USING SAS IN EDUCATIONAL RESEARCH

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ABSTRACT

This paper will present a variety of applications of using SAS for the data analyses in educational research. Research topics vary from instructional design, multimedia courseware development, online education, to technology integration, and student attitudes. SAS procedures used in these studies include: analysis of variance, repeated measurements, multiple regression, and logistic regression. Data analysis procedures and results of the studies will be introduced.

INTRODUCTION

In educational research, statistic tools are used in most quantitative studies to describe, compare, or correlate the relevant variables. Among those statistics tools, SPSS is one of the widely used statistics software by educators. However, compare with SPSS, SAS is friendlier in data management especially for data of large size from multiple sites, provides more functions of various data analyses, and produces better plots (Liu, 2002; Liu & Fernandez, 1999). The issue is, for most educators, the learning curve of SAS is relatively longer than that of SPSS, and SAS procedures are more complex. Besides, educators are not programmers; they may not be very good at playing around with either SAS or SPSS coding. It is the author's hope to introduce some convenient ways of using SAS that work for educators. This paper will also demonstrate how to use certain well developed SAS macros for data analysis.

Research topics introduced in this paper vary from instructional design, multimedia courseware development, online education, to technology integration, and student attitudes. SAS procedures used in these studies include: analysis of variance, repeated measurements, multiple regression, and logistic regression. The following are four examples, and in each example demonstrated are: purpose of the study, research questions, variables examined in the study, statistics method, procedures to call SAS macros, and results of the studies.

USING ANALYSIS OF VARIANCE

The first example is a study in which one-way mixed ANOVA is used for data analysis.

Purposes and Research Questions

The purpose of this study was to investigate the effectiveness of three methods of system analysis in designing the navigations of a multimedia application. The three methods of system analysis are: (a) free style method, (b) outline method, and (c) structured modeling method.

The following research questions were examined in this study:

1. Is there any difference between the navigation designs of a multimedia application produced from *free style* system analysis method and with *structured modeling* system analysis method?
2. Is there any difference between the navigation designs of a multimedia application produced from *outline* method and with *structured modeling* method?
3. Is there any difference between the navigation designs of a multimedia application produced from *free style* method and with *outline* method?

Subjects

The subjects of this study are 45 teacher education students enrolled in a basic computer technology course in an eastern state university. The subjects' ages range from 18 to 42 (the average age was 22.36), including 11 males and 34 females. Around 90% of them have no previous computer skills, beyond using a word processor.

Variables Examined in the Study

Independent variables are the three methods of system analysis: (a) free style method, (b) outline method, and (c) structured modeling method.

Dependent variable is the measurement of navigation-design score that is the sum of three link-measurements. (1) Linear links. This was the lowest level of links--the cards are linearly connected, from one card to the next card, from first card to the last card in one direction. Linear links would be scored 10 points. (2) Layers of links. This was the medium level of links—the cards are connected in several layers. Each layer would be scored 4 points. (3) Interactions. This was the highest level of links. Two kinds of interactions were measured: (a) interactions among cards in one layer scored 5 points; (b) interactions among cards across two layers scored another 5 points, and across three layers for another more 5 points.

Research Method and Data Analysis

Subjects were randomly assigned to the three groups. Therefore, it was assumed that all other conditions were under control and different system analysis methods would result in the differences of the navigation designs. According to the design of this study, one-way ANOVA was used for data analysis.

Procedure to Call SAS Macro

A SAS macro FIXANOVA (Fernandez, 1997) was used to perform the data analysis. The macro has been fully developed, we only need to run it for current data set to perform one-way ANOVA. The following procedures were used to call the macro:

```
%INC 'a:\macro\fixanova2.mac';
%fixanova(
DATA =  sysplan   ,/*RQ: SAS data name */
TRT    =  trt  , /*RQ: Treatment variable name*/
RESP   =  resp  , /*RQ: Response variable name*/
CLASS  =  trt     ,      /*RQ: List the
classification factors */
MODEL  =  trt     , /*RQ: List the model terms */
GROUP =  trt ,/*RQ: Treatment group for  box plot */
MEAN= %str(trt),/*Factor name for mean comparison */
ALPHA  =  0.05  , /* Specify the alpha level
options: 0.05 0.01 0.001 */
OTHMEAN  = lsd, /* Mean comparison option: lsd tukey
dunnett dunnettu duncan snk bon scheffe waller*/
ADJUST   =  %str()  , /* P-value adjustment in
lsmean options: adjust=TUKEY */
ANALYSIS =  standard, /* options: standard boxcox
robust arcsin  */
NTRT =  3  , /* Number of treatment levels */
POWER = yes,/*Power calculations options: yes  no */
NONPAR= yes,/*Non-parametric tests options:yes no */
METHOD =  wilcoxon, /* Nonparametric tests options:
wilcoxon median savage */
PLOT  =  oneql,/* Specify the type of plot: oneql */
MCMTD  =  tukey   , /*RQ: Mean comparison plot
options: lsd bon  tukey */
I     =  1,      /* ith response or ith model */
DIR =a:\plot,/* Folder to save the Graphics files */
OUTPUT = a:\listfile,/* Folder to save the output */
DEV   =  win   , /* Graphic  devices options: win
CGMWPCA cgmmwwc wmf hpgl */
EST  =
CONTRAST  ' a vs b'           trt  1    -1     0  ;
CONTRAST  ' c vs ean of (a,b)' trt  -1   -1     2  ;
CONTRAST  ' b vs c '           trt  0     1    -1  ;
CONTRAST  ' a vs c '           trt  1     0    -1  ;
ESTIMATE ' a vs b'             trt  1    -1     0  ;
ESTIMATE ' c vs mean of (a,b)' trt  -1    -1    2
/ DIVISOR=2 ;
ESTIMATE ' b vs c  '           trt  0     1    -1  ;
ESTIMATE ' a vs c'             trt  1     0    -1  ;
/*list contrast or estimate treatments*/
                              )      /* list any
optional contrast/estimate statements*/
```

Results

First, the results of descriptive analysis showed that the mean of free style group (group A) was 9.93, the mean of outline method group (group B) was 22.36, and the mean of structured modeling method group (group C) was 36.70.

Second, the results of analysis of variance show that significant differences among the three groups were found ($F_{2,42} = 55.34$, $p < 0.0001$), indicating that the treatments—the three system analysis methods—did make difference in the response variable, the link designs.

Third, a comparison analysis was performed to determine where the differences were. The results show that all three *F* ratios are significant, indicating that (1) significant differences were found between free style group and outline group ($F_{1,28} = 22.81$, $p < 0.0001$); (2) significant differences were found between outline group and diagram group ($F_{1,28} = 32.84$, $p < 0.0001$); (3) significant differences were found between free style group and Structured modeling/diagram group ($F_{1,28} = 110.38$, $p < 0.0001$).

USING REPEATED MEASUREMENTS

The second example is a study in which repeated measurements are used for data analysis.

Purposes and Research Questions

The purpose of this study was to investigate the quality of information from different Web sources, and provide guidelines for college students' research. Four Web sources are evaluated in this study: ".com", ".org", ".edu", and ".gov". Research question investigated in this study is:

1. Is there any differences among the quality of information form the four Web sources (".com", ".org", ".edu", and ".net") in terms of the accuracy, authority, coverage, currency and verifiability of the information?

Samples

Samples of the study are 1025 pieces of randomly selected Web information including articles, reports, news, and statistics, in which 256 are from ".com" web sites, 255 from ".org", 258 from ".edu" and 256 from ".gov".

Variables and Data Analysis Method

The dependent variable in this study is the quality of information. The quality of each piece of information is evaluated in terms of its five quality ceriteria (accuracy, authority, coverage, currency and verifiability), and each criteria is scored from 1 to 5. According to the purpose of the study, repeated measurements are performed for data analysis, comparing the information quality from four web sources (".com", ".org", ".edu", and ".net"), and repeatedly measured the information quality at five indicator levels.

Procedure to Call SAS Macro

A SAS macro MIXANOVA (Fernandez, 1997) was used to perform the data analysis. To run the macro for current data set to perform repeated measurements, the following procedures were used to call the macro:

```
%INC 'a:\macro\MXanova2.mac';
%MIxanova(
DATA  =  mxrepeat   ,/*RQ: name the SAS data set */
TYPE  =  explor     , /*RQ: Type of analysis options: Explor Mixed */
ANALYSIS =standard,/*RQ: options: Standard ROBUST */
TRT  =  trt  ,  /*RQ: name the treatment variable */
RESP =  resp,  /*RQ: name the response variable */
CLASS =  TYPE rep evalu , /*RQ: List the classification factors */
GLMMODEL =  TYPE rep(TYPE) evalu TYPE*evalu , /* RQ: List the model terms */
GLMDATA  =  glrepeat    , /*RQ: SAS data set name for GLMRM analysis */
RCLASS    =  TYPE rep  , /*RQ: List the classification factors for GLM  RM analysis*/
RRESP     =  acc aut cur cov ver ,  /*RQ: list RM variables for GLM RM analysis */
RMOD =TYPE,/*RQ: list RMmodel for GLM RM analysis */
RLEVEL =  evalu 5      , /*RQ Identify the RM factor and levels for GLM  RM analysis */
CONTRAST = %str (CONTRAST)   , /* Specify the contrast transformation options: %str(()polynomial) contrast  helmert  mean profile */
DIR = a:\plot,/* Folder to save the Graphics files */
OUTPUT = a:\listfile ,/*Folder to save the output */
DEV   =  win    /* Graphic  devices options: win cgmwpwa cgmmwwc wmf hpgl */
```

Results

	Accuracy	Authority	Coverage	Currency	Verifiability
.com	3.63	2.76	2.77	4.36	2.45
.edu	4.38	4.19	4.21	3.52	3.18
.gov	3.63	4.45	2.83	3.42	3.75
.org	3.59	3.66	3.65	2.62	2.52

Table 1. Mean Scores

First, the mean information quality scores form the four Web sources at the five quality criteria are shown in Table 1.

Second, the results of repeated measurement show that significant differences among the four web sources were found ($F_{3, 1018} = 198.26$, $p < 0.0001$), among the five quality criteria ($F_{4, 4117} = 445.08$, $p < 0.0001$), and the interaction between Web-source and quality criteria is significant ($F_{12, 4117} = 445.08$, $p < 0.0001$). The locations of differences are shown in Figure 1.

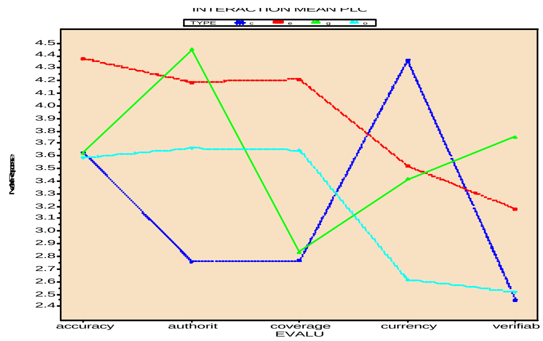

Figure 1. Interaction Mean Plot

USING MULTIPLE REGRESSION

The third example is a study in which multiple regression is used for data analysis.

Purposes and Research Questions

The purpose of this study is to investigate the relationships students' attitudes, time spent on computer, and learning achievements, specifically, to examine whether time spent on computer is an intermediate variable between computer attitudes and computer achievements. Student attitudes are expressed from four aspects: (1) *Enjoyment*—the degree to which students enjoy learning and using technologies (Temple & Lips, 1989; Cooper & Stone, 1996; King & Bond, 1996; Liu & Johnson, 1998; Christensen & Knezek, 2001); *Motivation*—the degree to which students are willing to learn and use technologies (Clariana, 1993; Kellenberger, 1996; Liu & Johnson, 1998, 2001; Christensen & Knezek, 2001); *Importance*—the extent to which students see learning and using technologies as important (Pelton & Pelton, 1996; Corston & Colman, 1996; Liu & Johnson, 1998, 2001); and *Computer Anxiety*—the degree of fear which students feel while learning and using technologies (Schumacher, Morahan-Martin, & Olinsky, 1993; Ayersman,1996; Liu, 1997; Christensen & Knezek, 2001).

The research questions examined in this study are:

1. To what extent can time spent on learning and using computer technologies be predicted from the computer attitude measures (*Enjoyment*, *Motivation*, *Importance*, and *Freedom from Anxiety*)?
2. To what extent can computer achievement be predicted from the measures of time spent on learning and using computer technologies?

Subjects

Subjects in this study were 609 teacher education students who had been enrolled in an introductory computer technology course over three semesters. The course was required for all teacher education students in the College of Education. The subjects' ages ranged from 18 to 51 (the average age was 23.26), including 381 females and 228 males. Around 80% had no previous computer skills, beyond using a word processor.

Variables and Data Analysis Method

Totally six variables involved in this study: computer achievement, time spent on the computer, and four attitude variables – enjoyment, motivation, importance, and computer anxiety. The measurement of computer achievement was the students' final score for that computer technology course. The measurement for the "*Time* spent on computer" variable was the self-reported average time (minutes) an individual spends on learning or working with a computer per week. Four computer attitude variables are measured by a Likert-type questionnaire consisting of 24 statements (Liu & Johnson, 1997).

According to the purpose of the study, two sets of regression analyses are performed. First, four attitude variables (predictor variables) are regressed to time (response variable); and second, time (predictor variable) is regressed to computer achievements (response variable).

Procedure to Call SAS Macro

A SAS macro MULTLREG (Fernandez, 1996) was used to perform the data analysis. To run the macro for current data set to perform repeated measurements, the following procedures were used to call the macro:

```
data compu7
…… (the combinations of the terms)                ;
run;
%inc 'a:\macro\multlreg.mac';
%multlreg(data  =compu7 , /*RQ: SAS data set name */
resp = x8 , /*RQ: Response variable */
pred = x1 x2 x3 x4   , /*RQ: Predictor variables */
term = x1 x2 x3 x4            , /*RQ: model terms */
weight= %str(       ),/*WLS option: Weight _wt_ ; */
other  =          , /* Other model options: noint */
test   = %str(        ), /* Parameter test option */
restrict = %str(          ), /* Restricted option */
ci = 95                  , /* Level of Confidence */
allcomb = x1sq x2sq x3sq x4sq x1x2 x1x3 x1x4 x2x3
x2x4 x3x4 x3x5, /* B_P test terms  */
size  = 1     , /* Font Size of title and axis */
dir = a:\plot     , /* Directory to save graphs */
dev = win )/* Change to "CGM" to save your graphs */
```

Results

The results from first regression analysis show: (1) the model is significant (F = 370.849, p<0.0001), indicating that at least one of the coefficients was not zero. (2) The linear regression trend was significant (F = 553.1, p<0.0001), indicating that the linear model was the desired model that represented the data better than other regression models. According to this, the model should include only *linear* terms (of the four predictor variables) that significantly contributed to the response variable (*Time*). (3) The t statistics for the four predictor variables were significant: *Enjoyment* (t = 6.493, p< 0.0001), *Motivation* (t = 7.248, p< 0.001), *Importance* (t = 4.724, p<0.0001), and *Freedom from Anxiety* (t = 18.889, p< 0.0001), so the linear terms of all four variables should be included into the model. The regression equation generated from the results is:

$$Y = -428.15 + 15.22\,(X1) + 3.34(X2) + 16.02(X3) + 5.57(X4)$$

The four attitude variables have linear relationship with time spent on computer, and can be used to predict time spent on computer.

The results from second regression analysis show that time spent on computer contribute significantly to computer achievements. The regression equation generated from the results is:

$$Y = 42.35 + 0.24\,(X)$$

Therefore, we conclude that time is the intermediate variable between computer attitudes and achievements, the relationships can be seen in Figure 2.

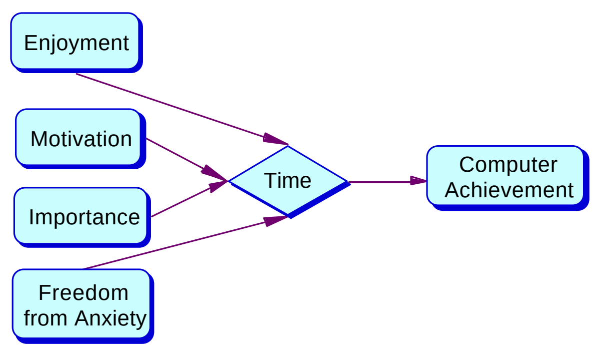

Figure 2. Time as Intermediate Variable

USING LOGISTIC REGRESSION

The fourth example is a study in which logistic regression is used for data analysis.

Purposes and Research Questions

The purpose of this study was to develop a technology integration model that can guide educators through necessary procedures of technology integration, and to identify what works and what does not work. Six instructional components were examined: (1) use of software – Type I or Type II applications, (2) use of Web-based instruction, (3) use of Web information resources, (4) use of problem-based learning, (5)instructional design methods – constructivism or behaviorism approach, and (6) use of multimedia courseware. According to the purpose of the study, we will determine whether or how these six variables influence the success of a technology integration case. The research questions examined in this study were:

1. Is there any relationship between each of the six technology integration instructional variables (Use of Software, Use of Web-Based Instruction, Use of Web Information Resources, Use of Problem-Based Learning, Instructional Designs, and Designing Multimedia Courseware) and the success of technology integration?
2. Can one or more of the six instructional variables predict the probability of a technology integration case to be successful?

Sample

The sample of this study was 102 technology integration case that covered all curriculum areas from preschool through graduate school, including 67 K-12 cases, 24 higher education teacher training cases, and 11 in-service teacher training cases.

Variables and Data Analysis Method

According to the purpose of the study, logistic regression was performed to determine whether the six instructional variables (as predictor variables) can be used to predict the probability of a technology integration case to be successful – the outcomes of the cases (response variable Y). The coding for the variables is shown in Table 2.

Response Variable	Explanatory Variables	1	0
(Y) Outcomes		Successful	Unsuccessful
	(X1) Use of Software	Type II	Type I
	(X2) Use of Web-Based Instruction	Yes	No
	(X3) Use of Web Information Resources	Yes	No
	(X4) Use of Problem-Based Learning	Yes	No
	(X5) Instructional Design	Constructivism	Instructivism
	(X6) Designing Multimedia Courseware	Yes	No

Table 2. Variable Coding in Logistic Regression

Procedure to Call SAS Macro

A SAS macro LOGITREG (Fernandez, 1996) was used to perform the data analysis. To run the macro for current data set to perform repeated measurements, the following procedures were used to call the macro:

```
data tech;
set tech;
%inc 'a:\macro\logitreg.mac';
%logitreg(
   data   = tech, /*RQ: SAS data set name */
   resp  = y      , /*RQ: Response variable */
   pred  = x1 x2 x3 x4 x5 x6, /*RQ: Predictor
   variables */
   term= x1 x2 x3 x4 x5 x6,/*RQ:model terms
   */
   other= ,/*Other model options:influence */
   test   = %str(            )    , /*
   Parameter test option */
   alpha   = 0.05                      ,
   scale   = none                      , /*
   Correction using:"Deviance" or "Pearson"*/
   size = 1,/* Font Size of title and axis */
   dir =a:\plot,/*Directory to save graphs */
   dev = win   ) /* Change to "CGM" to save
   your graphs */* RQ: Required values ;
```

Results

First, model selection was performed; three logistic regression runs were conducted with different combination of variables (see Table 3). To determine the best model, the AIC (Akaike Information Criterion) values, a goodness-of-fit measure, were compared. Since smaller AIC value indicates a more desirable model, the model (Model 3)that contains only three variables (use of software, use of problem-based learning, and instructional design method) was selected, as it has the smallest AIC value.

Models	AIC Values	Best Model
Model 1 (X1—X6)	76.899	
Model 2 (X1—X5)	75.995	
Model 3 (X1, X4, & X5)	74.389	√

Table 3. Akaike Information Criterion Values for Model Selection

Also, the receiver operating characteristic (ROC) curve, plotted from this model (See Figure 3), rises quickly and the area under the curve is considerably large, indicating that this logistic regression model has high predictive accuracy. This model indicated that the combination of the relationship between the instructional variables and the probability of a technology integration case being successful.

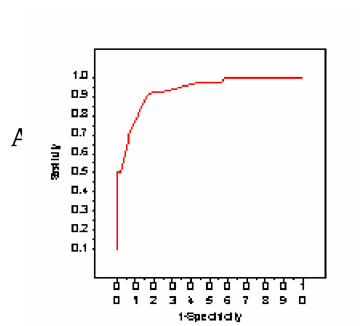

Figure 3. ROC Curve

As shown in Table 4, the three variables are significant predictors of success technology integration case. Another useful value in this table that helped in explaining the probability of response variable was the Odds Ratio. If the Odds Ratio was larger than 1, the probability of a success integration case would increase and if smaller than 1, the probability would decrease. In this model all three Odds Ratios for the three variables are larger than 1.

Variable	DF	Parameter Estimate	Wald Chi-square	P> Chi-square	Odds Ratio
Intercept	1	-5.2783	14.1148	0.0002	
Software	1	2.9049	12.3779	0.0004	18.264
Problem-Based Learning	1	3.9173	9.3159	0.0023	50.266
Instructional Design	1	3.2694	6.5084	0.0107	26.299

Table 4. Logistic Regression Results

SUMMARY

We have introduced four data analysis procedures using SAS macros. For those educators who are not statisticians can simply use the call files to run the four well developed SAS macros. In this way, using SAS to perform data analysis does not require any advanced programming skills, which makes SAS an easy and efficient tool for educators and their research. There are numerous ways to use SAS in data analyses. It is the author's hope to explore more methods to use SAS in a wider range of studies, and for people at different levels of statistics, so that SAS could be used in the field of education and benefit more and more educators and researchers.

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