The Effect of Computer Utilization for Problem Solving by Technology Students on Pedagogy

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Abstract

Industry has continually demonstrated the need to promote critical thinking and practical interdisciplinary education for engineering technology students. The instruction of many practical technical applications requires the utilization of mathematical concepts necessary for parametric analysis and problem solving methods. Qualitative statistical measures coupled with students surveys were used to track student work, problem solving strategies, self-assessment and insightful understanding.

Two different instruction methods were implemented in a robotics calibration class for mechanical and manufacturing engineering technology students at Farmingdale State College to determine the best pedagogical technique that resulted in improvement of student's scores as well as their understanding of the subject matter. The first method utilized computer programming for linear algebra, matrices and determinants evaluation. The second instructional method used longhand pencil and paper calculations as well as the manipulation of linear algebra equations. After each method of instruction, students were tested on the subject manner and given a survey.

While the results have shown that students benefitted greatly from the class instructions that engaged them in the critical thinking processes, they continued to express reservations with respect to hand calculations and manipulations which infringed upon their performance and achieving expectations. With the aid of the computer instructional programming model, students were able to perform sound analyses, save time and achieve correct answers that promoted higher standards of critical thinking and problem solving skills. The effect of computer utilization in solving mathematical and algebraic models did not seem to have a considerable effect on the students' in-depth understanding of the class lesson. It is the opinion of the authors that a combination of both longhand work and the use of computer modeling by students will provide the overall optimum results; however, this is at the expense of class time. Further research is needed to determine the impact of implementing computer instructional models as a part of the classroom instruction on learning and teaching.

Introduction

Today, professional, technical or managerial types of occupations account for nearly one-third of our workforce and 60% of all new jobs. These new jobs require highly skilled college graduates who are competent both in manipulation of numbers and in understanding technical concepts, according to a report made by Allan Greenspan, Chairman of the Federal Reserve Board (September 21, 2000 report to the US House of Representatives). He also suggested that a person who comprehends the concepts is a person who can grasp more complex and ambiguous relationships.

These types of jobs require higher order mathematical problem solving and critical thinking skills as well as technical competency that includes the ability to solve multiple step problems; thus, it is imperative that adult diploma and degree programs in colleges and other institutions of higher learning offer state of the art courses that can assist adults to update their skills in order to promote themselves intellectually and economically. In addition, not only do these adults need training for their present positions or career changes, they also will need to know how to learn effectively throughout their careers. The proliferation of information technologies and computer hardware and software throughout the economy has accelerated the shift in job requirements from routine work to non-routine interactive and analytic tasks. Therefore, workers who formerly only had training in one area now find themselves lifelong learners.

The teaching of adult learners requires different methods and approaches than those used in teaching younger students. Accordingly, colleges and other institutions of higher learning need to address these teaching requirements. Many are presently doing this by offering courses in a number of instructional modes of delivery: traditionally taught lecture courses, computer mediated (based) or assisted courses, and distance learning courses. On the other hand, many students are reported to be unmotivated and have a negative attitude towards the subject and often to technology. Healy [1] has suggested that education must move away from traditional methods of teaching using texts and the lecture approach and instead move toward the computer technology instructional approach. There has been some research that addresses the effectiveness of using Computer Mediation Instruction (CMI) to teach basic mathematics skills at the college level. This research addresses traditional methods of teaching mathematics and the CMI approach to teaching mathematics and its effects on achievement.

There has been a movement to increase the utilization of computer hardware and software in the classroom environment to assist students with understanding the technical concepts. However, there is very little research investigating how the use of computers in the classroom affects students' desires to learn engineering technology or improve their final exam scores (Burton, 1995 [2]; Roach, 1997; Bowen, 1992). Technology offers an alternative to the lecture /whole class instructional approach since the learning is private, self-paced, and flexible; computers give immediate feedback that is quite personalized (Nadasen[5], 1998; Hagopian [3], 1996; Treadway[6], 1997). Recently, Computer-Assisted Instruction impact on Students' Conceptual Understanding was investigated in the areas of Mathematics, Science and Technology by a number of researchers [7] and [8]. Thus, this

research study is relevant as it can determine how the implementation of computer programs affects student achievement in an engineering technology course such as a robotics calibration class.

Method and Analysis

The primary purpose of this study is to investigate the effectiveness of introducing computer software compared to traditional instruction on the academic achievement of technical college students' conceptual understanding, knowledge retention and calculation time. Computer hardware and software are utilized on a regular basis by engineering technology students for problem solving and system parametric analysis. Practice oriented curriculum learners, like technology students, are classified as global learners with tactual and visual learning styles. Global learners also represent 55% of the total student body. The student task is described in a case study that was conducted in a robotics calibration class at Farmingdale State College to investigate the effect of computer utilization by students in the classroom on pedagogy. The present study included the determination of one plane equation from the three faces or planes of a four sided calibration bar located in a three dimensional (3D) fixture. The students' work required the utilization of linear algebraic matrices to expand and develop the equations of these three planes, as shown in the following plane equations:

$$A_1X + B_1Y + C_1Z = D_1$$
$$A_2X + B_2Y + C_2Z = D_2$$
$$A_3X + B_3Y + C_3Z = D_3$$

Each face on the calibration bar is identified by three dial indicators fixed to a 3D fixture and touches the side of the calibration bar in three points as Figure 1 exhibits. The cross product of the two vectors V1 and V2 generate the coefficients of the plane equation.

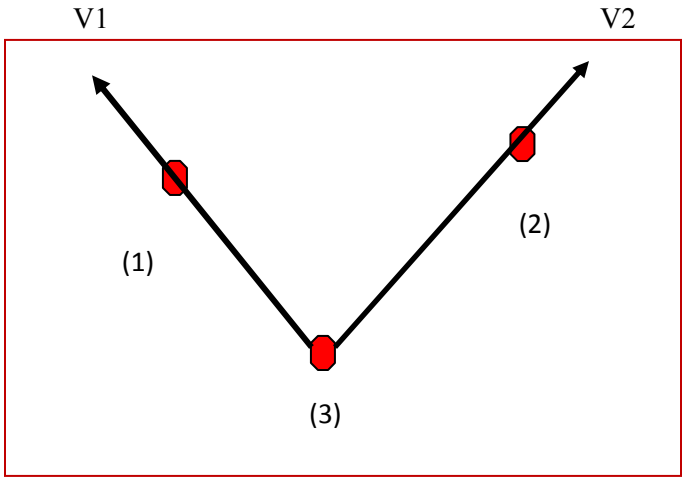

Figure 1: Shows the location of the three indicators on the calibration bar side plan

The coordinates of point (1) are X1, Y1, Z1, point (2) are X2, Y2, Z2, and point (3) are X3, Y3, Z3. Accordingly, V1 is defined by X1-X3, Y1-Y3, Z1-Z3 and V2 is described by X2-X3, Y2-Y3, Z2-Z3. The students are asked to measure and identify all nine coordinates and set up the matrix to perform cross product calculations as shown below:

$$V1XV2 = \begin{matrix} I & J & K \\ X1-X3 & Y1-Y3 & Z1-Z3 \\ X2-X3 & Y2-Y3 & Z2-Z3 \end{matrix}$$

This topic was introduced to the students in three different methods of instruction, namely, 1) regular class instruction, 2) detailed class instruction with longhand solved numerical examples, and 3) class instruction including the utilization of computer software developed by the instructor to expand the above matrix and obtain the plane equation. After each instruction method, a one problem solving quiz directly related to the subject matter was given to the students. A twelve question survey was also administered to the class as the final stage of the interaction with students. The results of the twelve questions of the survey collected from fourteen students in the robotics class are summarized in Table 1 as shown in the following:

Table 1: Survey results of 14 students for 12 questions

	1	2	3	4	5	6	7	8	9	10	11	12	AVERAGE (Out of Possible 5)	Standard Deviation
1	2	2	3	2	2	4	2	2	4	3	2	3	**2.58**	0.79
2	2	2	3	2	2	4	1	1	5	1	1	5	**2.42**	1.51
3	1	3	3	2	3	3	3	3	3	1	3	4	**2.67**	0.89
4	3	3	2	2	3	3	4	4	4	2	3	3	**3.00**	0.74
5	2	3	4	3	4	3	2	3	5	2	3	4	**3.17**	0.94
6	4	4	4	3	3	3	4	4	4	3	4	4	**3.67**	0.49
7	4	4	4	4	4	4	3	4	5	3	4	5	**4.00**	0.60
8	3	4	4	3	4	4	5	4	5	3	5	5	**4.08**	0.79
9	2	5	1	2	5	1	1	3	5	1	5	3	**2.83**	1.75
10	2	5	2	1	5	2	2	3	5	1	4	3	**2.92**	1.51
11	2	5	4	2	5	4	1	2	5	2	5	3	**3.33**	1.50
12	3	5	4	4	5	2	3	3	4	3	4	2	**3.50**	1.00
13	2	5	2	3	5	1	1	2	5	1	5	3	**2.92**	1.68
14	3	4	5	3	4	5	3	4	5	3	4	5	**4.00**	0.85
	2.40	**3.73**	**3.20**	**2.67**	**3.93**	**3.27**	**2.80**	**3.33**	**4.87**	**2.60**	**4.20**	**4.27**	**3.44**	0.77

The statistical mean analysis performed on this indicated that the use of the computer program as a part of class instruction produced the best test scores with minimal computation errors and time but produced less knowledge retention and insightful understanding than the longhand method in a class setting. The normality of the data was examined and justified by the utilization of the probability plots and the linear tendency of the data as shown in Figure: 2 for all 168 data points. The solid line in this figure demonstrates the direction of the data clustering and supports the normality assumption through the utilization of the probability plot statistical method. This is a necessary step to examine and guarantee meaningful inferences of the study.

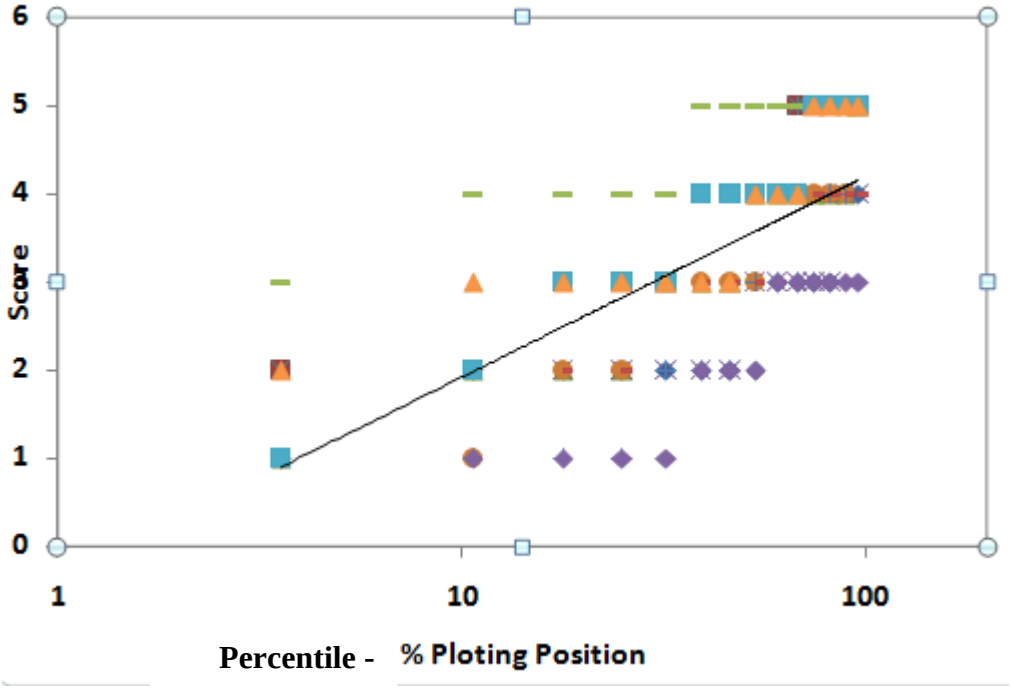

Figure 2: Probability plot for all Survey data

As indicated earlier, Table 1 exhibits all the survey results for the class of 14 students. The students test and quizzes results are also included in this table. The surveying result of column # 8 and # 11 in Table 1 were randomly selected of all data presented to further examine the normality of the data. Similarly, testing for normality of survey question #8 and #11 were also performed using the probability plot. Normality was once again confirmed as Figure 3 and Figure 4 depict and the 95% confidence level ($\alpha = 0.05$) has measured up to the values of 0.503 and 0.608, respectively.

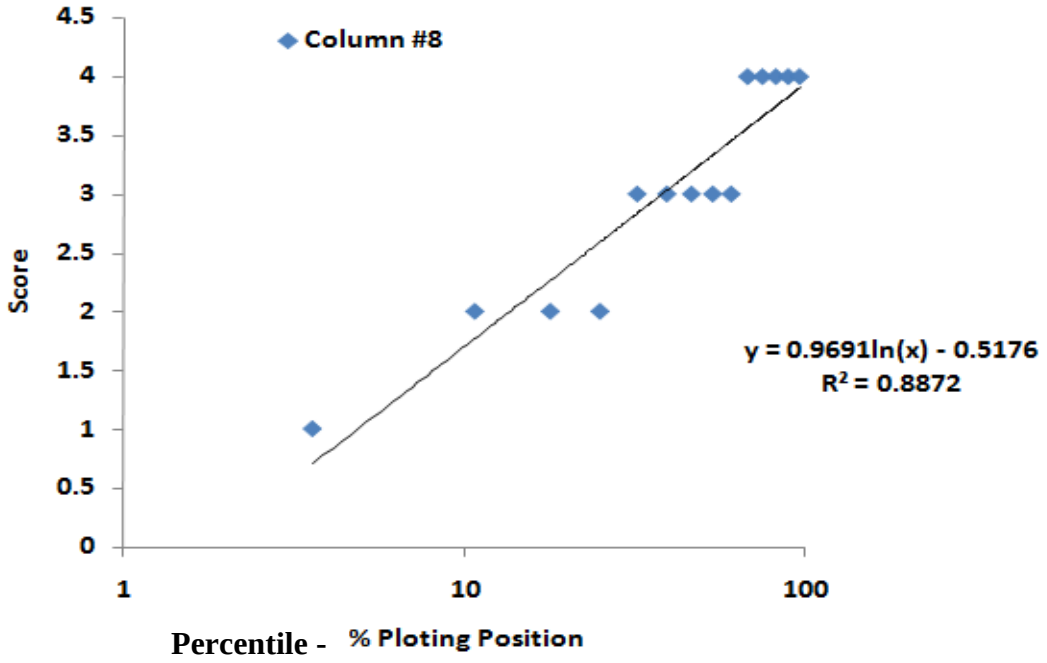

Figure 3: Probability plot for question #8 in the survey

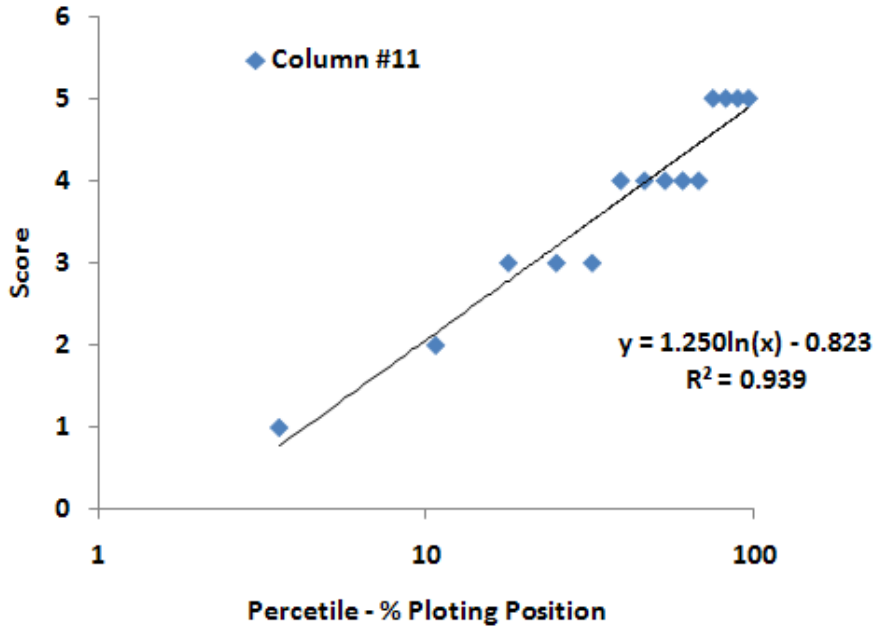

Figure 4: Probability plot for question #11 in the survey

Analysis

The current study was based on the statistical analysis of the results of a 12 question students survey (Appendix) and the students test scores (Table 2) acquired from mechanical and manufacturing engineering technology undergraduate senior students at the State University of New York College of Technology at Farmingdale, Long Island, NY. The following are the main aspects that were investigated in this study and they are as follows:

- Insightful understanding of the subject matter
- Knowledge retention
- Computation and class time
- Educational method

From the study and the analysis shown in Tables1, and 3 indicated that the use of computer programs in problem solving has reduced calculation time and produced the best test results. However, the students' insightful understanding of the subject matter and knowledge retention, computer utilization was not the most favorable among other pedagogical techniques. Detailed instruction methods combined with longhand calculation was proven to yield better results in the students understanding of the subject matter and enhanced their knowledge retention.

Table2: Students' Grades

Name	TEST 1 (03.04.08)	Question 4 Test	Question 4 Hand	Question 4 Computer	Quiz 1 (04.01.08)		Average	Standard Deviation
Student # 1	22	10	90	100	58		**55.90**	40.01
Student # 2	29	0	100	100	0		**45.80**	50.87
Student # 3	37	0	100	85	57		**55.80**	39.61
Student # 4	22	0	69	100	0		**38.20**	44.58
Student # 5	59	10	100	100	68		**67.40**	37.05
Student # 6	41	0	60	100	70		**54.20**	37.06
Student # 7	90	80	95	100	0		**73.00**	41.47
Student # 8	42	10	100	100	80		**66.40**	39.43
Student # 9	79	17	100	100	0		**59.13**	47.53
Student # 10	69	10	90	100	95		**72.80**	37.04
Student # 11	64	0	90	100	90		**68.80**	40.71
Student # 12	49	10	70	95	0		**44.80**	39.97
Student # 13	76	60	100	100	85		**84.20**	16.98
Student # 14	39	10	55	70	70		**48.80**	25.19
Average	**51.25**	**15.48**	**87.07**	**96.43**	**48.07**		**59.66**	32.64
Standard Deviation	21.85	24.06	16.34	8.64	38.67		12.99	

Table (3) Analysis and Correlations

1	Test Results	Basic Instruction produced the worst test results.
		Detailed instruction produced the median test results.
		The use of a computer program / calculator produced the best test results.
2	Level of Understanding	As the level of instruction increased, understanding increased .
		The use of a computer program / calculator yielded the median understanding.
3	Level of Retention	As the level of instruction increased, retention increased.
		The use of a computer program / calculator yielded the median retention.
4	Computatin Time	As the level of instruction increased, computation time decreased.
		The use of a computer program / calculator yielded the best computation time.
5	Level of Education	Basic instruction was the least educational method.
		Detailed instruction was the median educational method.
		Use of a computer program / calculator was the most educational method.

Conclusions

(1) The statistical mean analysis performed on these data indicated that the use of the computer program as a part of class instruction produced the best test scores with minimal computation errors and time but produced less knowledge retention and insightful understanding than the longhand method in a class setting.

(2) Presenting students with a mix of both techniques provides the desirable results and constitutes the best education mechanism.

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Biography

LORRAINE TAWFIK is currently the Assistant Dean of the School of Education at the SUNY College at Old Westbury. She was the Chair of Arts and Sciences and Math Professor for the prior 8 years at Briarcliffe College. Dr. Tawfik obtained a doctoral degree in education from St. John's University and three Master Degrees in Materials Science and Engineering, and Math and Statistics from Stony Brook University and Biostatistics and Epidemiology Master Degree from McMaster University.

HAZEM TAWFIK is a SUNY Distinguished professor and the Director of the Institute for Research and Technology Transfer of SUNY College of Technology at Farmingdale**.** He has more than 60 technical publications in the fields of thermal sciences, robotics, statistical process control and hydrogen fuel cells. Since he earned his doctoral degree in Mechanical Engineering from University of Waterloo he has held various positions in academia and industry.

KAMAL SHAHRABI is the Dean of the School of Engineering Technologies at Farmingdale State College. Prior to his current post, Dr. Shahrabi was the Technology Department Chair at Kean University in New Jersey for more than 20 years. He has more than 30 publications in the electrical engineering and education fields as well as managing large research programs.

Appendix

Farmingdale State College

Student Name: _____

MECHANICAL ENGINEERING TECHNOLOGY DEPARTMENT
ROBOTICS COURSE

Survey

If we agree to define the basic class instruction as a general explanation of the class lesson, detailed instruction includes the step by step explanation of the class lesson supported with an actual example, and computer/calculators indicates the utilization of the Excel software program given to you by the Instructor to solve similar problems; please read carefully all the following statements and make the appropriate choices:

1. Basic instruction of the 3D plane equation and long hand use of matrices enabled me to reach a high level of insightful understanding of the subject matter. Please circle one of the following most suitable number

   Strongly disagree 1 2 3 4 5 Strongly agree

2. Detailed instruction of the 3D plane equation and long hand use of matrices enabled me to reach a high level of insightful understanding of the subject matter. Please circle one of the following most suitable number

   Strongly disagree 1 2 3 4 5 Strongly agree

3. Computer/calculators use for solving 3D plane equation using matrices enabled me to reach a high level of insightful understanding of the subject matter. Please circle one of the following most suitable number

   Strongly disagree 1 2 3 4 5 Strongly agree

4. Basic instruction of the 3D plane equation and long hand use of matrices enabled me to reach a high level of knowledge retention. Please circle one of the following most suitable number

   Strongly disagree 1 2 3 4 5 Strongly agree

5. Detailed instruction of the 3D plane equation and long hand use of matrices enabled me to reach a high level of knowledge retention. Please circle one of the following most suitable number

Strongly disagree 1 2 3 4 5 Strongly agree

6. Computer/calculators use for solving 3D plane equation and use of matrices enabled me to reach a high level of knowledge retention. Please circle one of the following most suitable number

Strongly disagree 1 2 3 4 5 Strongly agree

7. Basic instruction of the 3D plane equation and long hand use of matrices enabled me to save computation and class time. Please circle one of the following most suitable number

Strongly disagree 1 2 3 4 5 Strongly agree

8. Detailed instruction of the 3D plane equation and long hand use of matrices enabled me to save computation and class time. Please circle one of the following most suitable number

Strongly disagree 1 2 3 4 5 Strongly agree

9. Computer/calculators use for solving 3D plane equation and use of matrices enabled me to save computation time. Please circle one of the following most suitable number

Strongly disagree 1 2 3 4 5 Strongly agree

10. In general, basic instruction of the 3D plane equation and long hand use of matrices was the most educational method. Please circle one of the following most suitable number

Strongly disagree 1 2 3 4 5 Strongly agree

11. In general, detailed instruction of the 3D plane equation and long hand use of matrices was the most educational method. Please circle one of the following most suitable number

Strongly disagree 1 2 3 4 5 Strongly agree

12. In general, computer/calculators use for solving 3D plane equation and use of matrices was the most educational method. Please circle one of the following most suitable number

Strongly disagree 1 2 3 4 5 Strongly agree