Integrated Computer Application for Student Problem Solving Across Courses in Physics, Statistics and Physical Therapy Research

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Introduction:

Application of modern software in course work challenges students to concentrate on application of concepts living the routine calculation work to computers. Because students have deal with mathematical and statistical processing of data in problem solving across the various courses and research activities the authors have developed an integrated computer assisted approach for applications in Physics, Statistics and Physical Therapy Research.

This emerging pedagogy requires students to interact with classmates and faculty across courses using computer based technology. At the beginning of Physics, Statistics and Physical Therapy Research courses, students are provided with a manual that guides students' mastery of data management in the form of interactive software instruction. Specifically, the use of Microsoft (MS) Excel and MS Word releases students' time from repeated dull calculations, building graphs and organizing reports for more creative activities.

Physics:

In Physics, the series of experiments were designed to incorporate the computer-based technology into the lab sessions. From the very beginning of Lab sessions students are mastering the basis of Excel and use it in their learning process. In one experiment, for example, students have to decide which one of the two identically looking batteries is more suitable for the use in the electrical circuits. The batteries, not connected to the load have approximately the same emf (voltage), so the decision can be made only by measuring the internal batteries' resistance by indirect method. Following instruction, students assemble the circuit, do the measurements and organize data in the form of the following Excel's Table (Figure 1).

Figure 1. **Battery #1**

Experiment #	Emf, V	R_{ext}, Ohm	I, mA	r_{int}, Ohm	$V_{across\ terminals}$, V
1	1.45	200	7.20	1.30	1.44
2	1.45	181	7.96	1.23	1.44
3	1.44	152	9.39	1.31	1.43
4	1.45	120	11.95	1.37	1.43
5	1.43	95	14.52	3.50	1.38
6	1.44	76	18.18	3.20	1.38
7	1.41	56	23.66	3.60	1.32
8	1.41	35	36.15	4.00	1.27
9	1.42	24	52.21	3.20	1.25
10	1.4	12	105.90	1.22	1.27
Average:				2.39	
Variance:				1.41	

In this Table (Figure 1) the calculation of internal resistance r_{int} is made by applying the same formula:

$$r_{int} = Emf/I - R_{ext}$$

to all of the cells in the r_{int} column. Students also use the standard Excel functions AVERAGE and VAR to find an average and variance of the found internal resistance.
The across terminal voltage can be measured or can be calculated according the formula:

$$V = IR_{ext}$$

that is applied to the cells of the column $V_{across\ terminals}$. The data for the battery #2 presented in the Table below (Figure 2) are obtained by the same method:

Figure 2. **Battery #2.**

Experiment #	Emf, V	R_{ext}, Ohm	I, mA	r_{int}, Ohm	$V_{across\ terminals}$, V
1	1.37	221	4.93	57.10	1.09
2	1.37	197	5.48	53.00	1.08
3	1.37	173	6.00	55.17	1.04
4	1.36	144	7.04	49.14	1.01
5	1.37	117	7.98	54.76	0.93
6	1.36	94	9.56	48.20	0.90
7	1.35	67	11.40	51.40	0.76
8	1.36	43	13.84	55.24	0.60
9	1.35	25	17.23	53.33	0.43
10	1.35	11	21.47	51.87	0.24
Average:				52.92	
Variance:				7.94	

Having gained time by Excel's calculation, students can concentrate on the analysis of obtained experimental data. For this purpose they use the Excel's Chart Wizard and build the graph (Figure3):

Figure 3. **Voltage-current battery testing**.
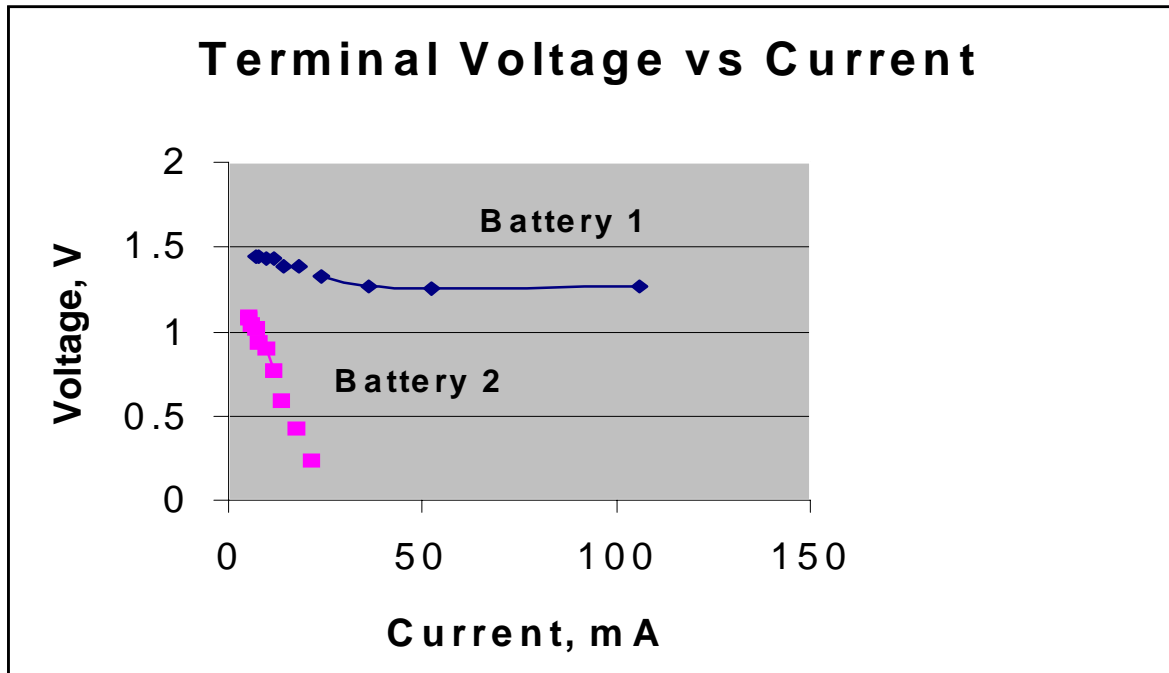
As can be seen from the graph, both batteries have approximately the same voltage when currents they deliver are small. Once current is increasing, the battery with large internal resistance (battery #2) drops its terminal voltage very soon, while the "good" battery #1 delivers to the circuit just slightly diminished current. Students can relate this experiment to their personal experience with starting the car having headlights turned on. The lights dim considerably during start if battery is old and therefore has large internal resistance.

Along with the development of the basic computer skills, Physics course students are provided with the initial experience in using and operating microprocessor controlled devices and collecting data units. In the Physics Lab we use the Personal Science Laboratory (PSL) system that consists of interface, set of sensors and appropriate software. This PSL software allows some statistical analysis of the data collected from various physical sensors. While using this specialized program we prefer, however, the data to be imported and processed with a variety of statistical tools available in Excel. The initial experience with computer controlled equipment that students gain in the Physics Laboratory, is important for their further work with such apparatuses as the MP100WSW data acquisition system, CSD 500 strength dynamometer or others in the advanced courses for the Physical Therapy students.

Statistics:

In Statistics the material is divided into logical units. Authors familiarize students with various calculation techniques in Excel: such as use of simple mathematical operations, functions, formula construction, statistical functions, and the Excel Analysis Tool Pak. Furthermore, students learn to manipulate and export data sets to specialized statistical programs such as Prophet and SPSS.

The following Tables (Figures 4-5) illustrate how Excel facilitates student understanding of statistical inference. Students input group means, variance and sample size per group to calculate a oneway ANOVA to determine difference between groups. They learn that difference between means can be used to calculate between group variance. Group variances are used to calculate the overall within group variance. Increasing sample size of groups decreases the estimate of within group variance. The ratio of between group differences over the estimate of within group variance (error) provides an F value. The calculated F value is compared with the critical tabled F value or the calculated p value is compared with the selected alpha level for statistical inference. The degree of differences between groups can be shown in the calculation of effect size.

Students grasp the significant interrelationships of mean differences, variance and sample size in considerations of alpha selection, power, type I error, and type II error. They are asked to think critically regarding the meaning of differences for statistical conclusion and for professional relevance. Once overall significance is determined and the null hypothesis is rejected, post-hoc procedures can be applied to determine specific group differences.

Figure 4: **Input for ANOVA Calculation**

Input		
Sample Mean Group 1	m	11.8
Sample Mean Group 2	m	3.8
Sample Mean Group 3	m	7.6
Variance Group 1	S^2	5.700
Variance Group 2	S^2	10.200
Variance Group 3	S^2	10.300
Sample Size Group 1	n	5
Sample Size Group 2	n	5
Sample Size Group 3	n	5
Number of Groups	k	3
Alpha Significance Level	α	0.01

Figure 5: **Output for ANOVA Calculation**

Output			
Grand Mean		GM	**7.7333**

Source	Sum of Squares	df	Mean Square	F	p
Between	160.1333	2	80.0667	9.1679	0.0038
Within	104.8000	12	8.7333		
Total	264.9333	14			

F Critical Table Value	6.92660	Family alpha inflation	0.0297
Effect Size f	1.738431458	# of Pairwise comparisons	3

Post hoc tests control for alpha inflation where the number of comparisons could lead to an unacceptable level of type I error. The first example (Figure 6) shows the Tukey Honestly Significant Difference (HSD) for pairwise comparisons. The table (Figure 6) indicates which pairwise means are significantly different at alpha of .05 and .01 levels.

Figure 6: **Critical Values for Tukey and Dunnet Test and Output for Tukey Test**

Input Tukey HSD Post-Hoc; Pages 622-623		Input Dunnett Control Group 1	
Table Q for Alpha .05	3.77	Table D Alpha .05	2.5
Tabled Q for Alpha .01	5.05	Tabled D Alpha .01	3.39

Tukey Pairwise Post Hoc	Calculated Q	Absolute	Significant .05	Significant .01
Means 1 and 2	*6.053*	*6.0532*	*Significant*	*Significant*
Means 1 and 3	*3.178*	*3.1779*	*Not*	*Not*
Means 2 and 3	*-2.875*	*2.8753*	*Not*	*Not*

The Tukey HSD are followed by the Bonferroni correction and the Scheffe tests for post hoc comparison of differences between means (Figures 7 and 8).

Figure 7: **Bonferroni Post Hoc Test**

Bonferroni Post Hoc	t-test two tail	p value	Significant .05	Significant .01
Means 1 and 2	*4.280*	*0.0011*	*Significant*	*Significant*
Means 1 and 3	*2.247*	*0.0442*	*Not*	*Not*
Means 2 and 3	*-2.033*	*0.0648*	*Not*	*Not*
Critical p for family alpha .05	0.01667			
Critical p for family alpha .01	0.00333			

Figure 8: **Scheffe Post Hoc Test**

Scheffe Post Hoc	Calculated F	p value	Significant .05	Significant .01
Means 1 and 2	*18.321*	*0.0011*	*Significant*	*Significant*
Means 1 and 3	*5.050*	*0.0442*	*Not*	*Not*
Means 2 and 3	*4.134*	*0.0648*	*Not*	*Not*
Critical F family alpha .10	5.61359			
Critical F family alpha .05	7.77058			

The last post hoc test (Figure 9) compares the control group with the treatment groups. It is assumed that in this example, group 1 is the control group.

Figure 9: **Dunnet Control Group Post Hoc Test**

Comparison with Control	Calculated D	Absolute	Significant .05	Significant .01
Means 1 and 2	4.280	4.2803	Significant	Significant
Means 1 and 3	2.247	2.2471	Not	Not

The above illustrations introduce concepts of statistical inference and post hoc analysis. Students are required to interpret significance of results from statistical and clinical context. Data sets from texts and previous student research helps students apply measurement, research design, and interpretation relevant to physical therapy practice.

Similar worksheets for dependent measures, mutifactorial designs, and nonparametric tests are part of the course design. Students learn to manipulate and transform data within Excel and to import data sets into statistical programs for analysis. Interpretation of computer program output occurs in relation to required assumptions, limitations, and meaning within professional context.

Physical Therapy Research:

Students conduct research during the last 3 semesters of the graduate program. Calibration of equipment and measurement mechanical forces and physiological function are foundational to many experimental designs in physical therapy. Computer skills and data analysis learned from physics and biological sciences aid the student in this process.

In completing these projects, students work together in data collection and analysis. Students write their papers using Microsoft Word. They analyze their data using Excel and other statistical and graphical packages. Students present their studies using Microsoft PowerPoint. Figures 10 and 11 present selected slides from PowerPoint which illustrate student use of computer technology in physical therapy research.

Figure 10: **Selected PowerPoint Presentation Slides Panel 1**

A COMPARISON OF HOLD TIMES OF STATIC STRETCHING FOR MAXIMAL HAMSTRING LENGTHENING:

A DOUBLE BLIND PRETEST-POSTTEST PROSPECTIVE STUDY

William R. Bell, SPT
Kelly S. Mahon, SPT
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Theories

- Mechanical Component
  - Viscoelastic Properties of Myofibrils

- Neurophysiological Component
  - Stretch Reflex
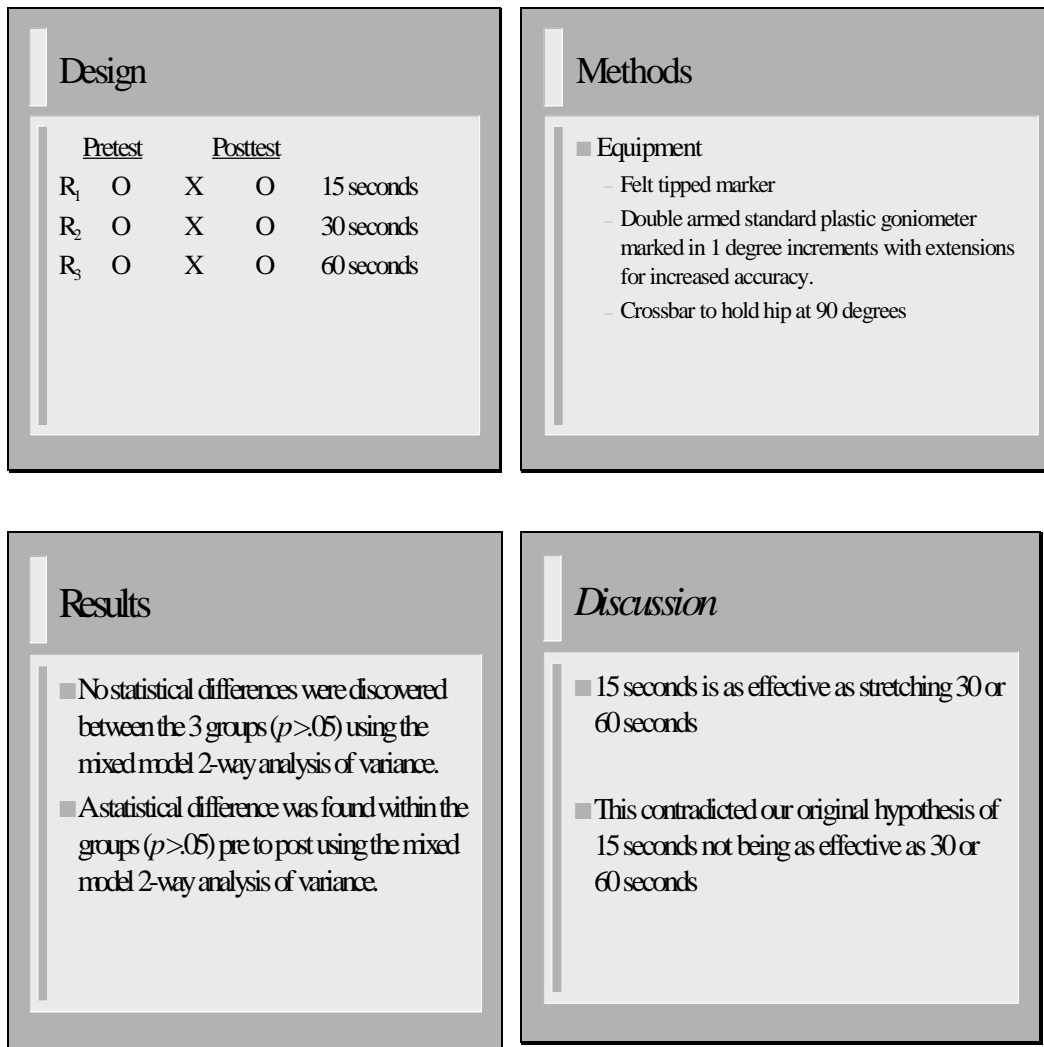 - Inverse Stretch Reflex

Importance of Stretching

Research suggests stretching:
- -Prevents Musculotendonous Injuries
- -Minimizes Muscle Soreness
- -Improves Performance

Types of Stretches:

- Dynamic
- Ballistic
- Proprioceptive Neuromuscular Facilitation
- Static

Figure 11: **Selected PowerPoint Presentation Slides Panel 2**

Design

	Pretest		Posttest	
R_1	O	X	O	15 seconds
R_2	O	X	O	30 seconds
R_3	O	X	O	60 seconds

Methods

- Equipment
  - Felt tipped marker
  - Double armed standard plastic goniometer marked in 1 degree increments with extensions for increased accuracy.
  - Crossbar to hold hip at 90 degrees

Results

- No statistical differences were discovered between the 3 groups ($p>.05$) using the mixed model 2-way analysis of variance.
- A statistical difference was found within the groups ($p>.05$) pre to post using the mixed model 2-way analysis of variance.

Discussion

- 15 seconds is as effective as stretching 30 or 60 seconds

- This contradicted our original hypothesis of 15 seconds not being as effective as 30 or 60 seconds

Summary:
Preliminary results of student research are presented as part of the Honors Program at Clarke College. The completed study is presented and evaluated prior to graduation. Some of the student research has been presented at national conferences and has also been submitted for publication.

This paper presents the an example of computer technology implementation which sequences student learning experiences in the acquisition of computer proficiency. Moreover, this approach provides students the opportunity to master modern technology while developing critical thinking skills.