tutorials make the user take an active part in the training. In contrast, printed and online documentation are passive. The active nature of many online tutors may provide a better learning environment. Carroll points out that "learning a system on the system itself can narrow the gap between "learning" and "doing" "[8].

1.4.5 Usability Testing of User Assistance

Testing and evaluating user interfaces is an essential part of application development today. Despite developers best intentions to provide intuitive interfaces, user testing is necessary to find those parts that are unclear. Such testing should be extended to the user assistance materials provided with a program, such as the online help, printed documentation and tutorials [38, 2, 22, 47]. Al-Awar, Chapanis and Ford note "that the carefully
CHAPTER 1. INTRODUCTION

written prose over which you have labored so long and diligently will be misinterpreted in
the most astonishing ways” [2].

1.4.5.1 Online and Printed Documents

A difficulty faced during formative evaluation of reference and training materials is that
the application being described will change during evaluation of the materials [38, 47].

Simpson argues that developers should carry out usability testing iteratively throughout
the development of online assistance products [47]. However, he also points out the difficulty
of testing online material before the online vehicle has been implemented. Performance
tests are not applicable during early stages of development, if a prototype simulates the
functionality of the final online reference system. However, interviews of potential users
for their opinions about the prototype and alternatives to it, as well as ranking those
alternatives, may be useful.

Prototype testing of online and paper documents is also suggested by Brockman [7].
He does not suggest that developers evaluate the entire help system, but that they test
a portion representative of the “layout/format/design, writing style, tone, and reference
aids” that will appear in the production of the full-scale manual. He also recommends field
testing the final version of a document.

Another approach to iterative documentation development, offered by Guillemette, is to
initially develop the training and reference material for basic core tasks [22]. These central
core tasks may be discovered by their anticipated frequency of use. Evaluators may use
these core documentation elements as the representative sample in formative evaluation as
suggested by Brockman [7].

1.4.5.2 Tutorials

As with online documentation, it is difficult to evaluate a tutorial that teaches the use of
a program that is still under development. Since the user assistance system is as much a part
of the interface as any control, however, the tutorial and application should be developed
and tested together. This was the approach taken at Wang Laboratories by Perkins, Blatt, Workman and Ehrlich [38]. Through iterative development and testing, they found that not only did users’ task completion time decrease, but the time to complete the tutorial was reduced, while the number of features it described increased.

1.5 Summary

The aim of Project GeoSim is to develop simulation based introductory geography education software. By creating simulation software that does not require more than introductory expertise in the field, Project GeoSim hopes to provide students with a more stimulating geography experience than they might get from more traditional instruction techniques. To maximize a student’s geography education with the software, Project GeoSim has developed three user assistance and training methods: online help, printed manual, and online interactive tutorial. The purpose of this study is to compare the implementations of these three user assistance technologies and determine which best prepares Project GeoSim students to use the simulation software.

While users refer to online material more often than printed material, research has found that users perform more efficiently when using printed instead of online documentation. However, little research has evaluated the effectiveness of online interactive tutorials. No study has directly compared all three of these user assistance and training methods.
Chapter 2

User Assistance in IntlPop

We do not expect users of Project GeoSim software to have much experience with
computer software. We are therefore concerned that they may become bogged down learning
to operate the program, missing the points of geography being presented to them. By
providing user assistance, we hope that students will quickly become familiar with the
techniques they need to effectively use the software.

Additionally, we are concerned that students enjoy a positive experience with the educa-
tion software. Al-Awar, Chapanis and Ford warn that the negative attitudes of many people
toward computers are due, in part, to the manner in which computers are first introduced
[2].

This chapter discusses the design and implementation of user assistance in IntlPop.
Section 2.1 describes the main functions and interface elements of IntlPop. The follow-
ing sections describe the development of the three user assistance methods provided with
IntlPop: Online Help, Printed Manual and Online Interactive Tutorial.

2.1 An Overview of IntlPop

This section describes the main functions and interface elements of IntlPop. Further
details on the use of IntlPop may be found in the user’s manual in Appendix A.

2.1.1 Selecting a Country or Region of the World

The first step of using IntlPop is to select a country or region of the world with which
to run simulations. This is accomplished through the Country/Region selection window,
CHAPTER 2. USER ASSISTANCE IN INTLPPOP

Figure 2.1: Country/Region Selection Window

shown in Figure 2.1. In this window, a country or region may be selected in three ways. All three selection methods are described in the training materials.

- Click on a country or region in one of the two maps. The view of countries in the bottom map is controlled by dragging the rectangle in the top map, and with the $\pm$ and $\pm$ Zoom buttons.

- Click on the name of the desired country or region in the list. Students control the position within the list with the scroll bar.

- Type the name of the desired country or region and press return. As users type the letters in a name, the scroll list searches for the best match and redisplay the list with the mouse positioned over that match.

2.1.2 Running Simulations

After a country or region of the world is selected, the program presents the 1990 values of population and simulation variables to the student. The student may now simulate population change in five year increments by pressing $[\text{Sim} \pm]$ (see Figure 1.1). The simulation
CHAPTER 2. USER ASSISTANCE IN INTLPOP

will calculate the new values for cohorts of the population pyramid, the population growth graph, and the current total population.

After running a simulation based on the 1990 values of a country or region of the world, the student may wish to run another simulation for comparison. To accomplish this, the student needs to press [Options] and select “Run another simulation” from the menu. The 1990 population is redisplayed for the new simulation. As the new simulation is run, a new growth line will be displayed in a new color, and new population totals will be displayed in the rightmost box. Up to three simulations may be run.

2.1.3 Adjusting Parameters of the Simulation

2.1.3.1 Three Main Parameters

There are three main factors that a student may manipulate to investigate their effect on population:

Total Fertility represents the average number of children a woman has during her lifetime in the selected country or region of the world.

Life Expectancy is the expected number of years a person lives in the selected country or region of the world.

Net Migration is the net annual change in population due to migration to or from the selected country or region of the world.

When one of these buttons is pressed, a window appears that allows the student to change the setting of that variable. Additionally, the student may elect to have the value change gradually from its current setting to the new setting by the year specified. Figure 2.2 displays the parameter adjustment window for Total Fertility Rate.
CHAPTER 2. USER ASSISTANCE IN INTLPOP

Figure 2.2: An example of a parameter adjustment window. A student may change the value of one of the three main simulation parameters: Total Fertility Rate, Life Expectancy, and Net Migration.

2.1.3.2 Cohort Birth and Death Rate Adjustment

The student may also gain finer resolution control of the Total Fertility Rate and Life Expectancy parameters. The birth and death rates of each cohort may be adjusted by using $+$ and $-$ buttons. When the student selects “View birth/death rate buttons” from the Options menu, the death rate buttons appear to the left of the population pyramid and the birth rate buttons appear to the right. This selection disables the Total Fertility and Life Expectancy buttons, since those values are based on the rates of each cohort. A cohort’s deaths or births per thousand may be increased or decreased by pressing the $+$ or $-$ button respectively for that cohort. Figure 2.3 displays the birth and death rate adjustment buttons.

2.1.3.3 Changing the Number of People in a Cohort

*Dragging* the bar of a cohort in the population pyramid simulates a reduction in the number of people in that cohort. With this control, users may investigate cohort specific effects, such as a decrease in the male population in the 20-29 age group that may result from a war. Figure 2.4 shows a user dragging a cohort.
CHAPTER 2. USER ASSISTANCE IN INTLPOP

Figure 2.3: The cohort birth and death rate adjustment buttons adjust the births and deaths per thousand in each cohort.

Figure 2.4: A decrease in the number of people in a cohort may be simulated by dragging the bar of that cohort in the population pyramid.
CHAPTER 2. USER ASSISTANCE IN INTLPoP

Figure 2.5: The online help system of IntLPoP. The help window can display 25 lines of 80-character text. A context-sensitive message window appears at the bottom of the screen.

2.2 Online Help

Online help was the first user assistance method developed for IntLPoP. The main reason for selecting online help instead of the other means of user assistance was its availability to the user as discussed in Section 1.4.1.1. The online help system was initially intended to be the only training and assistance method developed for IntLPoP. We tried to create the best online help we could.

2.2.1 Project GeoSim Online Help System

The online help consists of two parts, both of which are displayed in Figure 2.5:

Help menu – A Help button appears at the top of the screen. Pressing this brings up a menu of Help topics from which the user may choose. Selecting one brings up a window with the text of a file that explains elements of the program in detail. The help window can display twenty-five lines of eighty-character text.

Context-sensitive message window – A three-line window at the bottom of the screen provides users with context-sensitive messages about what features of the program are currently available.
CHAPTER 2. USER ASSISTANCE IN INTLPPOP

Figure 2.6: The “Quick-start” screen of IntLPop.

Because users did not read the online help text, we added a “Quick-start” screen to the online help system. This screen labels all of the major controls described in Section 2.1. Figure 2.6 shows the “Quick-start” screen. To force the user to get some instruction, IntLPop displays the “Quick-start” screen when it is first started. Students may later redisplay this screen by selecting it from the [Help] menu.

2.2.2 Text of Online Help

There are many different ways to organize and write online help systems. Because IntLPop is a small system with few functions, we chose to organize the online help linearly, similar to that of a book.

We believe that this organization is just as effective in a small system, such as IntLPop, as more complex organizations (such as hierarchical tree structure, or Hypertext) would be. Weldon, Koved and Schneiderman found that users of a linear structured technical manual performed tasks as quickly and accurately as users of a tree structured manual [51]. This lack of effect was true in both the online versions of the technical manual and the paper versions.
CHAPTER 2. USER ASSISTANCE IN INTLPop

2.2.2.1 Help Menu

The content of IntLPop’s online help system is broken into three sections. The full text of each of these sections is in Appendix C.

Tutorial Help takes the reader through the steps required to select a country or region of the world. Elements of the display, such as windows and simulation parameters, are also described. There are six pages of text under “Tutorial Help.”

Options Help lists and describes the functions of the five menu items under the Options button. There are two pages of text under “Options Help.”

Controls Help categorizes and describes the four main types of controls available in IntLPop: Simulate, Options, Parameter Adjustment, and Cohort Population Adjustment. The first page lists and briefly describes these categories. Following pages give detailed descriptions of the functions and effects of these controls. There are six pages of text under “Controls Help.”

2.2.2.2 Info Menu

In addition to the online help system, information about Project GeoSim and the technical details of the simulation is available. This information is not part of IntLPop’s User Assistance system and so does not appear under the Help menu, but under the Info menu. The information found is not instructive, like the help menu items, but descriptive of the technical details of the program. Three sections of information are available:

About This Program provides copyright and license information. Development credits, version information and a brief description of IntLPop are also included in the two pages of text.

GeoSim Info lists the principle investigators of Project GeoSim and describes the purpose of Project GeoSim. There are two pages of text under “GeoSim Info.”
CHAPTER 2. USER ASSISTANCE IN INTLPop

Technical Info contains the technical details of the simulation, such as the equations used and definitions of the parameters of the simulation. "Technical Info" contains eight pages of text.

2.2.3 Content and Style

No amount of online help will benefit the user, if it is poorly written. Therefore, I tried to ensure that the text of the online help system was accurate, brief and clear.

Cherry and Jackson showed that content and style of online help can affect both the number of times that help is accessed and the number of viewed help screens [14]. When I joined Project GeoSim, text for the online help pages already existed. I revised them following Cherry and Jackson's list of changes. Whether my revisions of IntlPop's help files match the success of Cherry and Jackson's revised help system is open to question. However, the following examples of my use of their guidelines are offered in defense. The full text of IntlPop's help files is in Appendix C.

• Content

Adding detailed information for inexperienced users – The entire text of the Intro Help (Appendix C.1) targets new users of both IntlPop and computers. It contains a brief description of IntlPop and instructions on the usage of a mouse.

Adding explanations for terms, prompts, or task steps – Tutorial Help (Appendix C.2) contains definitions and descriptions for “window”, ”scroll bar” and “dragging”, and the major parameters of a simulation.

Removing trivial, repetitive, and irrelevant information – The Controls Help (Appendix C.4) contains a list of the menu items available under the Options control. However, more information about each item is available in Options Help (Appendix C.3).

Making the help text specific to a situation – When explaining how to accomplish a task, the help files do not require the user to refer to another section for
CHAPTER 2. USER ASSISTANCE IN INTLPOP

details of subtasks.

• Writing style

Making sentences terse – No sentence exceeds three 80 character lines; most fall between one and two lines.


Naming a task followed by the instructions for performing the task – This guideline was consistently followed. For example, the Intro Help (Appendix C.1) contains the following:

To exit the program, first press the button marked 'Quit,' then ... .

• Presentation of the text

Highlighting important information – Emphasis is provided by using upper-case characters sparingly. Headers are underlined, and items in lists are out-dented to focus attention on them.

Reformatting some paragraphs into lists and tables – Lists appear throughout the text of the online help system.

Providing a quick reference before giving a full explanation – When providing step-by-step instructions, each section of the instructions has a title followed by a short instruction. Users familiar with the terms in the short instruction need not read the remaining details of the task. For example, the Tutor Help (Appendix C.1) contains the following:

PICKING FROM THE MAPS – Click on the Region or Country.

To select from the maps, move the arrow to a region/country ....
CHAPTER 2. USER ASSISTANCE IN INTLPopl

2.2.3.1 Readability

Avoid Overload — Seven plus or minus Two  Houghton warns that to avoid document-
tation overload, sections of help should follow the “seven plus or minus two” rule [27].
That is, help screens should include no more than seven concepts, plus or minus two, at
once. We have limited the number of ideas to five plus or minus two per help screen. The
Quick-Start screen, for example, labels five sets of controls.

Readability Measures  Several measures of readability indicate the general reading level
of a document. Table 2.1 displays three readability scores reported by Grammatik 5 for
each file in Intlpopl’s Online Help System [20]. Full statistics, including such measures as
average number of words per sentence and average syllables per word appear in Appendix D.

In contrast to the fairly readable scores of the Help files, the readability scores for the
Information files indicate more difficult reading. Table 2.2 lists the scores for the information
files included with Intlpopl.

Flesch Reading Ease  The Flesch Reading Ease score ranges from 0 to 100; higher scores
suggest easier reading. A score between 60 and 70 suggests a reading level of seventh to
eighth grade. Grammatik uses the following formula to calculate the Flesch Reading Ease.

\[
Ease = 206.835 - (1.015w + 0.846s)
\]

Where \( w \) is the average number of words per sentence and \( s \) is the number of syllables per
100 words.

The information files (Table 2.2) are considered difficult to read with scores ranging from
32 to 41. However, with scores ranging from 57 to 77, the Intlpopl Help files (Table 2.1)
range from standard reading ease to fairly easy.

Gunning’s Fog Index  The Fog Index is commonly used as a measure of readability. It
is an indication of the grade level a reader must have achieved to understand the writing.
CHAPTER 2. USER ASSISTANCE IN INTLP~

Table 2.1: Readability scores of Online Help Files

<table>
<thead>
<tr>
<th>Help Menu Item</th>
<th>Flesch Reading Ease</th>
<th>Gunning's Fog Index</th>
<th>Flesch-Kincaid Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intro</td>
<td>77</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Tutorial</td>
<td>77</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Options</td>
<td>57</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Controls</td>
<td>65</td>
<td>10</td>
<td>7</td>
</tr>
</tbody>
</table>

[23, 1]. It is calculated from the following:

\[ \text{Fog} = 0.4(w + s_{3+}) \]

Where \( w \) is the average number of words per sentence and \( s_{3+} \) is the number of words containing three syllable or more.

\textbf{IntlPop}'s Help files' Fog index scores range from 8 to 11 (Table 2.1), indicating that a reader should have completed the eleventh grade to understand the most difficult of them. We expect such achievement of our users, since \textbf{Project GeoSim} software is targeted at first year college students. Because of the technical details included in them, however, the information files' Fog index scores range from 14 to 16 (Table 2.1).

\textbf{Flesch-Kincaid Grade Level} Similar to Gunning's Fog Index, the Flesch-Kincaid's Grade Level is an indication of the grade level at which the document is written.

\[ \text{Grade} = (0.39w + 11.8s_w) - 15.59 \]

Where \( w \) is the average number of words per sentence and \( s_w \) is the average number of syllables per word.

The Flesch-Kincaid's Grade Level scores for \textbf{IntlPop} are lower than the Fog Index scores for the same text. Scores between 6 and 10 are considered most effective for a general audience. \textbf{IntlPop}'s information file scores are in the 11 to 12 range and the help file scores range from 6 to 8.
CHAPTER 2. USER ASSISTANCE IN INTLPPOP

Table 2.2: Readability scores of Online Information Files

<table>
<thead>
<tr>
<th>Info Menu Item</th>
<th>Flesch Reading Ease</th>
<th>Gunning's Fog Index</th>
<th>Flesch-Kincaid Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>About Program</td>
<td>38</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>GeoSim Info</td>
<td>32</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Technical Info</td>
<td>41</td>
<td>16</td>
<td>12</td>
</tr>
</tbody>
</table>

2.2.4 Evaluation and Improvement of Online Help

The online help facility was used by students that took part in the IntLPpop formative evaluation. The Quick-Start screen seemed to present too much information to students when they first began the program. We reformatted it, but no further testing has determined whether the new version is less overwhelming. In response to students' comments, we shortened some lists and reworded some phrases, but the help system remained generally unchanged.

2.3 Printed Manual

Despite the efforts to make the best possible online help system, we found that many students nonetheless did not refer to the help menu when faced with difficulty. We postulated then that students might prefer to have a printed manual in hand as they used IntLPpop. Therefore, the Project GeoSim team developed a four-page user's manual. As with the development of the online help, we created the best printed manual we could. There were no plans at that time for development of any other user assistance methods.

2.3.1 Format

Since Project GeoSim software is distributed on the Internet, the documentation had to be developed in a commonly available electronic format. We distribute the IntLPpop user's manual in three common electronic text formats.
CHAPTER 2. USER ASSISTANCE IN INTLPOP

1. \LaTeX is freely available for most computer platforms including the three supported by Project GeoSim.

2. Postscript is supported by many printers and provides high quality formatting and font capabilities.

3. ASCII is the least common denominator among computer platforms and printers. Despite the availability of \LaTeX, many sites do not use it. Postscript is also not available everywhere.

Because of its formatting capabilities and its availability on many computer platforms, the user’s manual was written in \LaTeX. In this way, geography instructors can annotate or edit the manual to suit the needs of their courses.

Project GeoSim also distributes sample laboratory exercises with the software in three formats: Word, Hewlett Packard LaserJet, and ASCII text. These sample exercises were not used in this study, but were the basis for the tasks used in the experiment.

Because of the need for a portable format, no graphics are included in the manual. This is unfortunate, since the ability of the print medium to include illustrations is considered one of its strong points [40].

However, since \LaTeX allows the inclusion of line drawings, buttons are written in the following format: [Help]. This format emulates the appearance of buttons on screen: a sans serif font label inside a rectangle. Additionally, since these boxes stand out from regular text on a page, a button is easy to find.

2.3.2 Content and Style

Many of the online help guidelines discussed above pertain equally to the content and style of printed material. Although their guidelines were developed specifically to revise online documentation, Cherry and Jackson’s list may be applied to printed documentation [24].
CHAPTER 2. USER ASSISTANCE IN INTLPOP

Table 2.3: Readability scores of Printed Manual

<table>
<thead>
<tr>
<th>Flesch Reading Ease</th>
<th>Gunning's Fog Index</th>
<th>Flesch-Kincaid Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 2.3 displays the readability scores for the Printed Manual using the same measures as for the online help described in Section 2.2.3.1.

Flesch Reading Ease  The Flesch Reading Ease score of 71 indicates that the manual is “fairly easy” to read [26, p. 89].

Gunning’s Fog Index  The Fog Index of 9 indicates that the printed manual is written to an audience that has achieved at least a ninth grade education. Adams, Halasz and Adams recommend a seventh to ninth grade reading level for users from “the general public” [1, p. 164]. Since Project GeoSim software is developed for first year college students, we can assume that users have the equivalent of a twelfth grade education. However, we do not intend to restrict use of Project GeoSim programs to only that audience. Therefore, we have tried to keep the readability as high as possible.

Flesch-Kincaid Grade Level  The printed manual has a Flesch-Kincaid Grade Level of 6, which is well below our target audience.

2.3.3 Review and Improvement of Manual

We did not conduct formative evaluation of the printed manual. However, several members of Project GeoSim reviewed the material and recommended improvements.

2.4 Online Interactive Tutorial

Despite our best efforts to create effective online help and printed documentation, we observed that students were not referring to either. Therefore, we decided to create an
online interactive tutorial for **IntlPop**. Schneiderman says that “Online help, manuals, and tutorials that use the same interactive system to provide training, reference, and reminders about specific features and syntax have become expected components of most systems.” [45, p. 440]

### 2.4.1 Description of IntlPop Tutorial

The online interactive tutorial may be started at the beginning of execution by invoking **IntlPop** with a `-w` parameter. With this parameter, an instructor can cause the online tutorial to be automatically displayed at startup. The tutorial may also be started while running **IntlPop** by selecting “Walk-Through Tutorial” from the Help menu. Should one wish to exit the tutorial before completing all steps, pressing the `Quit Tutor` button at the top of the screen will return the program to the state it was in before the tutorial was begun. The opening screen of the tutorial is shown in Figure 2.7.

The tutorial employs part of the already existing online help system: the context-sensitive message window along the bottom of the screen. At the opening screen, a pop-up window directs the student to read instructions from the bottom message window. We noticed during formative evaluation that despite the useful information contained therein, students generally do not read the context-sensitive messages. We postulated that having
CHAPTER 2. USER ASSISTANCE IN INTLP Pop

Figure 2.8: The student is experimenting with a previously learned interface control. The tutorial will not advance until the instructions in the bottom message window are carried out.

students read from this window during the tutorial would condition them to look to it for guidance later during normal program execution.

The tutorial presents step-by-step instructions to the student on the use of IntLP Pop. In this guided practice form of instruction, the student is told exactly what controls to use at each step of the tutorial. While Charney and Reder showed that problem solving practice leads to the best performance, they also note that it is more difficult for users. Guided practice examples may be better when the use of the software will immediately follow training, which is the case with our tutorial [13].

Interface controls are disabled until the tutorial has taught them to the student. This blocks the student from jumping ahead of the lesson, but allows him or her to experiment with and practice already learned controls and techniques [8]. For example, in Figure 2.8 the tutorial is instructing the student to press the Sim button; the student is instead dragging a cohort bar, which was taught previously. The tutorial will not advance, however, until the user carries out the instruction in the bottom window.

All previously learned elements do not remain available to the student, however, in cases where using them would affect the current portion of the lesson. For instance, a student
CHAPTER 2. USER ASSISTANCE IN INTLPOP

may not return to the country/region selection window after a selection has been made and the [Done] button was pressed. Doing so would cause the simulation to load a different data set, erasing the information on which later parts of the tutorial depend.

As Horton recommends, the student controls the speed of the tutorial [25]. No information is erased or replaced after an arbitrary amount of time, since the student is required to perform some action before the tutorial will advance.

2.4.2 Content and Style

The text of the tutorial was written as a “reading to learn to do” document, as described by Redish [43]. While the tutorial is written in a conversational tone, it avoids anthropomorphism by not using first person in reference to the software, as recommended by Houghton and Hix and Hartson [27, 24]. Nevertheless, it directly instructs the user at each step using second person and avoiding passive voice sentences.

Each message of the tutorial contains an instruction for the student to do something. In this way, the tutorial requires the student to interact with the software. Such forced interaction provides a better learning experience for users than passively watching a demonstration.

2.4.2.1 Readability

The readability scores for the tutorial are displayed in Table 2.4 using the same measures as for the online help described in Section 2.2.3.1. The full text of the online tutorial is in Appendix E.

Flesch Reading Ease The Flesch Reading Ease score of 75 suggests that the online tutorial is “fairly easy” to read [20, p. 89].

Gunning’s Fog Index The Fog Index of 8 indicates that the text of the tutorial is written to an audience that has achieved at least an eighth grade education.
CHAPTER 2. USER ASSISTANCE IN INTLPOP

Table 2.4: Readability scores of Online Tutorial

<table>
<thead>
<tr>
<th>Flesch Reading Ease</th>
<th>Gunning’s Fog Index</th>
<th>Flesch-Kincaid Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

Flesch-Kincaid Grade Level  Well below the achievement level of our target audience, the text of the online tutorial has a Flesch-Kincaid Grade Level of 5.

2.4.3 Tutorial is Part of IntlPop

As opposed to a separate product, the IntlPop online tutorial is part of the actual software. That is, the tutorial uses the same execution instructions and data as the actual application.

The alternative would be to create an interactive tutorial that is a simulation of the program. Such a tutorial might be implemented with an authoring system. An advantage to this approach is that it is often easier to create tutorial type applications with authoring systems than within the application. Authoring systems include support for such tutorial elements as labels, pointers, and graphics special effects such as wipes, fades and animations. A tutorial may be difficult to create within an application that does not include such graphics support. Using screen shots of the actual program, a tutorial simulation may be so complete as to look and feel exactly like the original.

However, a simulation cannot provide the same functionality or data as the actual application (if it did, the actual application would be superfluous). Carroll points this out as a problem, since learners may try to practice on their own during the tutorial [8]. A canned presentation of functions and data does not allow such practice or exploratory learning.

Another problem with creating a separate package for the tutorial, is that it may be difficult to keep the tutorial and the application synchronized during development. When the application interface changes even slightly, perhaps by moving the location of a button
CHAPTER 2. USER ASSISTANCE IN INTLPPOP

or changing the color of a window, the screen shots for the tutorial must be recaptured and loaded. This is only a problem if the tutorial is developed while the application is subject to change. However, given the iterative nature of software development, applications are almost always subject to change — even after final release. Additionally, it is unlikely that customers are willing to await the delivery of fully functional software while training material is being prepared.

We have experienced these problems in Project GeoSim. A tutorial for another Project GeoSim module, Migration Modeling (MigModel) was developed using Authorware Professional. When we improved the interface of MigModel, we had to recapture screen shots of the program. Portions of the tutorial were dropped, since recreating them with new screen shots would have been difficult.

In contrast, the IntIPop tutorial is part of the application. While the tutorial blocks the use of an interface control until it has been presented, after that the student is free to practice and experiment with the interface item. The tutorial will respond in the same way as the application, since they are the same. Furthermore, simple changes to the interface, such as changing properties of artifacts, do not require the tutorial to be changed at all, since they are reflected in the tutorial automatically.

2.4.3.1 Implementation of IntIPop’s Tutorial

An independent function is a routine in the Project GeoSim Interface Library (GIL) environment that is not part of any specific interface element. This is in contrast to a button’s call-back function, which is considered a property of that button [5]. The tutorial is an independent function that the user starts by selecting “Walk-Through Tutorial” from the Help menu. If the program is executed with the \(-v\) flag, the tutorial starts after the user clears the introductory help screen.

The tutorial function is implemented as a set of condition-action pairs. At each step, the tutorial requires the student to use some interface control, such as pressing or dragging an artifact. The Project GeoSim Application Program Interface (API) library keeps a
record of the name of the last control used in the application. This record provides support for walk-through tutorials.

Condition: The tutorial function checks the name of the last control used against the expected name of a control, based on the current state of the tutorial. If the control names match, the tutorial executes the actions specified by that condition-action pair. In some cases, the application program sets a flag that the tutorial function checks in addition to or instead of a control name.

Action: The actions that the tutorial takes are to display the next tutorial message and activate or deactivate the appropriate interface controls.

2.4.4 Evaluation and Improvement of the Tutorial

After the initial development of the online tutorial was complete, I conducted an informal formative evaluation. Four participants were asked to go through the tutorial and then use IntlPop to answer the same laboratory exercise questions given to geography students. The participants were two computer science graduate students, a geography graduate student, and a graduate with little computer or geography experience.

I started IntlPop and the tutorial for the participants. I then observed the participants progress through the tutorial and the subsequent exercises. When they seemed to have a problem, I asked them to describe what they were thinking.

In response to the information collected, I made several changes to the tutorial. After making the following improvements, I also expanded the tutorial to cover more features of IntlPop.

- Additions

  
  - **Quit Tutor** button – Users wanted to be able to exit the tutorial any time.
  - **Introduction** – Information on how to use and quit the tutorial.
CHAPTER 2. USER ASSISTANCE IN INTLPopa

Disabled more controls – Participants got into trouble if they tried to use interface controls before they learned how to use them.

“Press Continue” – In cases where the user is to press the Continue button, the tutorial explicitly instructs them to do so.

Command line parameter – The -w command line switch was added to cause IntLPop to start up with the tutorial. This was added so that the instructors using IntLPop in their class can cause the program to begin with the tutorial.

Tutorial tells how to rerun tutorial – Participants wanted to know how to rerun the tutorial.

• Deletions

Quick-Start Screen – The Online Help system’s Quick-Start Screen had been the first thing presented to users by the tutorial. However, users seemed overwhelmed by the amount of information it presented. Since the controls labeled in the Quick-Start are introduced one-by-one in the tutorial, the screen was removed from the tutorial sequence.

More Controls not Disabled – Users sometimes wanted to practice or play with the controls they had just learned. The tutorial had been disabling controls after they were taught.

2.5 Summary

Project GeoSim has developed three means of user training and support: an online help system, a printed user’s manual, and an online interactive tutorial. The online help system was the first to be implemented. It was originally intended to be the only user training and assistance for the program. Through formative evaluation, we saw that users did not take advantage of the online information when faced with a problem. In response, a “Quick-Start” screen was added and the online help text was revised. Unless the program
CHAPTER 2. USER ASSISTANCE IN INTLPop

is started with the tutorial activated, \textbf{Intlpop} displays the “Quick-Start” screen when it is invoked, causing a student to see some information before he or she uses the program.

Additionally, we developed a four-page printed user’s manual, so that users could have a reference in hand as they used the software. Despite our efforts to create the best manual possible, we considered it insufficient as a training tool, since users generally did not read it.

An online interactive tutorial was developed that shows and teaches the interface elements and functionality of the program to users. Like the “Quick-Start” of the online help system, the interactive tutorial can be made active when the program is begun. Students need to read some information on screen to get past the “Quick-Start” or tutorial. No such requirement can be enforced with the user’s manual or the online help text. We believed that forcing users to go through the tutorial would remove the problem of students not using the other training materials. We evaluated and enhanced the interactive tutorial before including it in a release of \textbf{Intlpop}.
Chapter 3

Method

3.1 The Three Treatments plus Control

The independent variable in this experiment is the user training and assistance method: Online Help, Printed Manual, and Online Interactive Tutorial. A control condition of no training or user assistance was also evaluated.

Control Participants in the control group did not have any training or user assistance other than the context-sensitive messages available in all three methods. The “Quick-Start” screen was not displayed. They were not aware of the existence of the other user training and assistance methods. Neither the Help or Info menu buttons appeared on the screen for this group. Further, they were not able to initiate the walk-through tutorial. Finally, they did not have a printed reference manual.

Walk-Through Tutorial Participants in the walk-through tutorial group began IntIPop with a brief introduction message describing IntIPop. When they cleared the screen, the tutorial began. The tutorial made no reference to online help information or the printed manual. The Info menu button did not appear on the screen. “Walk-Through Tutorial” was the only item available from the Help menu. The “Quick-Start” screen was not displayed. The program displayed context-sensitive help messages.

Printed Manual Members of the printed manual group used the same interface as the control group. That is, the Help and Info menu buttons did not appear on screen and the “Quick-Start” screen was not displayed. However, they were given a copy of the printed
CHAPTER 3. METHOD

manual. The version of the manual used in the experiment made no reference to online help or the walk-through tutorial. Context-sensitive help messages were displayed.

Online Help Participants in the online help group began **Int1Pop** with the introduction screen. The introduction informed the user that more information was available from the help menu and how to select an item from a menu. After participants cleared the introduction help screen, the program displayed the “Quick-Start” screen. The help menu did not list the walk-through tutorial; no help screen made reference to the printed manual or the walk-through tutorial. All other online help information was available from the Help and Info menus.

3.2 Resources

The experiment took place in the Human Computer Interaction Laboratory located in Whittemore 530, Virginia Tech, Blacksburg, Virginia. This laboratory is used by members of the Computer Science and Industrial Systems and Engineering Departments to conduct studies of human computer interaction.

3.2.1 Hardware

**Computer:** I conducted the experiment using an IBM PC compatible computer with an Intel 80486 - 33 megahertz CPU, 8 megabytes of main memory (of which, 579 kilobytes were available to **Int1Pop**), and a Microsoft mouse. This machine provided quick response during simulations.

**Miscellaneous:** A Hi-8 video tape camera recorded each session of the experiment. The camera recorded the time of day directly onto the video tape. I referred to the video in a few cases where I had not properly recorded the time to complete a task.

A digital stop watch with a resolution of hundredths of a second measured time. The stop watch had a lap counter that allowed the timer to continue running while I recorded
CHAPTER 3. METHOD

an intermittent time.

3.2.2 Software

The software vehicle of the experiment was IntelPop version 2.0.6, dated February 23, 1994. I used separate configuration, interface and help files for each of the four treatments. The configurations restricted users' access to the appropriate user assistance method, as described in Section 3.1. I made no modification to the executable program, its source code or the data files. The program ran on MS-DOS version 6.2 under MS-Windows version 3.1.

3.3 Participants

The twenty-four participants in the study were volunteers from introductory geography classes here at Virginia Tech. The volunteers had not used any Project GeoSim software before the experiment. Each received five dollars for taking part in the study. The 24 participants were randomly assigned to the four treatment groups, yielding six participants in each group.

The experiment was run in the semester following that in which the participants had attended the introductory geography course. In this way, participants were familiar with population demographics concepts and terminology, such as population distribution pyramids, age cohorts, and fertility rates.

All participants were required to read and sign an informed consent form, which provided the subjects with a brief overview of the purpose of the study and their rights as participants. They were also asked to read and sign a non-disclosure agreement, which states that the participant agrees not to discuss the experiment with anyone other than me, my advisor or the Virginia Tech Institutional Review Board. Both forms are in Appendix H. I gave the top portions of the forms to the participants and kept the bottom portions containing their signatures.

Although prior computer experience was not a requirement, all participants reported
that they had previously used a mouse to operate a computer program. In a pre-experiment questionnaire, I asked participants to rate themselves on a scale of 0 (Novice) to 6 (Expert). The responses ranged from 1 to 5 with a mean of 2.67 and a standard deviation of 0.96. Since the participants each have their own ideas as to the definition of novice and expert, I also rated their experience based on the software they said they used. My ratings were generally lower than the respondents, with a mean of 2.04 and a standard deviation of 0.55.

3.4 Procedure

3.4.1 Pretest

To ensure competence with a mouse, subjects took two pretests (Figure 3.1). Appendix G contains instructions for the pretests.

In the first pretest, a screen of six by six disabled buttons was displayed. After the participant pressed the [Start] button, the rectangle on a button changed from gray to white. When the participant pressed that button, it returned to gray and another one changed from gray to white. This procedure continued until all buttons had been pressed. The sequence by which the buttons activated was random, but the same for each session.

In the second pretest each letter of the English alphabet was displayed in a button. The participant pressed the [Start] button, then pressed the buttons of the letters in a word, then
CHAPTER 3. METHOD

pressed the [End] button. The three words spelled were: GEOGRAPHY, UNIVERSITY, and a nonsense word, SOQYEPBELRTJ.

3.4.2 Training

Following the pretests, the participants received the training method of their assigned treatment group, or no training for the control group. I asked participants to spend as much time with the training material as they needed and to inform me when they were done.

For the online tutorial, I started the program with the tutorial active. Each subject executed all of the steps of the tutorial. No participant practiced after the tutorial was completed.

The online help group was presented with the IntlPop introduction screen followed by the Quick-Start screen. The subjects were allowed to read any further Help or Info screens they desired. They were not prevented from experimenting with the program; two did so.

For each member of the printed manual group, I started the program and gave the participant a copy of the four-page IntlPop User’s Manual, Version X1.5, which is the same as version 1.5 but has all references to the online help system removed. One participant experimented with the interface after having read the manual.

3.5 Dependent Measures

3.5.1 Pretest Task Completion Time

Log Files The Project GeoSim API library records each use of an interface control in the file error.log. The name of the control, the time of day, and the milliseconds since the program began are logged in the file each time a control is used.

I found each participant’s time to complete a pretest from this log file. For the first pretest, the time between the press of the [Start] button and the last button was the total time to complete the task. For the second pretest, the task completion time was that between the press of the [Start] button and the [End] button.
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3.5.2 Task Completion Time

The program also created log files while the participant completed the nine questions of the experiment. However, since there is no “start” or “end” button in the Int1Pop interface, the times to complete tasks could not be extracted from these files. The interface could have been changed to include such “start” and “end” buttons (perhaps participants could have been required to press a “print” button at the end of each question). However, doing so would have required changing the interface to Int1Pop and the use of those controls would need to be added to each of the training methods. Since I was most interested in comparing the training methods of Int1Pop as they are distributed with the software, I made as few changes to the interface and training as possible.

In order to eliminate individual reading speeds from the task completion times, I asked the participants to first read and understand the question, then tell me when they were ready to use the software to answer the questions. They also informed me when they had finished writing the answer. I recorded the time between when the subject said he or she was ready to begin and when he or she finished writing.

If the participant failed to inform me when he or she was ready to begin, I began timing when the participant began to move the mouse. I stopped the lap counter when the participant finished writing, leaving the timer running until the participant went on to the next task. In this way, I could continue timing in case the participant was not finished.

**Task Not Completed:** If a participant was unable to complete a task, I recorded a time greater than that taken by any subject that did complete a task. The time used for not completing a task is 335 seconds, since the longest time to complete a task was 333.24 seconds.

3.5.3 Accuracy of Responses

Participants wrote their answers to each question on the question sheet. I determined the accuracy of the responses by grading the answers with two methods described in Section 4.3.
CHAPTER 3. METHOD

3.5.4 Steps Taken to Complete a Task

In addition to the log files that record each control used during a session, I directly observed the participants and recorded the steps they took as they worked through the tasks. This information allowed me to discover what errors participants made, if they answered questions incorrectly.

3.5.5 Qualitative Data

Following the completion of the tasks, participants filled out a questionnaire of nine questions. The questions were the same for each treatment, except that the name of the training method corresponded to the treatment group to which the participant belonged. Appendix I contains each treatment group’s questionnaire.

The questions were designed to determine the participants’ subjective reactions to the system and training method they received. The first two indicate a participant’s confidence in the answers he or she gave with the program. Questions 3 and 4 aim to determine a user’s satisfaction with the training method he or she received. The last five questions are designed to find a user’s reaction to IntelPop. I hypothesized that users who have trouble with the program would rate it lower than users that did not.

3.6 Summary

The experiment consisted of four treatments: online help, printed manual, online interactive tutorial, and a control. Twenty-four participants that had completed an introductory geography course were randomly assigned to the four groups, yielding six participants in each treatment. The members of each group received the training method of that treatment and did not have access to any other training material.

Two pretests were administered to determine a participant’s mouse proficiency. Participants then received the training method of their group and answered nine questions using IntelPop. Participants also completed a questionnaire. Dependent measures were: times to
CHAPTER 3. METHOD

complete pretests, times to complete each question, accuracy of answers, steps to complete answers, and a questionnaire.
Chapter 4

Results

4.1 Task Completion Times

There were two independent variables in the performance test of time to complete task: the user assistance method and the task. All task completion times are listed in Appendix J.

4.1.1 Approach 1 – Analysis of Variance

The first approach to analyzing task completion times was to use a two-way analysis of variance (ANOVA) design. This analysis indicates that the main effects of both task ($p = 0.000$) and treatment ($p = 0.015$) are significant. Table 4.1 summarizes the analysis of variance for times to complete task. Appendix K contains the complete analysis of variance.

4.1.1.1 Interaction of Task and Treatment

Although the analysis of variance shows no significant interaction between task and treatment, some interaction is seen in Figure 4.1. Table 4.2 lists the means and standard deviations for each task and treatment.

Generally, for each task, the mean time for the walk-through tutorial is less than the mean times for the online help and printed manual groups, which are generally less than the mean time for the control group. Two exceptions appear in the plots of tasks 5 and 9.

In task 5, the mean of the control group is significantly below that of the online help and printed manual groups. The reason for this is that the standard deviations of the online help and printed manual groups are considerably greater than those of the control and walk-through tutorial groups. With such variance, the means of the observed data do
CHAPTER 4. RESULTS

Table 4.1: Analysis of Variance for Time to Complete Task by Treatment

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean of Squares</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
<td>8</td>
<td>187637</td>
<td>23455</td>
<td>7.03</td>
<td>0.000</td>
</tr>
<tr>
<td>Treatment</td>
<td>3</td>
<td>35717</td>
<td>11906</td>
<td>3.57</td>
<td>0.015</td>
</tr>
<tr>
<td>Task*Treatment</td>
<td>24</td>
<td>67949</td>
<td>2831</td>
<td>0.85</td>
<td>0.671</td>
</tr>
<tr>
<td>Error</td>
<td>180</td>
<td>600650</td>
<td>3337</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2: Means and standard deviations of time in seconds to complete tasks

<table>
<thead>
<tr>
<th>Task</th>
<th>Tutorial</th>
<th>Online Help</th>
<th>Printed Manual</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Stdev</td>
<td>Mean</td>
<td>Stdev</td>
</tr>
<tr>
<td>1</td>
<td>64.06</td>
<td>25.62</td>
<td>109.07</td>
<td>96.11</td>
</tr>
<tr>
<td>2</td>
<td>31.20</td>
<td>8.87</td>
<td>42.47</td>
<td>7.98</td>
</tr>
<tr>
<td>3</td>
<td>23.09</td>
<td>5.79</td>
<td>36.82</td>
<td>24.19</td>
</tr>
<tr>
<td>4</td>
<td>81.27</td>
<td>27.14</td>
<td>106.44</td>
<td>50.90</td>
</tr>
<tr>
<td>5</td>
<td>74.02</td>
<td>32.43</td>
<td>120.72</td>
<td>61.83</td>
</tr>
<tr>
<td>6</td>
<td>81.50</td>
<td>13.43</td>
<td>107.16</td>
<td>36.92</td>
</tr>
<tr>
<td>7</td>
<td>88.59</td>
<td>59.81</td>
<td>137.08</td>
<td>98.57</td>
</tr>
<tr>
<td>8</td>
<td>73.72</td>
<td>34.95</td>
<td>65.54</td>
<td>12.63</td>
</tr>
<tr>
<td>9</td>
<td>125.00</td>
<td>109.46</td>
<td>129.75</td>
<td>58.79</td>
</tr>
</tbody>
</table>

not reliably correspond with the actual population means.

In task 9, the mean of the control group is considerably less than the means of the walk-through tutorial and online help groups. The mean of the control group is also less than that of the printed manual group, but not much. Similar to task 5, the standard deviations of the walk-through tutorial, online help, and printed manual are considerably greater than the control group's standard deviation.

4.1.1.2 Multiple Comparisons of Treatments

To find the order of the population means, I performed multiple comparison tests. Appendix K.3 contains the complete analysis.

I performed Tukey’s pairwise comparisons using an experimentwise error rate of 0.20,
CHAPTER 4. RESULTS

Figure 4.1: Mean times to complete task by treatment

which yields an individual error rate of 0.0493 for each comparison. The comparisons show that the population mean of the walk-through treatment is less than those of both the printed manual and control treatments. Table 4.3 shows the difference in the confidence intervals between each pair of treatments.

4.1.1.3 One-way ANOVA for each Task by Treatment

I also wanted to see if the treatments differed significantly in each of the nine tasks. The complete one-way ANOVA by treatment for each task is in Appendix K.2. While the two-way analysis of variance shows significant difference in the treatments with respect to task completion times, the one-way analysis of each task does not ($\alpha = 0.05$). This lack of significance is likely due to the variance in the observed times for each treatment in each task, as discussed below in Section 4.1.1.4.
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Table 4.3: Results of Tukey’s Pairwise Comparison. Intervals for (column level mean) - (row level mean). Intervals that do not include 0 indicate difference. These are printed in bold.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Tutor</th>
<th>Online Help</th>
<th>Printed Manual</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutor</td>
<td>-</td>
<td>(-0.6, 47.8)</td>
<td>(1.2, 49.7)</td>
<td>(10.7, 59.1)</td>
</tr>
<tr>
<td>Online Help</td>
<td>(-47.8, 0.6)</td>
<td>-</td>
<td>(-22.4, 26.1)</td>
<td>(-12.9, 35.5)</td>
</tr>
<tr>
<td>Printed Manual</td>
<td>(-49.7, -1.2)</td>
<td>(-26.1, 22.4)</td>
<td>-</td>
<td>(-14.8, 33.7)</td>
</tr>
<tr>
<td>Control</td>
<td>(-59.1, -10.7)</td>
<td>(-35.5, 12.9)</td>
<td>(-33.7, 14.8)</td>
<td>-</td>
</tr>
</tbody>
</table>

4.1.1.4 Reliability of ANOVA results

There are two aspects of the task completion times that present difficulty in the analyses: small sample size and incomplete tasks. Since the sample size for each treatment is small ($n = 6$), the standard deviations of task completion times are not precise. Additionally, the mean and standard deviation of a treatment in a task is skewed by the occurrence of a participant not completing a task. When a participant was unable to complete a task, the time recorded was 335 seconds, which is greater than the longest time taken to complete any task (333.24 seconds), which was itself an outlier. There were three such occurrences during the experiment.

However, combining all of the tasks in the two-way analysis of variance increases the samples per treatment from 6 to 54. Therefore, the analysis is not affected by the small sample size. Moreover, the three occurrences of participants not completing a task do not as strongly affect the mean and standard deviation of a treatment. In this way, the two-way ANOVA shows overall significant difference that is not found in the one-way ANOVA’s of each task.

4.1.2 Approach 2 – Nonparametric Tests

To confirm the difference indicated by the two-way analysis of variance (see Section 4.1.1) and the order of the population means, nonparametric tests were also used to analyze the task completion times. The nonparametric tests used are not affected by variance in the
CHAPTER 4. RESULTS

observed data, as discussed in Section 4.1.1.4. Additionally, the following tests do not assume that the populations are normally distributed.

4.1.2.1 Jonckheere-Terpstra Test for Ordered Alternatives

The Jonckheere-Terpstra test for ordered alternatives tests the null hypothesis of equality among population means against the alternative hypothesis in which the order is specified [18].

\[ H_0 : \mu_1 = \mu_2 = \cdots = \mu_k \]
\[ H_A : \mu_1 \leq \mu_2 \leq \cdots \leq \mu_k, \quad \text{with at least one strict inequality} \]

Because the major statistical analysis software, such as SAS, Minitab or Mathematica, do not include this test, I implemented the test myself. I used the algorithm from Daniel [18] and tested the implementation on the example he cites. The C++ source code for this test is in Appendix M.1.

The results of the Jonckheere-Terpstra test are summarized in Table 4.4; the complete output is contained in Appendix L.1. In the case of task completion times for all tasks, the results indicate a rejection of the null hypothesis \( (p = 0.0011) \). Additionally, difference with respect to task completion times is detected \( (p < 0.05) \) in tasks 1, 2, 3, 6, and 7.

4.1.2.2 Multiple Comparison

To find the order of the means of the populations of the four treatments, I performed Dunn’s multiple comparison test [18]. The test compared treatments in all tasks together and in each task individually. The test used an experimentwise error rate of 0.30, which yields an individual error rate of 0.05 for each pairwise comparison. Table 4.5 summarizes the results. For the by-task results, only tasks in which a difference was found by the Jonckheere-Terpstra test are listed. The complete listing of the multiple comparisons is located in Appendix L.2; Appendix M.2 contains the C++ source code for Dunn’s multiple comparison test.

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Table 4.4: Results of Jonckheere-Terpstra test for ordered alternatives. Critical value for \( J \) is 141.

\[
\begin{array}{ccc}
\text{All Task Times} \\
J & z & p \\
10328 & 3.076 & p = .0011 \\
\end{array}
\]

\[
\begin{array}{ccc}
\text{Each Task Times} \\
\text{Task Number} & J & p \\
1 & 152 & p < .023 \\
2 & 153 & p = .010 \\
3 & 161 & p < .005 \\
4 & 119 & .200 < p \\
5 & 137 & .053 < p \\
6 & 146 & p = .027 \\
7 & 141 & p = .048 \\
8 & 123 & .200 < p \\
9 & 73 & .510 < p \\
\end{array}
\]

In the test for overall order, the mean overall task time for the online tutorial treatment is less than those of the online help and control. In the tests for each task, we see that the online tutorial’s mean is less than mean of the control group. Additionally, in tasks 2 and 7, the online tutorial has a mean less than that of the printed manual group.

The results of the overall Dunn multiple comparison test seem to contradict those of the Tukey pairwise comparison (see Table 4.3). Dunn’s test indicates the online tutorial group was significantly faster than the online help group, but not significantly different from the printed manual group. Tukey’s test, on the other hand, indicates the online tutorial group was faster than the printed manual group, but not significantly different from the online help group. This effect may be the result of the variance in observations, which affects the results of Tukey’s test, but not those of Dunn’s multiple comparison.

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Table 4.5: Results of Dunn’s Multiple Comparison Tests.

<table>
<thead>
<tr>
<th>All Tasks</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>μtutor</td>
<td>{μline help, μcontrol}</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Each Task</th>
<th>Task Number</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>μtutor</td>
<td>1</td>
<td>μcontrol</td>
</tr>
<tr>
<td>μtutor</td>
<td>2</td>
<td>{μmanual, μcontrol}</td>
</tr>
<tr>
<td>μtutor</td>
<td>3</td>
<td>μcontrol</td>
</tr>
<tr>
<td>μtutor</td>
<td>6</td>
<td>μcontrol</td>
</tr>
<tr>
<td>μtutor</td>
<td>7</td>
<td>{μmanual, μcontrol}</td>
</tr>
</tbody>
</table>

4.2 Training Time

Having received no training, the control group clearly spent the least amount of time in training. However, we are also interested in determining if there is a difference in time spent with training material among the other three treatments. One-way analysis of variance of training time shows no significant difference among the three (p = 0.478).

Because of the concern about small sample size and variance of observed data (discussed in Section 4.1.1.4), I also analyzed the training times with nonparametric tests. Kruskal-Wallis one-way analysis of variance fails to reject the null hypothesis that the population distributions are the same (p = 0.173). The Jonckheere-Terpstra test also fails to reject the null hypothesis; however, the value p = 0.05805 is almost significant, with the tutorial group spending the most amount of time with training material (Table 5.1, page 65). Because of this low value for p, I also performed Dunn’s multiple comparison with an experimentwise error rate of 0.15, which yields an individual comparison error rate of 0.05. Again, the difference among the treatments is not significant. Appendix N contains the ANOVA and nonparametric tests’ results.
CHAPTER 4. RESULTS

Table 4.6: Number of correct and incorrect answers by both scoring methods.

<table>
<thead>
<tr>
<th></th>
<th>Scoring Method 1</th>
<th>Scoring Method 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(errors always count)</td>
<td>(consistent errors count only once)</td>
</tr>
<tr>
<td>Tutorial</td>
<td>Online Help</td>
<td>Manual</td>
</tr>
<tr>
<td>Correct</td>
<td>34</td>
<td>32</td>
</tr>
<tr>
<td>Incorrect</td>
<td>20</td>
<td>22</td>
</tr>
</tbody>
</table>

|                     | Tutorial           | Online Help       | Manual | Control |
| Correct             | 42                | 40                | 33      | 36      |
| Incorrect           | 12                | 14                | 21      | 18      |

Table 4.7: Chi-square test for accuracy.

<table>
<thead>
<tr>
<th>Scoring Method</th>
<th>df</th>
<th>Chi-square value</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>4.266</td>
<td>p &gt; 0.10</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>4.291</td>
<td>p &gt; 0.10</td>
</tr>
</tbody>
</table>

4.3 Accuracy

Accuracy was analyzed using two scoring methods. In the first, a wrong answer for whatever reason counts as wrong. In the second method, I graded the answers so that consistent errors only counted once. That is, if the participant reached an incorrect solution as a result of making an error that he or she made previously, but the answer would otherwise have been correct, then the answer was counted as correct. The numbers of correct and incorrect answers for each treatment by both scoring methods are shown in Table 4.6.

I analyzed the number of errors for both scoring methods. In both cases, Chi-square analysis indicates no significant difference in the accuracy of responses among the treatments. The Chi-square test results are listed in Table 4.7.
CHAPTER 4. RESULTS

4.3.1 Types of Errors

I recorded the steps taken by each participant to reach the answers they gave. Using these notes of the observations and the record of controls used by each participant as recorded in the log files, I found the errors that led to an incorrect answer. The following errors are with respect to scoring method one. Note that an incorrect answer may be the result of more than one error.

**Question 1** What is the initial (1990) population of the United States?

To find the answer to this question, the student needs to select the United States. The procedure for doing so is to press [Options], then choose “Select region/country for simulation” from the menu. The United States may be selected from either the Countries Map or the scrollable list (see Figure 2.1). Selecting a country or region displays its 1990 population in a simulation window (see Figure 1.1).

Twenty participants completed this question correctly, while four selected North America from the Regions Map instead.

**Question 2** What is the initial (1990) population of Mauritius?

Very similar to Question 1, students may find Mauritius in either the Countries Map or the scrollable list (see Figure 2.1). However, Mauritius was chosen for this question to force students to use the scrollable list, since it is unlikely they know its location on the map.

All students accurately completed this question using the list to select the country.

**Question 3** If all factors remain unchanged from their initial 1990 values, what will be the population of Mauritius in the year 2040?

This question demonstrates the most basic use of IntlPop to simulate population growth and decline. To complete this question, students needed to press the [Sim→] button ten times or press and hold it until the simulation year reached 2040 (see Figure 1.1).

Twenty-one of the participants accurately answered this question. All three of the
CHAPTER 4. RESULTS

participants that reached the wrong answer did so by selecting “Run another simulation with (year 2000) data.” This incorrect selection appears in the same menu as the correct selection “Run another simulation.”

**Question 4** If all factors remain unchanged from their initial 1990 values, except the Life Expectancy gradually rose beginning in 1990 from its 1990 value of 69.5 to reach 75.1 by the year 2010, what will be the population of Mauritius in the year 2040?

To correctly answer this question, a user must return the simulation to 1990. This can be achieved by pressing \(<\text{Sim}\) until the simulation year returns to 1990. Alternatively, the user may select either “Run another simulation” or “Reset the simulation” from the Options menu.

The more important step to answering this task is to correctly adjust the Life Expectancy value. From 1990, the user needs to set the value to 75.1 and the “By Year” to 2010 (see Figure 2.2).

Only five participants correctly answered this question. The other nineteen made the following errors: five did not run the simulation to 2040; five reversed the simulation to 2010, instead of 1990; three did not change the “By Year” value; three selected “Run another simulation with (year 2000) data” from the options menu (two made this error previously); two did not reverse or otherwise reset the simulation; and one changed the “By Year” value to 2040.

**Question 5** If all factors remain unchanged from their initial 1990 values, except the Total Fertility Rate gradually rose beginning in 2000 from its 2000 value of 2.1 to reach 4.1 by the year 2020, what will be the population of Mauritius in the year 2040?

Again the simulation needs to be returned to its initial 1990 values. Although a user could press \(<\text{Sim}\) until the simulation year returns to 1990, the Life Expectancy value
CHAPTER 4. RESULTS

will not return to its initial 1990 value, but to the value that the user set in the previous question. This question aims to see if users can return a simulation to its 1990 values by selecting either “Run another simulation” or “Reset the simulation” from the Options menu. The simulation should also be advanced twice to the year 2000 before adjustment to the Total Fertility Rate is made.

Four participants accurately answered this question. The remainder made the following errors: eight did not reset the simulation (six made this error previously); five began the adjustment to Total Fertility Rate in 1990, instead of 2000; three did not run the simulation to 2040 (one had previously made this error); three selected “Run another simulation with (year 2000) data” from the options menu (one had done so previously); three did not use the “By Year” setting (two made this error previously); and one did not adjust the Total Fertility Rate at all.

**Question 6** If all factors remain unchanged from their initial 1990 values, except the Total Fertility Rate gradually declined beginning in 1990 from its 1990 value of 2.1 to reach 0.7 by the year 2010 and the Net Migration gradually rose beginning in 1990 from its 1990 value of -4000 to reach 46000 by the year 2020, what will be the population of Mauritius in the year 2040?

This question is similar to the previous two questions, but the user must set two variables instead of just one.

Fifteen participants answered question 6 correctly. The errors made by the others were: five did not reset the simulation (all had made this error previously); two did not use “By Year” (one had previously made this error); one reset the simulation between setting Total Fertility Rate and Net Migration; one ran the simulation with year 2000 projected values (this one had made the same error previously); and one reversed the simulation to 2020, instead of 1990;

**Question 7** If all factors remain unchanged from their initial 1990 values, except
CHAPTER 4. RESULTS

the number of females in the 20-29 cohort were reduced by approximately one half in 1990, what would be the population of Mauritius in the year 2040?

For this question, a user must again reset the simulation, then drag the 20-29 female cohort bar until it is half its original size (Figure 2.4).

Nine participants correctly answered this question. The following errors were made: seven did not reset the simulation (six of whom had made this error previously); three changed the birth rate of the cohort; two were unable to complete the question; one set the cohort value to 0; one did not simulate to 2040; and one adjusted both the male and female cohort bars.

**Question 8** If all factors remain unchanged from their initial 1990 values, except the 1990 birth rate of women in the 10-19 cohort was 0, what would be the population of Mauritius in the year 2040?

After resetting the simulation, the user needs to select “View birth and death rate buttons” from the Options menu. Then press the birth rate \([-]\) button to the right of the 10-19 cohort until the value reaches 0. Finally, the simulation should be advanced to 2040.

Ten of the subjects correctly answered this question. Of the fourteen who incorrectly answered the question: ten reset the 10-19 cohort bar (instead of birth rate); four did not reset the simulation (all of whom had made this error previously); one did not run the simulation (this participant made this error previously); and one selected “Run another simulation with (year 2000) data” from the Options menu.

**Question 9** If all factors remain unchanged from their initial 1990 values, except the 1990 Infant Mortality Rate of Mauritius were 65, what would be the population of Mauritius in the year 2040?

The procedure for correctly answering this question is the same as that for question 8, except that the \([+]\) button over the Infant Mortality Rate should be pressed.

Sixteen participants correctly answered this question. Errors made by the remainder
CHAPTER 4. RESULTS

were: six did not reset the simulation (they had all made this error previously); one did not run the simulation (this error was also made previously); one incorrectly set the infant mortality rate; and one was unable to complete the task.

4.3.1.1 Common Errors

A few of the errors made by users were recurrent. Participants reached the wrong answer forty-four times because of incorrectly resetting the simulation. In thirty-two of these cases, participants either did not attempt to return the simulation to 1990, or they used the button to reverse the simulation, which does not return the simulation variables to their initial (1990) values. In twelve cases, a participant used values projected for the year 2000 by having selected “Run another simulation with (year 2000) data” from the Options menu in the current or a previous question.

Another common error, occurring eleven times, was to not run the simulation at all. This often followed a case of not having returned the simulation to 1990.

Finally, some participants did not correctly use the “By Year” parameter when setting one of the three main parameters: Total Fertility Rate, Life Expectancy and Net Migration. This error occurred nine times.

4.4 Questionnaire

Since the subjective ratings that participants gave in response to the questionnaire (see Appendix I) are ordinal, but not necessarily normally distributed, I used the Kruskal-Wallis one-way analysis of variance by ranks to determine if significant difference existed among the treatments. Table 4.8 gives the results of the test with values adjusted for ties; the full listing of the test is contained in Appendix O. Question 4 has 2 degrees of freedom, because the control group was not asked that question. No significance exists with respect to treatment in any of the questions.
CHAPTER 4. RESULTS

Table 4.8: Kruskal-Wallis test for differences in questionnaire responses. Values reported are adjusted for ties.

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>H</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1</td>
<td>3</td>
<td>1.79</td>
<td>0.618</td>
</tr>
<tr>
<td>Question 2</td>
<td>3</td>
<td>5.73</td>
<td>0.126</td>
</tr>
<tr>
<td>Question 3</td>
<td>3</td>
<td>5.31</td>
<td>0.151</td>
</tr>
<tr>
<td>Question 4</td>
<td>2</td>
<td>1.86</td>
<td>0.395</td>
</tr>
<tr>
<td>Question 5</td>
<td>3</td>
<td>1.42</td>
<td>0.701</td>
</tr>
<tr>
<td>Question 6</td>
<td>3</td>
<td>1.73</td>
<td>0.630</td>
</tr>
<tr>
<td>Question 7</td>
<td>3</td>
<td>2.12</td>
<td>0.548</td>
</tr>
<tr>
<td>Question 8</td>
<td>3</td>
<td>3.31</td>
<td>0.346</td>
</tr>
<tr>
<td>Question 9</td>
<td>3</td>
<td>1.78</td>
<td>0.619</td>
</tr>
</tbody>
</table>

4.5 Summary

This chapter presents the analysis of the dependent measures of the experiment. I used two approaches to analyze task completion times: ANOVA and nonparametric. Significant difference among the treatments was detected using both approaches. Both Tukey’s and Dunn’s multiple comparison tests show that the online interactive tutorial’s population mean time is less than that of the control population. Tukey’s test also indicates that the tutorial group’s mean time is less than the control group’s mean time. However, Dunn’s multiple comparison test indicates that the online tutorial group performed faster than the online help.

No significant difference among treatments was detected regarding accuracy. I also described the types of errors made by participants on each question. Although the control group spent the least amount of time in training, there was no significant difference among the other three treatments. Nor was difference detected with regard to subjective satisfaction.

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Chapter 5
Discussion and Conclusions

5.1 Time to Learn

The first of Schneiderman’s human factors with which this study is concerned is Time to Learn. The control group received no training, so users in this group clearly spent less time training than users in the other treatments. Analyses showed no significant difference among the three treatment groups (See Section 4.2).

However, the difference between the time spent with training material by the printed manual group is almost significantly less than that of the walk-through tutorial group. Even if the results were significant, however, I do not believe it would be an advantage of the printed manual. It is likely due to users’ aversion to reading, which Carroll noted [8, p. 8] and we observed during formative evaluations of IntlPop.

Referring to Table 5.1, we can see that while the walk-through tutorial treatment has a larger mean than the others, its standard deviation is much less than that of the online help and printed manual. This variance is because some students spent considerable time with the printed manual (max = 1190 seconds) or online help (max = 757.3 seconds), while others spent very little time (min = 367 and 185.9 seconds, respectively). In contrast, students with the walk-through tutorial spent similar amounts of time to complete it (min = 540 and max = 824.5 seconds).

This points to an advantage of the online interactive tutorial, which is that students are forced to use the training material, not just spend time with it. A user of the printed manual said that it was “too much to read and try to comprehend at once . . . . I like to experiment first.” While users of printed manuals can experiment while they read, they
CHAPTER 5. DISCUSSION AND CONCLUSIONS

Table 5.1: Means and standard deviations of time in seconds spent with training material

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tutorial</td>
</tr>
<tr>
<td>Mean</td>
<td>685.1</td>
</tr>
<tr>
<td>StdDev</td>
<td>109.4</td>
</tr>
<tr>
<td>Min</td>
<td>540.0</td>
</tr>
<tr>
<td>Max</td>
<td>824.5</td>
</tr>
</tbody>
</table>

generally do not.

5.2 Speed of Performance

In the tasks that indicated difference by the Jonckheere-Terpstra test, the mean of the walk-through tutorial is consistently less than the mean of the control treatment. Some training is better than none, and the walk-through tutorial is significantly better, whereas the printed manual and online help are not. This is consistent with the findings of Perkins, Blatt, Workman and Ehrlich, who compared task completion times between subjects trained to use software with an online interactive tutorial and subjects with no training [38].

Additionally, according to the Tukey’s pairwise comparisons, the tutorial group was faster than printed manual group, whereas according to Dunn’s multiple comparison test, the tutorial group was faster than the online help group. Since these results conflict, I draw no conclusion based on them.

Members of the printed manual and online help groups did not perform significantly faster or slower than members of the tutorial group. This lack of difference may be the result of the those users having read some of the information contained in the printed or online documentation.

However, users of the printed manual and online help also did not complete tasks significantly faster or slower than members of the control group. This is explained by recalling the initial reason for developing the training and assistance systems beyond the initial online help system (i.e., the printed manual and then the online tutorial): users did not take
CHAPTER 5. DISCUSSION AND CONCLUSIONS

advantage of the help system (or the printed manual when it became available). Users of the online tutorial, however, were forced to read the information provided by the tutorial. At each step of the tutorial, they had to read and carry out the instructions written in the context-sensitive message window. In fact, because they were explicitly presented with the training material, I believe that the participants in this study used more of the online help and printed manual than students using IntIPop in a course would.

The interactive nature of the online tutorial also contributes to that treatment's superior task completion times. While the same information is contained in the three training and assistance methods, users of the online tutorial practice as they are learning. One participant that used the printed manual commented, "When reading the manual, you have to try each thing as they describe [it] to actually understand how they work . . . . Running actual simulations instead of reading the manual would make it easier." When working through the online interactive tutorial, users are "running actual simulations."

The online tutorial also provided students with some familiarity with the program before they attempted to answer questions with it. After having completed the tutorial, participants in this treatment had already used the system to explore geography issues. Users of the other methods did not get any experience with the software until they used the software to answer the first question. As one participant of the online help group put it, "Reading the Help part before the experiment didn't help me a ton. I mostly played around until I figured out what I needed to."

Finally, the online tutorial gives examples of situations where the use of an interface control would be appropriate. In contrast, the online help and printed manual describe the use of a control without providing information about when it would be appropriate to do so.
CHAPTER 5. DISCUSSION AND CONCLUSIONS

5.3 Rate of Errors

I had hypothesized that beyond performing tasks more quickly, users of the online interactive tutorial would also complete tasks with greater accuracy than members of the other three treatments. However, no treatment group scored more accurately than the others.

In all training methods, the error rate is high: 44 percent over all treatments with scoring method 1 and 30 percent with scoring method 2. Some of this high rate may be attributed to the difficulty of questions asked in this study, which were designed to test all of the elements of the program. Actual laboratory exercises generally ask questions that require less proficiency with the program. However, users made a few errors recurrently, suggesting that the interface needs to be improved.

5.4 Subjective Satisfaction

Given the results of Granda, Halstead-Nussloch and Winters survey, described in Section 1.4.3.1, I expected to see some difference in the subjective ratings given by participants on the questionnaire. Additionally, I was surprised by the lack of significant difference between responses to question 4. This question asks, “When I had questions and needed a reference, the <training method> was: Useless to Useful.” Although three users of the online help and five users of the printed manual referred to those documents during a task, no member of the online tutorial group replayed the tutorial when faced with a difficulty completing a task. I had therefore expected the tutorial to have been rated lower as a reference than the other treatments.

The lack of difference may be due to the between-subjects design of this experiment, because participants in this study had no alternatives with which to compare their experience. If subjects had received more than one training method, they would have had some basis from which to make a comparison.
CHAPTER 5. DISCUSSION AND CONCLUSIONS

5.5 Conclusions

With the success of this first iteration of the online interactive tutorial, some refinements could be made to further improve its efficiency. As noted above, no student referred back to the online tutorial when faced with a difficulty, while several members of the printed manual and online help treatments did refer to those documents. This may be due to the length of the tutorial and the lack of any navigation tools to access subsections of it. Currently, the student must start at the beginning each time he or she runs the tutorial, whether it is to learn Int1Pop for the first time or to review a subsection of the tutorial. If it were broken into lessons that a student could select from, he or she could complete only those parts of the tutorial required. In this way, the tutorial might be useful as a reference after training in addition to up-front training.

In response to the high error rate seen in this study, we will try to improve Int1Pop’s interface. We will add a top-level control with which to reset a simulation. Currently, a user must go through a menu to reset the simulation. Adding a visible reset control should lessen the frequency of users not resetting a simulation. This addition should also reduce the occurrences of users incorrectly selecting “Run another simulation with (year 2000) data”, which some users selected when trying to reset a simulation.

Participants in the online interactive tutorial group consistently completed tasks more quickly than participants of the control group. There was no significant difference between the treatments with respect to training time, accuracy, or subjective satisfaction.

I believe that the superior performance time of the online interactive tutorial is due to several aspects of the tutorial. The tutorial:

- forced users to read the training material.
- allowed users to practice using the interface controls.
- familiarized users with the program.
- gave examples of situations where the use of a control would be appropriate.
CHAPTER 5. DISCUSSION AND CONCLUSIONS

Instructors using Project GeoSim software can take advantage of coercing students to use the training presented in the walk-through tutorial. In class assignments, students start IntlPop by pressing the Begin Simulation button of the HumPop geography tutorial. HumPop can start IntlPop with the online interactive tutorial active (by invoking it with the -w command line parameter). I believe students will use the online help or printed manual less in actual practice than they did in this study. For that reason, starting the program with the online interactive tutorial may provide even more effective training compared to the other training methods in practice than it did in this study.
REFERENCES


REFERENCES


REFERENCES


REFERENCES


Appendix A
IntlPop User’s Manual

Project GeoSim: IntlPop
User’s Manual, Version X1.5

A.1 What is IntlPop

IntlPop is a program that provides a means by which a student may explore factors that affect the population of any country or region of the world. IntlPop simulates changes in population based on factors such as Birth Rate, Life Expectancy, and Migration Rate. IntlPop allows you to modify them and compare changes in the population projections based on different values.

A.2 How to use IntlPop

A.2.1 Using the Mouse

You will use the mouse on your desk to control IntlPop. When you slide the mouse around on your desk, the white arrow on the screen moves with it in the same direction.

There are two kinds of buttons that you will use: buttons on the mouse and buttons on the screen. The buttons on the mouse are on the top of the mouse, toward its “tail.” The screen buttons are blue rectangles on the screen with labels that describe what they do. In this manual, a screen button is written like [File] to simulate how it looks on screen.

To press a mouse button, press it with your finger. To press a screen button, use the mouse to move the arrow on the screen over the screen button, then press the left button on the mouse.

A.2.2 What Happens First

IntlPop will first show a screen with a short introduction. Read this information and press [Done] when you have finished.

Next, the main screen of IntlPop will appear. IntlPop divides the screen into areas called windows. A window is a large rectangular region of the screen.
A.2.3 What You See on the Screen

The main screen of IntlPop consists of two large windows called Simulation Windows. You can compare two countries at the same time by running simulations in each of the two windows. A small message window along the bottom of the screen gives hints about what you can do at any moment in the program. The following buttons appear at the top of the screen:

- **Quit**: To exit the program, press this button, then press on the menu item also marked Quit.
- **Glossary**: Press this to return to the tutorial program.

A.3 Tutorial

A.3.1 First Step: Select a Country or Region.

At first, the two Simulation windows contain no information. Before you can run a simulation, you must choose a country for one (or both).

A.3.1.1 Making a Selection: Pick from list or map.

The two simulation windows are controlled separately. Press the [Options] button of the window in which you want to start a simulation. A window will appear listing five options. To select a country, press: Select region/country for simulation. A window will then appear which contains two maps of the world and a list of regions/countries.

A.3.1.2 Picking From the List: Click on the name.

The regions and countries are in alphabetical order. To select a region or country, simply move the arrow over the name you want and press the left mouse button. Your selection will appear under the label Current Selection. Press [Done] to complete the selection. You can change your selection any time before you press [Done].

To the right of the list is a control called a 'Scroll Bar.' You can use this to view more regions and countries in the list. There are several ways to use the scroll bar:

- **Press the up or down arrow buttons.** This will cause the list to scroll up or down one line at a time.
- **Drag the scroll button.** Move the mouse arrow over the button inside the scroll bar, then press and hold the mouse button. Now as you move the mouse up or down, the list will scroll up or down correspondingly until you release the mouse button.
- **Press inside the bar above or below the scroll button.** This will cause the list to scroll up or down by one page at a time.
A.3.1.3 Picking From the Map: Click on the Region or Country.

To select from the map, move the arrow to a region or country and press the mouse button. The name of your selection will appear under the label Current Selection. Press Done to complete the selection. You can change your selection any time before you press Done.

There are two maps:

Regions of the World – in the upper left shows the whole world.

Countries of the World – in the bottom left half of the screen. This is a closeup view from part of the Regions Map.

Press either of the two scale buttons, [+ ] and [ - ], to zoom in or out on the country map.

A white rectangle in the Regions map indicates what is shown in the Countries map. The rectangle can be moved around by dragging it with the mouse. Press and hold the left mouse button anywhere in the Regions map to recenter the rectangle. While holding the mouse button down, you may move the whole rectangle to a new position. When the rectangle is in the right place, release the mouse button.

A.3.1.4 What Appears on Screen After Picking Country/Region

Along with the name of the country or region that you picked and its 1990 population, the following information will appear in the main display:

The Population Pyramid represents the 1990 age distribution. It appears on the left.

Birth and Death Rates appear to the left and right (respectively) of each age group in the pyramid.

Infant Mortality is the death rate at the bottom.

Three Parameter Buttons Total Fertility, Life Expectancy, and Net Migration, appear in the lower middle.

Initial and Current Population are shown in the box to the right of the population graph.

A.3.2 Second Step: Running a Simulation

A.3.2.1 Controls

There are four types of controls:

1. Simulate — Run the simulation forward or backward.
APPENDIX A. INTLPOP USER'S MANUAL

2. **Options** — List and select general options relating to a simulation, such as picking a country, or starting another simulation for the current country.

3. **Parameter Adjustment Buttons** — Change the value of Total Fertility Rate, Life Expectancy, and Migration Rate.

4. **Cohort Population Adjustment** — Change the size of a particular age group.

**A.3.2.2 Simulate**

The simulations are run in 5 year increments. The two Sim buttons run the simulation:

- \[ \text{Sim}$\rightarrow$ \] runs the simulation forward 5 years.
- \[ \text{Sim}$\leftarrow$ \] runs the simulation back 5 years.

Each time you press a Sim button, the population pyramid, population graph, and the current total population values will be updated. If you hold the mouse button down, many simulation steps will be executed.

**A.3.2.3 Options**

Pressing the [Options] button brings up a window with the list below.

- Select region/country for simulation.
  - Lets you select a country for a simulation as described in Section A.3.1.
- Run another simulation.
  - Lets you run an additional simulation for a region or country. The 1990 population is redisplayed for the new simulation. As you run the simulation, a new growth line will be displayed in a new color, and new population totals will be displayed in the rightmost box. Up to three simulations may be run for a region/country.
- Run a simulation with (year 2000) data.
  - Lets you run a simulation with the official projection of Total Fertility Rate and Life Expectancy values for the year 2000.
- View birth and death rates.
  - Switches between two modes for changing birth and death rates. See Sections A.3.2.4 and A.3.2.5 for more information.
- Reset the simulation.
APPENDIX A. INTLPOP USER’S MANUAL

- Clears and restarts the simulation for the current country. All information returns to the 1990 values.

When the list appears, some of the items may be written in black text, while others are in dimmed grey. You may select anything listed in black text. If an item is listed in dimmed grey text, it is not available for selection, because it would not be applicable at that time during a simulation.

A.3.2.4 Parameter Adjustment Buttons

There are three parameters that you can adjust: Total Fertility Rate, Life Expectancy, and Net Migration Rate.

You can adjust any of them by pressing the blue button that has the name of the value. Doing so brings up an adjustment window. On the left are $+$ and $-$ buttons. Press them to increase or decrease the value of the parameter. Press Done when you have finished making adjustments.

There are also $+$ and $-$ buttons on the right. These change the year by which your new value is to take affect. The value will change gradually to reach the new value in the year that you specified. If you don’t change the year, your new settings will take place immediately.

When you change the Total Fertility rate or Life Expectancy, the Birth or Death rate values for each cohort (age group) are also changed.

A.3.2.5 Changing Cohorts’ Birth and Death Rates

Another way to change Total Fertility and Life Expectancy is to change the Birth and Death Rates of specific cohorts. To do that, you must press Options, then press ‘View birth and death rates.’ $+$ and $-$ buttons will be displayed next to each cohort. Press them to raise or lower the values.

A.3.2.6 Cohort Population Adjustment

At any time you may adjust the population of a particular cohort. Move the mouse arrow inside the population pyramid to the cohort bar you wish to change. Press and hold the left mouse button. The bar will move in and out with the arrow. Release the mouse button when the bar is at the position you want.
Appendix B

Readability Analysis of Printed Manual

Statistics for D:\BO\GEOSIM\INTLPOP\EXE\INFO\INTLPOP.ASC

Readability Statistics

Flesch Reading Ease: 71
Gunning’s Fog Index: 9
Flesch-Kincaid Grade Level: 6

Paragraph Statistics

Number of paragraphs: 56
Average length: 2.4 sentences

Sentence Statistics

Number of sentences: 138
Average length: 11.7 words
End with ‘?’: 0
End with ‘!’: 0
Short (< 12 words): 103
Long (> 30 words): 1

Word Statistics

Number of words: 1670
Average length: 4.53 letters
Syllables per word: 1.47
Appendix C
Online Help and Information Text

C.1 Introduction Screen

Getting Started
=============

If you already know how to use INTLPOP you may press the 'Done' button to quit the tutorial now. If you are new to INTLPOP, please read the following to get started...

You will use the mouse on your desk to control INTLPOP. When you slide the mouse around on your desk, the white arrow on the screen moves with it in the same direction.

There are two kinds of buttons that you will use: buttons on the mouse and buttons on the screen. The buttons on the mouse are on the top of the mouse, toward its 'tail.' The screen buttons are blue rectangles on the screen with labels that describe what they do.

To press a mouse button, press it with your finger. To press a screen button, use the mouse to move the arrow on the screen over the screen button, then press the left button of the mouse.

Now, press the blue button labeled 'Next Page' to see the next page of this tutorial.

--------------------------Page Break--------------------------

INTLPOP is a population simulation program that projects changes in population. Factors such as Birth Rate, Life Expectancy, and Migration Rate affect these projections. INTLPOP allows you to modify them and compare changes in the population projections based on different values.
APPENDIX C. ONLINE HELP AND INFORMATION TEXT

At the top of the screen you should see four buttons. Press the one labelled 'Help' for more information on how to use this program. When you press 'Help,' a list of items will appear. You may select an item in the list by moving the arrow over the item and pressing the left mouse button.

The small window at the bottom of the screen will also give you suggestions on what to do next.

To exit the program, first press the button marked 'Quit,' then select the menu item marked 'Quit.'

Press the 'Done' button and read the 'Quick Start' operating instructions on the next screen.

C.2 Tutor Help

Tutorial

======

SCREEN LAYOUT - The main regions of the screen.

INTLPOP divides the screen into areas called 'windows.' A window is any rectangular region of the screen.

The main screen for INTLPOP consists of two large windows, called 'Simulation Windows.' You can compare two countries at the same time by running simulations in the two windows.

A small message window along the bottom of the screen tells you what you can do at any moment in the program.

FIRST STEP - Select a Region or Country.

At first, the two simulation windows contain no information. Before you can run a simulation, you must choose a country for one (or both). Press 'Next Page' to learn how....

--------------Page Break----------------------

MAKING A SELECTION - Pick from list or map.
APPENDIX C. ONLINE HELP AND INFORMATION TEXT

The two simulation windows are controlled separately. Press the 'Options' button of the window in which you want to start a simulation. A menu will appear listing five options. To select a region/country, press:

- Select region/country for simulation.

A window will appear which contains two maps of the world and a list of regions/countries.

For information on the other four options, read the 'Options Help' information under the HELP button.

-------------------------Page Break-------------------------

PICKING FROM THE LIST - Click on the name.

The regions and countries are in alphabetical order. To select a region or country, simply move the arrow over the name you want and press the left mouse button. Your selection will appear under the label 'Current Selection:' Press 'Done' to complete the selection. You can change your selection any time before you press 'Done.'

To the right of the list is a control called a 'Scroll Bar.' You can use this to view more regions and countries in the list. There are several ways to use the scroll bar:

-Press the up or down arrow buttons:
  This will cause the list to scroll up or down one line at a time.
-Drag the scroll button:
  Move the mouse arrow over the button inside the scroll bar, then press and hold the mouse button. Now as you move the mouse up or down, the list will scroll up or down correspondingly until you release the mouse button.
-Press inside the bar above or below the scroll button:
  This will cause the list to scroll up or down by one page at a time.

-------------------------Page Break-------------------------

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APPENDIX C. ONLINE HELP AND INFORMATION TEXT

PICKING FROM THE MAPS - Click on the Region or Country.

To select from the maps, move the arrow to a region/country and press the left mouse button. The name of your selection will appear under the label 'Current Selection.' Press 'Done' to complete the selection. Before you press 'Done,' you can select a different region/country.

There are actually two maps:

- Regions of the World - in the upper left; shows the whole world.
- Countries of the World - in the bottom left half of the screen. This is a closeup view from part of the Regions Map.

Press either of the two scale buttons, '+' and '-', to zoom in or out on the Countries map.

-----------------------------Page Break-----------------------------

PICKING FROM THE MAP (Continued)

A white rectangle on the Regions map indicates what is shown in the Countries map. The rectangle can be moved around by 'dragging' it with the mouse. Press and hold the left mouse button anywhere in the Regions map to recenter the rectangle. While holding the mouse button down, you may move the whole rectangle to a new position. Release the mouse button when the rectangle is in the right place.

----------------------------------Page Break------------------------

MAIN SCREEN - Population Information

Along with the name of the region/country that you picked and its 1990 population, the following information will appear in the main display:

* The Population Pyramid represents the 1990 age distribution. It appears on the left.

* Birth and Death Rates appear to the left and right of
each age group in the pyramid.

* Infant Mortality is shown in the lower left of the window.

* Three Parameter Buttons: Total Fertility, Life Expectancy, and Net Migration appear in the lower middle.

* Initial and Current Population will appear in a box to the right of the population graph.

Now read the remaining HELP menu items to learn how to simulate population growth with INTLPOP.

C.3 Options Help

OPTIONS

The 'Options' button lets you choose various display features. Press 'Options' to get the following list. When the list appears, some items may be written in dim grey text. Such items are not selectable at that moment.

- Select region/country for simulation.
  Lets you select a country for a simulation. See 'Tutorial Help' for a complete description.

- Run another simulation.
  Lets you run an additional simulation for a country or region. The 1990 population is redisplayed for the new simulation. As you run the simulation, a new growth curve will be displayed in a new color, and new population totals will be displayed in the rightmost box. Up to three simulations may be run for a country/region.

--- Page Break ---

- Run a simulation with (year 2000) data.
  Lets you run a simulation with the official projection
APPENDIX C. ONLINE HELP AND INFORMATION TEXT

of values for the year 2000. These values come from
the database and represent an official projection of
growth.

- View birth and death rates:
  Switches between two modes for changing birth and death
  rates.

  When you select 'View birth and death rates,' '+' and
  '-' buttons appear next to the birth and death rates of
each cohort in the population pyramid. Press these
buttons to increase or decrease each rate.

  Read the 'Parameter Adjustment' section under 'Controls
Help' for more information.

- Reset simulation:
  Clears and restarts the simulation. All information
will return to the 1990 values. The population
graph will be cleared of all growth curves.

C.4 Controls Help

         CONTROLS
            ========

There are four types of controls:

1) Simulate
   - Run the simulation forward or backward.

2) Options
   - List and select general options relating to a
simulation, such as picking a country, or starting
another simulation.

3) Parameter Adjustment
   - Change the value of Total Fertility Rate, Life
Expectancy, and Migration Rate.

4) Cohort Population Adjustment
   - Change the size of a particular age group.
APPENDIX C. ONLINE HELP AND INFORMATION TEXT

The following describes each in more detail:

1) SIMULATE:

Two 'Sim' buttons control the direction of the simulation. The 'Sim' buttons are on the lower right side of both simulation windows.

    Sim--> runs the simulation forward 5 years.
    <--Sim runs the simulation back 5 years.

Each time you press a 'Sim' button, the population pyramid, population graph, and the current total population values will be updated.

If you keep the mouse button pressed, many simulation steps will be executed. The longer you hold the button, the faster the simulation will go.

Hint: Run the first simulation for each country without making any changes. Then you can compare changes to this baseline population projection.

2) OPTIONS:

Pressing the 'Options' button brings up a menu list with the following items:

1) Select region/country for simulation.
2) Run another simulation.
3) Run a simulation with (year 2000) data.
4) View birth and death rates.
5) Reset the simulation.

See the 'Options Help' menu item under the 'Help' button for more information.
APPENDIX C. ONLINE HELP AND INFORMATION TEXT

---Page Break---

3) PARAMETER ADJUSTMENT:

There are three main parameters which affect the population projection:

1) Total Fertility Rate
2) Life Expectancy
3) Net Migration Rate

The values of these parameters are shown in the bottom edge of the simulation window. You can adjust any of them by pressing the blue button that has the name of the value.

This brings up an adjustment window. On the left are '+' and '-' buttons. Press them increase or decrease the value of the parameter. Press 'Done' to finish making adjustments.

There are also '+' and '-' buttons on the right. These change the year BY WHICH your new value is to take affect. The value will change gradually to reach the new value in the year that you specified.

---Page Break---

3) PARAMETER ADJUSTMENT (continued):

When you change the Total Fertility rate or Life Expectancy, the Birth or Death rate values for each cohort (age group) are also changed. The Total Fertility rate or Life Expectancy are distributed among the cohorts.

Another way to change the Total Fertility and Life Expectancy is to change the Birth and Death Rates of specific cohorts. To do that, you must press 'Options,' then press 'View birth and death rates.' Now '+' and '-' buttons will appear next to each cohort. Press them to raise or lower the values.
APPENDIX C. ONLINE HELP AND INFORMATION TEXT

When you change the birth rate in a cohort, the Total Fertility rate is updated to include your change. Likewise, if you change the death rate of a cohort, the Life Expectancy value will reflect your changes.

After each simulation step, you may make additional demographic changes.

-------------Page Break-------------------

4) COHORT POPULATION ADJUSTMENT:

At any time you may adjust the population of a particular cohort. You may only shorten the size of a cohort, not lengthen one.

Move the arrow inside the population pyramid to the cohort bar you wish to change. Press and hold the left mouse button. The bar will move in and out with the arrow as you move the mouse on your desk. Release the mouse button when the bar is at the position you want.

C.5 About This Program

PROJECT GEOSIM: INTERNATIONAL POPULATION MODULE

This program is copyrighted by Virginia Tech. It is distributed under the terms of the GNU GENERAL PUBLIC LICENSE, Version 1 as modified by the file 'useterms.doc' both distributed with this software.

THIS PROGRAM IS DISTRIBUTED WITHOUT ANY WARRANTY. See the GNU General Public License for more details.

Originally written for the Macintosh by Sheryl K. Kriss.
Data collated by Tom Baily, Cara Cocking and Clifford A. Shaffer.
Ported to MS-DOS 80x86 by Mark Lattanzi.
Enhanced by Bo Begole, Colin Klipsch, Mark Lattanzi and Clifford A. Shaffer.

Version 2.0.6

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APPENDIX C. ONLINE HELP AND INFORMATION TEXT

Mon Feb 14 15:53:10 GMT 1994

Copyright (C) 1991, 1992, 1993
Virginia Polytechnic Institute and State University.

Project GeoSim is supported in part by the National Science Foundation under grant USE-9155943, the Fund for the Improvement of Post Secondary Education under grant P116E20130, and Virginia Tech.

This module exposes students to the population growth and age distribution of selected countries and regions of the world. Population projections for each country can be simulated, and students may modify birth and death rates to investigate any resulting effects on the projected populations.

Operating instructions help may be obtained from the Help menu. Additional information about Project GeoSim may be obtained by choosing items from the General Info menu.

C.6 GeoSim Info

PROJECT GEOSIM

Clifford A. Shaffer - Dept. of Computer Science
Laurence W. Carstensen - Dept. of Geography
Robert W. Morrill - Dept. of Geography
Edward A. Fox - Dept. of Computer Science

Virginia Polytechnic Institute and State University.

Members of the Departments of Geography and Computer Science, College of Education, and Learning Resources Center at Virginia Tech have initiated project GeoSim: computer aided instruction (CAI) software for the teaching of introductory geography.
APPENDIX C. ONLINE HELP AND INFORMATION TEXT

Geography is unique among disciplines in its focus on the spatial aspects of physical processes and human actions. GeoSim applies the immense capabilities of Geographic Information Systems (GIS) and simulation to the teaching of Geography, beginning at the first geography course. In this manner, the most exciting aspects of geography are made available to the widest audience, and in a manner that stresses dynamic processes over static information.

GeoSim provides an integrated series of interactive GIS-based computer modules to be used as supporting material for existing courses in college level introductory geography. GeoSim modules are available via gopher or anonymous ftp at geosim.cs.vt.edu.

For more information on Project GeoSim, contact:

Dr. Cliff Shaffer  
Department of Computer Science  
Virginia Tech  
Blacksburg VA 24061  
703-231-4354  
geosim@cs.vt.edu

C.7 Technical Info

Technical Information

International Population Module currently runs under MS/DOS on 80286/386/486 PCs with VGA graphics, and on DECstations running X Windows. An earlier version runs on the Apple Macintosh. We hope to update the Macintosh version by the end of 1993.

<table>
<thead>
<tr>
<th>Population</th>
<th>Projection</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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APPENDIX C. ONLINE HELP AND INFORMATION TEXT

International Population's population projection model is simplistic but sufficient for the purpose of teaching basic demographics. The model maintains an array of one year cohorts, starting with the 0th year (infant) and ending with all population age 80 or over grouped in the 80th year.

Initial country selection loads the age array with 1990 populations derived from the 1990 five year age cohort populations as stored in the database. Where information on population age, birth and deathrate distributions are not available for any country, it is approximated by using the distribution from a similar country.

-------------------Page Break-------------------

Internally, the simulation model works in one year time steps. Each step of the simulation "ages" the population by updating the age array and deriving the projected age group populations and total population from the updated array. Every fifth year, the new projection is used to update the Country Display. The "aging" process subtracts the number of deaths from each age, ages the population one year by shifting every value up one year in the array, and adds the new births to the 0 age group. Note that the 80+ age group is the sum of the surviving 79 and 80+ age groups from the previous year.

The model uses the current birth rates to calculate the number of births resulting from each age group. The number of new births for the year is then calculated as the sum of these numbers of births. The following formula calculates the numbers of births:

\[
\text{new births due to an age group} = \frac{\text{age group birth rate}}{1000 \text{ females}} \times \text{age group female population}
\]

The model uses the current death rates to calculate the number of deaths occurring in each age. The number of deaths occurring in the 0 age group is calculated as a special case using the infant mortality rate. This is
necessary to accurately reflect the large proportion of yearly deaths in a population that result from infant deaths. The following formula calculates the numbers of deaths:

\[
\text{number of deaths in an age} = \frac{\text{death rate of age group}}{1000} \times \text{population of group}
\]

The populations of each age then decrease by these numbers.

\[
\text{Total Fertility Rate}
\]

When a student selects a country for display, the program uses the current birth rates stored for that country to calculate an estimated total fertility rate. The total fertility rate is the total number of children a woman is expected to bear in her lifetime. The program calculates this value by summing the birth rates for the 10-19, 20-29, 30-39, 40-49, and 50-59 age groups and dividing the sum by (rate per thousand women for 10 years).

--- Page Break ---

Once initial data for a country are displayed, the program allows the student to directly modify the birth rate for each age group. Since the completed family size is based on these birth rates, modification to any birth rate dictates recalculation of the completed family size.

If a student selects the "Reset simulation" option, the program reinitializes the data displayed in the Country Display. It recalculates the original values for the birth rates, and recalculates the completed family size as well to correctly reflect these original rates.

\[
\text{Life Expectancy}
\]

When a student selects a country for display, the program
APPENDIX C. ONLINE HELP AND INFORMATION TEXT

uses the current death rates stored for that country to calculate an estimated life expectancy for people born this year. Life expectancy is defined as the expected number of years to be lived for a child at birth. Calculations begin with a working population of 100,000 people.

The program calculates the number of people who die at each age, ranging from age 0 through age 110, according to the following formula:

\[
\text{number of deaths} = \frac{\text{death rate of the age group containing the age}}{1000} \times \text{working population}
\]

The working population decreases by each calculated number of deaths before the next calculation occurs. The program multiplies each number of deaths by a half less than the current age, and accumulates these values. The deaths at age 0 represent the infant deaths, thus the program multiplies this number by 0. Subsequent averaging of the accumulated values produces the estimated life expectancy.

Derivation of Birth and Death Rates

Birth and death rates for each of the age groups are necessary to model population projections. These data are not available from our source, and must be derived from data which are available.

The program can retrieve the number of total births and deaths occurring in selected age groups from arbitrary years directly from the database, as well as midyear population estimates for selected years. If midyear population estimates exist for the arbitrary years from which the numbers of births and deaths come, these data can be used to derive birth and death rate figures.
APPENDIX C. ONLINE HELP AND INFORMATION TEXT

The numbers of births resulting from the females in selected age groups exist in the database in the following intervals: 0-15, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, and 50+. These numbers typically come from census surveys conducted in a specific year, as indicated in the database. Birth rates are derived for the following ten year intervals: 10-19, 20-29, 30-39, 40-49, and 50-59. Thus it is necessary to convert these numbers of births from groups in the database into the numbers of births for age groups used by the simulation. If this information were stored in the database in the age groups required by the simulation, no conversion would be necessary. We do not store the age groups required directly in the database, however, because we want to use whatever data are actually available in the database. This prevents the database from becoming degraded, and retains the extra level of data resolution for future changes to the simulation. The model assumes a zero birth rate for the remaining age groups.

In order for the program to derive birth rates for the age groups used in the simulation, the population of each of these age groups for the specific year indicated in the database must be known. Only the midyear population for this year exists in the database, so these age group populations must be derived as well. The program derives them from 1990 age group populations such that their distribution is similar to that of the 1990 distribution. The following formula calculates these age group populations:

\[
\text{age group population for the arbitrary year} = \\
\text{age group population for 1990} / \text{1990 population} \times \text{arbitrary year population}
\]

The following formula then determines the birth rate figures:

\[
\text{age group birth rate} = \\
\text{number of births occurring in the arbitrary year} / \text{1000} \times \text{age group population for the arbitrary year}
\]
APPENDIX C. ONLINE HELP AND INFORMATION TEXT

These formulas produce birth rates which are the number of births per 1,000 people. The implementation maintains these birth rates as the number of births per 1,000 women, as is traditional. The population model assumes that half of each age group population is female, thus each of the age group birth rates doubles to produce the correct figure.

The numbers of deaths occurring in selected age groups for a specific year exist in the database in the following intervals: Infant, 1-4, 4-9, 10-14, ..., 74-49, and 80+. Death rates are derived for infants and for the following age groups: 1-9, 10-19, 20-29, ..., and 80+. Once again we must convert from database age groups to simulation age groups.

A derivation of death rates for each of the age groups is done in a fashion similar to that used to derive birth rates. The implementation maintains death rates as the number of deaths per 1,000 people, as is traditional.

Net Migration Rate

The Net Migration Rate for a country represents the average number of people moving into or out of that country per year. A positive migration value will mean a yearly increase in population. A negative migration value will mean a yearly decrease in population.
Appendix D
Readability Analysis of Help Files

D.1 Introduction Screen

Statistics for D:\BO\GEO\SIM\INTLPOP\EXE\INFO\TUTOR1.HLP

Readability Statistics

  Flesch Reading Ease:  77
  Gunning’s Fog Index:  9
  Flesch-Kincaid Grade Level:  7

Paragraph Statistics

  Number of paragraphs: 10
  Average length:  1.9 sentences

Sentence Statistics

  Number of sentences: 19
  Average length:  15.8 words
  End with ‘?’:  0
  End with ‘!’:  0
  Short (< 12 words):  7
  Long (> 30 words):  1

Word Statistics

  Number of words:  321
  Average length:  4.31 letters
  Syllables per word:  1.34

D.2 Tutor Help

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APPENDIX D. READABILITY ANALYSIS OF HELP FILES

Statistics for D:\BO\GEOSIM\INTLPOP\EXE\INFO\MAIN.HLP

Readability Statistics

Flesch Reading Ease: 74  
Gunning's Fog Index: 8  
Flesch-Kincaid Grade Level: 6

Paragraph Statistics

Number of paragraphs: 28  
Average length: 2.0 sentences

Sentence Statistics

Number of sentences: 56  
Average length: 12.0 words  
End with '?' : 0  
End with '!': 0  
Short (<12 words): 35  
Long (>30 words): 0

Word Statistics

Number of words: 686  
Average length: 4.52 letters  
Syllables per word: 1.43

D.3 Options Help

Statistics for D:\BO\GEOSIM\INTLPOP\EXE\INFO\OPTIONS.HLP

Readability Statistics

Flesch Reading Ease: 57  
Gunning’s Fog Index: 11  
Flesch-Kincaid Grade Level: 8

Paragraph Statistics

Number of paragraphs: 8
APPENDIX D. READABILITY ANALYSIS OF HELP FILES

Average length: 3.0 sentences

Sentence Statistics

Number of sentences: 24
Average length: 9.8 words
End with '?' : 0
End with '!' : 0
Short (< 12 words): 20
Long (> 30 words): 0

Word Statistics

Number of words: 237
Average length: 4.91 letters
Syllables per word: 1.65

D.4 Controls Help

Statistics for D:\B0\GEOSIM\INTLP0\EXE\INFO\CONTROLS.HLP

Readability Statistics

Flesch Reading Ease: 65
Gunning's Fog Index: 10
Flesch-Kincaid Grade Level: 7

Paragraph Statistics

Number of paragraphs: 27
Average length: 1.8 sentences

Sentence Statistics

Number of sentences: 51
Average length: 10.9 words
End with '?' : 0
End with '!' : 0
Short (< 12 words): 34
Long (> 30 words): 0
APPENDIX D. READABILITY ANALYSIS OF HELP FILES

Word Statistics

Number of words:  572
Average length:   4.71 letters
Syllables per word: 1.55

D.5  About This Program

Statistics for D:\BO\GEOSIM\INTLPOP\EXE\INFO\POP.TXT

Readability Statistics

   Flesch Reading Ease:  38
   Gunning’s Fog Index: 14
   Flesch-Kincaid Grade Level: 11

Paragraph Statistics

   Number of paragraphs: 8
   Average length: 2.0 sentences

Sentence Statistics

   Number of sentences: 16
   Average length: 12.6 words
   End with ‘?‘: 0
   End with ‘!‘: 0
   Short (< 12 words): 13
   Long (> 30 words): 0

Word Statistics

   Number of words: 210
   Average length: 5.48 letters
   Syllables per word: 1.84

D.6  GeoSim Info

Statistics for D:\BO\GEOSIM\INTLPOP\EXE\INFO\GEO.TXT
APPENDIX D. READABILITY ANALYSIS OF HELP FILES

Readability Statistics

Flesch Reading Ease: 32
Cunning’s Fog Index: 16
Flesch-Kincaid Grade Level: 12

Paragraph Statistics

Number of paragraphs: 6
Average length: 2.3 sentences

Sentence Statistics

Number of sentences: 14
Average length: 12.6 words
End with ‘?’: 0
End with ‘!’: 0
Short (< 12 words): 10
Long (> 30 words): 0

Word Statistics

Number of words: 193
Average length: 5.77 letters
Syllables per word: 1.92

D.7 Technical Info

Statistics for D:\BO\GEOSIM\INTLPOP\EXE\INFO\TECH.TXT

Readability Statistics

Flesch Reading Ease: 41
Cunning’s Fog Index: 16
Flesch-Kincaid Grade Level: 12

Paragraph Statistics

Number of paragraphs: 22
Average length: 3.0 sentences
APPENDIX D. READABILITY ANALYSIS OF HELP FILES

Sentence Statistics

Number of sentences: 67
Average length: 18.3 words
End with ‘?’: 0
End with ‘!’: 0
Short (< 12 words): 25
Long (> 40 words): 0

Word Statistics

Number of words: 1334
Average length: 4.88 letters
Syllables per word: 1.74
Appendix E
Text of Online Tutorial

The following are the messages displayed by the online tutorial. They are arranged in the order in which they are presented to the user.

Welcome to the INTLPOP Walk-through tutorial.
Follow the instructions in the bottom window to learn how to use INTLPOP.
You can exit this tutorial by pressing QUIT TUTOR.

Now, read the bottom window to get started.

Information and instructions will appear in this window. To learn INTLPOP, follow the instructions that will appear. Press DONE to begin the tutorial.

The first thing to do is select a region/country for the simulation. This is one of the options provided by the Options button. Press the 'Options' button in the top window.

Notice that only one option is available. Press 'Select region/country for simulation' to select a region/country with which to run a simulation.

Now you see two maps. The top map shows Regions of the World. The bottom map displays Countries of the World. (Press 'Continue' for more information....)

To select a region or country from the maps, move the arrow over the one that you want, press and release the left mouse button. Select any country or region from one of the maps now.

Your selection now appears under 'Current Selection:'. You can 'drag' the rectangle in the top map to control what is shown in the bottom map. (Press 'Continue' to see how....)
APPENDIX E. TEXT OF ONLINE TUTORIAL

To 'drag' the rectangle in the top map, move the arrow into it, press and HOLD the left mouse button. The rectangle will follow your mouse movements until you release the button. Try it now.

The bottom map is a zoomed view of part of the top map. You can control the zoom with the + and - buttons. Press the + button to zoom in.

Did you notice that the rectangle inside the top map shrunk? That rectangle indicates what part of the top map is shown in the bottom map. Now press the - button to zoom out.

Select a region/country from the list on the right. Move the arrow over a name and press the left mouse button. Your choice will appear under 'Current Selection'.

There are more regions/countries in the list than you see. Press the ▼ button once to make the list 'scroll' up one line. Try it now.

Did you see the list move up a line? Press the the △ button to return the list to its previous position. Keep your eye on the list and watch the 'scroll' button between the △ and ▼ buttons.

Did you see that the Scroll button (the button between △ and ▼ also moved? You can control the position of the list by dragging the Scroll button. (Press 'Continue' to learn how....)

To drag the Scroll button (the button between △ and ▼), put the arrow over it, press and HOLD the left mouse button. The button will follow your movement until you release it. Try it now.

There is a faster way to find a region/country. Just type the name you want and the list will find it. Now, Type in 'eu' to find Europe.

If it is not already there, move the arrow over 'Europe' in the list. Then press the left mouse button to select Europe.

You may select a different country now, or press 'Done' to finish the selection.
APPENDIX E. TEXT OF ONLINE TUTORIAL

A population pyramid appears in the left of the top Simulation Window. The Deaths/1000 and Births/1000 for each cohort appear to the left and right of the pyramid. (Press 'Continue'...)

Also notice the Infant Mortality Rate in the lower left corner of the top Simulation Window. The name of your selection is shown in the top middle of the window. (Press 'Continue'...)

Also note the Current and Initial population figures. When you press the SIM--> button, the simulation will advance 5 years. Press SIM--> now, to see for yourself.

Did you see that the Year and Current Population changed? Also notice that a growth curve was drawn in the center. To reverse the simulation, press <--SIM.

Run the simulation as far as it will go. From 1990, you need to press SIM--> 12 times. Or press it and hold it down until the simulation reaches the year 2050. Do either now.

You can run another simulation to compare to this one. To do so, first press the 'Options' button in the top window. Press 'Run another simulation.'

Notice the year has returned to 1990, but the growth curve for your first simulation remains. A new curve will be drawn in a different color for this simulation. (Press 'Continue'...)

You can change three factors: Total Fert. Rate, Life Expectancy, and Net Migration. Press Total Fert. Rate now to learn how to change these.

The + and - buttons raise and lower the values in this window. Press the - button under Children until the value is at 0.5 (that is as low as it can go).

Press the + button under By Year until it reaches 2010. As you run the simulation, the Fert. Rate value will gradually change to reach 0.5 by the year 2010.
Now press DONE to complete your changes.

Press SIM--> until it reaches 2050 again. Watch the Total Fert. Rate value gradually change to reach 0.5 by the year 2010.

Compare the two simulation growth curves. The lower Total Fert. Rate of this simulation leads to less population growth than the first simulation. (Press 'Continue'...)

There are a few more controls you can use in IntlPop. To learn about them, first press the 'Options' button in the top window.

After you select 'Reset the simulation,' the simulation will return to 1990 and all the growth curves will be cleared. Press 'Reset the simulation.'

Notice that 'resetting' the simulation returned everything to 1990 and cleared the growth curves. To learn about more controls, press the 'Options' button in the top window again.

After you select 'View birth and death rate buttons,' buttons will appear on both sides of the population pyramid. Press 'View birth and death rate buttons' to see them.

Notice the '+' and '-' buttons beside the population pyramid and the Infant Mortality Rate. These allow you to adjust the death and birth rates for each cohort. (Press Continue...)

Press the '-' button to the left of the 70-79 cohort until it reaches 10. Watch the Life Expectancy value rise at the same time.

You can also adjust the number of people in a cohort (age group) by dragging the cohort bar in the pyramid. (Press 'Continue' to learn how....)

To 'drag' a cohort bar, move the arrow into it, press and HOLD the left mouse button. Then the bar will move in and out with your mouse movements until you release the button. Try it now.
APPENDIX E. TEXT OF ONLINE TUTORIAL

Dragging a cohort simulates a reduction in the number of people in that cohort. To see the effects of your changes, press SIM--> until it reaches 2050 again.

This completes the Walk-Through Tutorial of IntlPop. You may run the tutorial again by pressing 'Help' and selecting 'Walk-Through Tutorial.' (Press 'Continue' to clear the tutorial.)
Appendix F

Readability Analysis of Online Tutorial Text

Statistics for C:\THEESIS\IP_INF.TXT

Readability Statistics

Flesch Reading Ease: 75
Gunning’s Fog Index: 8
Flesch-Kincaid Grade Level: 5

Paragraph Statistics

Number of paragraphs: 40
Average length: 2.8 sentences

Sentence Statistics

Number of sentences: 115
Average length: 10.1 words
End with ‘?’: 4
End with ‘!’: 0
Short (< 12 words): 79
Long (> 30 words): 0

Word Statistics

Number of words: 1168
Average length: 4.43 letters
Syllables per word: 1.44
Appendix G

Pretest Instructions

Squares Instructions

When you have read and understand these instructions, press the [Start] button to begin.

After you press [Start], one of the rectangles on the buttons on the screen will change from gray to white. Press that button. When you press the button, it will return to gray and another one will change from gray to white. Continue to press buttons until all of them have been pressed.

When you are ready to begin, press [Start].
APPENDIX G. PRETEST INSTRUCTIONS

Alpha Instructions

Read and understand these instructions before you begin.

1. Press [Start].

2. Press the buttons of the letters in the word:
   GEOGRAPHY.

3. Press [End].
APPENDIX G. PRETEST INSTRUCTIONS

Read and understand these instructions before you begin.

1. Press [Start].

2. Press the buttons of the letters in the word: UNIVERSITY.

3. Press [End].
APPENDIX G. PRETEST INSTRUCTIONS

Read and understand these instructions before you begin.

1. Press [Start].

2. Press the buttons of the following letters (this is not a real word):
   SOQYEPBELRTJ.

3. Press [End].
Appendix H

Informed Consent and Nondisclosure Agreement Form

Participant’s Informed Consent Form

This form constitutes informed consent by you to participate in this study. Please read this entire form and then sign it if you agree to participate.

Thank you for participating in this research. This study is being conducted by James M. A. Begole, graduate student, and Dr. Cliff Shaffer, advisor, for the Project GeoSim research group. The study examines the effectiveness of software training methods. If you choose to participate in this research, you will be asked to perform several exercises on a computer followed by a questionnaire. No physical activities other than using a mouse and typing will be required. The experiment will last one hour. You will be paid $5.00. There are no known sources of discomfort in this study.

If at any time during the experiment you feel that you cannot participate further or that you need help understanding any portion of the task or equipment, please inform the experimenter.

Information collected during the study will be confidential. The experiment will be video taped. These tapes will be reviewed by James M. A. Begole and will be erased by July 1, 1994.

As a participant in the study, you have certain rights:

1. You may withdraw from the experiment at any time for any reason.

2. At the conclusion of your participation, you may see your data, if you desire. If you decide to withdraw your data, please inform the experimenter immediately.

If you have any questions now or in the future about this experiment, please contact the researcher or his advisor:

- Researcher: James M. A. Begole, “Bo”. office: 335 McBryde, (703) 231-7371
  home: (703) 951-2174

- Advisor: Dr. Cliff Shaffer. office: 331 McBryde (703) 231-4354

Additional questions regarding your rights as a participant should be addressed to Dr. Janet M. Johnson, Chairman of the Institutional Review Board at (703) 231-6077 (301 Burruss Hall).
APPENDIX H. INFORMED CONSENT AND NONDISCLOSURE AGREEMENT FORM

Your signature below indicates that you have read this document (Participant’s Informed Consent Form) in its entirety, that your questions have been answered, and that you consent to participate in the study described.

Printed name: _______________________________________

School Address: _______________________________________

Student ID #: _______________________________________

Signature: _______________________________________

Date: __________
APPENDIX H. INFORMED CONSENT AND NONDISCLOSURE AGREEMENT FORM

Participant’s Nondisclosure Agreement

This form constitutes agreement by you not to discuss any part of this experiment with anyone other than the researcher, his advisor or members of the Institutional Review Board until April 30, 1994.

To protect the integrity of this study, you are asked to agree not to discuss any part of this experiment or your participation in it with anyone other than the researcher, his advisor or members of the Institutional Review Board any time before April 30, 1994. After that time, you may discuss the experiment and your participation with anyone.

The purpose of this agreement is to ensure that other participants in the study are not influenced in any way by your experience in the experiment. Such influence could invalidate the results of the experiment.

If you have any questions about this experiment, please contact the researcher or his advisor:

- Researcher: James M. A. Begole, “Bo”. office: 335 McBryde, (703) 231-7371
  home: (703) 951-2174
- Advisor: Dr. Cliff Shaffer. office: 331 McBryde (703) 231-4354

Additional questions regarding your rights as a participant should be addressed to Dr. Janet M. Johnson, Chairman of the Institutional Review Board at (703) 231-6077 (301 Burruss Hall).

Your signature below indicates that you have read this document (Participant’s Nondisclosure Agreement) in its entirety and that you agree not to discuss the experiment with anyone other than the researcher, his advisor or the Institutional Review Board any time before April 30, 1994.

Printed name: ____________________________________________________________

School Address: __________________________________________________________
                  __________________________________________________________
                  __________________________________________________________

Student ID #: ____________________________________________________________________________________________

Signature: ________________________________________________________________________________________________

Date: __________
Appendix I

Questionnaires

Questionnaire (walk-through tutorial)

Please answer the following questions. For each question, circle the number that most closely matches your response. Please write any comments about a question next to the question.

The questions were:

Difficult 0 1 2 3 4 5 6 Easy

The answers I found with the program are correct.

Disagree 0 1 2 3 4 5 6 Agree

The walk-through tutorial training I received was:

Useless 0 1 2 3 4 5 6 Useful

When I had questions and needed a reference, the walk-through tutorial was:

Useless 0 1 2 3 4 5 6 Useful

The simulation program, IntlPop was:

Difficult to Use 0 1 2 3 4 5 6 Easy to Use

Overall Reactions to the system:

Terrible 0 1 2 3 4 5 6 Wonderful

Difficult 0 1 2 3 4 5 6 Easy

Dull 0 1 2 3 4 5 6 Stimulating

Frustrating 0 1 2 3 4 5 6 Satisfying

Comments: Please write any comments you have concerning the following subjects. You may use extra sheets of paper.

1. Training:

2. IntlPop Program:

3. Anything else:
APPENDIX I. QUESTIONNAIRES

Questionnaire (online help)

Please answer the following questions. For each question, circle the number that most closely matches your response. Please write any comments about a question next to the question.

The questions were:
   Difficult 0 1 2 3 4 5 6 Easy

The answers I found with the program are correct.
   Disagree 0 1 2 3 4 5 6 Agree

The online help training I received was:
   Useless 0 1 2 3 4 5 6 Useful

When I had questions and needed a reference, the online help was:
   Useless 0 1 2 3 4 5 6 Useful

The simulation program, IntlPop was:
   Difficult to Use 0 1 2 3 4 5 6 Easy to Use

Overall Reactions to the system:
   Terrible 0 1 2 3 4 5 6 Wonderful

   Difficult 0 1 2 3 4 5 6 Easy

   Dull 0 1 2 3 4 5 6 Stimulating

   Frustrating 0 1 2 3 4 5 6 Satisfying

Comments: Please write any comments you have concerning the following subjects. You may use extra sheets of paper.

1. Training:

2. IntlPop Program:

3. Anything else:
APPENDIX I. QUESTIONNAIRES

Questionnaire (printed manual)

Please answer the following questions. For each question, circle the number that most closely matches your response. Please write any comments about a question next to the question.

The questions were:

Difficult 0 1 2 3 4 5 6 Easy

The answers I found with the program are correct.

Disagree 0 1 2 3 4 5 6 Agree

The printed manual training I received was:

Useless 0 1 2 3 4 5 6 Useful

When I had questions and needed a reference, the printed manual was:

Useless 0 1 2 3 4 5 6 Useful

The simulation program, *IntlPop* was:

Difficult to Use 0 1 2 3 4 5 6 Easy to Use

**Overall Reactions to the system:**

Terrible 0 1 2 3 4 5 6 Wonderful

Difficult 0 1 2 3 4 5 6 Easy

Dull 0 1 2 3 4 5 6 Stimulating

Frustrating 0 1 2 3 4 5 6 Satisfying

**Comments:** Please write any comments you have concerning the following subjects. You may use extra sheets of paper.

1. Training:

2. IntlPop Program:

3. Anything else:
APPENDIX I. QUESTIONNAIRES

Questionnaire (control)

Please answer the following questions. For each question, circle the number that most closely matches your response. Please write any comments about a question next to the question.

The questions were:

Difficult 0 1 2 3 4 5 6 Easy

The answers I found with the program are correct.

Disagree 0 1 2 3 4 5 6 Agree

The simulation program, IntlPop was:

Difficult to Use 0 1 2 3 4 5 6 Easy to Use

**Overall Reactions to the system:**

Terrible 0 1 2 3 4 5 6 Wonderful

Difficult 0 1 2 3 4 5 6 Easy

Dull 0 1 2 3 4 5 6 Stimulating

Frustrating 0 1 2 3 4 5 6 Satisfying

**Comments:** Please write any comments you have concerning the following subjects. You may use extra sheets of paper.

1. IntlPop Program:

2. Anything else:
Appendix J
Collected Data

Figure J.1: Boxplots of Task Completion Times by Treatment

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### APPENDIX J. COLLECTED DATA

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Appendix K
ANOVA of Task Completion Times

K.1 Two-way ANOVA of Times by Treatment and Task

MTB > ANOVA 'Time' = Task | Treat;
SUBC> EMS;
SUBC> Means Task | Treat.

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APPENDIX K. ANOVA OF TASK COMPLETION TIMES

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MTB > ANCOVA 'Time' = Task | Treat;  
SUBC> Covariates 'Pt4';  
SUBC> Means Task | Treat.  

Factor   Levels Values  
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Treat    4  1  2  3  4  

Analysis of Covariance for Time

Source       DF    ADJ SS    MS      F      P
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Task         8   187637  23455  7.12  0.000
Treat        3   42480   14160  4.30  0.006
Task*Treat   24   67949   2831  0.86  0.657
Error       179   589806  3295
Total       215   891954

Covariate   Coeff   Stdev  t-value    P
pt4         1.238   0.633   1.814   0.071

ADJUSTED MEANS

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APPENDIX K. ANOVA OF TASK COMPLETION TIMES

<p>| | | | |</p>
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K.2 One-way ANOVA of Times by Treatment for each Task

MTB > Oneway 'T1' 'Group'.

ANALYSIS OF VARIANCE ON T1

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<td>18454</td>
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<td>108338</td>
<td>5419</td>
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<td>23</td>
<td>126842</td>
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</table>

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

LEVEL | N | MEAN | STDEV |--------|--------|
<table>
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<tbody>
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<td>1</td>
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<td>89.61</td>
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<td>--------</td>
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<td>6</td>
<td>141.59</td>
<td>61.28</td>
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POOLED STDEV = 73.62

60 120 180

MTB > Oneway 'T2' 'Group'.

ANALYSIS OF VARIANCE ON T2

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<td>388</td>
<td>2.82</td>
<td>0.065</td>
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<td>2757</td>
<td>138</td>
<td></td>
<td></td>
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INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

LEVEL | N | MEAN | STDEV |--------|--------|
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<th></th>
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<td>31.20</td>
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<td>--------</td>
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<tr>
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<td>6</td>
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<td>7.98</td>
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<td>3</td>
<td>6</td>
<td>49.93</td>
<td>12.01</td>
<td>(-------</td>
<td>--------</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>45.89</td>
<td>16.27</td>
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POOLED STDEV = 11.74

24 36 48 60

126
APPENDIX K. ANOVA OF TASK COMPLETION TIMES

MTB > Oneway 'T3' 'Group'.

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<tr>
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<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
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<td>14294</td>
<td>4765</td>
<td>2.14</td>
<td>0.128</td>
</tr>
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<td>ERROR</td>
<td>20</td>
<td>44615</td>
<td>2231</td>
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<tr>
<td>TOTAL</td>
<td>23</td>
<td>58909</td>
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INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

<table>
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<tr>
<th>LEVEL</th>
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<th>STDEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>23.09</td>
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<td>4</td>
<td>6</td>
<td>88.43</td>
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POOLED STDEV = 47.23

MTB > Oneway 'T4' 'Group'.

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<tbody>
<tr>
<td>Group</td>
<td>3</td>
<td>4159</td>
<td>1336</td>
<td>0.40</td>
<td>0.752</td>
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<tr>
<td>ERROR</td>
<td>20</td>
<td>68645</td>
<td>3432</td>
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<tr>
<td>TOTAL</td>
<td>23</td>
<td>72804</td>
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INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

<table>
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<th>MEAN</th>
<th>STDEV</th>
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<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>81.27</td>
<td>27.14</td>
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<tr>
<td>2</td>
<td>6</td>
<td>106.44</td>
<td>50.90</td>
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<tr>
<td>3</td>
<td>6</td>
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</tr>
<tr>
<td>4</td>
<td>6</td>
<td>117.09</td>
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POOLED STDEV = 58.59

MTB > Oneway 'T5' 'Group'.

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<tbody>
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<td>11339</td>
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<td>20</td>
<td>68075</td>
<td>3404</td>
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APPENDIX K. ANOVA OF TASK COMPLETION TIMES

TOTAL  23  79415

LEVEL    N    MEAN    STDEV
1        6    74.02    32.43
2        5    120.72   61.83
3        6    130.44   90.19
4        6    98.71    24.63

POOLED STDEV = 58.34

MTB > Oneway 'T6' 'Group'.

ANALYSIS OF VARIANCE ON T6
SOURCE    DF    SS      MS    F    p
Group      3    7340  2447  1.31  0.299
ERROR     20  37367  1868
TOTAL     23  44708

LEVEL    N    MEAN    STDEV
1        6    81.50    13.43
2        6    107.16   36.92
3        6    100.92   52.81
4        6    130.49   56.05

POOLED STDEV = 43.22

MTB > Oneway 'T7' 'Group'.

ANALYSIS OF VARIANCE ON T7
SOURCE    DF    SS      MS    F    p
Group      3  26997  8999  1.19  0.339
ERROR     20 151399  7570
TOTAL     23 178396

LEVEL    N    MEAN    STDEV
1        6    88.59    59.81
2        6    137.08   98.57
3        6    167.62   92.67

INDIVIDUAL 95 PCT CI’S FOR MEAN
BASED ON POOLED STDEV

50    100    150    200

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APPENDIX K. ANOVA OF TASK COMPLETION TIMES

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<tr>
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<tr>
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<td>87.01</td>
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MTB > One way 'T8' 'Group'.

ANALYSIS OF VARIANCE ON T8

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<td>2741</td>
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<td>0.75</td>
<td>0.536</td>
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<tr>
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<td>1222</td>
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INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

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<th>STDEV</th>
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<tbody>
<tr>
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<td>73.72</td>
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<td>65.54</td>
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<tr>
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<td>6</td>
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<td>94.48</td>
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POOLED STDEV = 34.96

MTB > One way 'T9' 'Group'.

ANALYSIS OF VARIANCE ON T9

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INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

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<td>6</td>
<td>66.92</td>
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POOLED STDEV = 68.91

K.3 One-way ANOVA of Times by Treatment for all Tasks

MTB > One way 'Time' 'Treat';
SUBC> Tukey .2;
APPENDIX K. ANOVA OF TASK COMPLETION TIMES

SUBC> Fisher 5;
SUBC> Dunnett .15 4;
SUBC> MCB .2 1.

ANALYSIS OF VARIANCE ON Time

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INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

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POOLED STDEV = 63.55

Dunnett’s intervals for treatment mean minus control mean

Family error rate = 0.150
Individual error rate = 0.0608

Critical value = 1.88

Control = level 4 of Treat

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<td>11.70</td>
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<tr>
<td>3</td>
<td>-32.45</td>
<td>-9.46</td>
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Hsu’s MCB (Multiple Comparisons with the Best)

Family error rate = 0.200

Critical value = 1.34
APPENDIX K. ANOVA OF TASK COMPLETION TIMES

Intervals for level mean minus smallest of other level means

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<th>Center</th>
<th>Upper</th>
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<tr>
<td>4</td>
<td>0.00</td>
<td>34.92</td>
<td>51.31</td>
<td>---</td>
<td>---</td>
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</tr>
</tbody>
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---

Tukey's pairwise comparisons

Family error rate = 0.200
Individual error rate = 0.0493

Critical value = 2.80

Intervals for (column level mean) - (row level mean)

\[
\begin{array}{ccc}
1 & 2 & 3 \\
2 & -47.8 & 0.6 \\
3 & -49.7 & -26.1 \\
& -1.2 & 22.4 \\
4 & -59.1 & -35.5 \\
& -10.7 & 12.9 \\
& & 14.8 \\
\end{array}
\]

Fisher's pairwise comparisons

Family error rate = 0.202
Individual error rate = 0.0500

Critical value = 1.971

Intervals for (column level mean) - (row level mean)
### APPENDIX K. ANOVA OF TASK COMPLETION TIMES

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<th>3</th>
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<td>-10.8</td>
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<td>14.6</td>
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Appendix L

Nonparametric Analyses of Task Completion Times

L.1 Jonckheere-Terpstra test for ordered alternatives

L.1.1 All Tasks Combined

Jonckheere-Terpstra test for ordered alternatives
Comparing all task times by treatment.
$K = 4, n_i = 54, N = 216$

$J = 10328.000$
Large-sample approximation. $z = 3.076$

Compare $z$ to tabulated values of normal distribution.

L.1.2 Each Task

Jonckheere-Terpstra test for ordered alternatives

Critical value for $J$ is 141.
(alpha = .05, $k=4, n=6$)

Task Number 1: $J = 152.000 > 141$ Reject H0.
Task Number 2: $J = 153.000 > 141$ Reject H0.
Task Number 3: $J = 161.000 > 141$ Reject H0.
Task Number 4: $J = 119.000$
Task Number 5: $J = 137.000$
Task Number 6: $J = 146.000 > 141$ Reject H0.
Task Number 7: $J = 158.500 > 141$ Reject H0.
Task Number 8: $J = 123.000$
Task Number 9: $J = 73.000$
APPENDIX L. NONPARAMETRIC ANALYSES OF TASK COMPLETION TIMES

L.2 Dunn’s Multiple Comparison

L.2.1 All Tasks Combined

Dunn’s Multiple Comparison Test

Significant value for $|R_i - R_j|$ is 23.574,
where $R_k$ is the mean of the ranks of treatment $k$.
Experimentwise error rate, Alpha, for these 4 treatments is 0.30
Pairwise error rate, Alpha, is 0.050

R_1 = 85.648
R_2 = 113.241
R_3 = 108.648
R_4 = 126.259

R_1 - R_2 = -27.593 Significant: $|27.593| > 23.574$
R_1 - R_3 = -23.000
R_1 - R_4 = -40.611 Significant: $|40.611| > 23.574$
R_2 - R_3 = 4.593
R_2 - R_4 = -13.019
R_3 - R_4 = -17.611

L.2.2 Each Task

Dunn’s Multiple Comparison Test

Significant value for $|R_i - R_j|$ is 8.002,
where $R_k$ is the mean of the ranks of treatment $k$.
Experimentwise Alpha for these 4 treatments is 0.30

Task Number 1:

R_1 = 7.500
R_2 = 12.500
R_3 = 12.500
R_4 = 17.500

R_1 - R_2 = -5.000
R_1 - R_3 = -5.000
R_1 - R_4 = -10.000 Significant: $|10.000| > 8.002$
R_2 - R_3 = 0.000
R_2 - R_4 = -5.000
R_3 - R_4 = -5.000

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APPENDIX L. NONPARAMETRIC ANALYSES OF TASK COMPLETION TIMES

Task Number 2:
\[ R_1 = 6.000 \]
\[ R_2 = 13.000 \]
\[ R_3 = 16.667 \]
\[ R_4 = 14.167 \]
\[ R_1 - R_2 = -7.000 \]
\[ R_1 - R_3 = -10.667 \] Significant: \(|-10.667| > 8.002\)
\[ R_1 - R_4 = -8.167 \] Significant: \(|-8.167| > 8.002\)
\[ R_2 - R_3 = -3.667 \]
\[ R_2 - R_4 = -1.167 \]
\[ R_3 - R_4 = 2.500 \]

Task Number 3:
\[ R_1 = 7.000 \]
\[ R_2 = 12.000 \]
\[ R_3 = 13.000 \]
\[ R_4 = 18.000 \]
\[ R_1 - R_2 = -5.000 \]
\[ R_1 - R_3 = -6.000 \]
\[ R_1 - R_4 = -11.000 \] Significant: \(|-11.000| > 8.002\)
\[ R_2 - R_3 = -1.000 \]
\[ R_2 - R_4 = -6.000 \]
\[ R_3 - R_4 = -5.000 \]

Task Number 4:
\[ R_1 = 11.000 \]
\[ R_2 = 14.000 \]
\[ R_3 = 10.500 \]
\[ R_4 = 14.500 \]
\[ R_1 - R_2 = -3.000 \]
\[ R_1 - R_3 = 0.500 \]
\[ R_1 - R_4 = -3.500 \]
\[ R_2 - R_3 = 3.500 \]
\[ R_2 - R_4 = -0.500 \]
\[ R_3 - R_4 = -4.000 \]

Task Number 5:
APPENDIX L. NONPARAMETRIC ANALYSES OF TASK COMPLETION TIMES

\[ R_1 = 6.667 \]
\[ R_2 = 15.333 \]
\[ R_3 = 14.333 \]
\[ R_4 = 13.667 \]

\[ R_1 - R_2 = -8.667 \quad \text{Significant: } |\text{-8.667}| > 8.002 \]
\[ R_1 - R_3 = -7.667 \]
\[ R_1 - R_4 = -7.000 \]
\[ R_2 - R_3 = 1.000 \]
\[ R_2 - R_4 = 1.667 \]
\[ R_3 - R_4 = 0.667 \]

Task Number 6:
\[ R_1 = 7.667 \]
\[ R_2 = 14.333 \]
\[ R_3 = 11.500 \]
\[ R_4 = 16.500 \]

\[ R_1 - R_2 = -6.667 \]
\[ R_1 - R_3 = -3.833 \]
\[ R_1 - R_4 = -8.833 \quad \text{Significant: } |\text{-8.833}| > 8.002 \]
\[ R_2 - R_3 = 2.833 \]
\[ R_2 - R_4 = -2.167 \]
\[ R_3 - R_4 = -5.000 \]

Task Number 7:
\[ R_1 = 6.500 \]
\[ R_2 = 11.833 \]
\[ R_3 = 15.167 \]
\[ R_4 = 16.333 \]

\[ R_1 - R_2 = -5.333 \]
\[ R_1 - R_3 = -8.667 \quad \text{Significant: } |\text{-8.667}| > 8.002 \]
\[ R_1 - R_4 = -9.833 \quad \text{Significant: } |\text{-9.833}| > 8.002 \]
\[ R_2 - R_3 = -3.333 \]
\[ R_2 - R_4 = -4.500 \]
\[ R_3 - R_4 = -1.167 \]

Task Number 8:
\[ R_1 = 11.500 \]
\[ R_2 = 11.500 \]
APPENDIX L. NONPARAMETRIC ANALYSES OF TASK COMPLETION TIMES

\[ R_{\cdot 3} = 12.000 \]
\[ R_{\cdot 4} = 15.000 \]

\[ R_1 - R_2 = 0.000 \]
\[ R_1 - R_3 = -0.500 \]
\[ R_1 - R_4 = -3.500 \]
\[ R_2 - R_3 = -0.500 \]
\[ R_2 - R_4 = -3.500 \]
\[ R_3 - R_4 = -3.000 \]

Task Number 9:

\[ R_{\cdot 1} = 13.833 \]
\[ R_{\cdot 2} = 17.000 \]
\[ R_{\cdot 3} = 10.500 \]
\[ R_{\cdot 4} = 8.667 \]

\[ R_1 - R_2 = -3.167 \]
\[ R_1 - R_3 = 3.333 \]
\[ R_1 - R_4 = 5.167 \]
\[ R_2 - R_3 = 6.500 \]
\[ R_2 - R_4 = 8.333 \quad \text{Significant: } |8.333| > 8.002 \]
\[ R_3 - R_4 = 1.833 \]
Appendix M
Source Code of Nonparametric Tests

M.1 JT.CPP — Jonckheere-Terpstra test

/***************************************************************************/
* * James "Bo" Begole  04/19/94
* JT.CPP
* *
* Performs Jonckheere-Terpstra statistical test for ordered alternatives.
* *
* H0:  m1 = m2 = m3 = m4
* H1:  M1 <= m2 <= m3 <= m4
* *
* Reference:
* W.W. Daniel, {\em Applied Nonparametric Statistics},
* *
* *
* Input files:
* 9 input files: TASKn.C.DAT (n = 1..9)
* *
* Output files:
* JT-OUT.TXT
* *
* ***************************************************************************/

#include <string.h>
#include <stdio.h>

#define JCRIT 141 // Critical Value of J.
                 // Taken from table A.13 in Daniel

#define K 4       // Number of Treatments
APPENDIX M. SOURCE CODE OF NONPARAMETRIC TESTS

#define N 6                // Number of observations per treatment
#define TOTAL_N K*N       // Total number of observations
#define NUMTASKS 9         // Number of tasks

int main(void)
{
    FILE * file[NUMTASKS];   // input files
    FILE * outfile;          // output file

    char filename[80];       // filename string
    char inbuffer[256];      // read a line at a time
    int treatflag[K];        // 0 == this line not of treatment[j]
    float cov[K], val;      // covariates and value for each input line
    float value[K][N];       // values of all observations for one task
    int counts[K];           // counts of values seen so far for each treatment

    // Open output file
    strcpy(filename, "jt-out.txt");
    if ((outfile = fopen(filename, "wt")) == NULL)
        printf( "Error, cannot open file: %s\n", filename);

    // Print header information
    printf("\n\nJonckheere-Terpstra test for ordered alternatives\n\n"ijn
    printf("\nCritical value for J is %d, JCRIT);\n")
    printf("\n(alpha = .05, k=4, n=6)\n\n\n")
    fprintf(outfile,  
    "\n\nJonckheere-Terpstra test for ordered alternatives\n\n")
    fprintf(outfile, "\nCritical value for J is %d, JCRIT);\n")
    fprintf(outfile, "\n(alpha = .05, k=4, n=6)\n")

    // Open data files
    for (int i = 0; i < NUMTASKS; i++)
    {
        sprintf(filename, "task%d-c.dat", i+1);
        if ((file[i] = fopen(filename, "rt")) == NULL)
APPENDIX M. SOURCE CODE OF NONPARAMETRIC TESTS

    printf("Error, cannot open file: %s\n", filename);
    }

    // For each task, run the test.
    for (int task = 0; task < NUMTASKS; task++)
    {
        for (int j = 0; j<4; j++)  /* remove first four lines */
            fgets(inbuffer, 256, file[task]);

        for(j = 0; j < K; j++)    /* init counts array */
            counts[j] = 0;

        for (int n = 0; n<24; n++)    /* process lines */
            {
                fgets(inbuffer, 256, file[task]);
                sscanf(inbuffer, "%d %f %d %f %d %f %d %f",
                    &treatflag[0], &cov[0],
                    &treatflag[1], &cov[1],
                    &treatflag[2], &cov[2],
                    &treatflag[3], &cov[3], &val);

                /* load the values array with this value */
                for (j = 0; j<K; j++)
                    if (treatflag[j])
                        {
                            value[j][counts[j]] = val;
                            counts[j]++;
                            break;
                        }
            }

    /* Perform J-T test */
    float J=0;

    // start with first treat, go thru k-1 treats
    for (int treat1 = 0; treat1< K-1; treat1++)
        // compare treat1's data to remaining treats
        for (int treat2 = treat1+1; treat2 < K; treat2++)
            // start with first element of data for treat1
            for (int valindex1 = 0; valindex1 < N; valindex1++)
APPENDIX M. SOURCE CODE OF NONPARAMETRIC TESTS

    // start with first element of data for treat2
    for (int valindex2 = 0; valindex2 < N; valindex2++)
        if (value[treat1][valindex1] < value[treat2][valindex2])
            J++;
        else if (value[treat1][valindex1] == value[treat2][valindex2])
            J += 0.5;

    /* Report the value for J */
    printf("    Task Number %d: J = %8.3f", task+1, J);
    fprintf(outfile, "        Task Number %d: J = %8.3f", task+1, J);

    /* if J is greater than critical value */
    if (J > JCRIT)
    {
        printf(" > %d Reject H0.", JCRIT); // reject Null Hyp
        fprintf(outfile, " > %d Reject H0.", JCRIT);
    }
    printf("\n");
    fprintf(outfile, "\n");

    fcloseall(); // clean up
    return 1;
}

M.2 MULTICOM.CPP -- Dunn's Multiple Comparison

/**********************
*
* James "Bo" Begole   04/19/94
* MULTICOM.CPP
* 
* Performs nonparametric multiple comparison test to find differences
* between treatments.
* This may be appropriately applied following Kruskal-Wallis or
* Jonckheere-Terpstra analysis has determined difference between
* treatments.
* 
* Reference:
* W.W. Daniel, {\em Applied Nonparametric Statistics},
* 
*
APPENDIX M. SOURCE CODE OF NONPARAMETRIC TESTS

*  *  Input files:
*  *  9 input files: TASKn-C.DAT (n = 1..9)
*  *  Output files:
*  *  MC-OUT.TXT
*  *
*  ***********************************************

#include <math.h>
#include <search.h>
#include <string.h>
#include <stdio.h>

#define ALPHA 0.30  // alpha spread out over the multiple comparisons
#define Z_ALPHA 1.96 // Z value that has ALPHA/K(K-1) area to its right
                 // from Table A.2 of Daniel

#define K 4         // four treatments
#define N 6         // six observations in each treatment
#define TOTAL_N K*N // total number of observations

#define DATAPATH ".//jt/"

int float_cmp( const void *a, const void *b);
int find(float *sorteddata, int size, float key);

int main(void)
{
    FILE * file[9];     // input files
    FILE * outfile;     // output file

    char filename[256]; // filename string
    char inbuffer[256]; // read a line at a time
    int treatflag[K];  // 0 == this line not of treatment[j]
    float cov[K], val; // covariates and value for each input line
    float value[K][N]; // values of all observations for one task
    int counts[K];     // counts of values seen so far for each treatment

    // Code continues here...
APPENDIX M. SOURCE CODE OF NONPARAMETRIC TESTS

float significant_value; // significant value at which H_0 is rejected

// Determine the value that determines significant difference when
// |R_i - R_j| > significant_value
significant_value = Z_ALPHA*(sqrt(((double)K*(double)(TOTAL_N+1)/6)));

// Open output file
strcpy(filename, "mc-out.txt");
if ((outfile = fopen(filename, "wt")) == NULL)
    printf("Error, cannot open file: %s.\n", filename);

// Print header information
printf("\n\n\n Dunn's Multiple Comparison Test\n");
printf(" "


==================\n\n\n" Significant value for |R_i - R_j| is %6.3f,\n", significant_value);
printf("where R_k is the mean of the ranks of treatment k.\n");
printf(" Experimentwise Alpha for these %d treatments is %3.2f\n", K, ALPHA);
fprintf(outfile, "\n\n Dunn's Multiple Comparison Test\n");
fprintf(outfile, " "


==================\n\n\n" Significant value for |R_i - R_j| is %6.3f,\n", significant_value);
fprintf(outfile, "where R_k is the mean of the ranks of treatment k.\n");
fprintf(outfile, " Experimentwise Alpha for these %d treatments is %3.2f\n", K, ALPHA);

// Open data files
for (int i = 0; i < 9; i++)
{
    sprintf(filename, "%stask%d-c.dat", DATAPATH, i+1);
    if ((file[i] = fopen(filename, "rt")) == NULL)
        printf("Error, cannot open file: %s.\n", filename);
}

// For each task, run the test.
for (int task = 0; task < 9; task++)

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APPENDIX M. SOURCE CODE OF NONPARAMETRIC TESTS

{

    printf("Task Number \%d: \n", task+1);
    fprintf(outfile, " Task Number \%d: \n", task+1);

    for (int j = 0; j<K; j++)    /* remove first four lines */
        fgets(inbuffer, 256, file[task]);

    for(j = 0; j<K; j++)    /* init counts array */
        counts[j] = 0;

    for (int n = 0; n<K*N; n++)    /* process lines */
    {
        fgets(inbuffer, 256, file[task]);
        sscanf(inbuffer, "%d %f %d %f %d %f %d %f %f",
               &treatflag[0], &cov[0],
               &treatflag[1], &cov[1],
               &treatflag[2], &cov[2],
               &treatflag[3], &cov[3], &val);

        /* load the values array with this value */
        for (j = 0; j<K; j++)
            if (treatflag[j])
                {
                    value[j][counts[j]] = val;
                    counts[j]++;
                    break;
                }
    }

    /* Sort the values */
    int ranks[K][N];
    float data[K*N];

    for(int ctr1 = 0; ctr1<K; ctr1++)
        for (int ctr2 = 0; ctr2<N; ctr2++)
            data[ctr1*N+ctr2] = value[ctr1][ctr2];

    qsort((void*)data, K*N, sizeof(float), float_cmp);

    // Now find the ranks of the sorted data

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for(ctr1 = 0; ctr1 < K; ctr1++)
    for (ctr2 = 0; ctr2 < N; ctr2++)
        ranks[ctr1][ctr2] = find(data, K*N, value[ctr1][ctr2]);

    // Calculate the rank means for each treatment
    float rankmeans[K];     // Means of ranks for each treatment
    for(ctr1 = 0; ctr1 < K; ctr1++)    // initialize rankmeans[] to 0
        rankmeans[ctr1] = 0;

    for(ctr1 = 0; ctr1 < K; ctr1++)
    {
        for (ctr2 = 0; ctr2 < N; ctr2++)
            rankmeans[ctr1] += ranks[ctr1][ctr2];
        rankmeans[ctr1] /= N;
        printf("R_%3d = %.3f\n", ctr1+1, rankmeans[ctr1]);
        fprintf(outfile, "R_%3d = %.3f\n", ctr1+1, rankmeans[ctr1]);
    }
    printf("\n");
    fprintf(outfile, "\n");

    /* Report the value for R_i - R_j */
    /* start with first treat, go thru k-1 treats */
    for (int treat1 = 0; treat1< K-1; treat1++)
        /* compare treat1's mean to rt2 = treat1+1; treat2 < K; treat2++ */
        {
            float difference = rankmeans[treat1]-rankmeans[treat2];
            printf("R_%3d - R_%3d = %.3f", treat1+1, treat2+1, difference);
            fprintf(outfile, "R_%3d - R_%3d = %.3f", treat1+1, treat2+1, difference);
            if (fabs(difference) > significant_value)
            {
                printf("Significant: |%4.3f| > %4.3f\n", difference, significant_value);
                fprintf(outfile, "Significant: |%4.3f| > %4.3f\n", difference, significant_value);
            }
            else
            {
                printf("\n");
            }
APPENDIX M. SOURCE CODE OF NONPARAMETRIC TESTS

```c
fprintf(outfile, "\n");
}
}
printf("\n");
fprintf(outfile, "\n");
}
closeall();  // clean up

return 1;
}

/********************************************************************************
 *
 * Returns: -1 if a < b
 *          0 if a == b
 *          1 if a > b
 *
 *********************************************************************************/
int float_cmp( const void *a, const void *b)
{
    if (*((float *)a) < *((float *)b))
        return -1;
    else if (*((float *)a) == *((float *)b))
        return 0;
    else
        return 1;  // a > b
}

/********************************************************************************
 *
 * Performs linear search for key.
 *
 * Returns: index of key in sorteddata
 *          -1 if key not in sorteddata
 * Pre: sorteddata is a sorted array of floats in ascending order
 *
 *********************************************************************************/
// key must be in sorted data
int find(float *sorteddata, int size, float key)
{

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APPENDIX M. SOURCE CODE OF NONPARAMETRIC TESTS

int index;

for (index = 0; index < size; index++)
    if (sorteddata[index] == key)
        return index+1; // ranks start at 1, not 0

return -1;
}
Appendix N
Analysis of Training Time

N.1 ANOVA

MTB > Oneway 'TrainTim' 'TrainTre';
SUBC>  Tukey .2;
SUBC>  Fisher 5;
SUBC>  MCB 5 -1.

ANALYSIS OF VARIANCE ON TrainTim

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
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<tbody>
<tr>
<td>TrainTre</td>
<td>2</td>
<td>85031</td>
<td>42515</td>
<td>0.78</td>
<td>0.478</td>
</tr>
<tr>
<td>ERROR</td>
<td>15</td>
<td>821209</td>
<td>54747</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>17</td>
<td>906240</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>N</th>
<th>MEAN</th>
<th>STDEV</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>685.1</td>
<td>109.4</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>521.0</td>
<td>213.1</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>570.8</td>
<td>326.9</td>
</tr>
</tbody>
</table>

POOLED STDEV = 234.0

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.0500

Critical value = 2.07

Intervals for level mean minus smallest of other level means

<table>
<thead>
<tr>
<th>Level</th>
<th>Lower</th>
<th>Center</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-115.5</td>
<td>164.2</td>
<td>443.8</td>
</tr>
<tr>
<td>2</td>
<td>-329.5</td>
<td>-49.8</td>
<td>229.8</td>
</tr>
<tr>
<td>3</td>
<td>-229.8</td>
<td>49.8</td>
<td>329.5</td>
</tr>
</tbody>
</table>

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Tukey’s pairwise comparisons

Family error rate = 0.200
Individual error rate = 0.0904

Critical value = 2.56

Intervals for (column level mean) - (row level mean)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-80</td>
<td>409</td>
</tr>
<tr>
<td>3</td>
<td>-130</td>
<td>-294</td>
</tr>
<tr>
<td></td>
<td>359</td>
<td>195</td>
</tr>
</tbody>
</table>

Fisher’s pairwise comparisons

Family error rate = 0.117
Individual error rate = 0.0500

Critical value = 2.131

Intervals for (column level mean) - (row level mean)

<table>
<thead>
<tr>
<th></th>
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<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-124</td>
<td>452</td>
</tr>
<tr>
<td>3</td>
<td>-174</td>
<td>-338</td>
</tr>
<tr>
<td></td>
<td>402</td>
<td>238</td>
</tr>
</tbody>
</table>

N.2 Kruskal-Wallis ANOVA

MTB > Kruskal-Wallis 'TrainTim' 'TrainTre'.
APPENDIX N. ANALYSIS OF TRAINING TIME

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>NOBS</th>
<th>MEDIAN</th>
<th>AVE. RANK</th>
<th>Z VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>651.8</td>
<td>12.8</td>
<td>1.87</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>539.3</td>
<td>8.0</td>
<td>-0.84</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>484.8</td>
<td>7.7</td>
<td>-1.03</td>
</tr>
<tr>
<td>OVERALL</td>
<td>18</td>
<td></td>
<td>9.5</td>
<td></td>
</tr>
</tbody>
</table>

\( H = 3.52 \) d.f. = 2 p = 0.173

N.3 Jonckheere-Terpstra test

The order of treatments in this test is Printed Manual, Online Help, and Walk-Through Tutorial.

Jonckheere-Terpstra test for ordered alternatives

Critical value for J is 75.
\((\alpha = 0.05, k=3, n=6)\)
Training Times: \( J = 74.000 < 75 \) Fail to reject \( H_0 \).

N.4 Dunn's Multiple Comparison

Dunn's Multiple Comparison Test

Significant value for \( |R_i - R_j| \) is 6.041, where \( R_k \) is the mean of the ranks of treatment \( k \).
Experimentwise Alpha for these 3 treatments is 0.15

\[
\begin{align*}
R_1 &= 12.833 \\
R_2 &= 8.000 \\
R_3 &= 7.667 \\
R_1 - R_2 &= 4.833 \\
R_1 - R_3 &= 5.167 \\
R_2 - R_3 &= 0.333
\end{align*}
\]
Appendix O
Analysis of Questionnaire

MTB > Kruskal-Wallis 'Q1' 'Group'.

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>NOBS</th>
<th>MEDIAN</th>
<th>AVE. RANK</th>
<th>Z VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>4.500</td>
<td>13.8</td>
<td>0.50</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>4.000</td>
<td>11.2</td>
<td>-0.53</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>5.000</td>
<td>14.8</td>
<td>0.93</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>4.000</td>
<td>10.2</td>
<td>-0.90</td>
</tr>
<tr>
<td>OVERALL</td>
<td>24</td>
<td></td>
<td>12.5</td>
<td></td>
</tr>
</tbody>
</table>

H = 1.66  d.f. = 3  p = 0.646
H = 1.79  d.f. = 3  p = 0.618 (adj. for ties)

MTB > Kruskal-Wallis 'Q2' 'Group'.

23 CASES WERE USED
1 CASES CONTAINED MISSING VALUES

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>NOBS</th>
<th>MEDIAN</th>
<th>AVE. RANK</th>
<th>Z VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>5.000</td>
<td>17.0</td>
<td>1.86</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>4.000</td>
<td>9.3</td>
<td>-1.12</td>
</tr>
<tr>
<td>3</td>
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H = 4.92  d.f. = 3  p = 0.178
H = 5.73  d.f. = 3  p = 0.126 (adj. for ties)

MTB > Kruskal-Wallis 'Q3' 'Group'.

23 CASES WERE USED
1 CASES CONTAINED MISSING VALUES

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151
## APPENDIX O. ANALYSIS OF QUESTIONNAIRE

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$H = 4.76$  d.f. = 3  $p = 0.191$

$H = 5.31$  d.f. = 3  $p = 0.151$ (adj. for ties)

MTB > Kruskal-Wallis 'Q4' 'Group'.

18 CASES WERE USED
6 CASES CONTAINED MISSING VALUES

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$H = 1.73$  d.f. = 2  $p = 0.421$

$H = 1.86$  d.f. = 2  $p = 0.395$ (adj. for ties)

MTB > Kruskal-Wallis 'Q5' 'Group'.

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$H = 1.26$  d.f. = 3  $p = 0.738$

$H = 1.42$  d.f. = 3  $p = 0.701$ (adj. for ties)

MTB > Kruskal-Wallis 'Q6' 'Group'.

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<th>Ave. Rank</th>
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152
**APPENDIX O. ANALYSIS OF QUESTIONNAIRE**

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H = 1.21 d.f. = 3 p = 0.751  
H = 1.73 d.f. = 3 p = 0.630 (adj. for ties)

MTB > Kruskal-Wallis 'Q7' 'Group'.

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H = 1.97 d.f. = 3 p = 0.579  
H = 2.12 d.f. = 3 p = 0.548 (adj. for ties)

MTB > Kruskal-Wallis 'Q8' 'Group'.

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H = 3.05 d.f. = 3 p = 0.384  
H = 3.31 d.f. = 3 p = 0.346 (adj. for ties)

MTB > Kruskal-Wallis 'Q9' 'Group'.

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</table>

H = 1.65 d.f. = 3 p = 0.649  
H = 1.78 d.f. = 3 p = 0.619 (adj. for ties)
VITA

James Michael Allen Begole  
Date of Birth: June 26, 1963  
Place of Birth: McPherson, Kansas

Education:  
Graduate — August 1992 - June 1994  
Virginia Polytechnic Institute and State University, Blacksburg, Virginia  
Computer Science  
Master of Science Candidate

Undergraduate — August 1989 - May 1992  
Virginia Commonwealth University, Richmond, Virginia  
Mathematical Sciences/Computer Science  
Bachelor of Science, summa cum laude

Experience:  
1993-1994  
Graduate Research Assistant  
Project GeoSim, Department of Computer Science  
Virginia Polytechnic Institute and State University

1992-1993  
Graduate Teaching Assistant  
Computer Science Department  
Virginia Polytechnic Institute and State University

1989-1992  
System Administrator  
Pembroke Occupational Health  
Richmond, Virginia

1981-1989  
Arabic Translator/Interpreter  
United States Army  
Fort Campbell, Kentucky; Sinai, Egypt; Athens, Greece
Publications:

