Experimental teaching, Perceived usefulness, Ease of use, Learning Interest and Science Achievement of Taiwan 8th Graders in TIMSS 2007 Database

Pei Wen Liao, Tsung Hau Jen

***Abstract*—**the data of Taiwanese 8^{th} grader in the 4th cycle of Trends in International Mathematics and Science Study (TIMSS) are analyzed to examine the influence of the science teachers' preference in experimental teaching on the relationships between the affective variables (the perceived usefulness of science, ease of using science and science learning interest) and the academic achievement in science. After dealing with the missing data, 3711 students and 145 science teacher's data were analyzed through a Hierarchical Linear Modeling technique. The major objective of this study was to determine the role of the experimental teaching moderates the relationship between perceived usefulness and achievement.

***Keywords*—**TIMSS database, Science achievement, Experimental teaching, Perceived Usefulness, Perceived Ease of Use

I. Introduction

PEOPLE seem to believe that more mathematics and science in the school curricula would help students to compete in the technology-rich world. It has been taken for granted that mathematics and science achievement is a good measure of labor-force quality, and thus an important determinant of the income of nations [1]. According to the fourth cycle of Trends in International Mathematics and Science Study (TIMSS), study that comparative international assessments dedicated to improving teaching and learning in mathematics and science for students around the world. TIMSS 2007 collected detailed information about mathematics and science curriculum coverage and implementation, as well as teacher preparation, resource availability, and the use of technology. TIMSS provides data about trends in mathematics and science achievement over time. Several recent discussions of instructional design have examined the importance of learner characteristics, such as motivation and self-beliefs, for achieving effective learning outcomes [2]. Student attitudes and motivation were incorporated into a proposed cognitive model of instructional design [3] and a motivational model of instructional design has been developed to improve instructional materials [4][5]. Although research on academic self-regulation has proliferated in recent years, no studies have investigated the question of whether the perceived usefulness and the ease of use provide a differential prediction of academic achievement for students.

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Ruban, McCoach, Mcguire, Reis, [6] research add the perceived usefulness, conceptual skills, to find the results of this study contribute to the knowledge base about the academic self-regulation of postsecondary students with learning disabilities and may provide additional insights about the differential impact of perceived usefulness and the actual use of standard self-regulated learning strategies and compensation strategies between students with and without learning disabilities. Our research tries to merge Fishbein and Ajzen [7], Davis [8] to explore the factors relates to 8^{th} graders science achievement. Further, we investigate teaching method relates to achievement.

Those successful students must develop effective study strategies and methods. The purpose of this study was to investigate the relationship between student perceived usefulness, ease of use, learning interest, experimental teaching and science achievement. So, we developed and tested a model explaining interrelationships among perceived usefulness, ease of use and learning interest variables and add the teacher's experimental approach using Hierarchical Linear Modeling for TIMSS's database collection students (n =3711) and integrate the teacher's data(n = 145) for data analysis. Findings and implications of the research are discussed.

II. Theoretical Framework

Fishbein and Ajzen [7] believed that an attitude toward performing a particular behavior is formed depending on: one's beliefs about the consequences of performing the particular behavior; and one's evaluation of those possible consequences. And Davis [8] published the results of a study that developed and validated new scales for two constructs, perceived usefulness and perceived ease of use, which are hypothesized to be fundamental determinants of user acceptance of information technology.

Our research model as figure 1, Attitude mean student cognitive perception, include perceived usefulness, perceived ease of use, and learning interest. A number of studies have found that student self-beliefs are significantly related to academic achievement. For instance, students' level of academic aspiration exerted a significant influence on achievement in several school subjects [9]. Further, students' self-efficacy beliefs and attributions for academic success and failure are significantly related to achievement outcomes [10][11]. Students' academic self-concept and achievement expectancies have been shown to be significant predictors of several types of academic achievement outcomes such as cumulative grade performance [12] and continued enrollment in school [13]. Such as Ruban et al. [6] research find perceived

usefulness significantly related to achievement. Students prefer a collaborative learning environment and that motivation for science learning would increase in a classroom environment that incorporates collaborative activities [14]. These study hypotheses are follows:
H1: Perceived usefulness positively relates to achievement.
H2: Perceived ease of use positively relates to achievement.
H3: Learning interest positively relates to achievement.
H4: Experimental approaches moderate the relationship between perceived usefulness and achievement, such that this positive association is stronger for students who perceive more positive achievement.
H5: Experimental approaches moderate the relationship between perceived ease of use and achievement, such that this positive association is stronger for students who perceive more positive achievement.
H6: Experimental approaches moderate the relationship between learning interest and achievement, such that this positive association is stronger for students who perceive more positive achievement.

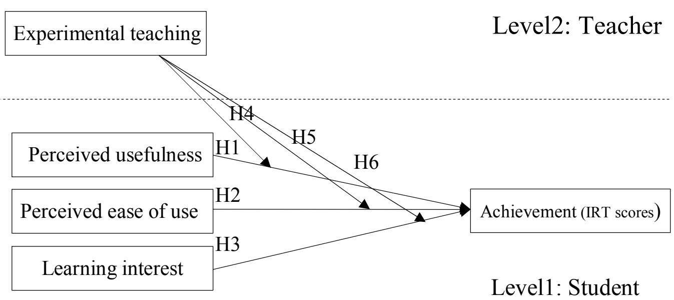


Fig. 1 Research model

III. Method

A. Measures

By using a secondary analysis approach, the data of Taiwanese 8^{th} graders participating in TIMSS 2007 are utilized to examine the proposed model (http://timss.bc.edu). The items corresponding to the independent variables involved in the proposed model were demonstrated in Table 1. The students' plausible values in science are used as the data of dependent variable in our model. Content validity was studied among 2 expert professionals at TIMSS centre. Expert opinion was obtained for the content validity of the scale.

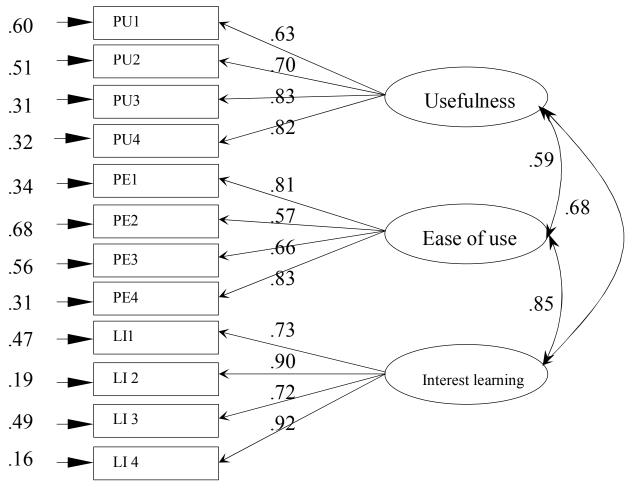
TABLE I
STUDENT AND TEACHER QUESTIONNAIRE

Variable	Item	Scale
Perceived usefulness	PU1. I think learning science will help me in my daily life PU2. I need science to learn other school subjects PU3. I need to do well in science to get into the <university> of my choice PU4. I need to do well in science to get the job I want	1=disagree a lot, 2=disagree a little, 3=agree a little, 4=agree a lot
Perceived ease of use	PE1. I usually do well in science PE2. Science is more difficult for me than for many of my classmates(-) PE3. Science is not one of my strengths(-) PE4. I learn things quickly in science	
Learning interest	LI1. I would like to take more science in school LI2. I enjoy learning science LI3. Science is boring(-) LI4. I like science	
Experimental teaching	EA1. Watch me demonstrate an experiment or investigation EA2. Design or plan experiments or investigations EA3. Conduct experiments or investigations EA4. Work together in small groups on experiments or investigations	1=never, 2=some lessons, 3=about half the lessons, 4=every or almost every lesson

B. Reliability and validity

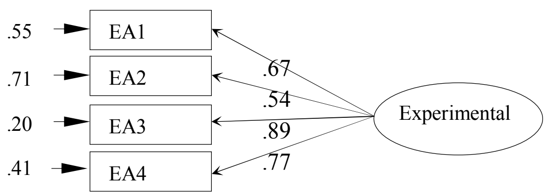
Using standard statistical software packages, such as SPSS18, the item mean scores for each grade can be easily obtained. We used confirmatory factor analysis with a structural equation modeling analysis (using LISREL 8.08), and to test the measurement model and the extent to which our measured indicators adequately related to their associated latent variables. If we obtained an acceptable fit of the measurement model, we then tested the hierarchical model. We were analyzed for construct reliability, convergent and divergent criteria, ISREL-based CFA analyses of goodness-of-fit, indicator loadings, construct composite reliability, average variance extracted. To evaluate model fit, we relied on the chi-square test statistic and three indices of fit, including the standardized root-mean-square residual (SRMR), the root-mean-square error of approximation (RMSEA) [15], and the comparative fit index (CFI) [16].

Thus, to provide the information necessary to evaluate model fit, we present four statistics: the chi-square and the three fit indices of CFI, RMSEA, and SRMR. The student and teacher measurement model are shown in figure 2, 3. From Table 2, Respondents also reported a high level of traits. Mean and standard deviation of traits reported by the entrepreneurs are presented above. To verify the dimensionality and reliability of the measurement we performed construct and confirmatory factor analysis, tested for composite reliability, and calculated Cronbach's alpha coefficients. Reliability analyses show the following Cronbach's Alpha values 0.81~0.89. Composite reliability (CR) between 0.81~0.89, Average Variance Extracted (AVE) was 0.53~0.67. These procedures are necessary for complex sampling designs and provide unbiased variance estimates to enable appropriate statistical tests of significance to be made.



χ^2=2121.13 , CFI = 0.97, RMSEA=.105, SRMR=0.059

Fig. 2 Confirmatory factor analysis of student data



χ^2=16.36 , CFI=0.94, RMSEA=.22, SRMR=0.061

Fig. 3 Confirmatory factor analysis of teacher data

TABLE II
DESCRIPTIVE, RELIABILITY AND VALIDITY STATISTICS

Variable		Mean	S.D.	CR	AVE	Alpha
Student N=3711	Perceived usefulness	2.60	.74	.84	.56	.83
	Perceived ease of use	2.35	.73	.81	.53	.82
	Learning interest	2.52	.82	.89	.67	.89
Teacher N=145	Experimental teaching	2.07	.45	.81	.53	.81

IV. RESULTS

The effects of education exist both between and within the units at each level of educational systems. Thus, recognizing the multilevel nature of educational data — i.e., schools of their teachers or as aggregates of students and processes within them — is vital for a better understanding and prediction of social issues and phenomena. HLM facilitates modeling of within and between school phenomena, thus allowing for the direct representation of the influence of school factors on structural relations within schools through a set of regression coefficients.

In this study, restricted maximum likelihood procedures were used to plausible values the relative contribution and level-1weighting ads HOUWGT of each variable toward the explanation of science achievement. We tested the hypothesized model with a Hierarchical Linear Modeling (using HLM 6.08).

We first examined the degree of between-group variance in individual achievement as required by HLM. Using this simple random-effects analysis of variance (ANOVA) model, the ICC is the ratio of the between class variance to the total variance. The between class variance in reading comprehension (τ_{00}**)** is 1491.149. The within class variance (σ^2**)** in reading comprehension is 6392.583. Therefore, the interclass correlation is the between-cluster variance divided by the total variance, $\tau_{00} / (\tau_{00}+\sigma^2)$**,** which is 0.189; meaning 18.9% of the variability in reading comprehension scores is accounted for by the cluster (classroom). The degree of relationship among units from the same cluster is captured by the intraclass correlation coefficient (ICC)[17].

In the within school (or random coefficients) model, Y_{ij} represents the math achievement score for student *i* in school *j* as a function of various student background characteristics and the random error r_{ij}. Equation one below represents our child-level or level-1 model (outcomes model table 3):

Level1

$Y_{ij} = \beta_{0j} + \beta_{1j}$* (Perceived usefulness) $+\beta_{2j}$* (Perceived ease of use) $+\beta_{3j}$* (Learning interest) + r_{ij}

Level2

$B_{0j} = \gamma_{00} + \gamma_{01}$* (Experimental teaching) $+\mu_{0j}$

$B_{1j} = \gamma_{10} + \gamma_{11}$*(Experimental teaching)

$B_{2j} = \gamma_{20} + \gamma_{21}$*(Experimental teaching)

$B_{3j} = \gamma_{30} + \gamma_{31}$*(Experimental teaching)

TABLE III
FINAL SLOPES AND INTERCEPTS AS OUTCOMES MODEL

Parameter	Full model	
	Parameter Estimate	S.E.
Fixed effects		
Intercept(γ_{oo})	560.749***	3.618
Experimental teaching (γ_{o1})	1.919	7.271
Perceived usefulness (γ_{10})	22.686***	2.863
Experimental teaching(γ_{11})	18.742*	7.299
Perceived ease of use (γ_{20})	13.038***	2.755
Experimental teaching (γ_{21})	-4.531	6.622
Interest learning (γ_{30})	18.742***	7.299
Experimental teaching (γ_{31})	-7.346	4.981
Variance estimates	**Variance Component**	**Chi-square**
Within-class variance(σ^2)	1543.586	1204.290
Intercept variance(τ_{00})	5365.688	

As shown in Table III, HLM results revealed that perceived usefulness was significantly related to achievement (γ_{10} = 22.686, p < .001). The perceived ease of use was significantly related to achievement (γ_{20} = 13.038, p < .001). Interest learning was significantly related to achievement (γ_{30} = 18.742, p < .001). These results suggest hypotheses 1, 2 and 3 are supported by our data. Experimental approach wasn't significantly related to achievement, but experimental approach moderate the relationship between perceived usefulness and achievement, such that this positive association is stronger for students who perceive more positive achievement (γ_{11} = 18.742, p < .05).

V. Conclusion

Perceived usefulness, perceived ease of use, and learning interest are positively relates to achievement. And our research major discovery was to determine the role of the experimental teaching in the science achievement of student. The experimental teaching was taught by the direct method: student watch teacher demonstrate an experiment, design experiment, conduct experiments by themselves, and work together in small groups on experiments. And experimental approaches moderate the relationship between perceived usefulness and achievement, such that this positive association is stronger for students who perceive more positive achievement.

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References

[1] S. S. Chen, and M. C. Luoh, M. C. "Are mathematics and science test scores good indicators of labor-force quality?" *Social Indicators Research*, vol. 96 no. 1, pp. 133-143, 2010.

[2] H. J. Daniel, "Cognitive-motivational characteristics and science achievement of adolescent students: results from the TIMSS 1995 and TIMSS 1999 assessments," *International Journal of Instructional Media*, vol. 31 no. 4, pp. 411-424,2004.

[3] R. D. Tennyson, "An educational learning theory for instructional design, " *Educational Technology*, vol. 32 no. 1, pp. 36-41, 1992.

[4] J. M. Keller, Motivational design of instruction. In C.M. Reigeluth (Ed.), Instructional Design Theories and Models (pp. 383-434). Hillsdale, N.J.: Lawrence Erlbaum Associates, 1983.

[5] J. M. Keller, and T. W. Kopp, An application of the ARCS model of motivational design. In C.M. Reigeluth (Ed.), Instructional Theories in Action (pp. 289-320). Hillsdale, NJ: Lawrence Erlbaum Associates, 1987.

[6] L. M. Ruban, and D. B. McCoach, J. M. Mcguire, and S. M. Reis, "The differential impact of academic self-regulatory methods on academic achievement among university students with and without learning disabilities, " *Journal of learning Disabilities*, vol. 36 no. 3, pp. 270-286, 2003.

[7] M. Fishbien, and I. Ajzen, Beliefs, Attitudes, Intention and Behaviour: An Introduction to Theory and Research, Addison-Wesley, Reading, M.A., I.,1975.

[8] F. D. Davis, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology, " MIS Quarterly, vol. 13 no. 3, pp. 319-339, 1989.

[9] M. M. Abu-Hilal, "A structural model of attitudes towards school subjects, academic aspirations and achievement," *Educational Psychology*, vol. 20, pp. 75-84, 2000.

[10] B. Weiner, "Intrapersonal and interpersonal theories of motivation from an attributional perspective," *Educational Psychology Review*, vol. 12, pp. 1-14, 2000.

[11] K. R. Wentzel, and A. Wigfield, "Academic and social motivational influences on students' academic performance," *Educational Psychology Review*, vol. 10, pp. 155-174, 1998.

[12] J. D. House, "The relationship between self-beliefs, academic background, and achievement of adolescent Asian-American students," *Child Study Journal*, vol. 27, pp. 95-110, 1997.

[13] J. D. House, "The relationship between academic self-concept, achievement-related expectancies, and college attrition," *Journal of College Student Development*, vol. 33, pp. 5-10, 1992.

[14] G. C. Yuen-Yee, and D. Watkins, "Classroom environment and approaches to learning: An investigation of the actual and preferred perceptions of Hong Kong secondary school students," *instructional Science*, Vol. 22, pp. 233-246, 1994.

[15] J. H. Steiger, "Structural model evaluation and modification: An interval estimation approach," *Multivariate Behavioral Research*, vol. 25, pp. 173-180, 1990.

[16] P. M. Bentler, "Comparative fit indexes in structural models," *Psychological Bulletin*, vol. 107, pp. 238-246, 1990.

[17] B. McCoach, "Dealing with dependence (Part II): a gentle introduction to hierarchical linear modeling," *Gifted Child Quarterly*, vol. 54 no. 3, pp. 252-256, 2010.