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Abdellatif Tchantchane
University of Wollongong in Dubai, tchantch@uow.edu.au

Pauline Fortes
University of Wollongong in Dubai, pfortes@uow.edu.au

Swapna Koshy
University of Wollongong in Dubai, swapna@uow.edu.au

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Abdellatif Tchantchane, University of Wollongong in Dubai, Dubai, UAE

Pauline Fortes, Faculty of Computer Science and Engineering, University of Wollongong in Dubai, Dubai, UAE

Swapna Koshy, University of Wollongong in Dubai, Dubai, UAE

ABSTRACT

Teaching and learning in higher education has been influenced by the rapid rate of innovation in technology. A technology intervention was used to teach Foundation Statistics. This paper reports students' performance relative to those taught statistics using traditional teaching methods. Failure rate was reduced from 34% with traditional teaching to only 14% with the inclusion of technology, and in order to measure students' perception towards the integration of technology in the subject, a total of 144 students of 30 different nationalities were surveyed at the end of the semester before the final examination. The analysis of the survey highlighted the students' positive perception independent of their overall performance. Overall, the survey expressed a significant result showing that the use of technology helped students to perform better.

Keywords: *Education Technology, Integration of Technology, Multivariate Analysis, Student Performance, Teaching Statistics*

INTRODUCTION

Statistics plays a vital role in enabling us to comprehend the world around us. Its role is especially relevant as a tool to interpret, analyze and evaluate the findings of research inquiries which are crucial to the progress of the human race. Educators, especially those involved in teaching mathematics, are demanding that statistics should be introduced in all levels of education (Garfield & Ahlgren, 1988). Though there is substantial awareness of the relevance of statistics, university students' approach to it is anxiety laden as they perceive it as a difficult subject (Baharun & Porter, 2009; Fortes & Tchantchane, 2010). Adding to the challenge are the multi-cultural and multi-skilled student cohorts that populate classrooms today demanding diverse teaching methods (Peiris & Beh, 2006; Fortes & Tchantchane, 2010).Teaching statistics effectively has thus become a peda-

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gogical issue. This study attempts to improve student learning and performance in statistics using a technology intervention that simplifies operational statistics.

Integration of technology with traditional teaching methods has been perceived by educators as an important tool that aids effective teaching at all levels. This concept has been promoted by the National Council for Mathematics Teachers and the American Statistical Association. In the U.A.E. there has not been any documented evidence of the use of technology in teaching foundation Statistics. At the University of Wollongong in Dubai, Introduction to Statistics a compulsory General Education Subject for freshmen had been taught using traditional methods. Students were required to take down notes and solve problems with the aid of a scientific calculator during lectures and tutorials. Lecture notes and tutorial materials are also made available on the university website. However, this approach was inadequate as students were working with abstract formulae and were unable to explore real, large and complex data. To address these issues, we introduced technology as a tool to effectively teach statistics. Students were expected to get more time to analyse and interpret simple or complex data, and justify their conclusions. Student experience was enhanced through computer-based instruction and collaborative group work.

The objective of this study is to answer the following research questions: (i) Does a technology intervention have an effect on student's academic performance? (ii) What are the perceptions of the students towards the technology used in teaching statistics?

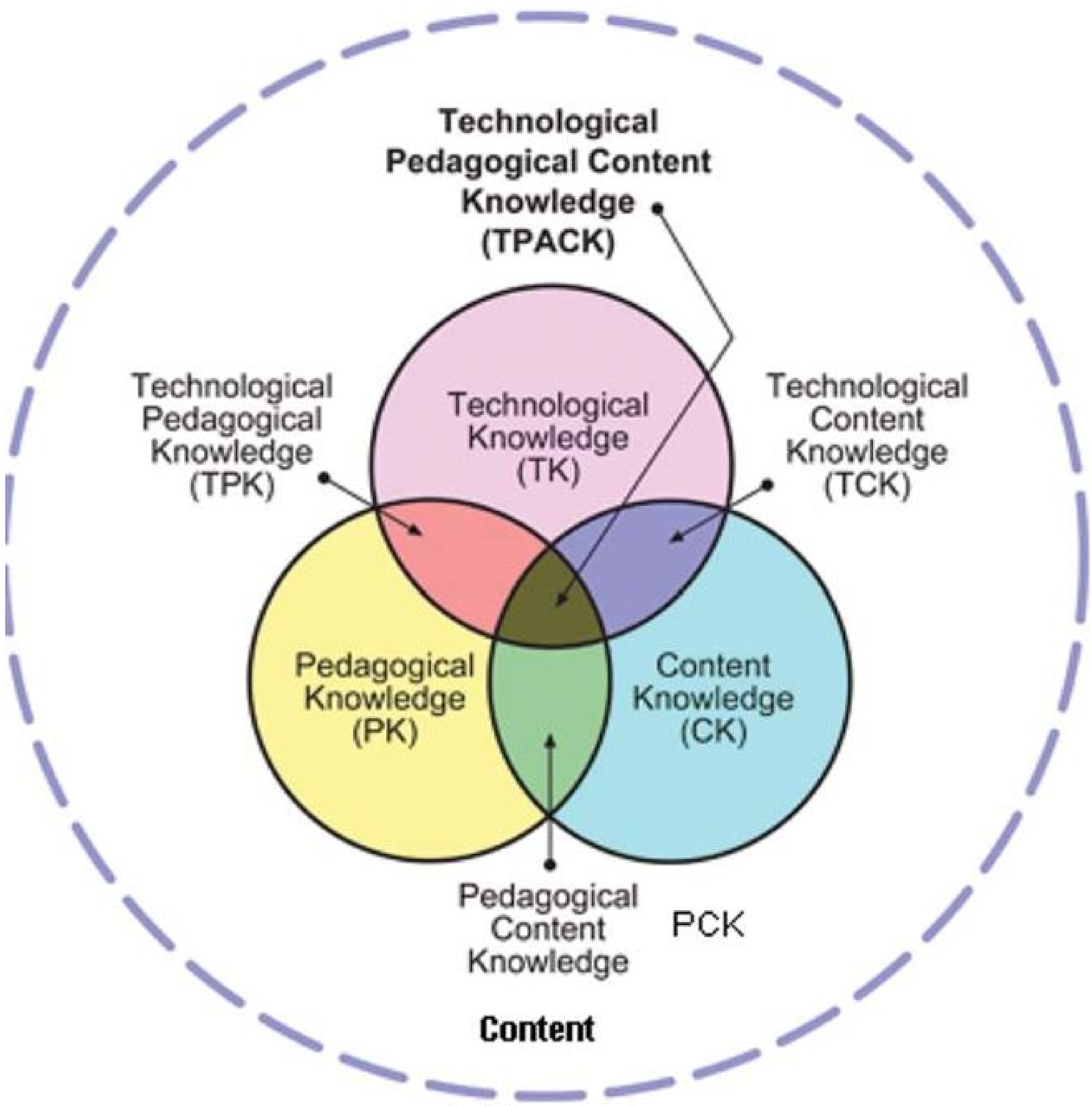
This study also attempts to fill the lacuna in research pertaining to the teaching of statistics in the region.

INTEGRATING TECHNOLOGY IN TEACHING STATISTICS

The advent of technology and its widespread use in the 21st century warranted the need to integrate technology in teaching and learning in Neiss (2005). This reform radically affects what we teach and alters our methods of teaching. In 2005, Thomas and Hong (as cited in Neiss, 2005) developed a teaching framework namely pedagogical technology knowledge (PTK), later named as TPCK. This framework acknowledges the use of technology as an important instrument for teaching and asserts the role of technology in linking the subject matter with teaching (Neis, 2005). Figure 1 illustrates the framework of technology, pedagogy, content and knowledge and the dynamics among these as conceived in TPACK. Integration of technology in teaching and learning is about ensuring effective pedagogy. In the case of teaching Statistics too, a substantial change can create strong synergies between technology, pedagogy, and content (Moore, 1997; Velleman, 1995). According to Moore (1997) requiring students to work in groups and discussing their work orally and in writing, using various diagnostic tools to analyze data, and computer-intensive statistical practice facilitates student learning.

In addition, the National Council of the Teachers in Mathematics supports the principle "Technology is essential in teaching and learning; it influences the mathematics that is taught and enhances learning" (NCTM, 2000). It further explained that technology such as calculators and computers are reshaping the mathematical landscape and encouraged school mathematics to reflect the changes. They observed that with appropriate and conscientious use of technology, students can learn mathematics more deeply, speculate and make inferences and be able to work at higher levels of generalization or abstraction (NCTM, 2000). These principles suggest therefore that technology plays a very important role in the learning curve of the students. Similarly, the American Statistical Association (ASA) supports the use of technology for developing conceptual understanding and analyzing real data (GAISE, 2007). Various investigations have been made on the different teaching methods using technology and the impact on student's learning (Baharun & Porter, 2009; Gorman, 2008; Prabhakar, 2008; Tsao, 2006; Neiss, 2005; Sam & Kee, 2004; Garfield, Chance, & Snell, 2000).

Figure 1. The Venn diagram of TPACK



As the rapid popularity of technology increased more software tools have been released. Some software that are popularly used have salient features that aid statistical analysis. Hence, the use of technology in teaching and learning statistics is inevitable and continuously developing. There are several types of technology being used in statistics instructions namely, statistical packages and spread sheets, Web or computer-based tools, graphic calculator and programming languages. Calculators and computers reduce the computational burden and allow more extensive exploration of statistical concepts. These remarkable features facilitate the wide use of technology in teaching. Yet, introducing technology into the classroom can present challenges like students' lack of acceptance (Gorman, 2008).

These challenges have been experienced the world over. In Malaysia, in 2000, teachers introduced the use of the graphic calculator. This was in spite of objections from many quarters including academics as well as parents who believed that using this technological tool may cause students to lose basic mathematical skills and understanding which are prerequisite for advance mathematics (Sam & Kee, 2004). However, the intervention resulted in a positive impact on the culture of statistical learning. Students showed more enthusiasm in group work and enjoyed learning statistics. Students showed improved understanding and enhancement of skills in statistics. Liang (2000) observes that when computer programs were used in teaching, students were attracted to the interactive computer programs designed for the business statistics course and they were motivated to attend classes. Furthermore, students were able to understand complicated topics, and believed that teaching them to use computer facilities improved their own abilities to apply similar programs in analysing real-world problems. As mentioned in Sharma and Barrett (2007), supporting a course with technology can allow learners and teachers more flexibility in both time and place, and complements and enhances face-to-face teaching.

The following are some of the positive effects of integrating new technology as pointed out by various research studies (Baharun & Porter, 2009; Gorman, 2008; Prabhakar, 2008; Morales & Roig, 2002; Su & Liang, 2000; Velleman, 1995):

- *Technology can be used as a tool for supporting and enhancing students' learning.*
- *Wider learning benefits may accrue from integrating ICT.*
- *Unique opportunities are provided for students to do mathematical tasks in new ways.*
- *Facilitates mathematical problem solving, reasoning, and exploration.*
- *Students are motivated to internalise concepts and device their own ways to command the computer to draw graphs or to solve numerical problems.*
- *Students can build their own understanding using computers as resource tools, or as a communication tool to share their ideas with other learners.*
- *They can share and compare their individual understanding and experiences.*

The student cohort that populates the classroom today is mainly from the Millennial group who have been christened Digital Natives by social scientists like Marc Prensky (2001). They are more inclined to use technology and it is therefore important to explore the use of technological tools in classroom teaching.

THE NEW TECHNOLOGY INTERVENTION USED

Traditional teaching can be defined as a combination of lectures, tutorials and the use of scientific calculators in problem solving while teaching with technology pertains to the use of computer applications as additional pedagogy. The typical content of the subject Introduction to Statistics is divided into three sections: descriptive statistics, probability theory and inferential statistics. Descriptive statistics includes presentation of data (charts, frequency distribution tables, histograms, polygons, scatter plots, and box-plots), measures of central tendency (mean, median, and mode), and measures of dispersion (range, inter-quartile, variance, coefficient of variation, standard deviation). Probability theory covers rules of addition and multiplication, independent and mutually exclusive events, marginal and joint probability, probability distributions, normal distributions; and inferential statistics includes sampling and estimating population mean and confidence interval. The innovative delivery of the subject now includes a lecture, a tutorial and a computer laboratory session all of which are for an hour's duration each. Students are expected to attend the lecture but attendance is not compulsory, while attendance is compulsory for most tutorials and computer laboratory sessions in a 13-week semester. Subject outlines, lecture notes, tutorial and laboratory worksheets and review materials for assessments are uploaded on the university intranet. MS Excel was introduced as a technological tool to enhance teaching and learning of statistics. Excel is a widely used package as it is user friendly, accessible and cost-effective. Students were expected to be able to (i) present data in spread sheets, (ii) post and solve real-life problems, (iii) examine large and complicated data sets, (iv) investigate patterns in the data, (v) produce summary statistics, and (vi) construct graphs or charts using data analysis tools and statistical commands which can be found in Excel.

SURVEY DESIGN AND ANALYSIS

In order to measure students' learning experience with respect to the technology intervention, a survey was conducted at the end of the semester. This was carried out before the final exam - the last summative assessment -and therefore before the release of the final marks. The survey instrument included a structured 40 item questionnaire measured on a 5-point Likert-scale, ranging from Strongly Disagree (SD) to Strongly Agree (SA). The instrument was administered to 162 students officially enrolled in the Introductory Statistics course. 144 students completed the voluntary and anonymous survey. Among the respondents, 47.2% were female and 52.8% were male from 30 different nationalities. About 60.4% (87 out of 144) were studying statistics for the first time while 39.6% (57 out of 144) had already studied statistics during their higher secondary education or were repeating the course. Survey details showing the percentages of their responses in each item with the corresponding mean and standard deviation are given in the Appendix. The survey results indicate the following:

- More than 86% of the students agreed that they had developed skills in organizing data in tables, producing graphs and summarizing data;
- Only 18% of the students feel that statistics is harder than Mathematics;
- 35% of the students feel that the 2 hour lab duration was too long while 47% are happy with that;
- 53% of the better performing students (with grades above 60%) think that a one hour lecture is not enough;
- 80% of the students have a positive perception towards the teaching staff;
- 40% of the weaker students (with less than 60% grade) found the textbook useful while only 30% of the better performing students, agreed with it;
- 56% among the weaker students find probability the hardest topic in Statistics;
- Those who were repeating the course scored marginally better grades (75.5) while student who were attempting the subject the first time scored about 71%.

FACTOR ANALYSIS OF THE SURVEY

We have employed factor analysis as a data reduction technique in order to define the underlying relation among the variables (item 1 to item 40). This technique groups highly correlated variables into groups or factors which would help us to find patterns of relations among the variables.

Using the SPSS program: *Analyze->Dimension Reduction->Factor* and based on the 40 items correlation matrix, *Principal Component* and *Varimax* have been used respectively as the extraction and rotation methods in the analysis. In order to make the output easier to scan and since factor loading less than 0.5 is too small to be considered, we suppressed the low absolute loadings at 0.5. Analysis results revealed that the first factor explains 44.21% of the total variance of all items. The second factor added 7.2% to the accumulated variance and the third factor explained only about 4% for a total of about 56%. While the results are not sensitive to the extraction and rotation methods, the number of factors retained is very crucial; we have retained three factors based on the Scree-plot and the interpretability of the factors. Examining the items clustering to each of the three factors, we conclude that the first factor measures students' *perception towards the delivery* of the subject. Twenty one items of the survey questions (8, 11, 14-16, 18, 19, 22, 23, 25, 27, 28, 30, 31, 33-40) cluster into this one single factor. The second factor measures *perception towards the use of technology* and includes 7 items (1-3, 5-6, 20, 24). The third factor measures students' *perception towards statistics* and clusters 5 items (4, 12, 21, 29, 32). Items 9 and 17, corresponding to whether Statistics is easier than Mathematics and to whether the computer lab timing was too long; as well the two items related to the text book did not hang to any of the three factors. Further, we have measured the reliability of each of the three sets of items corresponding to the three factors retained. The reliability analysis test confirms a Cronbach's alpha=0.96 for the first set of items, Cronbach's alpha=0.85 for the second set and Cronbach's alpha=0.83 for the third set. For the reliability analysis, no item had to be reverse-scaled. The values of the Cronbach alphas and their corresponding split half coefficients are found to be in agreement suggesting that there are no anomalies in the data survey and that each of the three sets of items measures a single construct. Based on Factor analysis, three new constructs are derived by averaging the items corresponding to each factor and are labelled by *delivery*, *technology* and *statistics*. As illustrated by Figure 2, these 3 constructs were used as a basis for a subsequent analysis testing our hypothesis.

SUBSEQUENT ANALYSIS: ONE WAY ANOVA

A one way ANOVA analysis was conducted to examine any association between each of the three new constructs *delivery*, *technology* and *statistics* and difference in students' performance when taught with the integration of technology. Students were grouped into three performance categories (Fail+Pass Conceded, Pass+Credit and Distinction + High Distinction). The categories means' for each construct are compared by ANOVA. As can be seen from Table 1, the means for the students' perception towards *technology* differ significantly ($p=0.005$) among students' performance categories. Similarly, the means for the students' perception towards *statistics* increases with respect to the performance but the difference is only significant at 5%. However students' perception about the subject *delivery* and

Figure 2. Overall model of subsequent analysis to factor analysis: ANOVA and discriminant analysis

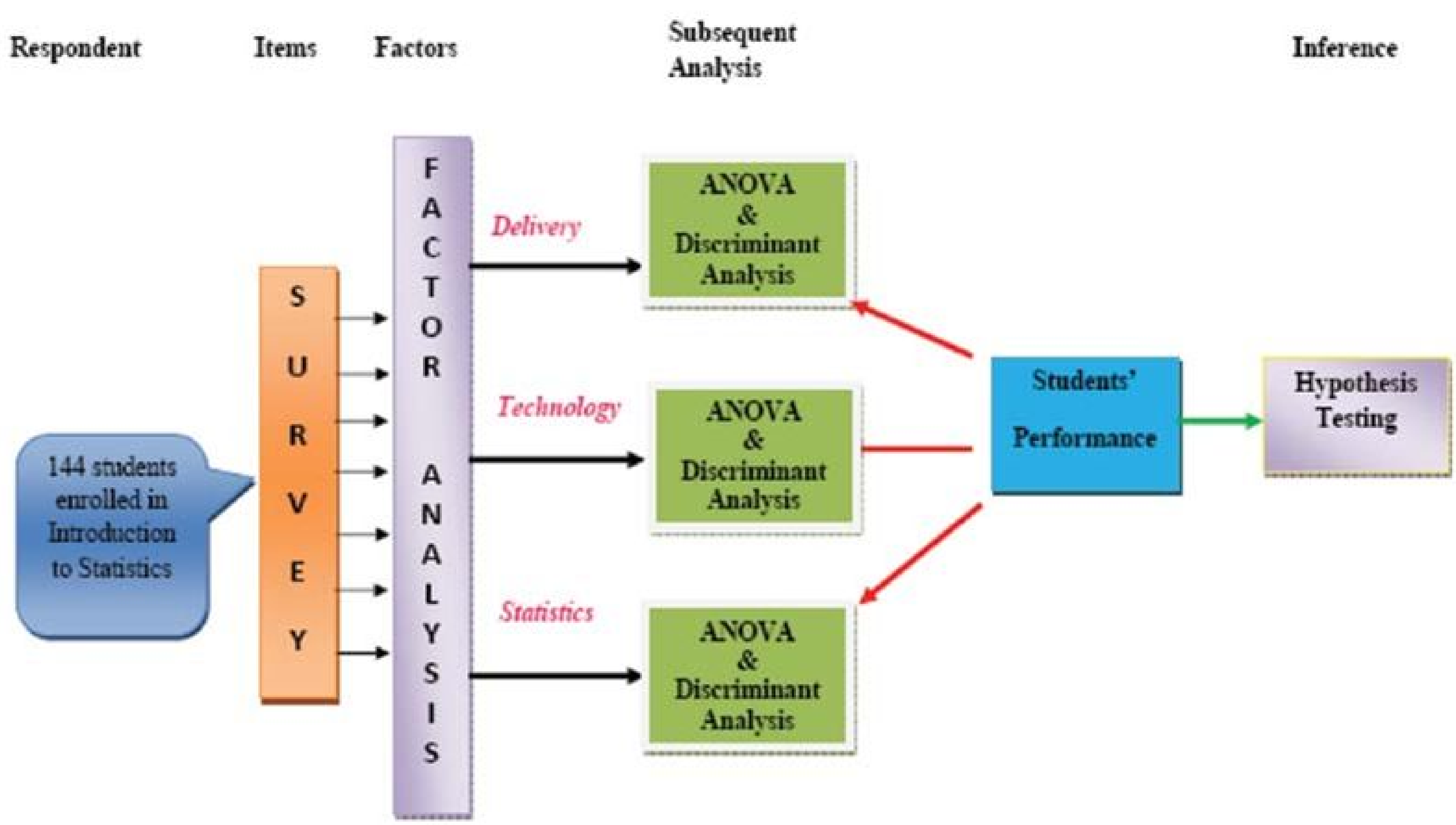


Table 1. Means' comparisons as a function of students' performance

Dependent Variable	Factor: Students Performance			
	Fail and Pass Conceded	Pass and Credit	Distinction and High Distinction	F_{STAT}
Delivery	3.78	4.01	4.11	2.1(.132)
Technology	3.90	4.01	4.32	5.5(.005)**
Statistics	3.44	3.85	3.88	3.1(.05)*

In parenthesis are p values. Means' scale is 1-5.
** Null hypothesis is rejected at 1%. * Null hypothesis is rejected at 5%.

teacher evaluation did not depend on students' performance.

SUBSEQUENT ANALYSIS: DISCRIMINANT ANALYSIS

An investigation similar to the above analysis testing whether differences in perceptions (subject delivery, technology benefits and Statistics) exist between the three students' performance groups is performed using Discriminant Analysis. Based on SPSS commands: *Analyze->Classify->Discriminant*, the three constructs are defined as independent variables and the three levels of students' performance as the grouping variable. Stepwise method reveals that only the factors *technology* and *statistics* are significant to predict students' performance from his/her response to the survey. The hit ratios using the two predictors are given in Table 2. As can be seen, students who did not do well in the subject were poorly discriminated from the other groups. The results reveal that the students who did not perform well in the subject had a relatively similar positive perception towards the delivery, the integration of technology and Statistics.

COMPARISON STUDENTS' PERFORMANCE TRADITIONAL VS. TECHNOLOGY TEACHING: Z TEST

The performances of student cohorts taught using traditional teaching are compared to those taught with technology. Columns 2 and 5 in Table 3, list the numbers of students in each performance category for both students taught with traditional teaching and with technology respectively.

In order to compare the two sets, each difference between the proportions in performance is transformed to an approximate standard normal distributed random variable Z using:

$$Z = \frac{\rho_{techno\log y,c} - \rho_{traditional,i}}{\sigma_{p_{techno\log y,c} - p_{traditional,c}}}$$

Table 2. Hit ratios of the two predictors

Performance Group	Hit Ratio	Hit Ratio with Cross Validation	Hit Ratio by Chance
Fail and pass conceded	5%	1%	14%
Pass and credit	30%	21%	30%
Distinction and high distinction	90%	89%	56%

Table 3. Test of significance on the difference in the performance between traditional and technology integrated teaching using Z-distribution

Performance Category	Traditional Teaching ($X_{traditional}$)	Proportion ($\rho_{traditional}$)	Technology Teaching ($X_{technology}$)	Proportion ($\rho_{technology}$)	Standard Error $\sigma_{\rho tech-\rho trad}$	Z_{stat}	p_{value}
High distinction (HD)	10	0.10(%)	51	0.32(%)	0.047	-4.08**	0.00
Distinction(D)	14	0.14	30	0.19	0.046	-1.02	0.15
Credit(C)	18	0.18	27	0.17	0.048	0.21	0.41
Pass(P)	17	0.17	21	0.13	0.046	0.84	0.20
Pass conceded (PC)	4	0.04	8	0.05	0.026	-0.38	0.35
Fail(F)	37	0.37	22	0.14	0.055	4.33**	0.00

** The difference is significant at 0.01

$\sigma_{p\text{-technolgy-p-traditional}}$ is the standard error of the difference between the two populations' proportions:

$$\sigma_{p_{techno\log y,c}-p_{traditional,c}} = \sqrt{\frac{\rho_{techno\log y,c}(1-\rho_{techno\log y,c})}{n_1} + \frac{\rho_{traditional,c}(1-\rho_{traditional,c})}{n_2}}$$

As can be seen from Table 3, the results reveal that students tend to achieve significant better performance with technology (p_{value} =0.00) and the failure rate when teaching with technology is reduced significantly from 37% to 14% (p_{value}= 0.00).

COMPARISON OF STUDENTS' PERFORMANCE IN TRADITIONAL VS. TECHNOLOGY INTEGRATED TEACHING: CHI-SQUARE TEST

Similar to the above test of whether there is no relationship between teaching methodology and the students' performance, a non parametric chi-square test has been conducted by testing the homogeneity of proportions of the various performance groups:

H_0: $\rho_{HD} = \rho_D = \rho_C = \rho_P = \rho_{PC} = \rho_F$
H_a: At least one of the proportions differs from the others.

A two-way contingency table Chi-square analysis reveals a chi-square value of 28.7 (p_{value}=0.0) indicating that the null hypothesis is rejected. Therefore there is a significant variation in the performance proportions between traditional teaching and teaching with technology. However, conducting a sub-hypothesis of the $\rho_D=\rho_C=\rho_P$ could not be rejected with a chi-square value of 0.5 (p_{value}=0.7) indicating that the difference in proportions in these three categories is not that significant. The sub-hypothesis $\rho_{HD}=\rho_F$ is rejected with a chi-square value of 27 (p_{value}=0.0). These results are in agreement with those determined using Z distribution.

CONCLUSION

The inclusion of technology has given students the opportunity to apply the statistical concepts to a large data set from a real-world situation. The students learned to present data in tables and charts in an easy manner and had the freedom to enhance their chart presentation confidently. They became comfortable with summarizing data using Excel data analysis tools. In addition, students showed more active participation in class and were more motivated to attend classes. Furthermore, the analysis of the survey highlighted that the students' failure rate was reduced from 34% to only 14% with the inclusion of technology. It is interesting to note that students with poor performance had the same positive perception towards teaching as those of the students who performed well. In contrast to popular belief that Statistics is a difficult subject, the students taught with the technology found the subject interesting and easier than foundation mathematics (Math 015). Overall, the survey expressed a significant result showing that with the use of Excel students performed much better.

The application of Excel at the foundation level of statistics teaching will help students maximize their efficiency in analyzing the data in other quantitative subjects such as accounting, finance, computer application, and management decision making tools. It is recommended that due to the successful outcome of the integration of technology, this added dimension in teaching should be permanently implemented in the curriculum. Nevertheless, we must be careful to integrate only learning tools that will help simplify the teaching of statistics. Thus, the focus of educators should be on teaching the concepts of statistics and not the technology used. Include how this study can be taken forward and also limitations of the study.

We recommend a further study to analyse the long term effect of integrating technology. We believe that there should be a balance between the use of technology as a tool and a means to meet the important learning outcomes corresponding to understanding the concepts taught in statistics.

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APPENDIX

Table 4. Percentages, mean, and standard deviation for each item

	Items	1 S.D.	2 D	3 N	4 A	5 S.A.	Mean	SD
1	I can organize data into tables and graphs using Excel program.	.7	3.5	5.6	43.1	47.2	4.00	.79
2	I can summarize data using computer program.		2.8	11.1	42.4	43.8	4.27	.76
3	I can easily interpret the data using Excel Program.	.7	3.5	9.0	46.5	40.3	4.22	.80
4	Statistics is relevant in my everyday life	.7	9.7	35.4	29.9	24.3	3.67	.97
5	Working with my classmates in the computer lab is very useful.			17.4	41.0	36.8	4.08	.89
6	Using computer program is very helpful in problem solving.	2.1	4.9	11.8	31.3	50	4.22	.97
7	The textbook is very helpful in answering my assignment.	11.8	14.6	36.8	23.6	13.2	3.12	1.17
8	Exercises given in the tutorial is very helpful			11.1	35.4	47.9	4.24	.91
9	I find Statistics easier than Mathematics	6.9	11.1	23.6	25	33.3	3.67	1.24
10	I recommend the textbook for Statistics related subjects	12.5	16.7	39.6	19.4	11.8	3.01	1.15
11	The concepts of Statistics is well explained in the lecture	.7	2.8	11.1	47.9	37.5	4.19	.79
12	The subject is interesting and fun	2.1	5.6	20.1	39.6	32.6	3.95	.97
13	One hour lecture is not enough to discuss concepts of statistics	8.3	25.0	19.4	29.2	18.1	3.24	1.24
14	Teachers are very helpful and supportive	2.1	5.6	11.8	38.2	42.4	4.13	.97
15	Hand-outs are helpful and excellent	2.1	2.8	7.6	43.8	43.8	4.24	.87
16	I can ask questions and get points clarified	1.4	6.9	15.3	44.4	31.9	3.99	.93
17	The tutorial and computer lab is too long	10.4	25.0	18.1	29.9	16.7	3.17	1.20
18	There is a sufficient review materials provided for the exams	1.4	3.5	16	43.8	35.4	4.08	.88
19	I can learn concepts when my teacher gives examples based on real life situations	1.4	7.6	16.7	49.3	25.0	3.89	.91
20	Computer lab session is better than purely lectures and tutorials	1.4	6.9	17.4	40.3	34.0	3.99	.96
21	I find statistics interesting and relevant	1.4	8.3	19.4	45.1	25.7	3.85	.94
22	I can easily learn and apply the concepts learned in the lecture using computer program and in the tutorial	.7	5.6	16.7	48.6	28.5	3.99	.86
23	Exercises given in the computer lab is very helpful	1.4	3.5	9.7	48.6	36.8	4.16	.84
24	Using computer program, I can analyze data better	1.4	4.2	13.9	47.2	33.3	4.07	.87
25	The teaching staff are approachable when I need help	2.8	6.3	14.6	41.7	34.7	3.99	1.00
26	I find probabilities hardest topic in Statistics	12.5	24.3	23.6	29.2	10.4	3.01	1.20
27	The teacher gives presentation helpful for examination	1.4	4.9	18.8	48.6	26.4	3.94	.87
28	The teacher encourages me to think on my own	2.8	4.9	16.7	45.8	29.9	3.95	.95
29	I can apply in other subjects what I have learned in Statistics	1.4	9.0	21.5	47.2	20.8	3.77	.92
30	My learning experience in this subject made me enthusiastic about further learning	3.5	6.9	25.7	41.7	22.2	3.72	1.00
31	The teachers give consultation hours where I can reach them and offer additional help	.7	6.3	18.1	47.2	27.8	3.95	.88

continued on the following page

Table 4. Continued

	Items	1 S.D.	2 D	3 N	4 A	5 S.A.	Mean	SD
32	I can relate that Statistics is used in the real world	2.1	7.6	18.1	50.7	21.5	3.82	.92
33	The teaching staff gives regular feedback		6.3	19.4	50.0	24.3	3.92	.82
34	The lecture notes, hand-outs are well-organized, well written and useful	.7	4.9	10.4	43.1	41.0	4.19	.86
35	The type of questions assigned for homework helps me learn the material better		6.3	7.6	44.4	41.7	4.22	.83
36	The midterm review lecture was informative and helpful	2.1	3.5	11.1	41.0	42.4	4.18	.91
37	The midterm exam difficulty level is fair	2.1	6.9	18.8	41.7	30.6	3.92	.97
38	Explanation of concepts is adequate	1.4	5.6	12.5	51.4	29.2	4.01	.87
39	Demonstration of solution process is adequate	.7	4.9	17.4	50.7	26.4	3.97	.83
40	There are enough examples given per lecture/tutorial	2.8	5.6	11.1	51.4	29.2	4.00	.93

Likert Scale: 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree