

# A Test of the Cue Summation Theory on Student Post-Test and Satisfaction in an Electronically-Delivered Unit of Instruction

Todd Brashears<sup>1</sup> and Matt Baker<sup>2</sup>  
Texas Tech University  
Lubbock, TX 79409



## Abstract

The development of electronic curriculum materials holds great promise and rewards for both educators and learners alike, but little research has been conducted to determine the effectiveness of incorporating multimedia components within an electronically-delivered unit of instruction. This research tested the theory of cue-summation (multiple cues across multiple channels) in a high school agricultural education setting and measured the effectiveness of the instruction and satisfaction level of the student. Curriculum materials were created and placed on compact disks (CD-ROM) for asynchronous delivery capability. Materials comprised a week-long unit of instruction on milk processing and were developed in three treatments; text-only materials, text and an audio/video component, and audio/video and still images. These three treatments represented single cue, redundancy, and cue summation, respectively. One-hundred and five high school agriculture education students participated in the study. Instrumentation used included a pretest/post-test for cognition as well as researcher-developed satisfaction and demographic instruments. The researchers found that students in treatments containing audio/video components scored significantly higher on the post-test than students who received text-only. Redundancy and cue-summation produced statistically similar post-test scores; however, students in the cue summation treatment group reported significantly higher satisfaction scores than students in the redundant condition group.

## Introduction

In the ever-changing world of education, trends, and innovations seem to come and go as often as classes of students. Teachers have little time to adopt new instructional techniques and curriculum before they are outdated and replaced with the “next big thing.” In this fluid environment, one innovation seems to have the potential to become not only a common educational instrument, but one that holds great promise for the future of education. Distance education is not a new concept. The origins

of this methodology can be traced back to correspondence courses, the so-called “home-study,” first formalized by the Chautauqua Institute in 1883 (Moore and Kearsley, 1996).

With the rise of the Internet, educational institutions now have the ability to not only transfer text-based materials, similar to the original correspondence courses, but to provide the student with hypertext, audio, video, interactive chat, and many other methods of instructional delivery. The teacher has now become a facilitator with the responsibility of collecting and disseminating information to the students in the most effective manner. Selecting a mode of delivery has become as important as the content.

For many facilitators, adequately learning and applying the knowledge needed to incorporate multimedia aspects into a distance-delivered course remains difficult. Computer programs, hardware, video cameras, microphones, and web-servers all play major roles in adding multimedia to a distance course. If facilitators at the secondary and post-secondary level are expected to invest a great deal of time and expense into producing a distance course, they should expect that their efforts will result in an increase in learning and retention by the student when compared to the traditional, text-only version.

## Theoretical Framework

This research was based on two theories of cognitive psychology. The overall theory was the theory of information processing. This theory focuses on how the human memory system acquires, transforms, compacts, elaborates, encodes, retrieves, and uses information. The model divides the memory system into three main storage structures: sensory memory, short-term memory, and long-term memory. Each structure is synonymous with a type of processing (Burton et al., 1995).

In the first type of memory, sensory memory, input is accepted primarily through sight and sound and is processed within three to five seconds. The sensory registers briefly hold the information until the stimulus is recognized or forgotten. According to Klatzky (1980), this assigns meaning to stimulus. For example, the letter “A” is recognized as a letter rather than just a

<sup>1</sup>Assistant Professor, Texas Tech University, Department of Agricultural Education & Communications, M.S. 2131; Phone: (806) 742-2816; Fax: (806) 742-2880; Email: Todd.Brashears@ttu.edu

<sup>2</sup>Professor and Department Chair, Texas Tech University, Department of Agricultural Education & Communications, M.S. 2131; Email: Matt.Baker@ttu.edu

group of lines. From the sensory memory, information travels to the short-term memory.

Information that is recognized and transferred to short-term memory can remain active for 15 to 20 seconds without rehearsal (Klatzky, 1980) and must be rehearsed, elaborated, used for decision making, or stored in long-term memory before it is forgotten. For this reason, Klatzky (1980) termed short-term memory, “working memory.” According to Miller (1956), the short-term memory has room for about seven chunks of information, plus or minus two, depending on the individual. Because of this limited cognitive capacity, information must be coded and stored into long-term memory.

Long-term memory is an unlimited and permanent storehouse of information that is complex in structure and function. Long-term memory receives information from both sensory memory and short-term memory. Information in the sensory registers is compared to information in long-term memory for recognition, and long-term memory stores input from sensory memory and short-term memory.

The second theory that applies to this study is cue summation, an information processing theory that deals specifically with learning and retention in a multimedia environment. The cue summation theory states that learning is increased as the number of available stimuli are increased (Severin 1967). Severin (1967) goes on to state that: “Multiple-channel communications appear to be superior to single-channel communications when relevant cues are summated across channels, neither is superior when redundant between channels, and are inferior when irrelevant cues are combined (presumably because irrelevant cues cause interference between them),” (p. 397). In other words, the stimuli provided on different channels have to be relevant to each other or the distraction would cause a decrease rather than an increase in learning and retention.

Severin (1968) found that the combination of auditory signals with a visual presentation, providing a different but related cue to the stimulus object, was more effective in producing recognition than a combination with a visual presentation of the same cue – a redundant condition.

## Purpose/Research Hypotheses

A unit of instruction on dairy processing was created using material provided by Instructional Materials Service (IMS) (Instructional Materials Service 1989). Three versions of this unit were

copied to CD-ROM and distributed to high school agricultural education students. The three treatment levels reflected the characteristics of the theory of cue summation (Severin 1967). The first treatment was a simple, text-only version of the curriculum (single cue). The second level included both text and an audio/video stream of the material (redundancy). The third treatment level used the same audio/video stream but replaced the text with relevant pictures (cue summation). Table 1 demonstrates the levels of the treatment. Students were asked to view the unit and complete the post-test on the material. Scores for high, low, and total cognition were recorded; however, the findings reported in this study are limited to total cognition and total satisfaction.

**Table 1. Treatment Levels of Delivery Method of Educational Content Based on Cue Combinations in Channels and Modes**

		Channels	
		Audio	Visual
Modes	Digital	Spoken word “pasteurizer” <sup>y,z</sup>	Printed word “pasteurizer” <sup>x,y</sup>
	Iconic	Sound of a pasteurizer in operation	Picture of a pasteurizer <sup>z</sup>

<sup>x</sup>Single Cue - Visual Channel, Digital Mode  
<sup>y</sup>Redundancy – Audio and Visual Channel, Digital Mode  
<sup>z</sup>Cue Summation – Audio and Visual Channel, Digital and Iconic Mode

The purpose of this study was to provide an asynchronous, electronically delivered unit of instruction to high school agricultural education students and compare performance based on the combination of channels used to provide the information. These channels (text, audio, video, and images) were incorporated in an instructional unit on milk processing and delivered to the students on CD-ROM.

## Research Hypotheses

As a means of accomplishing the purpose of the study, two major hypotheses were tested:

1. Within the constructs of a multimedia course, total student cognition will significantly increase as the number of differentiated channels used to deliver instruction increases, holding previous knowledge of the subject matter constant.

2. Students in treatment groups with material presented using cue summation will experience significantly greater course satisfaction than those presented with the redundant treatment and a single cue.

## Methods

### Population and Sample

The population for this quasi-experimental, non-equivalent control group design study (Gall, Borg & Gall 1996) included primarily first-year agricultural education students. The unit of instruction was administered by student teachers at six student teaching centers. Within these six schools, the entry-

## A Test

level agriculture course was taught in 12 classes, making up the sample for this study. Each of the 12 classes was then randomly assigned to a treatment group.

This sampling plan yielded a sample size of 169 students, with 50 students in treatment group one, 64 students in treatment group two and 55 students in treatment group three. During the course of the research, several issues came to light that would reduce the number of students in each treatment group. Mortality based on student transfers, failure to complete consent forms, and absences reduced the number of observations in each treatment group. Two classes were also removed for failure to complete the unit according to the instructions. These reductions resulted in 105 students that participated in all aspects of the study.

According to Gall et al. (1996), a group size of at least 15 observations is needed to accurately conduct experimental research, but in general, each group should be maximized as much as possible given researcher time and financial constraints. According to Kirk (1995), sample size can be calculated based on the number of levels of the independent variable being tested and the desired alpha level ( $\alpha$ ). In this case, the researchers were testing three levels of the independent variable and set the a priori alpha level at .05 for determining significance. In this case, group sizes of 21 subjects per treatment were required in order to meet these qualifications. The actual treatment groups of 26, 49, and 30 were more than required for this study.

### Instrumentation

The original pretest/post-test consisted of 10 true/false, 10 multiple-choice, and three short answer questions. The true/false and multiple-choice questions were derived from the two IMS curriculum unit tests provided in the teacher's guide (Instructional Materials Service 1989). The true/false questions were used exactly as presented by IMS, but the multiple choice questions were created from short answer and fill-in-the-blank type questions. Test alteration was done in order to ensure accuracy and constancy of scoring the instrument. The first 20 questions were all lower-level cognition items requiring only the memorization of facts in order to select the correct answer. These questions were written to match the objectives of the unit as stated by IMS.

The last three questions were researcher-developed, open-ended questions that allowed for higher order thinking in the responses as defined by Newcomb and Trefz (1987). The information in these three questions was not taught directly in the course of the unit, but required students to evaluate the information they had learned and apply it to a new situation.

Great care was taken by the researchers to ensure that items accurately reflected the con-

structs within the curriculum. Content and face validity of the pretest/post-test was verified by a national panel (Gall et al., 1996) of food science, dairy science, and dairy processing faculty members. Minor changes were made based on the panel's recommendations.

A sample of eighteen students was selected to pilot test the instrument for reliability. The students were instructed to carefully consider each question and make their best attempt to determine the correct answer. These scores were entered into Microsoft Excel® as 1 (correct answer) and 0 (incorrect answer). SPSS 11.0 was used to determine the KR-20 coefficient alpha. The results of this analysis yielded an  $r = .52$ . This process also determined that three of the original 20 questions were negatively impacting the reliability of the instrument. Eliminating these questions resulted in an  $r = .83$ . The three items which negatively impacted the reliability of the instrument were permanently deleted from the pretest/post-test before it was administered to the study participants. This yielded 17 true/false, multiple-choice questions as well as three open-ended, short answer questions. The post-hoc reliability score was  $r = .77$ .

Following the completion of the unit, students were administered an instrument to determine satisfaction levels. This instrument was designed to determine student satisfaction in three areas: Clarity, Delivery, and Content. Each section was comprised of five questions and allowed students to answer using a Likert-type scale with one being "Strongly Disagree" and five being "Strongly Agree." Face and content validity were verified using a team of three faculty members who possessed knowledge and experience in creating similar instruments. In order to determine reliability, a pilot test was conducted using 35 agriculture students enrolled in similar distance education courses. Cronbach's alpha was calculated on the items and was  $\alpha = .90$ , which remained constant in a post-hoc reliability test.

### Data Collection

Students in the selected schools were given an informed consent form to be read and signed by their legal guardians. The researchers traveled to each school to collect these forms as well as demographic data.

During these visits, the researchers administered the pretest. Data from the pretest and demographic instrument were coded and entered into SPSS for analysis at a later time. The informed consent forms were collected from the students and coded 1 (allowed) and 0 (disallowed) into the same database. Only data collected from students who were allowed to participate were included in the final statistical analysis.

The student teachers involved in the data collection process participated in a training session during the four-week, on-campus "block" before their field work began in the fall of 2003. During the week of Oct. 6-10, 2003, the student teachers facilitated the unit of



instruction, conducted the laboratory experiment, collected homework, and administered the post-test. All materials were returned and the tests were graded by the team of researchers.

**Analysis of Data**

Data were collected and imported to SPSS version 11.0 for Windows for analysis. In order to analyze the data on student cognition, several techniques were used. The student pretest was correlated to the post-test to determine the relationship between the two instruments. Trochim (2001) suggests that in order to use Analysis of Covariance (ANCOVA), the pretest should be highly correlated to the post-test. If a high correlation exists ( $r > .7$ ), it is recommended that ANCOVA be used to hold previous student knowledge constant by mathematically adjusting the post-test scores. A moderate or low ( $r < .7$ ) allowed the researchers to disregard the pretest scores and conduct a one-way Analysis of Variance (ANOVA) to determine the effect of the treatment groups on the post-test score. Contrast coding was used to determine differences in groups when the ANOVA indicates a statistically significant difference between treatment group scores. Treatment one was compared to treatments two and three, then treatment two was compared to treatment three.

Another purpose of using contrast coding was to check for the presence of trends in the data. The shape of the functions relating the treatment levels to the level of cognition were of interest to the researchers. SPSS for Windows 11.0 was used to determine effect size and was reported as eta squared ( $\eta^2$ ). In general,  $\eta^2$  is interpreted as the proportion of variance of the dependent variable that is related to the factor. Traditionally,  $\eta^2$  values of .01, .06, and .14 represent small, medium and large effect sizes, respectively (Green et al., 2000). In order to analyze the data on student satisfaction a similar technique was used.

**Results and Discussion**

**Research Hypothesis 1. Cognition Gain**

A Pearson Product Moment Correlation was calculated to determine the relationship between the pretest total score and the post-test total score. The resulting value for this calculation was determined to be  $r = .16$ . Because this value was less than  $r < .70$  (Trochim, 2001), a one-way ANOVA was conducted to evaluate the relationship

between total cognition and the three treatment levels of the independent variable. The dependent variable for this research hypothesis was the student's total

**Table 2. Changes in Total Post-test Scores for Text-Only Treatment, Text + Audio/Video Treatment, and Images + Audio/Video Treatment**

Group	n	M <sup>x</sup>	SD
Text-Only	26	11.19	2.980
Text + A/V	49	13.80	3.840
Images + A/V	30	13.72	3.923
Total	105	13.13	3.805

Source	SS	df	MS	F	p	$\eta^2$
Between	129.675	2	64.837	4.805	.010	.086
Within	1376.339	102	13.494			
Total	1506.014	104				

<sup>x</sup> 20-point scale

cognition for the unit of instruction as measured by the post-test total score for each individual student. Results of the one-way ANOVA are reported in Table 2.

The ANOVA was statistically significant,  $F(2, 102) = 4.805, p = .010$ . The strength of the relationship between the three treatments and the post-test score, as assessed by SPSS, was medium with the three treatment levels accounting for 8.6% of the variance of the dependent variable. Levene's statistic (Gall et al. 1996) was calculated to determine homogeneity of variances. The results of this test were not significant,  $F(2, 102) = 2.963, p = .056$ , therefore the researchers assumed that the variances of the three treatment groups were not significantly different from each other. Contrast coefficients (Gall et al. 1996) were used to evaluate differences among the means. Two contrast groups were created. Contrast one compared treatment one (text-only) to treatments two (text + Audio/Video (A/V)) and three (images + A/V). Contrast two compared treatments two and three.

Table 3 indicates that there was a statistically significant difference  $t(102) = 3.06, p = .003$ , between the text-only treatment and the treatments containing A/V components and that there was no statistically significant difference  $t(102) = -.09, p = .926$ , between treatments two and three. The groups that received an audio/video component in the curriculum scored significantly higher than the group that received the text-only treatment. There was no difference in the Second and Third treatments. A significantly linear trend was detected  $F(1, 102) = 6.578, p = .012$  as can be seen in Figure 1. Participants who received audio/video components in the unit of instruction scored 8.68% higher on the post-test than students who received text without an audio/video component.

**Table 3. Comparison of Treatment Effects on Cognitive Post-test Scores**

Contrast	Treatment 1 (text-only) <sup>x</sup>	Treatment 2 (text + A/V) <sup>x</sup>	Treatment 3 (images + A/V) <sup>x</sup>	Value of Contrast	Std. Error	t	df	p
1	-2	1	1	5.13	1.67	3.06	102	.003
2	0	-1	1	-.08	.90	-.09	102	.926

<sup>x</sup> Coding for contrasts.

## A Test

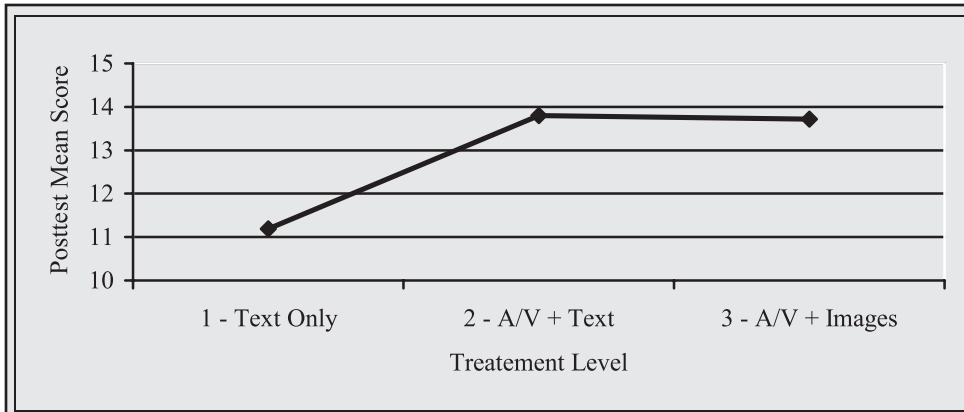


Figure 1. Cognitive Post-test Mean Score by Treatment ( $F_{Linear}(1, 102) = 6.578, p = .012$ ).

### Research Hypothesis 2. Course Satisfaction

An ANOVA was conducted to determine the relationship between total student satisfaction with the unit of instruction and each of the three treatment levels. The dependent variable in this ANOVA test was the sum of scores for the three satisfaction categories. Results of the General Linear Model (GLM) ANOVA (Gall et al. 1996) for total satisfaction of curriculum material are reported in Table 4.

Table 4. Differences among Treatment Groups on Total Satisfaction

Group	n	M <sup>x</sup>	SD
Text-Only	26	53.38	7.955
Text + A/V	42	48.88	10.787
Images + A/V	30	54.87	13.505
Total	98	51.91	11.282

Source	SS	df	MS	F	p	$\eta^2$
Between	704.148	2	352.074	2.873	.061	.057
Within	11642.025	95	122.548			
Total	12346.173	97				

<sup>x</sup> 75-point scale

The ANOVA was determined to be not significant,  $F(2, 95) = 2.873, p = .061$ . A visual analysis of these data in graphic form indicated that a quadratic relationship may have existed; therefore, the GLM ANOVA was conducted a second time incorporating the quadratic function into the model. Results for this analysis are shown in Table 5.

The quadratic model indicates a statistically significant difference  $F(1, 95) = 5.375, p = .023$  between total satisfaction with the unit of instruction and the treatment level. Figure 2 indicates the quadratic nature of the trend. The strength of the relationship between the three treatments and the

Table 5. Differences among Treatment Groups on Total Satisfaction in a Quadratic Model

Group	n	M <sup>x</sup>	SD
Text-Only	26	53.38	7.955
Text + A/V	42	48.88	10.787
Images + A/V	30	54.87	13.505
Total	98	51.91	11.282

Source	SS	df	MS	F	p
Between	704.148	2	352.074	2.873	.061
Linear	30.594	1	30.594	.250	.618
Quadratic	658.714	1	658.714	5.375	.023
Within	11642.025	95	122.548		
Total	12346.173	97			

<sup>x</sup> 75-point scale

Table 6. Comparison of Treatment Effects on Total Satisfaction for Unit of Instruction

Contrast	Treatment 1 (text-only)	Treatment 2 (text + A/V)	Treatment 3 (images + A/V)	Value of Contrast	Std. Err.	t	df	p
1	-2	1	1	-3.02	5.09	-.594	95	.554
2	0	-1	1	5.99	2.65	2.646	95	.026

total satisfaction score as assessed by SPSS, was low with the three treatment levels accounting for 5.7% of the variance of the dependent variable.

Two contrast groups were created (Field 2000). Contrast one compared treatment one (text-only) to treatments two (text + A/V) and three (images + A/V). Contrast two compared treatments two and three. Results from the contrast tests are shown in Table 6.

Table 6 indicates there was no statistically significant difference  $t(95) = -.594, p = .554$ , in total student satisfaction for the unit of instruction between the text-only treatment and the two treatments containing an audio/video component. There was, however, a statistically significant difference  $t(95) = 2.646, p = .026$ , between treatment two and three for satisfaction of delivery. Students in these treatment groups were significantly more satisfied with treatment three (images + audio/video) than with treatment two (text + audio/video).

## Summary

The results of this study indicate that a linear relationship exists between the number of differentiated channels and student post-test scores gained from the electronic unit of instruction, but the hypothesis was found to be untrue as student cognition increased significantly between

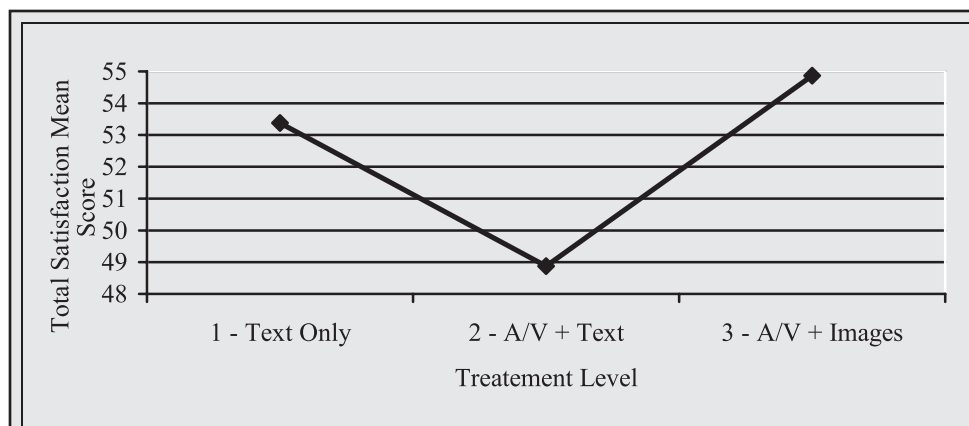


Figure 2. Total Satisfaction of Curriculum Mean Score by Treatment ( $F_{\text{Quadratic}}(1, 95) = 5.375, p = .023$ ).

treatments one and two but not significantly between treatments two and three. Severin (1968) stated that true cue-summation would lead to significantly more learning than single channel or redundant cues within the same channel. This study failed to confirm that supposition. The reason for this may be found in arguments made by Cushman (1973) who stated that a second channel had to add new information to the cues of the first channel or there could be no summation. If this is the case, then redundancy is taking place rather than cue-summation. The researcher's efforts to prevent this may have proven inadequate and produced two treatments of redundancy. Severin (1967), Cushman (1973), and Nugent (1982) determined that multiple cues (either redundancy or cue-summation) were superior to single channel cues. This research confirmed those findings in that students who were administered treatments containing multiple cues performed significantly higher than students who received only a single cue. This would indicate that providing multiple cues for students would be beneficial in the learning process, however, attempting to create cue summation may be more difficult than is practically feasible for most teachers.

The research also found that student satisfaction is not related linearly to redundancy and cue summation. Students who completed units comprised of the single cue were not significantly more satisfied than those who received multimedia components in the cue summation treatment group. Students who were administered units created using cue summation were, however, significantly more satisfied than those receiving redundant cues.

### Recommendations

The researchers caution against generalizing these findings outside the population used for this research; however certain recommendations can be made based on the findings that apply to courses delivered using electronic distance methods at the secondary and post-secondary levels.

### Recommendations for Improvement of Practice

The research presented here indicates that in the electronic format commonly used for distance education delivery, both redundancy and cue-summation are superior to a single cue in producing higher cognition levels. Researchers, teachers, and instructional designers should make concerted efforts to incorporate the use of multimedia content into future efforts. Because there was no difference in student performance between redundancy and cue summation, the researchers suggests using cue summation when possible because of the significant increase in student satisfaction scores.

### Recommendations for Further Research

The United States Department of Education, USDE (2003) makes several recommendations for research practices to ensure the quality and quantity of empirical evidence meets standards acceptable for use in general education settings. This research followed those guidelines in regards to the planning, collection and analysis of data, but several improvements could be made to improve future research. The USDE states: "A general guideline is that the study should lose track of fewer than 25% of the individual originally randomized – the fewer lost the better. This is sometimes referred to as the requirement for 'low attrition.'"

This study lost roughly 38% of the original participants through course transfers or administrative removal. This limitation should be addressed by future researchers and measures should be taken in order to reduce or eliminate student attrition during the course of the study.

A second area of concern based on the USDE recommendations has to do with long-term outcomes. The guideline from the USDE (2003) reads: "The study should preferably obtain data on long-term outcomes of the intervention so that you can judge whether the intervention's effects were sustained over time."

The final area of concern deals with sample size for finding a statistically significant result. The USDE (2003) recommends 50 to 60 classrooms or 300 individuals, contrary to Kirk (1995) whose calculations were used to arrive at the minimum for this study of 21 individuals per treatment group. We recommend that the observations be maximized to the fullest extent of the researcher's abilities and funding.

Given these guidelines, the researchers suggest that further research on populations outside the

## A Test

limited geographical scope of this project. It will be important for future researchers to make every attempt to increase population size to the point that classrooms could be the unit of observation rather than individual students, requiring a minimum 45 classes. Future research should also focus on determining the effects of scheduling variations on student performance. Additional creation and testing of multimedia curriculum should be conducted in an effort to determine the internal effects and nuances of cue-summation with a variety of images in an effort to select the most effective delivery method.

## Literature Cited

- Burton, J.K., D.M. Moore, and G.A. Holmes. 1995. Hypermedia concepts and research: An overview. *Computers in Human Behavior* 11(3-4): 345-369.
- Cushman, D.R. 1973. The cue summation theory tested with meaningful verbal information. *Visible Language* 7(3).
- Field, A. 2000. *Discovering Statistics Using SPSS for Windows*. Thousand Oaks, CA: Sage Publications.
- Gall, M.D., W.R. Borg, and J.P. Gall. 1996. *Educational research: An introduction*. 6th ed. New York, NY: Longman.
- Green, S.B., N. Salkind, and T. Akey. 2000. *Using SPSS for windows: Analyzing and understanding data*. 2nd ed. Boston, MA: Prentice-Hall.
- Instructional Materials Service. 1989. *Food Science and Technology*. Department of Agricultural Education. Texas A&M University & Texas Education Agency. Austin, Texas.
- Kirk, R.E. 1995. *Experimental design. Procedures for the behavioral sciences*. 3rd ed. Pacific Grove, CA: Brooks/Cole Publishing Co.
- Klatzky, R.L. 1980. *Human memory: Structures and processes*. New York, NY: W.H. Freeman.
- Miller, G.A. 1956. The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review* 63: 81-97.
- Moore, M.G. and G. Kearsley. 1996. *Distance education: A systems view*. Belmont, CA: Wadsworth Publishing Company.
- Newcomb, L.H. and M.K. Trefz. 1987. Levels of cognition of student tests and assignments in the College of Agriculture at The Ohio State University. In: *Proceedings of the Central Region 41st Annual Research Conference in Agricultural Education*, Chicago, Illinois, Feb.
- Nugent, G.C. 1982. Pictures, audio, and print: Symbolic representation and effect on learning. *Educational Communication and Technology* 30(3): 163-74.
- Severin, W.J. 1967. Another look at cue summation. *AV Communication Review* 15(4): 233-245.
- Severin, W.J. 1968. Cue summation in multiple-channel communication. Report from the media and concept learning project. Wisconsin Research and Development Center for Cognitive Learning. The University of Wisconsin, Madison.
- Trochim, W.M. 2001. *The Research Methods Knowledge Base*, 2nd ed. Cincinnati, OH: Atomic Dog Publishing.
- United States Department of Education. 2003. *Identifying and implementing educational practices supported by rigorous evidence: A user friendly guide*. Washington, DC: U.S. Government Printing Office.