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Developing a Predictive Model for the Enhanced Learning Outcomes by the Use of Technology

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Abstract: This paper reports on the initial outcomes of a study to develop a model to identify the relationship between technological facilities such as iPad, MacBook, Apps and software etc., pedagogy (that can be defined as any conscious activity by one person designed to enhance learning in another (Watkins and Mortimore, 1999 [1])), curriculum and learning. The new model can be called CPT Model. This is a new area of study. The model will test the difference between the observed learning outcomes and the learning outcomes predicted. *This model can predict the outcomes* for assessing the students' progress. Using a three-dimensional vector space in the form of 3D equations, after the integration between the ICT and the education, students' observed and predicted progress (that was calculated using the CPT model) were compared. These rates were very close to each other. Therefore the null hypothesis, "there is not a significant difference between the observed (actual) and expected outcomes".

1. Introduction

Research into the effect of technology on the learning process, using various mobile devices such as mobile devices is relatively new (e.g., Wong, Chin, Tan, & Liu, 2010 [2]). More specifically, the use of pocket PCs (e.g., Wong & Looi, 2010[3]), and Apple iPhones (e.g., Jong, Specht, & Koper, 2010 [4]) have been investigated. These researchers have found that involving the mobility and connectivity of mobile devices may lead to innovation in the learning for students across different environments (Looi et al., 2010 [5]; Tai, 2012 [6]). For instance, it has been shown that mobile telephones are increasingly used for improving both content knowledge and communication skills (Stockwell, 2010 [7]; Zhang, Song, & Burston, 2011 [8]).

Using mobile technology devices for educational purposes is becoming a common expectation of learners (Lan & Huang, 2012 [9]). For instance, Valk, Rashid, and Elder [10] demonstrated how mobile telephone-facilitated learning can give students in developing countries increased access to educational materials and services, particularly in rural and remote regions. However, the innovation of learning based on technology (referred to in this study as users Learning Technology using Mobile Technologies [LTMT]) continues to challenge educators to develop new teaching and learning pedagogies.

2. The Study

This study was carried out in the Institute of Applied Technology (IAT) – UAE. The study consists of two stages: the first stage (sample of teachers) was used to design the model and the second stage (sample of 124 students) was used to test the model and to check the validity of the CPT equations.

The study reported in this paper investigates the use of a predictive model for the learning outcomes through the integration of technology in the learning process. The model developed treats the Curriculum, Pedagogical approach and Technology integration as the three axes in a pseudo-vector space. In the model, which is to be known as the CPT model, the axes run as:

Curriculum:

C1: purely theoretical;
C2: theoretical and practical;
C3: theoretical, practical and interactive;

Pedagogical approach:

This axis draws on the work of Lin et al [11] who argue the case for four dimensions of pedagogy, direct teaching, cognitively active learning, constructive learning and social learning, in this paper the pedagogy dimensions will be distributed as follows:

P1: the teacher only applies one dimension;
P2: the teacher applies two dimensions;
P3: the teacher applies three dimensions;
P4: the teacher applies four dimensions.

Technology integration:

This axis considers the percentage of lesson content integrated with appropriate technology.

T1: 20% of the content integrated with technology;
T2: 40% of the content integrated with technology;
T3: 60% of the content integrated with technology;
T4: 80% of the content integrated with technology;
T5: 100% of the content integrated with technology.

This allows the three dimensional vector space to be constructed as shown below (see Figures 1a and 1b), using a standard (x, y, z) co-ordinate system plotted as (C, P, T):

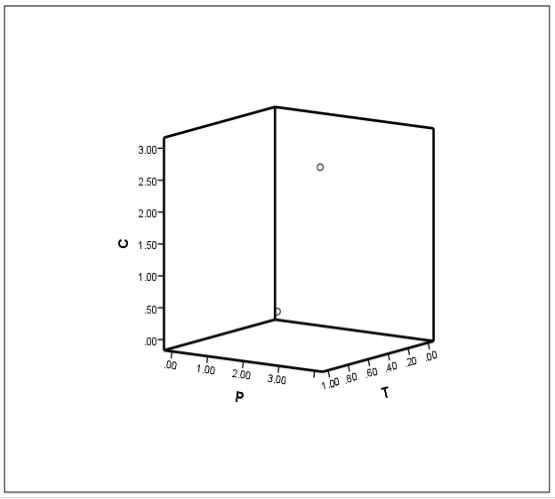

Figure 1a. The 3D vector space used in the model showing the points (0, 0, 0) and (4, 3, 1)

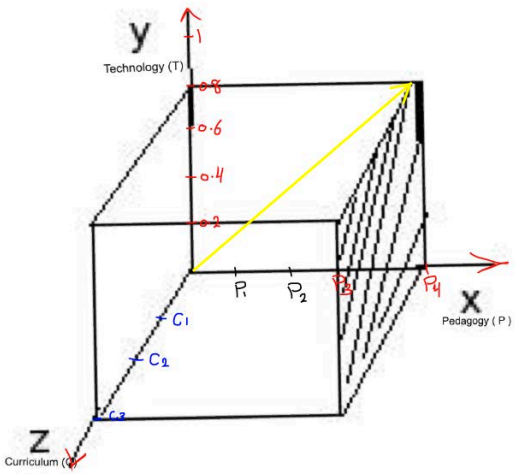

Figure 1b. The 3D vector space used in the model showing the point (C3=3, P4 = 4, T4=0.8)

This allows the resultant vector, R, to be calculated from:

$$R = \sqrt{P^2 + C^2 + T^2}$$

If no technology is integrated into the lesson then then:

$$R = \sqrt{P^2 + C^2}$$

Hence **Equation 1** calculates the technology enhanced vector

$$R_{enhanced} = \sqrt{P^2 + C^2 + T^2} - \sqrt{P^2 + C^2}$$

In this study the technology enhanced vector is taken to be the predicted enhanced progress for the learners.

The predicted enhanced learning for all CPT combinations can be calculated and these are given below (see Table 1, Table 2, Table 3 and Table 4):

Table 1. Predicted enhanced learning, P=1 series

P	C	T	$R_{enhanced}$
1	1	0.2	0.014
1	1	0.4	0.055
1	1	0.6	0.122
1	1	0.8	0.211
1	1	1.0	0.318
1	2	0.2	0.009
1	2	0.4	0.035
1	2	0.6	0.079
1	2	0.8	0.139
1	2	1.0	0.213
1	3	0.2	0.006
1	3	0.4	0.025
1	3	0.6	0.056
1	3	0.8	0.100
1	3	1.0	0.154

Table 2. Predicted enhanced learning, P=2 series

P	C	T	$R_{enhanced}$
2	1	0.2	0.009
2	1	0.4	0.035
2	1	0.6	0.079
2	1	0.8	0.139
2	1	1.0	0.213
2	2	0.2	0.007
2	2	0.4	0.028
2	2	0.6	0.063
2	2	0.8	0.111
2	2	1.0	0.172
2	3	0.2	0.006

2	3	0.4	0.022
2	3	0.6	0.050
2	3	0.8	0.088
2	3	1.0	0.136

Table 3. Predicted enhanced learning, P=3 series

P	C	T	$R_{enhanced}$
3	1	0.2	0.006
3	1	0.4	0.025
3	1	0.6	0.056
3	1	0.8	0.100
3	1	1.0	0.154
3	2	0.2	0.006
3	2	0.4	0.022
3	2	0.6	0.050
3	2	0.8	0.088
3	2	1.0	0.136
3	3	0.2	0.005
3	3	0.4	0.019
3	3	0.6	0.042
3	3	0.8	0.075
3	3	1.0	0.116

Table 4. Predicted enhanced learning, P=4 series

P	C	T	$R_{enhanced}$
4	1	0.2	0.005
4	1	0.4	0.019
4	1	0.6	0.043
4	1	0.8	0.077
4	1	1.0	0.120
4	2	0.2	0.004
4	2	0.4	0.018
4	2	0.6	0.040
4	2	0.8	0.071
4	2	1.0	0.110
4	3	0.2	0.004
4	3	0.4	0.016
4	3	0.6	0.036
4	3	0.8	0.064
4	3	1.0	0.099

3. Tools Were Used in This Study

1. The teachers have MacBook Pro laptops and iPads, provided by their institution – the institute of applied technology (IAT). These devices come with packages of software applications and apps meeting the expectations of the one-to-one technology integration plan, and curriculum requirements of IAT.
2. Classrooms, workshops, and laboratories are equipped with projectors, audio systems, and smart boards (technologies to serve the curriculum outcomes).
3. Learning Resource Center (LRC) has many multimedia resources to support curriculum implementation, and promote student's literacy and research skills such as report writing, analyzing lots of information from different sources, finding information off the Internet, critical thinking etc.
4. Electronic resources were provided for example iBooks, academic animation movies and PDF files.

4. Methodology

Using a pre and post-test approach, a content knowledge had been delivered using a selected set of CPT variables. In order that the environment and the integration of technology could be controlled:

- A learning environment was created to simplify the use of mobile devices for the students;
- Students were able to post responses to prompts provided by the instructor;

Class assignments were designed with the following criteria:

- Assessment required the use of mobile technology;
- Assessment must allow the use of technologies familiar to the learners;
- Assessment must allow the learner to give both quantitative and reflective responses.

5. Results

Case 1, N=35, P=3, C=3, T=0.6.

This represents 60% of the content being delivered through the integration of technology.

$R_{enhanced}$ = 0.042 or 4.2% (see Table 3 and Table 5).

Table 5. Pre and post-test results for P = 3, C = 3 and T = 0.6

pre-test %	post-test %	observed improvement %	predicted improvement %
79	85	6.0	4.2
56	64	8.0	4.2
40	43	3.0	4.2
61	66	5.0	4.2
90	93	3.0	4.2
76	80	4.0	4.2
85	91	6.0	4.2

56	60	4.0	4.2
52	60	8.0	4.2
42	48	6.0	4.2
89	96	7.0	4.2
61	68	7.0	4.2
86	92	6.0	4.2
91	93	2.0	4.2
53	60	7.0	4.2
66	71	5.0	4.2
48	52	4.0	4.2
70	77	7.0	4.2
50	57	7.0	4.2
75	69	-6.0	4.2
22	33	11.0	4.2
69	71	2.0	4.2
61	68	7.0	4.2
60	68	8.0	4.2
23	30	7.0	4.2
34	39	5.0	4.2
77	84	7.0	4.2
87	89	2.0	4.2
31	37	6.0	4.2
30	37	7.0	4.2
53	60	7.0	4.2
51	62	11.0	4.2
66	73	7.0	4.2
70	72	2.0	4.2
43	40	-3.0	4.2

Case 2, N = 35, P = 3, C = 3, T =0.8

This represents 80% of the content being delivered through the integration of technology.

$R_{enhanced}$ = 0.075 or 7.5% (see Table 3 and Table 6).

Table 6. Pre and post-test results for P = 3, C = 3 and T = 0.8

pre-test %	post-test %	observed improvement %	predicted improvement %
90	100	10	7.5
95	100	5	7.5
80	85	5	7.5
75	90	15	7.5
90	94	4	7.5
90	100	10	7.5
90	100	10	7.5
80	90	10	7.5
80	85	5	7.5
80	90	10	7.5
80	88	8	7.5
85	89	4	7.5
75	90	15	7.5
77	90	13	7.5
80	88	8	7.5
80	87	7	7.5
80	89	9	7.5
95	100	5	7.5
90	100	10	7.5
96	99	3	7.5
95	96	1	7.5
94	100	6	7.5
90	100	10	7.5
82	95	13	7.5
90	100	10	7.5
90	95	5	7.5
90	98	8	7.5
100	95	-5	7.5
70	90	20	7.5
90	95	5	7.5
90	78	-12	7.5
80	88	8	7.5
72	95	23	7.5
50	70	20	7.5
90	95	5	7.5

Case 3, N=28, P = 2, C = 2, T = 0.8

This represents 80% of the content being delivered through the integration of technology.

$R_{enhanced}$ = 0.11 or 11% (see Table 2 and Table 7)

Table 7. Pre and post-test results for P = 2, C = 2 and T = 0.8

pre-test %	post-test %	observed improvement %	predicted improvement %
80	88	8	11
63	73	10	11
50	47	-3	11
60	39	-21	11
64	94	30	11
50	72	22	11
77	88	11	11
64	73	9	11
70	90	20	11
40	60	20	11
84	94	10	11
74	91	17	11
77	86	9	11
60	70	10	11
78	87	9	11
45	60	15	11
97	80	-17	11
64	75	11	11
60	80	20	11
50	83	33	11

44	52	8	11
90	75	-15	11
77	91	14	11
66	72	6	11
54	64	10	11
87	67	-20	11
88	94	6	11
77	81	4	11

6. Analysis

For each of the cases 1 to 3 the null hypothesis can be stated as:

$H_{0:}$ there is no significant difference between the means of the predicted and observed improvement

Using a two-tailed paired t-test gives the following for p = 0.05 (see Table 8)

Table 8. Two-tailed paired t-test results

Case	N	t_{stat}	$t_{critical}$
1	35	1.93	2.03
2	35	0.53	2.03
3	28	1.01	2.05

Hence in no case can the null-hypothesis be rejected.

The effect size for each intervention can also be calculated giving (see Table 9):

Table 9. Effect size for the integration of mobile technology

Case	N	d	Level [11]
1	35	0.3	Medium
2	35	0.9	Large
3	28	0.6	Large

From the below figure (see Figure 2) it is possible to see and compare all three cases in regards to the observed progress, predicted progress and P_{value} and chi square test.

Case #	Number of students	$C_n P_n T_n$	The AVG observed progress	The predicted (expected) progress (Rn) $= \sqrt{Cn^2 + Pn^2 + Tn^2} \cdot \sqrt{Cn^2 + Pn^2}$	P_{value}	$\Sigma\ \chi^2$	The final result based on $\Sigma\ \chi^2$ and the P_{value}
1	35	C3, T3, P3	0.053	0.042	< 0.05	0.99	*NO significant difference between the expected values and the observed values.*
2	35	C3, T4, P3	0.080	0.075	< 0.05	1.94	
3	28	C2, T4, P2	0.107	0.111	< 0.05	2.70	

Figure 2. The summary of observed improvement against the expected improvement in different cases of CPT Model.

The array of tables and figures below illustrates the expected and the actual results of improvement, their average and comparison. (See Tables 10 -11 and Figures 3 - 5). Expected improvement values were calculated using Equation 1 (for more on

equations refer to sections 2 and 7) and the Observed improvement was taken from students' assessments results (see Tables 5-7).

Table 10. Observed improvement against the expected improvement in different bands: band 3 (B3): C3, P3, T3 and C3, P3, T4; band 2 (B2): C2, P2, T4 and band 1 (B1): C1, P1, T1.

Band, Tn	Observed improvement	Expected improvement (calculated from the formula)
C1, P1, T1	0.020	0.014
C2, P2, T4	0.107	0.111
C3, P3, T3	0.053	0.042
C3, P3, T4	0.080	0.075
AVG (average)	0.065	0.060

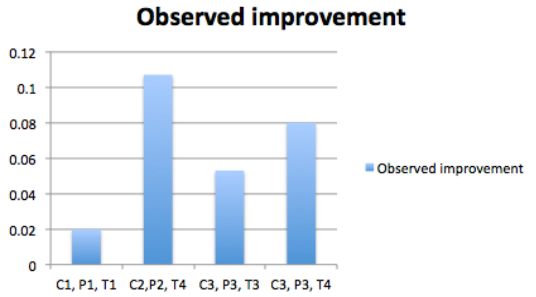

Figure 3. Observed improvement in different bands: band 3 (B3): C3, P3, T3 and C3, P3, T4" band 2 (B2): C2, P2, T4 and band 1 (B1) C1, P1, T1

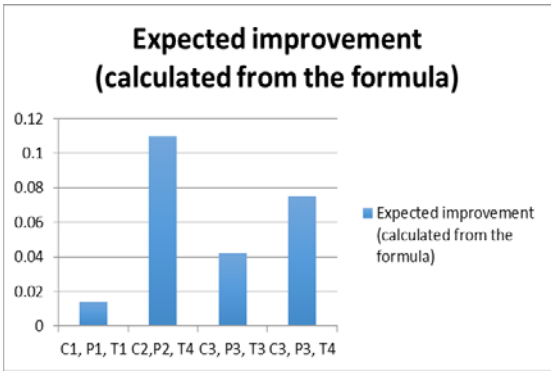

Figure 4. Observed improvement in different bands: band 3 (B3): C3, P3, T3 and C3, P3, T4" band 2 (B2): C2, P2, T4 and band 1 (B1) C1, P1, T1

Table 11. Average expected improvement and the observed improvement

	Observed improvement	Expected improvement (calculated from the formula)
Average	0.065	0.060

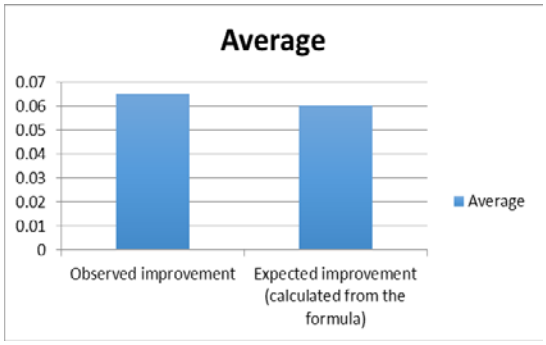

Figure 5. Average expected improvement and the observed improvement

7. Mathematical findings

The technology enhanced vector ($R_{enhanced}$) can be given in other forms, which give exactly the same results, these forms are given below in equations 2 and 3.

Equation 2. The technology enhanced vector

$$R_{enhanced} = R_{\cdot\cdot}(n)^2$$

The value of R**.** can be calculated using the following **Equation 3**

$$R_{\cdot} = \sqrt{Cn^2 + Pn^2 + 0.2^2} - \sqrt{Cn^2 + Pn^2}$$

"n" can take values from 1 to 5.
There for, T1=0.2, T2 = 0.4, T3 = 0.6, T4=0.8, T5=1

Example:
C1, P1, T1: the curriculum is purely theoretical, 20% of the content integrated with technology; the teacher only applies one dimension of pedagogy.

The point being (1, 1, 0.2)

The technology enhanced vector:

$$R_{enhanced} = \sqrt{C1^2 + P1^2 + T1^2} \cdot \sqrt{C1^2 + P1^2}$$

$$R_{enhanced} = \sqrt{1^2 + 1^2 + 0.2^2} - \sqrt{1^2 + 1^2}$$

$$R_{enhanced} = 0.014$$

Which can be calculated also using equations 2 and 3 as shown below.

The technology enhanced vector

$$R_{enhanced} = R_{\cdot\cdot}(n)^2$$

From equation 3:

$$R_{\cdot} = \sqrt{1^2 + 1^2 + 0.2^2} - \sqrt{1^2 + 1^2}$$

$$R_{\cdot} = 0.014$$

In this case n= 1, so that:

$$R_{enhanced} = 0.014 \times (1)^2 = 0.014$$

It gives the same value at point (1, 0.2, 1) that is calculated from equation 1.

For more examples about the technology enhanced vector $(R_{enhanced})$, which is calculated using The CPT model equations (1, 2 and 3) refer to the table below (see Table 12).

Table 12. The technology enhanced vector $R_{enhanced}$ calculated using The CPT model equations (1, 2 and 3) - with different values of n.

Cn, Tn, Pn	The technology enhanced vector $R_{enhanced} = \sqrt{Cn^2 + Pn^2 + Tn^2} - \sqrt{Cn^2 + Pn^2}$	The technology enhanced vector $R_{enhanced} = R.(n)^2$
C1, P1, T2	0.056	0.056
C2, P2, T1	0.007	0.007
C2, P2, T2	0.028	0.028
C3, P3, T3	0.042	0.042
C3, P3, T4	0.075	0.075
C2, P2, T4	0.111	0.111
C1, P1, T1	0.014	0.014

8. The CPT Model Contribution to the Future Studies

This model can be considered, as an entrance for a new research area that can be called *the mathematics behind the education*, in other words the integration between the mathematics and the education. Furthermore, it can be developed to involve the psychology, by studying the student's psychological attitude towards learning; therefore this model can be a rich research area for researchers in different departments: Education, Psychology and Mathematics to create eventually a developed model consisting of all of these subjects.

9. The Usefulness of the CPT Model

The developed model (CPT) can predict the learning outcomes for assessing the students' progress. Using a three-dimensional vector space (see Figures 1a and 1b). The potential impact of this research will be felt predominantly by curriculum designers and policy makers, by allowing outcomes from learning scenarios to be predicted in advance. The vigorous testing that will be done is intended to make this a predictive model. Authors believe that if the future researches will manage to develop the CPT model to be integrated between Education, Psychology and Mathematics *then in this case this model will serve the humanity all around the world by helping the educators to improve* their *students' level and performance by choosing the proper CPT strategy suitable for each student individually*.

10. Conclusion

At the group level, the authors claim that:

This pilot study has shown that a pseudo-vector space, where the resultant vector is taken to be the learner progress, can have predictive power. As demonstrated in Figure 2.

This pilot study has further shown that the integration of mobile technology into the learning environment has a positive effect on the learning outcome. As demonstrated in Table 9.

CPT model can be considered as an entrance for a new research area that can be called *the mathematics behind the education.*

11. References

[12] Cohen, J., "Statistical power analysis for the behavioral sciences (2nd ed.)", *Lawrence Earlbaum Associate*, Hillsdale, NJ, 1988.

[4] Jong, T., Specht, M., and Koper, R. "A study of contextualised mobile information delivery for language learning", *Journal of Educational Technology & Society*, *13*(3), 2010, pp. 110–125, Retrieved from http://www.ifets.info/journals/13_3/11.pdf .

[9] Lan, Y.-F., and Huang, S.M., "Using mobile learning to improve the reflection: a case study of traffic violation", *Educational Technology & Society*, *15*(2), 2012, pp. 179–193, Retrieved from http://www.ifets.info/journals/15_2/16.pdf

[11] Lin, J.M-C., Wang, P-Y., and I-Chun Lin, I-C., "Pedagogy, technology: A two-dimensional model for teachers' ICT integration", *British Journal of Educational Technology* Vol 43, No 1, 2012, pp. 97–108, doi:10.1111/j.1467-8535.2010.01159.x y * _1159 97..108

[5] Looi, C.K., Seow, P., Zhang, B., So, H.J., Chen, W., and Wong, L.H., "Leveraging mobile technology for sustainable seamless learning: A research agenda",

British Journal of Educational Technology, 41(2), 2010, pp.154–169, doi: 10.1111/j.1467-8535.2008.00912.x,

[7] Stockwell, G., "Using mobile phones for vocabulary activities: Examining the effect of the platform", *Language Learning & Technology*, 14(2), 2010, pp.95–110, Retrieved from http://llt.msu.edu/vol14num2/stockwell.pdf

[6] Tai, Y., "Contextualizing a MALL: practice design and evaluation", *Educational Technology & Society*, 15(2), 2012, pp. 220–230, Retrieved from http://www.ifets.info/journals/15_2/19.pdf

[10] Valk, J., Rashid, A.T., and Elder L., "Using mobile phones to improve educational outcomes: An analysis of evidence from Asia", *International Review of Research in Open and Distance Learning*, *11*(1), 2010, pp. 117–140. Retrieved from http://www.irrodl.org/index.php/irrodl/article/download/794/1507

[1] Watkins, C., and Mortimer, P., "Pedagogy: What do we know?" *In Mortimer P (Ed) Understanding pedagogy and its impact on teaching*, London, Paul Chapman publishing, 1999, pp. 1-19.

[3] Wong, L. H., and Looi, C. K., "Vocabulary learning by mobile-assisted authentic content creation and social meaning-making: Two case studies", *Journal of Computer Assisted Learning*, *26*(5), 2010, pp. 421–433. doi:10.1111/j.1365-2729.2010.00357.x

[2] Wong, L. H., Chin, C. K., Tan, C.L., and Liu, M., "Students' personal and social meaning making in a Chinese idiom mobile learning environment", *Journal of Educational Technology & Society*, *13*(4), 2010, pp. 15–26. Retrieved from http://www.ifets.info/journals/13_4/3.pdf

[8] Zhang, H., Song, W., and Burston, J., "Reexamining the effectiveness of vocabulary learning via mobile phones", *TOJET: The Turkish Online Journal of Educational Technology*, 10(3), 2011, pp. 203–214, Retrieved from http://www.tojet.net/articles/v10i3/10323.pdf