

LEARNING MATERIALS FOR
SURFACE WATER MONITORING

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Statistics

In partial fulfillment of the requirements
for the Degree of Master of Science
Colorado State University
Fort Collins, Colorado
Fall 2003

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November 11, 2003

Abstract

Learning materials related to aquatic monitoring, and intended for use by water quality personnel in the States and Tribes are being developed by the Space-Time Aquatic Resources Monitoring and Assessment Program (STARMAP) at Colorado State University in collaboration with DAMARS, Designs and Models for Aquatic Resources Surveys at Oregon State University. The materials focus on the sort of evaluations required for compliance with Section 305(b) of the Clean Water Act (CWA), using the approaches of United States Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP). A prototype of these materials was developed and available for testing and feedback during a workshop following the joint annual conference between STARMAP and DAMARS. The completed materials are planned to address these questions: Why monitor? Where to monitor? What to monitor? How to monitor? How to summarize? Case studies will be included. The materials are available using a web browser, but made available to individuals on a CD-ROM to avoid several problems including delays in web response and implementation. The current version displays an intermediate level of development of the user interface, and an early draft of the first two parts of the eventual materials, and a customized glossary. The completed materials will support diversity in perspective – monitoring administrator to monitoring field crew - and geographic context of the learner. Based on feedback during the workshop of the current draft, the learning materials received positive remarks and participants expressed interest in further development. Suggested improvements and educational viability were discussed in detail following the workshop.

Acknowledgements

The work reported here was developed under the STAR Research Assistance Agreement CR-829095 and awarded by the U.S. Environmental Protection Agency (EPA) to Colorado State University. This presentation has not been formally reviewed by EPA. The views expressed here are solely those of author and STARMAP. EPA does not endorse any products or commercial services mentioned in this report. The Instructional Services Department of Colorado State University assisted in the development of the web-based tutorial for this project. Greg Fencil developed the framework of the tutorial and assisted in the transformation of the original document to a web-page format. Darrin Goodman created the graphical headings and other web page graphical links. Seven individuals from the Pacific Northwest participated in a workshop designed to familiarize themselves to the learning materials and gave written evaluations of its educational viability.

Table of Contents

Introduction	4
Content of Learning Materials	5
Interface.....	6
Findings from evaluations	9
Proposed direction.....	12
Conclusion.....	13
Citations	14
References:.....	14
Appendix 1: PDF Tutorial Document	15
Appendix 2: Microsoft Word Original Document	50
Appendix 3: Tutorial Feedback Form Questions	84
Appendix 4: Short and Long Glossary	85

Introduction

The purpose of this project was to begin the development of learning materials for surface water monitoring. A cooperative agreement between the U.S. Environmental Protection Agency and Colorado State University funds the Space-Time Aquatic Resources Modeling and Analysis Program (STARMAP) in the Department of Statistics; a second cooperative agreement funds Designs and Models for Aquatic Resource Surveys (DAMARS) in the Department of Statistics at Oregon State University. The request for applications initiated by the EPA contained this specific provision: “Proposals should specifically address the extension of expertise on design and analysis to States and Tribes. Such a component should consider the level of statistical training that may be extant in State and Tribal environmental management and resource agencies. Research on and demonstration of distance learning concepts that allow individuals with basic statistics training to study and understand the concepts of design and analysis statistics are encouraged. Training as used here does not include work leading to a baccalaureate or advanced degree, but might include seminars, workshops, demonstrations, handbooks, and the like. This component must include an actual case study applying the distance learning concept and be readily transferable to others.” The primary focus of the learning materials is to train personnel from States and Tribes that are directly or indirectly involved with the monitoring of aquatic resources. This includes field crews, analysts, and scientists, as well as managers and administrators from both State and Tribal organizations.

States and Tribes are responsible for monitoring water quality for several reasons. The type of evaluations required by the federal government in section 305(b) of the Clean Water Act is one main reason for learning about water quality monitoring. A major disadvantage to States and Tribes in this situation is the lack of training and expertise to perform these evaluations, and in some cases, incorrect procedures and analyses are implemented that do not truly represent the water quality as a whole in a particular state or region. The intent of the EPA’s proposal is to give guidance to States and Tribes to allow them to make statistically correct conclusions based on properly collected data from the field and to use appropriate statistical analysis methods. In turn, they need to write reports on water quality which should include statements made with statistical confidence. Collectively, all States and Tribes should implement similar procedures in order to make better evaluations of water quality as a whole, especially in a large region such as the Rocky Mountains, which include several states. A snapshot of the quality of our nation’s aquatic resources can then be described with accuracy.

Content of Learning Materials

The learning materials in the final product will include the following topics:

- Why monitor water.
- Where to conduct water monitoring.
- What to monitor (measure) at each site.
- How to monitor (measure) at each site.
- How to summarize information once data is collected.
- Case studies are reviewed.

The first two objectives were the focus of my project. The learning materials will technically be a tutorial. The majority of the information contained in the tutorial is based on research and methodology from the EPA's Environmental Monitoring and Assessment Program, a research program to develop the tools necessary to monitor and assess the status and trends of national ecological resources. Its goal is to develop the scientific understanding for translating environmental monitoring data from multiple spatial and temporal scales into assessments of current ecological condition and forecasts of future risks to our natural resources.

The EPA believes that a probabilistic monitoring design (1) is an excellent approach to producing a regional snapshot of the quality of water in an area. The procedures used in a probabilistic design lend itself to being able to make conclusions with known confidence. The concepts and procedures described in the tutorial are all based on probabilistic designs.

To accommodate the wide variety of personnel using the tutorial, the final product will be individualized to the user in two aspects: perspective and geographic context. The level of involvement in the water monitoring process will determine a person's perspective. This can range from a senior manager in a State agency to a contracted manual laborer. An individual's perspective will ultimately determine the level of information that is accessed in the tutorial in order to perform their duties in the monitoring process. This does not mean that the individual cannot access information intended for other perspectives. All the information in the tutorial will be accessible to all. Geographic context refers to the ability for the learner to read examples and see visuals that are familiar to the individual because it will be customized to a particular region they are residing. A learner will internalize material more effectively if they have a sense of recognition and applicability. Someone from New England will not be familiar with environmental aspects of the deserts of New Mexico and Arizona. Therefore having the proper geographic context is important in the learning process.

Interface

The medium used in this project is a web-based tutorial on CD-ROM. The availability of computers with internet browsers has led to the decision to create this type of learning medium. CD-ROM has been chosen specifically over an internet-only based environment for the following reasons. Individuals using computers with slow download times can make users frustrated. Internet connections can be severed during transmission and need to be reestablished, which can take up to several minutes. The learning environment can be easily manipulated, for example, if new software is needed to conduct any analysis, it can be loaded easily if it is included with the CD-ROM(s). All the needed software can be loaded properly to ensure learners have all the necessary programs to perform water monitoring. Parts of the learning material can be taken into the field for training and/or review on laptops. Materials need to be accommodating for all types of browsers that may exist. Lastly, individualization can be done at the local level more accurately. A profile can be created to remember the level of the individual each time they access the materials.

To be an effective learning tool, the tutorial will have several features that are inherently proper on a computer-based medium. Audio files can be played to emphasize particular content, if appropriate. Dynamic graphics in the form of maps, graphs, and movies can be utilized to further the understanding of difficult topics. Static photos and images can also be used to make the materials more individualized for geographic context. The computer has many features that allow it to be an excellent tool for learning. The tutorial developed had a few of these ideas. It contained photos and images that were from the Pacific Northwest region to accommodate the individuals that were going to review the tutorial. Mountainous terrain, lakes, rivers, trees, and coastline were used on the web pages to give a sense of familiarity (Appendix 1, pages 4, 6, and 10). A dynamic graphic in the form of an animated GIF was used to present the idea of probability sampling of a branched stream by using Strahler order (CD tutorial, Section heading Where to Monitor, subsection Census vs. Sampling, page 8 of 22). Higher order sections of the stream were more likely to be chosen than lower level ones. The animated graphic conveyed that concept beautifully. A point on a section of a stream would be marked by an "X", and then another one "randomly" would appear on another section of the stream. I believe it displayed 25 of these x's, slowly at first, then appearing more rapidly at the end. Once they were all there, the x's disappeared and it would begin again. The only glitch was that it would cycle through the same "random" points. With some effort, it could have been truly random if you develop a program that allowed different points to be chosen on the different sections of the stream for each cycle. The tutorial had a map of the United States broken down into EPA regions to show learners how the

regions were separated (Appendix 1, page 12). Static images were used to describe the different sampling techniques used in probability sampling (Appendix 1, pages 13-16). Several simplistic multi-floor college dorm room buildings were viewed in cross section to describe five types of sampling: simple random sample, stratified random sample, systematic random sample, cluster sample, and convenience sample. Other images were used to describe in specific detail how to randomly choose water monitoring sites such as lakes and streams from a large grid section of a map (Appendix 1, pages 22-27). For example, lakes can be chosen at random from a large section of a map by first breaking it into small, equal grid sections and numbering them like addresses on streets. The small grid sections that had a lake in it was lined up in order, by address, on a separate image. A random starting point was chosen and a systematic sampling technique was used to randomly chose the required number of the lakes for the sample.

Other features of the tutorial that would be desirable is fast and easy navigation through the web pages. This includes links to different sections of the tutorial, a quick link to a glossary section that explains in detail terms that a learner may not understand reading the content (Appendix 4), and other links to separate text documents that support the learning materials (Appendix 1, page 2). A print only document could be accessed by linking to a PDF file and printed at a user's convenience. It would print only the sections desired by the user. The tutorial had all these features, with the exception of printing the PDF file of individual sections. If you linked to the PDF file of the tutorial, it would print all the sections in the tutorial (Appendix 1). This is undesirable as it contained a large number of pages. The last important feature is being able to contact, via e-mail, the administrator if you had questions concerning the learning materials, or wanted to give feedback regarding the tutorial. A link was created to do this, but the e-mail address was not created at the testing of the tutorial, therefore it did not operate.

The web-based CD-ROM interface had some interesting obstacles to overcome. We needed to design a tutorial that allowed the writer to concentrate on the writing aspect of the learning materials, and not be overwhelmed with the formatting issues involved with HyperText Markup Language (HTML) programming to create the web-based tutorial. XMLSpy and Toot-O-Matic were the solutions to this problem. XMLSpy is a software program that will allow a user to import a text document and convert it to an XML file. XML stands for eXtensible Markup Language. It is similar to HTML, but has different web design goals. XML was designed to describe data and to focus on what data is. HTML was designed to display data and to focus on how data looks. Once a document was converted to this XML file, Toot-O-Matic was used to create a simple tutorial based on the formatting of an original document. Toot-O-Matic

was developed by IBM developerWorks to assist in creating web-based tutorials. It is a tool that assists in converting an XML file into a web page with the correct formatting to display in any browser. It remarkably simplifies the process of changing a text document into a web-based tutorial. The only draw back is that one needs to learn the eccentricities of placing graphics and visuals where you want them in the final web page design. Admittedly, I did not concentrate on the conversion process in my project. That task fell on Greg Fencl, a computer guru that knew how to fix code if anything went wrong with the transformation. Another individual that assisted in the visual aspects of the final web tutorial was Darrin Goodman. He created the link buttons, and graphical headings. My task was to create the text and supporting visuals to convey the objectives of the learning materials.

Although the transformation from a text document into an XML file was a point and click operation, the XML file needed some modifications before importing it into Toot-O-Matic. Greg Fencl wrote a simple program to alter the XML file slightly. Using the Heading features in Microsoft Word, we decided that 'Heading 1' text was reserved for the main objective title for each web page. (Why monitor? Where monitor? etc.) Subheadings for the main objective were denoted by 'Heading 2' text. 'Heading 3' text was reserved for the main text for each web page in the tutorial. For example, under the main objective of 'Why Monitor?', a subheading 'Clean Water Act' was created, and a specific web page described 'Goals of the Clean Water Act'. In creating the original text document, 'Why Monitor?' was in Heading 1 font, 'Clean Water Act' was in Heading 2 font, and 'Goals of the Clean Water Act' was in Heading 3 font (Appendix 2, page 2). The text for that specific web page was in normal font following the title. The whole text of the tutorial was written in this manner (Appendix 2). Although I used the built-in styles for Microsoft Word, I could have defined any style and applied the same type of procedure to get the same results.

In order to allow viewing different perspectives, 'Heading 3' was reserved for the basics needed to understand water monitoring. 'Heading 4' text would be used to allow users to find out more detailed information (Appendix 2, pages 1, 7, 16, 19, and 28). 'Heading 5' would be used to describe even further for those that wanted to delve deeper into a particular topic. This type of system was used in order to preserve the simple transformation from text document to web page format. If another system is wanted, major modifications will need to be implemented. For the sake of testing the tutorial with a majority of the features in place, the Heading system was used. The ease of transforming a text file to web page was a priority. Any changes that could occur, corrections, deletions or additions, can be easily done in the original text file. The new text file would then be transformed into web based format easily. This system proved to be the least difficult to make changes, if needed. Other options discussed were to make

separate documents for each of the perspectives (field crew, scientist, manager, etc.). This system would be very difficult to make changes in. If a change was to be implemented in the field crew document, all the other perspective documents would need to be changed as well. Cross referencing would be a nightmare.

Once the text was converted to web based code, a folder was created that held all the individual web pages along with the supporting graphics and images. A simple subroutine was written in order to self start the CD-ROM once the disk was inserted into a computer. All these files were burned onto a write only CD and the tutorial was created. Ten copies were made for the upcoming workshop in Oregon. Colorful labels were attached. An image of a river flowing in the mountains was the background. Colorado State University and Oregon State University icons along with their program icons were added (STARMAP and DAMARS) to the image forefront. An EPA funding source icon was also added to the front. The title was 'Learning Materials for Aquatic Monitoring'. A copy of this CD-ROM accompanies this report. It is in a jacket inside the back cover.

Findings from evaluations

With the tutorial complete and saved in web-based format, we wanted to test it with individuals for whom it was designed. Seven individuals from the Pacific Northwest participated in a workshop designed to familiarize themselves to the learning materials. A four-hour block of time was set aside to have the participants go through the tutorial and give feedback to our work. A basic evaluation form was created to allow us to find out what these participants thought of the tutorial. The questions asked appear in Appendix 3.

The evaluators came from agencies in Washington, Oregon, and California. All have some experience in probability-based monitoring. Several of the evaluators have several years of monitoring experience; one is just getting started. The evaluators came from the Washington State Department of Ecology, the Oregon Departments of Environmental Quality and of Fish and Wildlife, the San Francisco Estuary Institute, and EPA Region 10. A tribal member of EPA's Tribal Council volunteered to be an evaluator, but was not able to come to Corvallis because a major forest fire was burning on his reservation when the evaluation was done. He has agreed to do a remote evaluation with results returned to the STARMAP Program Director, so as to not hold up the completion of this document.

The overall consensus from the participants was the tutorial is a good beginning point. There is ample room for improvement and development to arrive at the final product. All the participants want this work to continue to a final product. To effectively evaluate the tutorial at this beginning phase, the feedback form was divided into three sections: technical and visual aspects, content, and narrative evaluation.

The technical and visual aspects of the tutorial received positive remarks. This does not pertain to the content of the learning materials. Headings, subheadings, links and font size were evaluated, and most of the participants felt that the overall look of the web pages were good. A few of the individuals did not feel the photos used on each web page contributed to the content. They felt the photos were “attractive” and “pretty”. A few others stated that there was a lot of white space on each page. One person commented that the images should have been placed inside the text. An explanation is in order. The images could only be added to the beginning of a text section, or at the end. It could not be embedded in the text at the time the tutorial was being finalized. Greg Fencl tried to embed the images and photos, but had no success. As a last resort, I told him to add them to either the beginning or ending of a text section. There must be a way to do this, but more experimenting must occur.

The content aspect of the tutorial received the most positive comments from all the participants. The participants were told that the tutorial was not yet complete and had missing sections that are to be incorporated at a later time. This included more detailed sections if one wished to learn more about a particular topic that was briefly introduced in a web page. A link would transport the learner to more web pages with detailed examples, and more sophisticated explanations. Another link could also transport the learner to the next topic if the individual did not need to know the particulars. A key feature of the tutorial is that a profile would be created to allow learners to review material that was specific to the individual’s role in the water monitoring process. Any other information would be skipped, or reviewed if needed. This feature was not fully incorporated in this tutorial.

Most of the participants wanted to see more detailed examples and more relevant topics to their area of interest in the monitoring process. The transition from one topic to the next could have been gradual instead of abrupt. The one question that had a unanimous answer was the question concerning content contradictions. Everyone stated that they didn’t see any information in the tutorial that contradicted what they have seen anywhere else. The glossary was helpful to most participants. A few people wanted to see a direct link to the glossary page. As is stands, to reach the glossary, a term was highlighted in a sentence and if you clicked on the word, it would link you to the beginning of the glossary page. Originally, the idea was to mouse over a word, and a balloon would appear stating a short definition. If one wanted a more detailed explanation, a link would take you to it. Greg Fencl tried to make this work, but could not find the web code necessary to facilitate it. Personally, I have seen this option work properly in a web page I accessed in the past, but do not remember the web address to see how it was done. It is a great feature that needs to be

added to the final tutorial product. The short and long glossary appear in Appendix 4.

The narrative evaluation section received the most comments. This allowed the participants to discuss any aspect of the tutorial that was not directly asked in the other questions of the feedback form. All of the participants felt that the tutorial was a viable, educational outreach component to satisfy the needs of personnel that need the information to perform their duties at all the prospective levels in the water monitoring process. The question of improvements individuals would like to see generated a wide range of responses. A noteworthy comment from each individual will be discussed. Participant #1 stated that the tutorial should be kept simple. If people want to find more detail on a particular subject, a link can be provided. Not all the details should be contained in the tutorial. The internet can provide many statistical methods and technical details individuals seek. Participant #2 stated that a link should be provided for those individuals interested in state laws concerning water monitoring, and geographically relevant case studies to review. Participant #3 stated that they would like to see pros and cons of each type of sampling scheme to decide on which type to use based on monitoring objectives. Participant #4 stated that there needs to be a section explaining statistical theory so a layman can understand, but can be skipped if desired. Participant #5 stated that target and non-target populations can create a lot of problems in terms of assessment of water quality. If the majority of sites chosen for a survey is public land, as opposed to private land, how does this effect the overall water quality assessment of a region? Participant #6 stated that a flow diagram should be shown of the sequence of steps involved in the water monitoring process. Each step would be accompanied with examples, specific detail, and where appropriate, links to find more information. Several flow diagrams should be shown depending on the original objectives of the survey. Participant #7 stated that since this is a tutorial, simple problems can be asked to make sure learners understand the content. Some interaction would be appropriate.

After most of the participants completed the feedback form, a few of them wanted to have a round table discussion of some important aspects to improve the tutorial. A few items are discussed here. The connection between objectives, design and sampling scheme need more detailed explanation. The different perspectives outlined in the original proposal need to definitely be implemented. A section menu should be displayed on each page with the current section highlighted. More detailed explanations are needed for items not fully explained, such as confidence interval calculations. Examples of objectives and where it leads to problems of clearly stating objectives need to be explored. Lastly, include more coastal/estuary examples.

Proposed direction

This project paved the way in which to proceed with the final learning materials product. The CD-ROM web-based format is one of the best methods of delivery. Another option to explore should be the use of more PDF (portable document format) files within the web-based tutorial. The two formats can be used in conjunction to produce a very powerful tutorial. The important features of the intended tutorial can be incorporated into a PDF file. PDF files have the same characteristics as HTML documents (2) and need no translation, compression, or filtering on most web browsers. The navigational features of a PDF file can be utilized to accomplish the tasks required in the tutorial. Links, bookmarks, threads, and navigation buttons are some of the built-in features of a PDF file. The task of completing the final product with all the intended features, will be monumental, but will be a great resource for all involved with the water quality monitoring process. The feedback from the participants is an indication that the tutorial is a viable, educational form of training States and Tribes.

The inclusion of images and graphics is an integral part of the tutorial content. Special attention should be devoted to make this work properly. It was not mentioned earlier, but most of the graphics explaining sampling concepts were drawn by me using PowerPoint. Although the original images I created appeared to be accurate and detailed. After importing them to the files to be accessed by the tutorial, a number of the graphics were missing detail and lost some integrity (Compare Appendix 1, page 16 with Appendix 2, page 15; Appendix 1, page 26 with Appendix 2, page 26). I don't know if this was a data transfer problem or a web browser problem, but the graphics I created were not exactly the same as the ones displayed on the web pages. Most of the participants realized that some of the graphics were missing detail and I had to explain that the original images were not like the ones they saw. This glitch needs to be fixed. The placement of the images also needs to be resolved. It should be possible to place an image anywhere in the web page text area. It would have been nice to place them embedded in the text, or to the right of the text, or anywhere I choose.

Other proposed technology to be included in the tutorial should be researched. The idea of playing audio files is great for narratives, or explanations of dynamic graphics. Video clips of actual collection of data at targeted sites would be priceless. Interactive explanations of statistical concepts would be useful. For example, users should be able to alter parameters to see how changes affect a result in an algorithm. I could have included a program that would display points randomly onto a grid section with a random point generator. Each simulation would result in a different array of points. I came across a macro for use in ArcView that would randomly select sites on a river system if you specify the inclusion probabilities. The possibilities are endless. The determining factor

is the ability for all of this to work in the web-based environment. I am certain this can be done.

Conclusion

What did I learn from this project? As a teacher for the better part of 12 years, I am amazed at how one can constantly improve the way you can convey information to learners. There are many learning styles and modes, and to reach everyone in a single shot is a truly overwhelming task. I could have included many more examples than the ones I used to explain why we monitor water, and where to monitor water. The feedback from the participants was truly valuable. Things you would not normally think of are addressed by others looking at your work and progress. Positive criticism is an important aspect of improvement. My web-based tutorial is by no means perfect, but the way is paved to make it better. As an educator and statistician, I feel that my tutorial is a step in the right direction. There may be individuals that are more knowledgeable in statistics that have developed a tutorial similar to this one, but my background in education gives me an edge. Teaching at the secondary level and university level allowed me to understand some of the misunderstandings and obstacles learners make learning statistics.

I learned about web page design. There are many ways to make a web page, and there are many things to take into account when designing a web page. I believe we take the internet for granted. What I mean is the way information is displayed and formatted on each web page. I never realized the effort and code needed to make a web page display properly. I have a great deal of respect for those people that specialize in this area of computing. The latter part of my project was devoted to making the web pages display properly. Photos and graphics were difficult to place exactly where you wanted them. These issues need to be resolved so time and effort can be devoted to the content needed to finish this final product.

It was a great experience to work on a federally funded project such as this one that is leading the way to provide research that will be used on a national scale. I have done my small part in paving the way to produce an important learning component that will one day be used throughout the United States. One last note, the final product is included in the Appendix. It contains the text of all the web pages along with the appropriate graphics. The CD-ROM is contained at the back of this report for viewing on a PC computer. Any suggestions or comments can be addressed to the administrator of the STARMAP program at Colorado State University.

Citations

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