

An Interactive Workbook For Internet and Classroom Students

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Abstract

An interactive workbook, the class notes for an introductory Statistics course developed for both Internet and classroom students, is described in this paper. This interactive workbook is presented on the Internet in Portable Document Format (PDF) because this format allows easy inclusion of mathematical symbols. A statistical experiment reveals that this interactive workbook provides enough information for Internet students to perform at a level comparable to classroom students¹.

1 Introduction

Purdue University North Central (PU/NC) is a small two-year branch campus of Purdue University, located in northwest Indiana. Around eighteen hundred of the thirty-three hundred students at PU/NC are part-time. The Mathematics and Physics Section at PU/NC offers various general introductory statistics courses.

For three of the statistics courses, including those meant for the liberal arts, business and biologists, the Internet is used as a “passive” readily accessible electronic bulletin board to store not only class notes, homeworks and test solutions but also to post updated test scores throughout the academic semester. More advanced “interactive” use was made of the Internet for an algebra-based statistics course, called Elementary Statistical Methods (ESM), in essentially two ways. First, class notes were presented in a question-and-answer tutorial format, called an interactive workbook, on the Internet. Second, timed quizzes were conducted on the Internet. This paper focuses on the interactive workbook and, in particular, on the fact that it uses interactive Portable Document Format (PDF) files.

In the fall 1998 semester, there were, at the beginning of the semester, six Internet students and fifteen regular (class) students who took the ESM course. Two of the six Internet students were from off-campus: one was associated with Indiana University

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Purdue University Indiana and the other was associated with Ball State, Indiana. The other Internet students were from PU/NC, but, who, for various reasons, decided to undertake the course over the Internet. In the spring 1999 semester, there was one Internet student, associated with the West Lafayette campus of Purdue University and eighteen regular students.

Although it was possible to develop a course meant for Internet students only, the ESM course was, in fact, developed, essentially for budgetary reasons, to accommodate *both* Internet and class students, simultaneously, as members of one class. Internet and class students were treated in as equal a way as was possible. The same interactive workbook, quizzes, homeworks and final were given to both the Internet students and class students. Grading and office/telephone hours were the same for both. There were no extra computer lab hours. Both groups were given the same instruction in three one-hour per week periods over the entire semester.

An interactive workbook, written by the author, played a central role in the ESM course. The interactive workbook involved a series of exercises, where each exercise consisted of a variety of questions, including multiple choice (multiple and single answer), fill-in-the-blank, true/false and matching type problems. Both Internet students and classroom students were expected to try to answer the questions provided in the interactive workbook. The workbook was considered “interactive” in the sense that students had to understand the material enough to write answers to the questions given in the workbook during class time. The ESM *text*, on the other hand, was consider “passive” in the sense that although students were required to read and understand the material outside of class time and were given homeworks from the text, they were not asked to write answers to questions given out of the text during class time. The workbook was meant to serve as a significant supplement to the text: completed workbooks served as the class notes for the students in the ESM course.

Two versions of an interactive workbook were made available to all ESM students. One version was print-based and the other version was screen-based. Both versions of the workbook covered the same material. Both versions were posted on the Internet, side by side. Both appeared in Portable Document Format (PDF) ([Adobe 1999b](#)), although the screen-based version used enhanced features of PDF. The print-based interactive workbook was primarily meant to be printed (for later reference) although, as explained further below, it was also displayed on a computer screen for classroom viewing. The screen-based interactive workbook was meant to be displayed on a computer screen only and not to be printed. The print-based interactive workbook provided questions only and no answers, whereas the screen-based interactive workbook provided both questions and answers.

A classroom student was expected to bring a copy of the print-based interactive

workbook to class. This student then completed their copy of the interactive workbook during class discussion. To help the instructor in directing class discussion, the *print*-based (not screen-based) interactive workbook was displayed directly from the Internet, via a portable computer and overhead projector, onto a screen for class viewing. The screen-based workbook was, of course, available to a classroom student, but was meant to play only a secondary role for review or catching-up purposes outside of class time. For an Internet student, on the other hand, the screen-based workbook was meant to play the important role of mimicking class discussion. An Internet student was meant to sit in front of the computer with the print-based workbook in hand and, with the help of the *screen*-based workbook, complete the print-based workbook. The screen-based workbook is considered “interactive” in the sense that it automatically tells the Internet student whether the answers to each question they submit to the computer are correct or incorrect and also provides explanation, respectively, as to why the answers are right or why the answers are wrong.

The amount of material and pacing of the ESM course, dictated, essentially, by the workbook exercises, was designed as though a student was taking the traditional fifteen weeks of instruction at PU/NC. It was recommended that an Internet student take the course at the specified pace, although they were free to proceed at a faster pace. Internet students and classroom students were encouraged to spend at least 3 hours per week on the interactive workbook and 6 hours outside of class hours either doing homeworks or preparing for quizzes. The web page for the ESM course is designed to encourage Internet students to follow the weekly pace of the classroom students.

There are three sections in this paper. The first section identifies what others have done with regard to the interactive workbook approach to class notes and why this approach lead to the use of PDF on the Internet. The second section provides both an explanation and demonstration of how to use a sample exercise of the screen-based interactive workbook. The third section discusses the results of a statistical experiment which compared the homework scores of Internet students with the homework scores of class students and also provides a discussion on what students and instructor thought of the interactive workbook.

2 The Interactive Workbook and Portable Document Format

The interactive workbook approach to teaching was first used by the author in the fall of 1994 as a visiting faculty member at the Statistics department at the University of Michigan, under the guidance of M. Aliaga and B. Gunderson. Their book, Interactive Statistics, has just recently been published, (Aliaga and Gunderson 1999).

Print-based interactive workbooks are not just restricted to the field of Statistics. In the field of Physics, for instance, *Socratic Physics, Volume 1* has also just recently been published, (Mathew and Mathew 1999). The screen-based interactive workbook described in this paper is essentially an Internet version of these print-based workbooks.

The term “interactive” is often used in a way different than described in this paper. In particular, the interactive components on a web page usually refers to Java-applet-based animated pictures where the user can change the animation by manipulating one or more parameters. It appears that many college Statistics departments use the Internet in Java-applet-based interactive ways to teach statistics. For example, R. W. West and R. T. Ogden have developed a number of interesting and clever interactive animations for demonstrating various statistical concepts (West and Ogden 1998). Devising and creating Java applets, though, can be very time consuming for an instructor and can be used in only a few of the many topics covered in an introductory Statistics course. The interactive workbook described in this paper is probably not only less time consuming for an instructor to create, but also is much more able to cover “all” of the class notes taught in an introductory statistics course (a claim supported by the statistical experiment described below). However, it is hoped that animations can be added to the interactive workbook at a later date.

Much of the material which appears on the Internet today for statistical education is presented using, for the most part, Hypertext Markup Language (HTML). For example, the (non-interactive) lecture notes for the online statistics course at,

<http://courses.ncsu.edu/ST370>,

are written in the HTML language. Any mathematical notation that appears in the text is given as small “pictures”, Graphics Interchange Format (GIF) files, within the HTML structure. Both the printed-based and screen-based versions of the interactive workbook described in this paper, on the other hand, are a collection of PDF files where the text *and* mathematical notation are, together, an intrinsic part of these files. In other words, statistical class notes written in HTML must appear as text pages with small GIF files awkwardly (it might be argued) sprinkled throughout, whereas statistical class notes written in PDF appear with text and mathematical notation appearing naturally together.

Both HTML and PDF are presentation formats; that is, they describe documents that can be read, but not edited. However, HTML is essentially a *structural* language, whereas PDF is essentially a *layout* language (Thomas Merz 1998). The HTML language, and its predecessor Standard Generalized Markup Language (SGML), is designed to focus on how to arrange “large” elements like the “heading”, “paragraph”

or “listings” on a particular web page and how these elements on the same or different web page are interrelated to one another through hypertext links. The PDF language, and its predecessor, PostScript (PS) ([Adobe 1999c](#)), ([McGilton and Campione 1992](#)), however, is designed to ensure that typographically and graphically complex documents (such as documents using mathematical notation) will be preserved both on screen and in print. Extensive use of PDF has been employed for print-based interactive workbooks in all of the (mostly Statistics) courses the author has given on the Internet for the last two years, at,

<http://faculty.purduenc.edu/jkuhn/courses>

An enhanced interactive form of PDF ([Adobe 1999a](#)) has recently emerged to give PDF some of the structural flavor of HTML and which has, in fact, allowed the development of the screen-based interactive workbook. This most recent version of PDF allows for HTML elements such as hypertext links, not to mention the interactive check boxes, popup menus, text fields and radio buttons, to be placed in the screen-based interactive workbook. The Elementary Statistical Methods (ESM) course uses this interactive form of PDF and can be found at,

<http://faculty.purduenc.edu/jkuhn/courses/301s99/301s99.html>

Others who use the interactive PDF in course presentation on the Internet are [Story \(1998\)](#), and [Arnold \(1998\)](#). Although Story, in particular, has made extensive use of interactive PDF, he has used it for the somewhat limited purposes of creating Internet-based quiz or homework tutorials which serve to only support classroom activity and which is not used in distance learning over the Internet. This contrasts with the interactive workbook described here, where interactive PDF is used to create the screen-based version of the workbook and plays a central role for the distance learning students who take ESM over the Internet. Indeed, it would seem the interactive workbook is most relevant to Internet-based distance learning students, rather than classroom students.

Achieving interactivity with the display of mathematical notation is difficult on the Internet. The World Wide Web Consortium, which manages HTML, is in the process of preparing Mathematical Markup Language (MathML) ([Sutor and Dooley 1998](#)). The computer company IBM has produced a plug-in for Netscape Navigator and Microsoft Internet Explorer called *techeplorer Hypermedia Browser* ([Sutor and Dooley 1998](#)).

3 Sample Screen-Based Exercise

A sample screen-based exercise from an interactive workbook is now described. This sample exercise consists of five interactive PDF files. In addition to the PDF index,

called `ndex.pdf`, there are four interactive PDF question-and-answer files, `ques1.pdf`, `ques2.pdf`, `ques3.pdf` and `ques4.pdf`, which demonstrate the four basic different interactive question types: radio button, popup menu, text field and check box. First, the index file, `ndex.pdf`, is described. Second, the first question, `ques1.pdf`, is explained in great detail. Third, the other three questions are briefly discussed. Fourth, a demonstration is given of the sample screen-based interactive workbook exercise. Fifth, a brief mention is given of how this sample was created using a software package, developed by the author, called `Interactiveworkbook`.

3.1 The Index

The index page, shown in the figure below, has two components. The first component consists of introductory remarks on the four (although up to twenty are possible) questions which make up the exercise. The second component consists of a list of four rectangular link question buttons. Each of these buttons links to one of the four questions which make up this sample exercise. Positioning the cursor, by movement of the mouse, on one of the question button and left-clicking, causes a jump to the particular question chosen. These link buttons can be positioned anywhere on the index page.

Figure 1 goes here and includes “`samplendex`”

Figure 1. Index

3.2 The Radio Buttons Question

Clicking on Question 1 of the index PDF file causes the radio button question, `ques1.pdf`, to open up on the *first* (and only the first) question page (of three) of this file, as given on the left in the figure below. To begin with, the other two pages, correct response and incorrect response, shown in the middle and on the right in the figure below, remain hidden behind the first question page.

Figure 2 goes here and includes “`ques11`”, “`ques12`” and “`ques13`”.

Figure 2. Three Pages of the Radio Button Type Question

The first question page displays a radio button type of question about the correlation coefficient. After choosing one of the radio buttons, the user presses the “Submit” button found on the lower right of the question page. If the user chooses the correct radio button, the second, correct response page, appears on screen and replaces the question page. If the user chooses an incorrect radio button, the third, incorrect response page, appears on screen and replaces the question page.

There are five navigational buttons located at the bottom of the question page.

- *Clear*. This button, on the lower left of the question page, clears the question page of any answers.
- *Submit*. As mentioned, clicking on this button on the lower right of the question page both determines whether the given answer is correct or not and then jumps to either the correct response page or the incorrect response page.
- *Previous*. By clicking on this lower middle button, a jump is made *outside* the present correlation coefficient question to the previous question in the interactive *exercise* (which happens to be the index PDF file, `ndex.pdf`, in this case).
- *Index*. By clicking on this lower middle button, a jump is made outside the present question to the index PDF file in the interactive exercise.
- *Next*. By clicking on this lower middle button, a jump is made outside the present question to the *next* question in the interactive exercise, which, in this case, is a `ques2.pdf`, a popup type of question on statistical definitions.

Either a (blue colored) correct response comment or a (red colored) incorrect response comment are displayed just below the (black colored) question on the correct response (second) page and incorrect response (third) page, respectively . It is significant that the question and response comments can involve elaborate explanations with complicated mathematical expressions. As mentioned above, whereas it is difficult (awkward) to incorporate mathematical notation into HTML web pages, here, using interactive PDF, no such difficulty exists. In addition to the Previous, Index and Next navigational buttons, described above, the response pages also show two other buttons.

- *Answer*. This button, on the lower left, if clicked, displays the correct answer for the radio button.
- *Return*. Clicking on this button on the lower right of the question page returns the user to the first (question) page from either the correct response page or incorrect response page.

3.3 Three Other Types of Questions

The three other question types, popup menu, text field and check box, like the radio button question, all have three pages, including the question page, correct response page and incorrect response page. The first (question) pages of these three question types in this sample exercise are given in the figure below.

Figure 3 goes here and includes “ques2”, “ques3” and “ques4”.

Figure 3. Popup Menu, Text Field and Check Box Type Question

The popup menus, in this case, are used in a matchup type of question about statistical definitions. Clicking on the popup menu next to “population” in the first column, say, reveals a menu of choices which correspond to the seven candidate choices in the second column. The text field question, concerning the expected value, uses only one field, but it is possible to have up to five fields for this type of question. The check box question, involving a stem and leaf plot, allows none, one or more check boxes to be chosen at a time, in contrast to the radio button question above which allows only one button to be chosen at a time.

3.4 Demonstration of Sample Exercise

After making sure Adobe Acrobat Reader 4.0 (available free from Adobe’s website, at <http://www.adobe.com>), or higher, is installed and setting the File|General Preferences|Magnification|Default Zoom preferences to “Fit in Window”, the sample interactive workbook exercise discussed above can be activated in one of two ways. The easier, but slower (it may take a couple of minutes to load, depending on the Internet connection), way to run the sample exercise is to click on the following Uniform Resource Locator (URL) and open the following PDF file on the Internet.

<http://faculty.purdue.edu/jkuhn/distance-learning/ndex.pdf>

If in a Windows environment, a harder, but faster, way to run the sample exercise is to click on the following Uniform Resource Locator (URL), save the self-extracting samplezip.exe file on a local hard disk, unzip the five PDF files and then click on ndex.pdf. (This second method is recommended to Internet-based distance learning students.)

<http://faculty.purdue.edu/jkuhn/distance-learning/samplezip.exe>

3.5 Creating Interactive PDF Exercises

The *interactiveworkbook* software package gives the user the ability to write \LaTeX documents which, ultimately, create the interactive screen-based workbook exercises described in this paper. A self-extracting zip file of this package, called interactive-workbookzip.exe, can be found at

<http://faculty.purdue.edu/jkuhn/distance-learning/interactiveworkbookzip.exe>

The interactiveworkbook program is an adaptation of *pdfflash*, written by Montgomery (1998).

4 Discussion

A statistical experiment and a couple of observational studies were conducted to assess the validity of using the interactive workbook in the Elementary Statistical Methods (ESM) course.

4.1 Statistical Study

A statistical experiment was undertaken in the spring of 1999 to compare classroom performance with Internet performance. This study involved a *random* division of the *classroom* statistics students into “classroom” students and (temporary) “Internet” students for as many as two one week periods out of the fifteen weeks of the semester. By chance, some students were not assigned to receive any Internet teaching, while others were asked to be (temporary) Internet students for both of the one week periods. The (temporary) Internet students were expected to not attend class, to receive all instruction over the Internet, on computers at PU/NC campus, if need be, for the one week periods they had been assigned. The actual Internet students, the students who were on the Internet all semester by choice, and, of course, any classroom students who did not wish to participate, were *not* included in the experiment. This statistical study compared homework scores of classroom students with the same scores of (temporary) Internet students.

A two sample t test was used to compare the average homework scores of the Internet and class students for the two one week periods. A t test, rather than a z test, was used because of the small sample sizes involved. This test required that the homework scores of the two groups were independent of one another and that the homework scores follow a normal distribution. In fact, since it was probably the case students talked to one another about the homeworks and the distribution of homework scores tended to have a longer tail towards lower scores, these assumptions were likely violated and so the results of the two sample t test are somewhat suspect.

The average, standard deviation and number of homework scores, each marked out of a total possible score of 6, for the Internet students and classroom students, for the two weeks, chosen at random from the fifteen in the semester, were found to be as follows.

	<i>First Week</i>		<i>Second Week</i>	
	Internet	classroom	Internet	classroom
\bar{x}	2.500	2.364	2.556	2.920
s	2.345	1.899	1.828	1.800
n	4	11	9	6

Table 1. Test Score Statistics

Two 95% confidence intervals for the *difference* in average homework scores for the Internet and class students, for the two weeks, where the standard deviations were not pooled, were found to be,

<i>First Week</i>	<i>Second Week</i>
(-3.33, 3.60)	(-2.463, 1.740)

Table 2. 95% Confidence Intervals For Test Scores

This strongly indicates, since both intervals include zero, the Internet student homework scores were, on average, *no different* than the class student homework scores. These results imply that the Internet-based interactive workbook provided enough information for the Internet students to perform at a level comparable to the classroom students.

It might be argued, that since both classroom and Internet students had access to the screen-based interactive workbook, the only difference in teaching that the classroom and Internet students really experienced was the former had an instructor, whereas the latter did not. In other words, it might be argued that this experiment did not, in fact, test whether or not the interactive workbook did as good a job as the instructor, but, instead, tested whether students performed as well with the instructor as they did without the instructor. Although there is some validity to this argument, the observational studies, described further below, indicate that classroom students relied mostly on the instructor, in class time, rather than the screen-based interactive workbook, to complete the print-based interactive workbook.

No extra credit and/or inducements were used in the study. In fact, both classroom students and Internet students were treated in as similar a manner as was possible as far as grading and office/telephone hours were concerned. Only those students who volunteered to be included in the study were used and, more than this, students were able to drop out of the study (and remain in the class, of course) at any point in the semester. Students were told of the statistical study before entering the course, by academic advisors, and also during the first three lectures of the academic semester. Research participant consent forms were distributed during these first three lectures.

Students were asked if they wished to participate in the study, and, if so, to return their signed research participant consent forms to the instructor by the third lecture. Students followed the findings of the statistical study throughout the semester, if they desired, by downloading reports off of the Internet, posted by the instructor.

It is hoped that the results of this study can be used to infer conclusions about *all* students who *might* take ESM at PU/NC or, for that matter, more generally, at Purdue University, or even a “typical American University”, say. To the extent that the fifteen students in the experiment are somewhat representative of these more general populations, the results of this experiment can be extended to these more general populations.

More information on this statistical study can be found at,

<http://faculty.purduenc.edu/jkuhn/distance-learning/distance-learning.html>

4.2 Other Evaluations and Comments

Based on a questionnaire administered by the instructor and a survey conducted by another faculty member at PU/NC in the Mathematics and Physics section, it appears the classroom students found the use of the Internet-based interactive workbook easy to use, after some initial startup confusion. The *classroom* students did not seem to use the package that often—they found the instruction in the classroom adequate enough. If they did use the package, it was for review purposes before a quiz or final exam. Those who were interested in using this package on their home computers found it difficult to install the Adobe Acrobat Reader.

Based on an informal survey of the off-campus Internet students, it would appear that Internet students spent more time on the Internet-based interactive workbook than the classroom students and, in general, spent a larger amount of time on the course material per week than classroom students. Typographical errors are much more apparent to Internet students than to classroom students because Internet students relied much more heavily on the interactive workbook exercises. Although they found the Internet-based interactive workbook helpful, it did not replace a classroom-taught course.

The amount of work required for an instructor to prepare course material for the Internet is more than is required to teach a classroom-based course. All course material was typed using L^AT_EX. Pictures were drawn using Illustrator and Freehand. A lot of time is required by the instructor to become familiar with these packages. Although the Interactiveworkbook software package is easier to use than the earlier

pdfflash software package when creating interactive workbook exercises, it is still quite cumbersome.

Even though the Internet is fairly user-friendly, to a student with no or little computer background, it can be quite intimidating. Taking the time at the beginning of the semester, to talk to the Internet students over the telephone (and to take the class to the computer lab) and walk them through the use of the Internet seems to save valuable time later in the semester. Nonetheless, the use of the Internet is wonderful in distributing course material and for helping students to organize this course material. In particular, students cannot lose their homeworks or notes or solution sets because all of these items can always be found on the Internet.

5 Summary

An interactive workbook has been described in this paper. This interactive workbook is presented on the Internet in PDF because this format allows easier inclusion of mathematical symbols than other file formats. A statistical experiment indicates that the interactive workbook provides enough information for Internet students to perform at a level comparable to classroom students.

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