UNLV Theses, Dissertations, Professional Papers, and Capstones

5-14-2004

Evaluating the effectiveness of simulation-based instruction about water resources in Las Vegas

Stephanie Fincher
University of Nevada Las Vegas

Stephanie Fincher
ENV 499B
Drohan
14 May 2004

Evaluating the Effectiveness of Simulation-based Instruction about Water Resources in Las Vegas

Abstract

This study compared the effectiveness of simulation-based instruction to traditional teacher-directed instruction about water resource management in Las Vegas. Subjects, undergraduate students recruited from Psychology and Environmental Studies departments, participated in one of two treatments. All participants were given a pretest prior to instruction, a post-test immediately following instruction, and a retention-test 4 weeks after instruction. Evaluation instruments provided overall scores, gauged student learning in topic areas and different question difficulty-levels as well as attitudes toward the environment and water management. The treatments differed only in how students interacted with the system after receiving background information on Las Vegas valley's water issues. Students in the traditional group used a lecture format presentation of graphed results to show affects of changes to the system, while the students in the simulation-based group manipulated the interface of a model to explore variables and effect. The hypothesis was that students in simulation-based groups would outperform traditional groups in overall scores on post- and retention tests, and specifically on scores for conceptual and understanding questions. Additionally, all participants were expected to increase in attitudes, with the simulation treatment having stronger, more positive attitudes after treatment than the traditional treatment. Results did not support the main hypothesis, showing no significant difference between the two treatment groups for overall scores or other factors, within treatments, such as age, sex, and time of day. However, there was a significant difference between majors for scores on pretest and post-test, but learning (difference between pre- and post-test) was not significantly different for these groups. These results suggest that participants increase scores in a certain ratio regardless of treatment or current knowledge. There was a significant increase in attitudes from pretest to post-test for all students but simulation-users were not significantly higher than traditional groups. Although the hypothesis was not supported, unanticipated variables introduced during treatment and disproportionate distribution of subgroups among treatments made it difficult to ensure unbiased groups. Despite problems with the study design, it was concluded that all students learned no matter the treatment. Therefore, this simulation-based instruction treatment is at least as effective as traditional methods.

Introduction

Simulation-based instruction, or teaching that utilizes an interactive model to illustrate complex systems and behaviors, is increasingly being used in classrooms because it allows learners to explore difficult to understand systems and test hypotheses about these systems (Milrad 2002, Stave et al. 2003). The purpose of this study is to determine the effectiveness of a computer simulation about water resources in Las Vegas by comparing a simulation-based

instructional technique to a teacher-directed instructional technique. Students will be tested to determine if the simulation group will more completely understand the material presented, score higher on assessments, and retain the information longer than those exposed to a teacher-directed approach involving only lecture and discussion.

Simulations are not the only form of learning that utilizes computer technology, but they are one of the most powerful (Mustäjarvi 1998). There are many different terms used to describe instruction with computers (computer-aided learning, computer-based instruction, problem-based computer-assisted, computer-enriched learning, etc.). For this study the simulation, developed in Stave *et al.* (2003), is a screen that allows manipulation of a background model to run policy options for the water system of Las Vegas.

This study is based on the methods described in Stave *et al*. (2003) and uses a modified curriculum, modified evaluation instruments, and modified time-frame as recommended by similar studies (Stave *et al*. 2003, Chang 2001, Mustajärvi 1998, Kulik *et al.* 1980, Kulik and Kulik 1991, Milrad 2002, Swaak and De Jong 2001, Windschitl and Andre 1998, Gorrell 1992) and experts (Terenzini 1999, Kesidou and Roseman 2002, Eva 2000, Forrester 1992, Richmond 1990). In Stave *et al*. (2003), a simulation model and powerpoint presentation were used with 6th grade students to examine effectiveness of simulation-based methods compared to traditional methods. The study was during one class-period and took 4 consecutive days to complete. "Effectiveness" of learning was defined as the amount of material learned and retained, with more effective teaching methods leading to more effective learning. Effectiveness was measured using three tests, a pre-test prior to instruction, a post-test immediately after instruction, and a retention test approximately one month after treatment. Ninety-seven students participated in one of five groups of which all received a powerpoint background lecture. Two classes then

used a computer simulation model to explore the Las Vegas water system, and three classes received further information from powerpoint slides. Both groups participated in discussion following treatment. Results of Stave *et al.* (2003) showed no significant difference between the simulation and traditional groups. However, the researchers suggested that the inconclusive findings may have resulted from flawed testing instruments, problems with the way the simulation was introduced, choppy duration and framework, and perhaps a model that was not age-appropriate and therefore too difficult for 6th grade participants. In an effort to better retest the hypothesis, this study critically addressed these areas; specifically, ways for introducing simulation technology into the classroom, reducing possible bias, improving the user-interface for easier manipulation, using older participants, changing study to one solid block of time, ensuring that effective learning takes place, and properly measuring that learning with an evaluation instrument analyzing both factual and conceptual learning.

This study is important because of its implications for college curriculum and student learning, especially for explaining complex environmental topics to majors and non-major. Applying effectiveness to curriculum and learning *Educational effectiveness,* refering to the extent to which an experience changes attitudes or increases knowledge and ability (Mustajärvi 1998). Effectiveness in generally refers to how well a product meets its defined goals (Arendale 1998), so if the goal of schooling is to learn, then curriculum should be designed in a way that best promotes student learning.

Conventional curriculum in schools is often criticized for its emphasis on the importance of facts rather than a deeper and conceptual understanding of events and phenomena (Forrester 1992, Terenzini 1999). Unlike conceptual learning, facts cannot be abstracted to the world in other situations and are restricted to the subject they cover (Forrester 1992). Additionally, in the

current system, learners are passive receptors to facts; and since learning requires active

participation for brain stimulation as well as time for contemplation in order to lead to

conceptual understanding, the very method of transferring information to students may not be

appropriate (Richmond 1990, Terenzini 1999).

Table 1: Concepts for defining good curriculum (Kesidou and Roseman 2002)

I.	Providing a sense of purpose
II.	Taking account of student ideas
III.	Engaging students with relevant phenomena
IV.	Developing and using scientific ideas
V.	Promoting student thinking

Kesidou and Roseman (2002) propose five main concepts for defining good curriculum

as shown in Table 1. These education experts argue that addressing these areas in curriculum

will lead to a more effective learning experience for students of all ages. The criteria in Table 1

were used as guideline to ensure the material of this study met the standards of currently

practiced curriculum which are further detailed in Appendix A.

One of the major benefits of using computer simulations in education is that these models

specifically address the areas listed in Table 1. By providing quick answers and diverse

experiences that are not as easily accessible in other forms of education, simulations lead to

connections between action and consequence and a depth of understanding that extends beyond

the subject matter (Gorrell 1992, Forrester 1992, Mustajarvi 1998). Computer-aided learning

with simulation allows students to develop and explore their own ideas and hypotheses about a

phenomenon (satisfying concepts II, IV, and V above), addressing student misconceptions and

presenting a foundation for further interaction (Milrad 2002).

Multiple studies (e.g. Chang 2001, Eva *et al.* 2002, Swaak and De Jong 2001, Terenzini

1999, Forrester 1992, Milrad 2002, Richmond 1990) also agree with the need for a problem-

based, relevant, and purposeful design and goals for an effective learning experience (both I and

III above). Terenzini's (1999) learning study found that learning is maximized when learning activities and knowledge have meaning for the student. Additionally, Stave's *et al.* (2003) curriculum was originally designed using role-playing to increase participant interest and used the Las Vegas Valley water system and water management problems which have some relevance for all residents.

In addition to the above reasons, there is further support for simulations as effective tools for learning. Simulation-based teaching changes the focal point of learning from teacher-centered to learning and learner-oriented. In this new organization, student understanding becomes central instead of the amount of information the student can retransmit (Arendale 1998, Richmond 1990, Gorrell 1992). Also, as visually displayed in Figure 1, simulations engage users and offer very high levels of interaction and communication, not only between students and teachers, but also between experts and even the technology being used (Mustajärvi 1998). Therefore, if tied properly to effective curriculum, simulations can add tremendously to the learning experience (Richmond 1990, Milrad 2002).

In an effort to gain better understanding about the use of simulation and other computer technology in education, Kulik et al. (1980) completed one of the first meta-analyses of computer-aided learning. Their findings indicated a small, yet significant, positive change in attitudes toward subjects as well as decreased amount of time necessary for instruction. In a subsequent study, Kulik and Kulik (1991) found that scores significantly increased after computer-based instruction.

Hypotheses

This study's experimental design compares the performance of one group receiving traditional instruction to another receiving simulation-based instruction. Expected findings were

that students using the simulation-based, learner-directed instruction would have a better conceptual understanding of the material and retain the information longer than those exposed to teacher-directed instruction of the same material. Specifically:

I. Students in simulation-based groups will outperform traditional groups in overall scores on post- and retention tests
   1. Amount of learning, or increase in scores from pre- to post-test, will be higher for model users than for non-model participants.
   2. There will not be much difference between treatments for questions in the Knowledge category
   3. Simulation users will score higher for conceptual and understanding questions, categorized as Comprehension-level items.
   4. Simulation users will score higher on Application-level categories, which contain questions that propose new information or situations and require a deeper grasp of the material to be answered correctly.
II. Attitudes toward the environment and water issues will become more positive in the simulation-based group after treatment.
   1. Students with the strongest positive attitudes will score higher on overall assessment.
   2. Students, as a whole, will have positive changes in their attitudes toward water and describe effective ways they will use to conserve water after instruction.
   3. Environmental studies students will have significantly higher positive attitudes toward the environment and water resources than psychology students, as well as score higher on initial pretest

Methods

Objectives for both presented content and assessment questions were developed based on the recommendations of Bloom *et al.* (1981) and Kesidou and Roseman (2002). Using these objectives about water resources in Las Vegas, the powerpoint instruction and evaluation instrument of Stave *et al.*(2003) were analyzed for relevance. Each slide of the presentation and each item on the test were associated with their accompanying topic area or were either reworded or discarded if not applicable. Undergraduate students at the University of Nevada, Las Vegas (UNLV) were recruited from Psychology and Environmental Studies departments to participate in a workshop about water resources in Las Vegas. Participants were randomly assigned to one of the instructional treatment groups, either traditional or simulation-based. The treatments

differed only in how students interacted with the Las Vegas water system, or step number four in

Table 2. In the traditional group, students were presented with additional lecture-format

powerpoint slides graphically showing results of predetermined scenarios, while students in the

simulation-based group manipulated the interface of the simulation model individually to get

results. Both treatments were of the same duration, 2 hours for the first part of the study and a

half-hour session 4 weeks after instruction, for a total of 2.5 hours. Treatment sessions followed

the same format and time lengths for each step, as Table 2 shows:

Table 2: Step-by-step format of Sessions (modified from Stave *et al.* 2003).

1. Introduction, collection of consent forms	(5 minutes)
2. Pre-test	(20 minutes)
3. Instruction (powerpoint)	(15 minutes)
4. Treatment (simulation/ presentation)	(30 minutes)
5. Discussion	(25 minutes) *after a break
6. Post-test	(20 minutes)

Results of Kulik and Kulik (1991) showed that the greatest significant differences in

learning with computer-aids were associated with using different teachers for control and

experimental groups and shorter experiments compared to longer durations of instruction.

Therefore, all treatments were taught by the same instructor to eliminate any possible effect

different speakers would have on different groups (Kulik and Kulik 1991). Additionally, the

solid clock of time attempted to affect control of information so that increases in learning were

direct results of treatments.

Subjects

The subjects for this study were college students from both the Environmental Studies

and Psychology departments at UNLV. There were six groups, three for each treatment, and

forty-nine students participated. Students signed up for groups without any knowledge that there

were different treatments. In an effort to minimize possible time of day effects, both a traditional

and a simulation-based group were held at the same day and time in different weeks for comparison purposes.

Testing Procedures

Students were administered an evaluation instrument before, immediately after, and 4 weeks after instruction. The test contained 23 questions, five true-false 16 multiple choice, and two essay questions. Questions were categorized into 6 topic areas so that analysis could evaluate how much learning occurred in the different areas of the objectives.

Evaluation Instrument

In addition to the changes made to individual items, as mentioned above, questions were grouped into categories of both topic area and difficulty level. Using the examples in Chang (2001), questions on the testing instruments were placed into the first three levels of Bloom's Taxonomy of Learning—Knowledge, Comprehension, and Application (Bloom *et al.* 1981, Maynard). Questions which required only recall of presented information, such as definitions and facts, fall into the Knowledge category. Comprehension-level items draw on student understanding of concepts and interconnections. Finally, the last category, Application, requires a big-picture understanding that can be applied to new material not covered or discussed in treatments or instruction. The following questions, from the evaluation instrument in Appendix B, represent the types of questions for each of these categories (correct answers are in parentheses (*answer*)):

Knowledge
2. ____ of the Las Vegas water supply comes from the Colorado River out of Lake Mead.
    a. All
    b. 22%
    c. (*88%*)
    d. None

Comprehension

13. Which of the following is true about treated (or cleaned) water sent to the Las Vegas Wash?
    a. (*It increases the water supply*)
    b. It decreases the water supply
    c. It increases the demand for water
    d. It decreases the demand for water

Application

16. If a new type of "desert grass" that uses much less water and has all the same attributes as traditional grass was suddenly introduced in Las Vegas, what do you think would happen to water use?
    a. There would be no effect
    b. Demand would continue to grow, but would be reduced.
    c. Demand would lower to a stable, flat line.
    d. Demand would rise exponentially.

Pretest

Students received a pretest prior to instruction determining previous knowledge about the Las Vegas valley water system as well as initial attitudes toward water. Demographics of age, sex, and how long the participant has been a resident of Las Vegas were also collected. One question also asked what, if anything, students did anything at home to save water.

Instruction

All participants received the same information, in the form of a power point presentation, which provided the necessary background to understand water issues in Las Vegas. This material was the same basic curriculum from Stave *et al.* (2003), with slight revisions for more age-appropriate terminology. The instruction section lasted about 15 minutes and followed a script to ensure consistency. Examples of slides and script are included in Appendix C for reference.

Treatments

Sessions were randomly assigned to either simulation-based (model) or the traditional (non-model) group. Both treatments had a 30 minute duration to make certain that any differences in results were due to differences in the method of information gained and not because of extra time with the system. Additionally, both groups were asked to fill out datasheets tracking their hypotheses and reasoning before seeing results. The practice of forming hypotheses and justification has been shown to promote conceptual processes during activity, by building connections between new material and current knowledge as well as providing a separate measure of participants' progress with the system (Windschitl and Andre 1998).

Simulation-based, Model Group

The simulation-based model group received a quick overview of how to use the model interface screen, shown in Figure 2. One presenter-led sample run of the simulation ensured that students knew how to use the simulation and provided the only amount of specific direction students received in this treatment. The underlying model was created and validated for Stave (2003) using Vensim (Ventana Systems, Inc. 2002) and the interface is the same as for Stave *et al.* (2003). Datasheets for this treatment, shown in Appendix D, were used by students to record amount of increase or decrease in variables, a short description of why they chose those variables, and expected results. Next to this information, students graphed actual results given by the model on a pair of axes. This practice provided the opportunity for students to think through the model, reducing the chance of "playing a game," and stimulated subjects to make causal connections between changes and results (Windschitl and Andre 1998). Students worked alone on individual computer stations in order to reduce collaboration bias. Researchers were available to answer software and technical questions, but were not to come up with scenarios for students to try. Questions about the ouput or results from the model were answered if they dealt

only with understanding the literal meaning of the graph; interpretation questions or how results would impact the system or problem were put aside for discussion.

Traditional, Non-Model Group

The traditional group started the treatment section with the interface screen showing the different levers/variables that could be manipulated. However, instead of coming up with their own ideas for policy changes to the system, they were given a pre-determined theoretical change to the system and instructed to fill out a similar hypothesis-sheet, also shown in Appendix D, with what they thought certain adjustments to the system would cause. Next, the results were displayed in the same form as the graphs that had been previously used in the presentation. Figure 3 shows an example of the results shown after a scenario was described. The main difference of this treatment was that students did not formulate their own policies or scenarios and were controlled in which order they saw the results and for how long. Other differences were that most of the policy options were for individual variables with only one combination option, and that the results for each graph were described, according to a script, in terms of how it changed from the reference mode (or projected trends) graph. Questions about why certain changes produced certain effects and whether the options would be feasible were saved for the final discussion.

<u>Discussion</u>

Discussion followed a short break and lasted approximately 30 minutes. This discussion was primarily student led with scripted questions used to prompt further discussion. Goals of the study were not explicitly stated in this section and questions and comments followed the script. Notes were kept on specific topics covered in sessions, especially if very different from typical topics in most sessions. However, all groups tended to cover the same general topics.

<u>Post-test</u>

Students in both treatments received the same test at the end of the session to test for gains in knowledge, comprehension, and application plus shifts in attitudes. The test questions were not arranged in a different order and had the same questions that were used on the previous test (although some groups received additional questions on the post-test that were not included in the pretest because of changes to the test). This test also had a place for comments and suggestions about the study. After completing the post-test, students immediately scheduled a retention-test appointment for 4 weeks after instruction.

<u>Retention-test</u>

The retention-test contained the same content as the first two tests but questions were arranged in a different order. The retention test was intended to gauge longer term understanding of the system and attitudes. These tests were given during a second part of the study which lasted 30 minutes. Following the test, participants were debriefed on the study following university guidelines. The objectives, hypothesis, and preliminary results of the study were described. Any additional questions they had were answered and discussed in subsequent debriefing sessions.

<u>Analysis</u>

To evaluate the hypotheses, tests were analyzed using SPSS and Excel. All responses to questions, except essay questions, were entered into a database to calculate scores. Subject identification numbers (ID#s) were given to all subjects so each ID# was coded with additional variables to define the factors affecting that subject (age, sex, treatment, major).

To analyze whether the simulation-based treatment scored higher than the traditional treatment, the mean scores for all participants in each treatment were compared. To determine

the increase in score, the difference between pretest scores and post-test scores were calculated. This new variable showed the effect of the instruction and treatment on subjects and was considered as the amount of material learned by the student. The means of learning for each treatment were compared to determine how much scores increased for individuals in model groups to individuals in non-model groups.

Questions of a particular type (including Knowledge-level items, Comprehension-level items, Application-level items, and all six topic areas) were added together in new variables to create a total score of correct answers for each of the categories or topics. These scores were calculated within each treatment and for both pre- and post-tests. The total scores for each category were compared between treatments to determine any difference for both pretest and post-test. The same procedure was followed to examine topic area differences by treatment.

Attitudes were evaluated by looking at both the mean and mode for each question, according to either treatment or major. Attitudes were also compared for time, looking at responses for pretest compared to post-test. In addition, modes were also calculated for each question on the evaluation instrument to determine the most frequently selected answer and compare it to the correct response. Looking at overall scores for each question with modes, serves as a way to test the validity of the testing instrument (Bloom *et al.* 1981).

Independent t-tests were used to compare the means of all the above pairings for a significant difference. The significance level used was .05, or a confidence level of 95%. After preliminary results, mean scores (both overall and increases as well as categories and topic-areas) were also compared by the other factors of sex, age, and major (Environmental Studies versus Psychology).

Results

Forty-nine students participated in the experiment. The subjects were nearly evenly distributed among factors: 25 females and 24 males, 23 psychology students and 26 environmental studies students (including a pilot of 7 students), and 21 in non-model group and 28 in the model group (including pilot). Most students (28) were between 18 and 25 years old. Scores on pre- and post-tests were analyzed according to these different groups as possible predictor variables.

Removing scores from the pilot test, which had seven graduate students with more advanced knowledge of the system, there were 42 subjects analyzed. Both treatments consisted of 21 participants. Mean scores on pre- and post-tests for both treatments are shown in Table 3. Scores show an increase in learning among both groups, with the higher mean for both tests in the simulation group, but the greatest increase in learning in the traditional group.

Table 3: Mean scores of Treatment groups for pre- and post-tests.

Treatments		Pretest		Post-test		% increase scores (Difference)
		Mean	Std. Deviation	Mean	Std. Deviation	
Simulation-based Model	*N=21*	**74.9 %**	**.17**	**86.2 %**	**.12**	**11.3%**
Traditional Non-model	*N=21*	**66.7%**	**.14**	**82.8%**	**.13**	**16.1%**

Pretest scores were normally distributed for model and non-model groups (Kolmogorov-Smirnov values of .128 and .200, respectively), which indicate an unbiased sample. T-test results showed no significant difference between these values, but the pretest scores for model and non-model groups had the most difference from each other with a pvalue=.095. Prescores and postscores were significantly different from each other (p= .000), indicating increases in scores for almost every participant.

Figure 4 shows the distribution of scores for the treatments on pre- and post-test and, although there is no significance between these scores, the distribution shows a more narrow range in scores for the traditional treatment than for the simulation-based group.

Scores by the category of the question also showed no significant difference for treatment groups in either pretest or post-test. Knowledge questions were least dependent (p=.615) on treatment group for scoring correct answers on the post-test, while Comprehension questions

Topic	Q#	% Correct Pretest	% Correct Post-test	Increase in score	Mean Incr.	Topic	Q#	% Correct Pretest	% Correct Post-test	Increase in score	Mean Incr.
1	1	83.67	97.96	14.29	17.01	4	10	53.06	87.76	34.69	
	2	59.18	95.92	36.73		(Cont)	18	95.92	91.84	-4.08	
	11	97.96	97.96	0			20	57.14	59.18	2.04	
2	5	48.98	91.84	42.86	24.49	5	13	71.43	91.84	20.41	7.85
	12	79.59	85.71	6.12			16	70	69.05	-0.95	
3	3	95.92	95.92	0	22.45		19	81.63	85.71	4.08	
	4	**28.57**	**91.84**	**63.27**		6	14	53.06	85.71	32.65	16.80
	9	93.88	97.96	4.08			15	53.06	87.76	34.69	
4	6	81.63	81.63	0	6.80		17	97.96	95.92	-2.04	
	7	**34.69**	**22.45**	**-12.24**			21	76.67	78.57	1.9	
	8	63.27	83.67	20.41							

Area	Topics	Questions
1	Supply (where water comes from)	1,2,11
2	Demand (use distribution)	5,12
3	Problem Definition (not enough, year, popn)	3,4,9
4	Structure: where used goes, return flow defn.	6,7,8,10,18,20
5	Effect on supp/demand (popn, indoor), Mechanism	13,16,19
6	Consequence different actions, different options, effect of on ind/out, , tradeoffs	14,15,17,21

Table 4: Topic breakdown and percentage of topic questions correct from pre- and post-test.

were the closest in relationship (p=.186) but not significant. Analysis of scores on questions topic-wise revealed no significant difference between treatments and subject matter, although Topic area six did indicate possible differences that could be explored (p=.064). Table 4 shows the overall percentage of people getting different topics correct and the breakdown of topic areas.

Within the two treatment groups, age, sex, and major were also analyzed for differences in scores. Since age was not distributed very equally, it was difficult to determine the effect of age on scores, however Figure 5 shows boxplots for the scores and ranges of age. Since the most participants fell into the first age category, differences in scores for just this first age group revealed no significance in either treatment (p=.757). No differences in scores for any of the question levels or topic areas due to age are shown either. Sex likewise showed no significant difference within treatments between male and female postscores (.559 in model and .872 in non-model).

Differences were found between Environmental Studies and Psychology students within the two treatments. In the model group, prescores were significantly higher for environmental studies (.006) students and postscores were also significantly higher (.014), indicating a better overall performance. However, there was no significant difference on increase in scores (.286), demonstrating that the amount of material learned by these sub-groups within the model treatment was the same, regardless of initial knowledge. For the non-model treatment, there was no difference between pre- post- and difference-scores. Further comparison pairing majors of each treatment together showed no differences on overall performance or scores in any topic or categorical area.

Attitudes of the different majors was examined and the responses to the attitude questions, listed in Appendix B, are shown in Table 5. These attitudes, particularly numbers 6-10 have a significant increase from pre- to post- for individuals in all groups. There was no significant difference found between attitudes of model-users and the traditional group. Overall scores in attitudes of 40 or higher were considered strong positive attitudes, average response of 4=Agree on all 10 attitude questions.

Table 5: Attitudes toward env/water for Env Studies and Psych by pre- and post-test. See Appendix B

PRETEST				POSTTEST			
attitude #	overall	env	psych	attitude #	overall	env	psych
1	4.51	4.77	4.22	1	4.53	4.77	4.26
2	4.59	4.77	4.39	2	4.59	4.77	4.39
3	4.63	4.81	4.43	3	4.73	4.85	4.61
4	4.20	4.15	4.26	4	4.35	4.38	4.30
5	4.15	4.44	3.83	5	4.33	4.62	4.00
6	3.02	3.72	2.26	6	4.00	4.08	3.91
7	3.90	4.12	3.65	7	4.00	4.23	3.74
8	4.04	4.20	3.87	8	4.16	4.31	4.00
9	2.63	2.85	2.39	9	3.06	3.23	2.87
10	3.98	4.31	3.61	10	4.22	4.42	4.00
total	39.43	41.65	36.9	total	41.98	43.65	40.09

There was a significance in difference of scores on pretest Comprehension-level items (.045) and topic area #4—water system structure (.039) for subjects with positive attitudes compared to others. Looking at specific attitude questions also revealed some significance. Question six (I know a lot about water issues in Las Vegas), when marked 5=Strongly Agree, predicted higher scores in all topic areas and categories except pre-test topic areas 3 and 5 (see Table 4) and post-test category Knowledge-items and topic area 3.

All attitudes either increased or remained constant from pre- to post-test, though there was no significance between groups for increases and some individuals marked lower responses on the post test. Environmental studies students tended to have stronger and more positive responses for all attitude questions (except #4), but the difference to psychology was not a marked difference. In general, most ratings tended to have similar responses from both environmental studies and psychology students including questions with lower mean ratings.

Discussion

Results did not support the main hypothesis. There was no significant difference between simulation-based and traditional treatments. However, with such strong support for simulation-based instruction on improving the learning experience, it is probable that issues with the study

design have hindered any clear testing of the difference between methods. Some of the biggest

issues were distribution problems within the treatment groups, specific questions on the

evaluation instrument, and unexpected effects of treatments.

Table 6: Distribution of factors within treatments

	Traditional group (Non-Model)	Simulation-based group (Model)
Major		
Environmental Studies	7	12
Psychology	14	9
Sex		
Males	8	9
Females	13	9
Age		
1 18-25	18	11
2 26-35	2	7
3 36-45	0	2
4 46-55	1	1

Table 6 shows the distribution of different subgroups within the treatments. Although results indicated that there was no difference between simulation and traditional methods, these unequal numbers of student factors may have had an impact that mitigated any benefits from model groups. In future studies, such factors should be taken into

consideration. Since Environmental studies students definitely scored better regardless of

treatment, having unequal proportions of these groups skews the results into a comparison

between two majors instead of the treatments being utilized. For example, although there should

be relatively little or no difference between treatments for conceptual questions on pretests,

scores by category revealed a possible non-normal distribution in the treatment samples with

pretest Comprehension scores in the model treatment were higher and slightly significant

(p=.092), reflecting the impact having more environmental studies students had on the group.

Although Kolmogorov-Smirnov scores showed no significant difference between prescore

normality for treatments, t-tests yielded a number which is close enough to indicate some

significance and a potentially biased group (.095). Additionally, it was noticed during treatment

that disproportionate distributions tended to negatively impact the participation of the smaller

groups.

Although the evaluation instrument was improved substantially, results exposed problems with particular questions and how well it assesses learning generally. Scores on some of the questions showed decreases from pretest to post-test as can be seen in Table 4, by topic. In fact, question seven (see Appendix B for evaluation instrument) was answered incorrectly more often than it was answered correctly. Analyzing the mode response for this test item reveals that students consistently selected the same wrong answer, and therefore that option should be removed or the entire question thrown out of the test. However, not all questions have problems. The only other question that had a mode different than the correct answer was question four. For this question, students were asked to define part of the problem of the Las Vegas water system and although only 29% of students scored correctly on the pretest, 92% of students knew the answer on the post-test.

There are some interesting results which may indicate an area of difference between groups, particularly in some of the topic areas of the tests. Topic area two and five (see Figure 4 for topic area descriptions) actually had the exact same mean for both treatments, saying that there is absolutely no difference between treatments for learning these concepts. On the contrary, topic area one and six had close to significant differences (.083 and .063) which warrant further exploring. In either case, with such few questions in most categories, it is difficult to make meaningful use of topic-area scores and for future exploration of this topic should have more questions added in some categories to have more representative differences.

In attempting to improve methods and materials for this study, many other similar studies that were also looking at effectiveness of learning with computer technology were examined. Chang (2001) also used the first three areas of Bloom's taxonomy of learning (Knowledge, Comprehension, and Application) to organize questions by their different levels of difficulty and

understanding. However, despite attempting to ensure validity and reliability of the instrument by having professors (with no prior exposure to the materials of the project) independently categorize questions, placement was still very subjective. Although the goal Stave *et al.* (2003) set was to include more conceptual questions (Comprehension and Application items), the questions on the evaluation still focus mostly on the factual, or Knowledge side of the learning scale. There are currently 9 Knowledge, 10 Comprehension, and only 2 Application questions on the test.

Unexpected and uncontrolled variables of treatments may have caused a much different impact than was anticipated. For example, in the traditional group student exposure to the system was limited and controlled, students were shown only predetermined results and could not create their own scenarios to test. The idea was to limit the amount of interaction this treatment had with the system, but graphs were also described orally, which model-users did not receive and may impacted understanding of the output. Either the sequence variables were introduced or the way each variable was covered could have affected results.

Model-users were not controlled in how they went through material, which may explain the high variance in scores between treatments, shown in Figure 4. However, studies suggest that there is no significant difference between free manipulation and step-by-step control of the same technology (Swaak and De Jong 2001) so the order the results were covered might not have as much of an impact as other issues. Though outside the scope of this study, datasheets were collected for participants of both treatments and analysis of these forms might add valuable insight to the options and the order that model-users tried.   If any patterns are found, they can be tested against scores to see if a correlation exists between one pattern and higher scores.

Terenzini (1999) suggests that the process of reflection allows information to be internalized, connected to current understanding, and better retained. Therefore, the lack of difference in scores (or the surprisingly high non-model performance) was probably a result of allotted time-intervals for filling out hypothesis sheets. This structure, intended to make sure both groups were exposed to the system for the same duration, ensured that the traditional treatment's participants took a moment to contemplate what affects change would have and then write out the results. Although some students in these treatments finished their hypotheses in moments, the overall difference in time was very small compared to the model group. The simulation-based groups worked at their own pace within the time frame and, while instructed to fill out datasheets and think through their changes, there was no enforcement and many finished their scenarios within 15 minutes. Therefore, any increase received from interaction with the simulation may have been mitigated by the controlled pause for hypothesis and reflection in the traditional group. Additionally, graphed results for the traditional group were much larger, with clear crossing points, and year included, where a much smaller space (built into the interface) was dedicated to graphing results for the simulation.

This study is based on the premise that water resource problems in Las Vegas are interesting and relevant to the participants. Attitude questions on the pretest, included in Appendix B, asked participants to rate their agreement or disagreement with statements to determine if the study actually met this criterion. According to the mean and mode of the responses, subjects are interested in water issues and want to know more about them. Looking at attitude question six shows, regardless of scores on assessments which weren't shared with subjects, participants feel that they have learned about water issues. Prior to treatments, some students disagreed with the question and the most frequently selected answer was a 3 = Neutral,

while after treatment this increases to a 4 = Agree, with most students agreeing that they know a lot about water issues. Comments and suggestions on the post-test also showed that participants had very positive experiences with the study and enjoyed their treatment. The biggest complaints were the length of the study and the amount of time spent using the model.

Sub-hypothesis II.2 stated that students would be able to come up with creative ideas about what they would do to conserve water. Typically, students would select that they do activities at home to save water and these activities usually dealt with not leaving water running while brushing teeth, etc. Many students did make the connection between indoor and outdoor water use and how some outdoor uses of water could be brought inside to save waste due to evaporation. One student showed this understanding, even though it was not covered explicitly in materials or discussion, by using "start washing my dogs inside" as an example.

Retention is where the largest differences between treatments were expected and that is the most immediate step that needs to be taken for the study. Additionally, further analysis could be pulled from other collected information, such as the connection between attitudes and scores, as well as correlating the years of residency to predict attitudes toward water. In addition, it would be interesting to ask for class standing of freshman through senior, since age groups tended to be too large.

Furthermore, although essay questions and datasheets were filled out by students, they were not included in mean scores. Developing a method to analyze this information so a better interpretation of actual learning can be gauged would be very useful. Although tests provide a straightforward quantitative measure of learning, it is difficult to capture the type of benefits gained from simulations on a simple multiple-choice test. Comments from the breadth of all groups and sub-groups of students were very interesting and unique, indicating a depth of

understanding that may not have been captured by the testing instrument. Therefore, developing some way of capturing the information gained during discussion and analyzing it for its understanding of content would be a recommendation for future studies.

Better attitude-question formulation and testing would provide a better basis for analyzing scores. Creating attitudes specific to goals and repeated for reliability could better gauge any changes in the attitudes of students. Statements closer to policy options (Water should be more expensive) would show an increase in understanding how behaviors and actions impact the water supply, as well as reflect preconceptions and how they are affected by instruction. In addition, I am interested in how students feel about using the treatment they received. Non-model users could rate a level of agreement with the statement, "I would have liked to create and test my own policy options". Perhaps simulation does not increase how well students will do on standard testing assessments, but instead affects how students feel toward what they have learned and how interested they might be into learning more and at a deeper level.

Conclusion

Although results showed no significant difference between treatment groups, participants did learn regardless of treatment. Therefore the instruction was informative regardless of how students interacted with the information from the model. Additionally, these results show that simulation-based instruction is at least as effective as traditional methods. However, Eva (2000) warns that effective teaching and good teachers cannot be replaced by increasing complexity of tools and that computer-aided instruction should not try to keep pace with rapid advancements in technology. Because students are at the center of this approach to learning, understanding and connections should always be the goal. Tying teaching about some of the causal connections underlying the interface is probably the next step in examining effective learning. Forrester

(1992) and Richmond (1990) strongly emphasize the importance of teaching students how to think through complex problems and not just provide a new technology to find the solution. Additionally, the goal is not to increase test scores, but rather to improve understanding and build connections that can be transferred to new situations and domains (Terenzini 1999, Eva 2000, Windschitl and Andre 1998). Increasing motivation and enthusiasm for learning and changing attitudes is equally as important (Eva 2000, Forrester 1992). Future research in this area should try to uphold these ideals and always keep the student, and not the technology, at the center of the learning process.

List of Figures

Figures

Figure 1 Interactive communication of a simulation (Mustajärvi 1998, [org.]
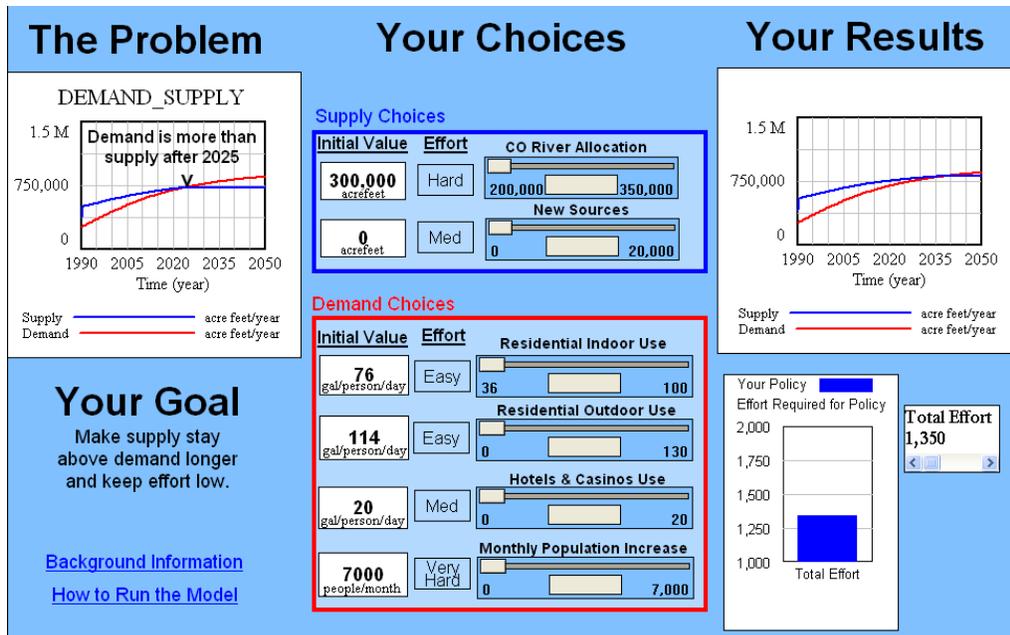**Pohjolainen & Ruokamo 1998)**

Figure 2 Interface screen used for simulation-based treatment group. Developed Stave *et al.* (2003)

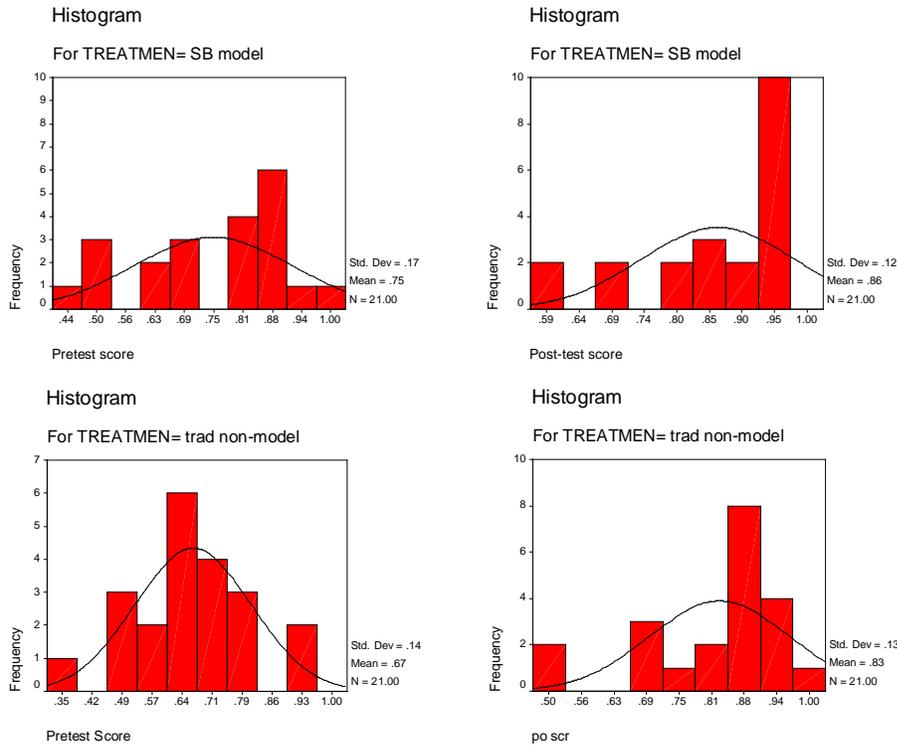**Figure 3: Slide of results for Traditional treatment.**

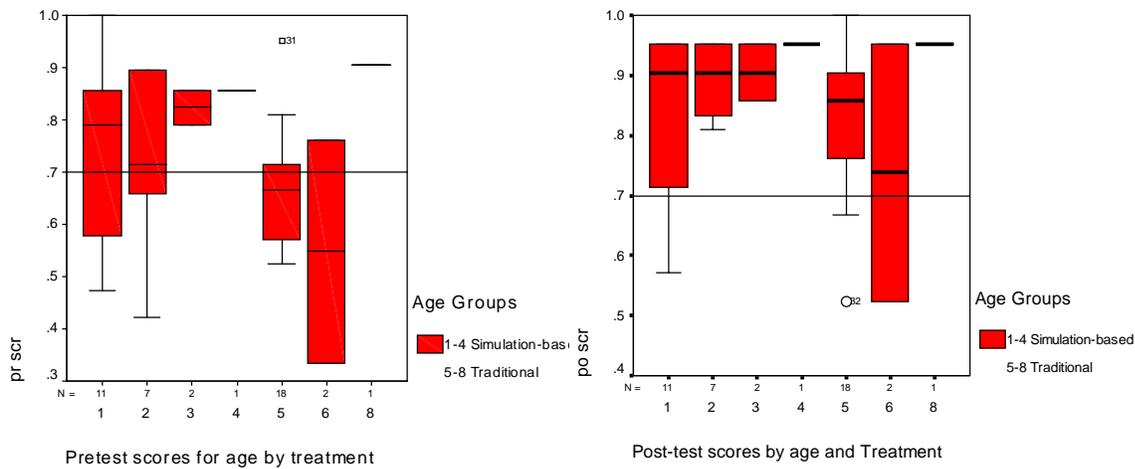**Figure 4: Distribution of overall scores for pre- and post-tests by treatment groups**

Figure 5: Pre- and post-test scores for age by treatment.

References

Arendale, David. Increasing Efficiency and Effectiveness of Learning for Freshmen Students through Supplemental Instruction. The role of developmental education in preparing successful college students. P. Dwinell, & J. S. Higbee (Eds.). 1998. Columbia, SC: The National Association for Developmental Education and the National Center for the Study of the First Year Experience and Students in Transition.

Bloom, B. S., Madaus, George F., Hastings, J. Thomas. Evaluation to improve learning. 1981. McGraw-Hill: New York.

Chang, Chun-Yen. 2001. Comparing the Impacts of a Problem-Based Computer-Assisted Instruction and the Direct-Interactive Teaching Method on Student Science Achievement. *Journal of Science Education and Technology.* **10**,2:147-153.

Eva, Kevin W. 2000. Maintaining the Characteristics of Effective Clinical Teachers in Computer-Assisted Learning Environments. *Advances in Health Sciences Education*. **5**:233-246.

Forrester, J.W. 1992. System Dynamics and Learner-Centered-Learning in Kindergarten through 12th Grade Education. Publication D-4337, Sloan School of Management, MIT. Available online as a document in Roadmaps at: URL: http://sysdyn.mit.edu/road-maps/rm-toc.html.

Gorrell, Jeffrey. 1992. Outcomes of Using Computer Simulations. *Journal of Research on Computing in Education.* **24**, 3.

Kesidou and Roseman. 2002. How Well Do Middle School Science Programs Measure Up? Findings from Project 2061's Curriculum Review. *Journal of Research in Science Teaching.* **39**,6:522-549.

Kulik, J., Kulik, C., Cohen, P. 1980. Effectiveness of Computer -based College Teaching: A Meta-analysis of Findings. Review of Educational Research. **50**, 4: 525-544.

Kulik, C. C., Kulik, J. A. 1991. Effectiveness of Computer Based instruction: An Updated Analysis. *Computers in Human Behaviour*. **g**:75-94

Maynard, John. "Bloom's Taxonomy: Model Questions and Key Words". *UT Learning Center*. URL: http://www.utexas.edu/student/utlc/handouts/1414.html [accessed 12/5/03]

Milrad, Marcelo. 2002. Using Construction Kits, Modeling Tools and System Dynamics Simulations to Support Collaborative Discovery Learning. *Educational Technology & Society.* **5**,4: 76-87.

Mustajärvi, Jari. 1998. The Use of Multimedia and Effectiveness of Learning. Forssa, Finland: Virtual Multimedia Factory Publications.

Richmond, B. 1990. Systems Thinking: A critical set of Critical Thinking Skills for the 90's and beyond. **'90, 2**:934-947. Proceedings of the 1990 International System Dynamics Conference. System Dynamics Society. Cambridge, MA.

Stave, K.A. 2003. A system dynamics model to facilitate public understanding of water management options in Las Vegas, Nevada. *Journal of Environmental Management.* **67**:303-313.

Stave, K.A., Upham, Lisa., Fincher, Stephanie., Blanchard, Kim. 2003. "Evaluating the Effectiveness of Simulation-based Instruction about Water Resources in the Middle School Science Classroom". (Poster.) 21st *International Conference of the System Dynamics Society.* New York City, NY, July 20-24, 2003.

Swaak, Janine and De Jong, Ton. 2001. Learner vs. System control in Using Online Support for Simulation-based Discovery Learning. *Learning Environments Research.* **4**:217-241.

Terenzini, Patrick T. 1999. Research and practice in undergraduate education: And never the twain shall meet? *Higher Education.* **38:**33-48.

Ventana Systems, Inc. *Vensim DSS*. Version 4. 1996-2004. Harvard, MA. Available: www.vensim.com.

Windschitl, Mark and Andre, Thomas. 1998. Using Computer Simulations to Enhance
Conceptual Change: The Roles of Constructivist Instruction and Student Epistemological
Beliefs. *Journal of Research in Science Teaching*. 35.2:145-160.

Appendices

Appendix A

(Appendix A from Kesidou and Roseman 2002)
Instructional Analysis Criteria [modified]
Project 2061's curriculum analysis procedure uses the following criteria, organized into seven categories, to determine the extent to which a material's instructional strategy is likely to support students learn the content. Each criterion in Categories I–VI is to be assessed with regard to specific learning goals, not just in general *[NOTE: category VII was removed as it was not applicable; certain items were also removed if they were not relevant to the current study/curriculum].*

Category I: Identifying and Maintaining a Sense of Purpose
  Conveying Unit Purpose. Does the material convey an overall sense of purpose and direction that is understandable and motivating to students?
  Conveying Activity Purpose. Does the material convey the purpose of each activity and its relationship to others?
  Justifying Activity Sequence. Does the material include a logical or strategic sequence of activities (versus just a collection of activities)?

Category II: Taking Account of Student Ideas
Attending to Prerequisite Knowledge and Skills. Does the material specify prerequisite knowledge or skills necessary to the learning of the key idea(s)?
Alerting Teacher to Commonly Held Student Ideas. Does the material alert teachers to commonly held student ideas (both troublesome and helpful)?
Assisting Teacher in Identifying Student Ideas. Does the material include suggestions for teachers to find out what their students think about familiar phenomena related to a key idea before the key ideas are introduced?
Addressing Commonly Held Ideas. Does the material explicitly address commonly held student ideas?

Category III: Engaging Students with Relevant Phenomena
Providing Variety of Phenomena. Does the material provide multiple and varied phenomena to support the key idea(s)?
Providing Vivid Experiences. Does the material include first-hand experiences with phenomena (when practical) and provide students with a vicarious sense of the phenomena when experiences are not first-hand?

Category IV: Developing and Using Scientific Ideas
Introducing Terms Meaningfully. Does the material introduce technical terms only in conjunction with experience with the idea or process and only as needed to facilitate thinking and promote effective communication?
Representing Ideas. Does the material include appropriate representations of the key ideas?
Demonstrating Use of Knowledge. Does the material demonstrate, model, or include suggestions for teachers on how to demonstrate or model skills or the use of knowledge?
Providing Practice. Does the material provide tasks or questions for students to practice skills or use of knowledge in a variety of situations?

Category V: Promoting Student Thinking about Phenomena, Experiences, and Knowledge
Encouraging Students to Explain Their Ideas. Does the material routinely include suggestions for having each student express, clarify, justify, and represent his or her ideas? Are suggestions made for when and how students will get feedback from peers and the teacher?
Guiding Student Interpretation and Reasoning. Does the material include tasks and/or question sequences to guide student interpretation and reasoning about experiences with phenomena and readings?
Encouraging Students to Think About What They Have Learned. Does the material suggest ways to have students check their own progress?

Category VI: Assessing Progress

Aligning to Goals. Assuming a content match between the curriculum material and the benchmark, are assessment items included that match the key ideas?

Testing for Understanding. Does the material assess understanding of key ideas and avoid allowing students a trivial way out, such as repeating a memorized term or phrase from the text without understanding?

Appendix B
Appendix B: Pretest, evaluation instrument (reduced for space)

Water Management Issues in Las Vegas Survey

Thank you for participating in this study. Please answer the following questions.

Section I

1) Sex: Male_____ Female_____   2) How many years have you lived in Las Vegas?
_____

Age: 18 to 25 years old _____
      26 to 35 years old _____
      36 to 45 years old _____   3) What city, region or country do
      46 to 55 years old _____   you consider "home"?
      56 to 65 years old _____   _____
      65 or older _____

4) The following questions ask about your views on water issues in Las Vegas. Please respond to each statement by checking one of the categories.

	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree
I care about the environment.					
It is important to protect the environment.					
It is important for people to save water.					
Las Vegas residents should be involved in water management decisions.					
I worry about water issues in Las Vegas.					
I know a lot about water issues in Las Vegas.					
I want to know more about water issues in Las Vegas.					
Poor water management in Las Vegas would seriously affect me.					
Whether I stay in Las Vegas in the future depends on how water is managed.					
The future of Las Vegas depends on how water is managed.					

5) Do you do anything at home to save water? If yes, please describe below. Yes _____   No _____

Section II

17. Where does most of the water people use in Las Vegas come from?
    a. From deep in the ground

      b. From the store

      c. From Lake Mead

      d. From water storage towers

18.   ____ of the Las Vegas water supply comes from the Colorado River out of Lake Mead.
      a. All

      b. 22%

      c. 88%

      d. None

19. What is the most important problem with the Las Vegas water system?
      a. There are not enough water treatment plants
      b. There may not be enough water
      c. There are not enough pipes
      d. There is no water problem in Las Vegas

20. Given projected trends in water supply and water demand, when is water demand likely to be greater than supply?
      a. Demand is already greater than supply.
      b. Demand will be greater than supply in 20-50 years.
      c. Demand will be greater than supply in 200 years.
      d. Demand will never be greater than supply.

21. Which of the following uses the most water in Las Vegas?
      a. Casinos
      b. Golf Courses
      c. Houses
      d. Businesses

22. After water is used inside your home, next it goes to:
      a. The Las Vegas Wash
      b. A water treatment plant
      c. The Colorado River
      d. It soaks into the ground.

23. After water is used in your yard, next it goes to:
      a. The Las Vegas Wash
      b. A water treatment plant
      c. The Colorado River
      d. It soaks into the ground.

24. If we want people to use less water, we could ask them to use less water indoors or we could ask them to use less water outdoors. Which of the following is TRUE:
      a. Unlike water used outdoors, water that is used indoors can be treated and reused.
      b. It is easier for people to change how much water they use indoors than outdoors.
      c. People use less water outdoors than indoors.

25. What is the connection between the number of people who live in Las Vegas and the overall amount of water used?
      a. The more people there are in Las Vegas, the more water the city will use.
      b. The more people there are in Las Vegas, the less water the city will use.
      c. There is no connection.

26. What is the best description of the Return Flow Credit?

    a. Water used indoors that gets counted back to supply
    b. Money that is credited for installing low-flow shower heads and appliances
    c. Water used outside that goes to Lake Mead
    d. Amount of water exceeding demand

27. What is water <u>supply?</u>
    a. How much water is consumed.
    b. How much water is available.
    c. How much water is in pipes.
    d. None of the above

28. What is water <u>demand</u>?
    a. How much water is consumed.
    b. How much water is available.
    c. How much water is in pipes.
    d. None of the above

29. Which of the following is true about treated (or cleaned) water sent to the Las Vegas Wash?
    a. It increases the water supply
    b. It decreases the water supply
    c. It increases the demand for water
    d. It decreases the demand for water

30. Which of the following is the most feasible way to ensure we have enough water in Las Vegas in the future?
    a. Taking more water from Lake Mead
    b. Building more water treatment plants
    c. Using less water indoors
    d. Using less water outdoors

31. Which of the following is most effective for causing the biggest decrease in the amount of water we use (demand) in Las Vegas?
    a. Using less water on golf courses
    b. Using less water on our lawns
    c. Taking fewer showers and baths
    d. Washing our clothes less often

32. If a new type of "desert grass" that uses much less water and has all the same attributes as traditional grass was suddenly introduced in Las Vegas, what do you think would happen to water use?
    a. There would be no effect
    b. Demand would continue to grow, but would be reduced.
    c. Demand would lower to a stable, flat line.
    d. Demand would rise exponentially.

True/False Answer each of the following as T for True and F for False.

33. Las Vegas water problems can be fully solved by taking more water from Lake Mead	T	F
34. Water used outdoors adds to the water supply	T	F
35. Conserving water indoors is more important than conserving outdoors	T	F
36. All water, if not evaporated, eventually goes to the Wash and Lake Mead	T	F

37. The water uses in column A send water to a treatment plant after it is used. The water uses in column B do NOT send the water to a treatment plant after it is used. If we are trying to extend the time that water supply is greater than water demand in Las Vegas it is better to reduce uses in column B than uses in column A.

                                                                                                  T   F

A	B
washing clothes in a washing machine	watering the lawn
taking a shower	using the hose to wash the sidewalk

running the kitchen faucet   filling the swimming pool
washing your car at a car wash   washing your car in the driveway

Short Answer

    38. Describe the difference between indoor and outdoor water use in terms of their effect on water supply.

    39. If you were a manager in Las Vegas in charge of the water system, what would you do about the potential water problem in Las Vegas?

Appendix C: Examples of Slides from instruction and accompanying script.

8
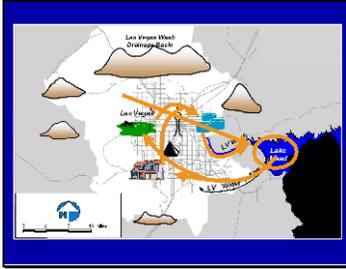
The bowl, the valley, is tilted toward the southeast.

[CLICK]
That means that the valley drains this way, down toward Lake Mead.
As I already said, we take most of our water supply from Lake Mead.
[CLICK]
We bring it into the city and use it in our houses, on golf course, and in businesses. After the water is used, the part that is used indoors is sent to the wastewater treatment plant [CLICK]
… where it is cleaned, …
[CLICK]… and then it is sent down the LV Wash back to Lake Mead.

9
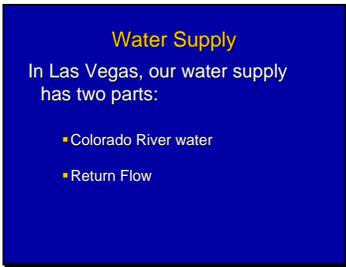
I have said that most of our water comes from Lake Mead.
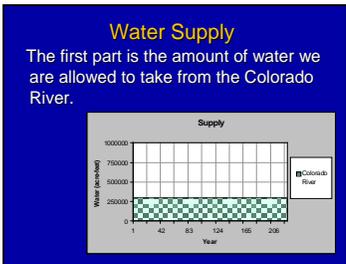But our water supply really has two parts.

[CLICK]
A **fixed** amount of water from the Colorado River, the amount we're allowed to take.

The second part is **variable** , something called "return flow".
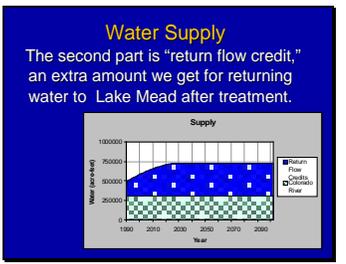[CLICK]

10

The first part is a fixed amount we are allowed to take from the Colorado River. That is 300,000 acre-feet per year.

[CLICK]

11

The second part is what is called "return flow credit". That is an extra amount we are allowed to take in exchange for returning water to Lake Mead after we clean it. The amount of return flow credit varies depending on the amount we use.

We only get return flow credit for the amount of water that is processed through our treatment plants.
[CLICK]

Appendix D: Datasheets for model group and Hypothesis-sheets for non-model groups
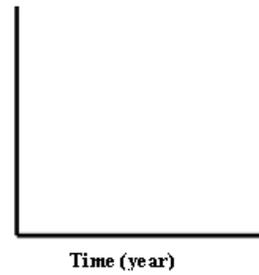
Simulation-based treatment

Datasheet

Scenario_____   ID# _____

| Fill in your changes. | What do you think will happen? Why? | What were the actual results? (include intersection point and Effort) |

Supply Choices
CO River Allocation
200,000 — 350,000
New Sources
0 — 20,000

Demand Choices
Residential Indoor Use
36 — 100
Residential Outdoor Use
0 — 130
Hotels & Casinos Use
0 — 20
Monthly Population Increase
0 — 7,000

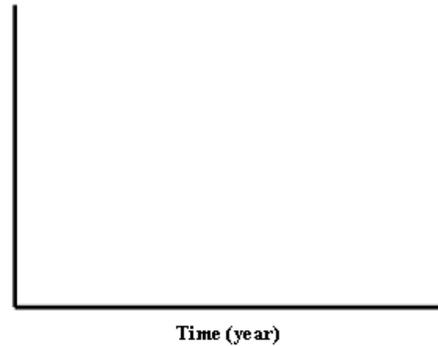Time (year)

Traditional treatment

Hypothesis Sheet

#____   ID# _____

Scenario/change:_____

How do you think this change would affect the system? Why?

Time (year)

Evaluating the Effectiveness of Simulation-based Instruction about Water Resources in Las Vegas

by

Stephanie Fincher

A thesis proposal submitted in partial fulfillment
of the requirements for the
Bachelor of Science Degree
Department of Environmental Studies
Greenspun College of Urban Affairs

Content Advisor:

Dr. Krystyna Stave, Associate Professor, Department of Environmental Studies, UNLV
kstave@ccmail.nevada.edu

ENV 499B Class Advisor:
Dr. Patrick Drohan, Assistant Professor, Department of Environmental Studies, UNLV,
patrick.drohan@ccmail.nevada.edu

University of Nevada, Las Vegas
14 May 2004