

Running Head: UTAH VIRTUAL LAB: TEACHING SCIENCE ONLINE

Utah Virtual Lab: JAVA Interactivity for teaching science and statistics on line

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Abstract

The Utah online Virtual Lab is a JAVA program run dynamically off a database. It is embedded in StatCenter (www.psych.utah.edu/learn/statsampler.html), an online collection of tools and text for teaching and learning statistics. Instructors author a statistical virtual reality that simulates theories and data in a specific research focus area by defining independent, predictor, and dependent variables and the relations among them. Students work in an online virtual environment to discover the principles of this simulated reality: they go to a library, read theoretical overviews and scientific puzzles, and then go to a lab, design a study, collect and analyze data, and write a report. A student's design and data analysis decisions are computer-graded and recorded in a database; the written research report can be read by the instructor or by other students in peer groups simulating scientific conventions.

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Early innovation (Bradley, 1978; Lehman, Starr, & Young, 1975, Rywick, 1975) and steady evolution (Bradley, 1993) have combined to lay a conceptual and practical groundwork for teachers to use computer simulations of laboratory experience as educational tools for teaching the principles of research methods. Among recent examples is the virtual lab developed by Colle and Green (1996) with graphical simulations of virtual subjects. Brown's (1999) Wildcat World allows students to design studies researching human facial features. Washburn's (1999) program gives students experience in distinguishing interpretations from findings. In the Utah Virtual Lab, which is one component of StatCenter at the University of Utah, students work in an online virtual environment. Using online tools for designing research, collecting and analyzing data, and writing reports, they explore a series of interrelated research puzzles to discover the principles underlying a simulated statistical reality authored and tailored to their course by an instructor.

The Utah Virtual Lab can be used to support any empirically based content course in the social sciences in which students would benefit from discovering for themselves an accepted knowledge base in addition to learning about it in traditional ways. Its authoring tool allows an instructor to create text-based research projects appropriate to any research area where statistics such as the mean, variance, t , F , Chi-square, r , and regression are appropriate. Students read the background text generated by the instructor and then use virtual tools to create experimental designs and collect data that addresses the research questions posed in the text. The major research design and data analysis decisions made by the student are computer graded.

Malloy (2000) has argued that learning the structure (or logic) of a program is a deep and important part of what students learn through interaction with simulation software and has

hypothesized that the logic of a simulation program can be used to teach students strategic thinking skills. Thus research simulation programs to the degree that they are structured after the logic of research design principles can, though probably to a lesser degree than actual labs, teach important research thinking skills.

Description of Virtual Lab Procedures

Public Access to Virtual Lab & Tutorial. The Utah Virtual Lab is a component of the University of Utah's StatCenter and can be accessed directly without login from a public access page at www.psych.utah.edu/learn/statsampler.html. The public access page has a link to an extensive tutorial on the use of the Virtual Lab. Note that the Lab itself is accessed by different links depending on a user's preferred web browser; this is because the Virtual Lab JAVA code must be slightly different to be compatible with different browsers. Since public users do not log in to the Lab they will not have records of data measuring their performance in research design and data analysis. Instructors and students who do not need performance data are welcome to use the Virtual Lab as public users.

Password Access for Educational Use. The public access page provides links that allow instructors who want records of student performance to contact site managers to set up login procedures and database connectivity for educational groups. Site managers can also provide access to and instructions for an authoring tool that allows instructors to create their own examples and their own simulated statistical realities.

Example. The Virtual Lab authoring tool allows an instructor to create research contexts that differ in sophistication and are therefore appropriate for various levels of statistics courses. The example used here will be simple and straightforward, involving made-up virtual entities called "Bots," but any content area can be authored.

It is recommended that new users, particularly students, print out and read the online tutorial, using its examples as a guide to navigate through Virtual Lab. The description of the Lab in this paper is not complete and is meant only to give an overview of its educational features.

Clicking the browser-specific link to Virtual Lab downloads an applet which allows students to navigate a series of screens giving a sense of place in a virtual reality. By clicking on the front door of the Lab, students enter a virtual library. Up the stairs and on the left side of the upper level of the library are books which contain the example described here; these books are labeled "Dr. Malloy PSYCH 3000." Clicking on the library shelves for PSYCH 3000 reveals a close-up view of several books. "*Bot Res Vol 4: Explorations*" is used early in a course when students have only learned basic descriptive statistics. Students select "*Bot Res Vol 4: Explorations*" by clicking on it and then clicking "Next." They then see a brief overview text describing a set of hypotheses and variables. After reading this literature overview, students click "Next" to see a set of book chapters each of which contains a research puzzle. Clicking on a puzzle piece selects a particular puzzle; for example, clicking on "The effect of language on Bot brain development" selects that puzzle piece. To read the puzzle, students click on the large blue bar that says "Read Effect of Language on Development." That chapter proposes the following puzzle which requires only the use of means in data analysis. "Ann, a Bot researcher, is interested in studying Bot brain development and function. You are her assistant. She hypothesizes that the number of computer languages known by Bots (they all know at least one) increases brain development in Bots. She wants you to do research to determine if training Bots to learn more languages increases Bot brain development. She would like you to randomly assign Bots to different groups who are taught different numbers of languages. Then she would

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Authoring. The simulated reality that students explore is authored by instructors. Along with the text of the literature overviews and chapters, the names of the IV's and all their levels are specified by the instructor, as are the names of all the DV's. Instructors specify which IV's have causal effects on which DV's and what the effect size is. They also specify which DV's are correlated and to what degree. Each book in the library can address different research literatures with different sets of variables and relations among variables. In this way instructors can customize the research context so that it fits the level of sophistication that they desire. Instructors who do not have time for such effort can send their students to existing books in the library authored by other instructors. It is hoped that over time a diverse library of research areas and examples will be built up by different instructors and be made publically available in the on-line library.

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Discussion

Utah Virtual Lab allows instructors to generate simulated realities based on statistical equations. These equations generate data uniquely for each student. Instructors can simulate principles and accepted research findings that they want students to learn. Like real researchers, no two students will get exactly the same results even when they do the same study. The Virtual Lab engages students in scientific discovery processes by giving them the compressed experience of making many systematic research strategy decisions with the goal of discovering the principles of a complex virtual reality. The data simulations of the Utah Virtual Lab are not as comprehensive nor as sophisticated as those developed by Bradley (1993), but they are well-tailored to an introductory course and are available online.

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Many educational virtual labs (e.g., Colle & Green, 1996; Hachette, Zivian, Zivian, & Okada, 1999; Keenan & Keller, 1980) are built around set research examples. The Utah Virtual Lab differs from these educationally valuable virtual labs in that it allows instructors to create custom research examples. In that regard, Virtual Lab is similar to the work of Eamon (1982). It differs that case in its graphical virtual reality and its availability on the Web.

Whatever technology and approach motivates a virtual lab with data simulation capabilities, the active experience of students doing research, albeit virtual, adds value over what a teacher can accomplish through in-person lectures because a teacher cannot give this kind of independent experience even in a one-on-one tutorial. Moreover, through new media interactivity (Malloy, 2000), virtual laboratory experiences can teach students the discovery-based thinking skills that underlie empirical research methodology.

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Author Note

This project was supported by a Utah Higher Education Technology Initiative grant. The JAVA programming for the Utah Virtual Lab was designed and written by Gary Jensen who also designed the Oracle database and its interaction with the JAVA applet. Correspondence regarding this article should be addressed to T. E. Malloy, University of Utah, Department of Psychology, 380 S. 1520 E., Room 502, Salt Lake City, Utah 84112-0251 (e-mail: malloy@psych.utah.edu).

Figure Captions

Figure 1. On the left is the tool for selecting the independent variable and its levels. On the right is the clipboard schematizing a student's research design choices.

Figure 2. On the left is the tool for selecting a dependent variable. On the right is the clipboard showing the research data.

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Figure Captions

Figure 1. On the left is the tool for selecting the independent variable and its levels. On the right is the clipboard schematizing a student's research design choices.

Figure 2. On the left is the tool for selecting a dependent variable. On the right is the clipboard showing the research data.

Languages

Finger Skills *One ON*

Learning Styles *Two ON*

Music *Three ON*

Four ON

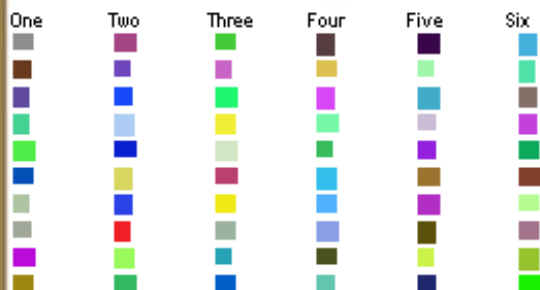
Five ON

IND means *Six ON*

close

IV is: # Languages
DV is:

IND means



close

Res Design

measure bots

Brain Development



Brain Electron Flow

Puzzle Solving Ability

Brain State

One

10

Two

10

Three

10

Four

10

Five

10

Six

10

close

IV is: # Languages

IND means

DV is: Brain Development

One	Two	Three	Four	Five	Six
19.4	26.7	42.2	43.6	41.2	38.3
20.5	31.6	47.2	33.2	40.7	42.3
25.1	26.9	36.6	37.8	37.9	43.0
25.0	30.0	32.6	37.1	39.3	31.4
24.2	21.7	33.0	37.5	48.6	49.4
26.9	28.5	35.3	35.5	46.9	45.8
26.3	30.9	35.7	46.3	41.4	37.2
22.8	28.3	36.7	36.4	29.6	34.1
22.3	33.1	33.7	39.2	47.4	34.3
29.8	23.2	41.9	39.9	31.7	42.1

M=24.2 M=28.1 M=37.5 M=38.7 M=40.5 M=39.8

S=2.9 S=3.4 S=4.5 S=3.6 S=5.9 S=5.3

close

Res Design

measure bots