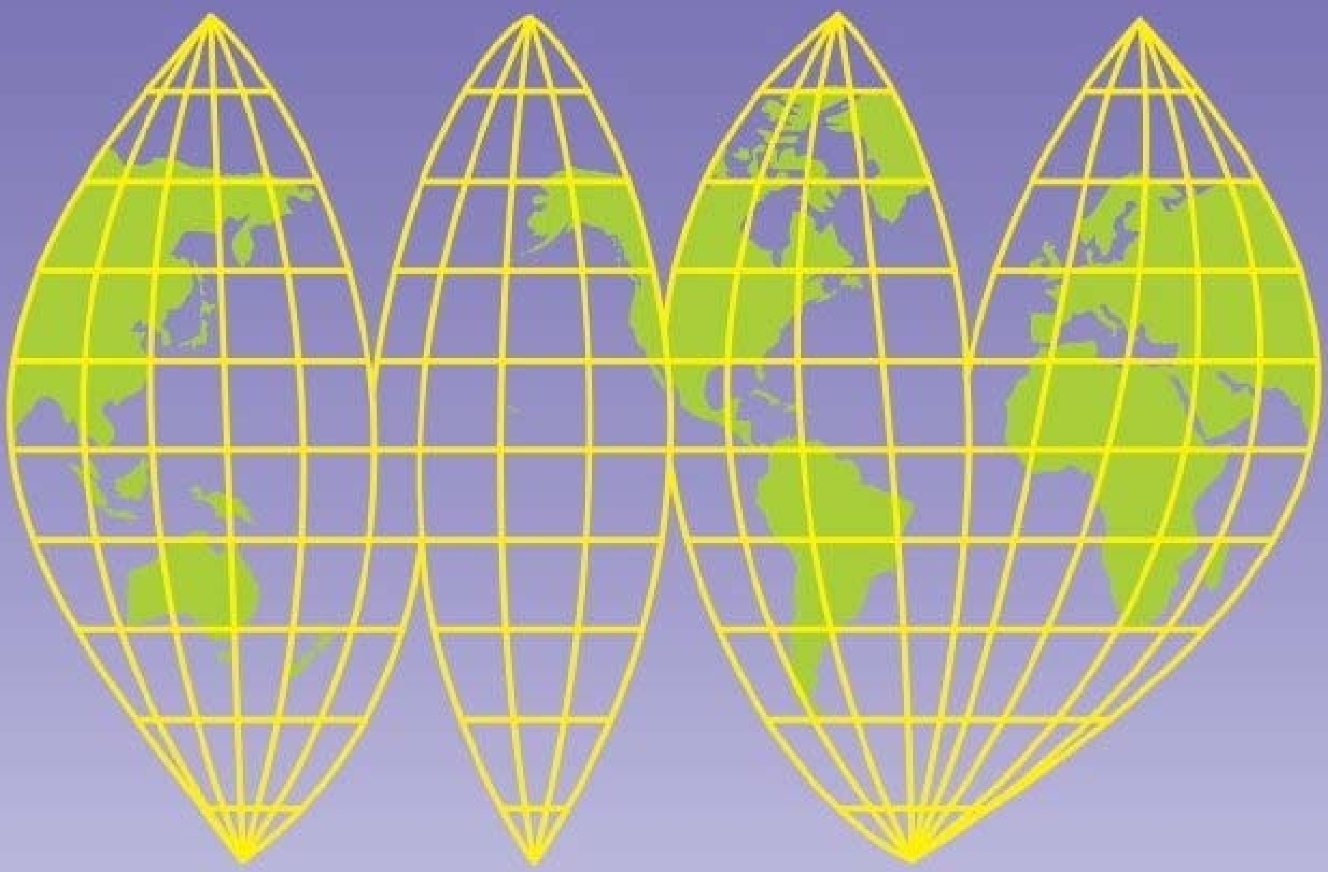
ISSN 1816-9325

International Journal of

Technology and Engineering Education

Vol. 9 No. 1 Summer 2012



International Journal of Technology and Engineering Education

Contents

Articles

Articles

An Investigation of Evaluative Criteria for Uncertainty Reduction in Overseas Learning

Yow-jyy Joyce Lee*, David Wen-Shung Tai, & Ray Wang*****

* Department of Applied English, National Taichung University of Science and Technology, Taichung City, Taiwan
**College of Management, Hungkuang University, Taichung City, Taiwan
*** Department of Hospitality Management, Hungkuang University, Taichung City, Taiwan

ABSTRACT

This paper aims to discover the dynamics attracting foreign students to pursue higher education in Taiwan with a novel approach. Many previous studies used pull-push terminology to explain student mobility as well as factors in the host countries pulling the students to choose particular destinations and/or push factors in home countries. What attracts students from developing or developed countries to choose a developing country for higher education study remains unexplored. This research selected 130 international students from parts of Taiwan with the Stratified Random Sampling Method. Fuzzy Importance-Performance Analysis (FIPA) revealed the degree of importance and satisfaction of the international students with the chosen education environment. The findings could help attract international students to study at universities in Taiwan.

Keywords: International Students, Satisfaction, Fuzzy Importance-Performance Analysis

INTRODUCTION

Education is essential in terms of personal knowledge, career attainment, and higher status in organizations and societies. Due to global competition, education nowadays does not stop at finishing high school or college; an increasing number of students are undertaking graduate studies (Marginson, 2006). Furthermore, education has become a global industry where more people are choosing an international education to increase their competitiveness. Hence, internationalization in higher education has long been a topic of interest for many researchers

In addition, international education has widened the scope in cross-border education with increasing student mobility, academic mobility, program mobility and institutional mobility (Naidoo, 2006). Given the wide variety of universities and countries from which students can choose, universities face challenges caused by an increase in the mobility of students worldwide.

As the need of international education is increasing day by day, the phenomenon presents opportunities and challenges to higher educational institutions around the world. Universities should view these challenges as threats as well as opportunities. Rhoads (2005) emphasized that globalization was the major driving force that push universities to change. The key objective of universities is not only to attract but also to retain students through superior educational services delivery and to maintain student satisfaction and loyalty.

Superior customer value delivered to international students has become important in creating continuous advantage in a highly competitive international education market. One of the major goals that universities strive for is student satisfaction, which is illustrated by a satisfied student population with positive outcomes such as positive word of mouth (WOM) communication, student retention and loyalty (Arambewela & Hall, 2009). Besides, universities are also expected to overcome challenges like cultural diversity, differences in learning styles, changing demands of students who are provided with greater choice of study destinations, educational programs and study environments. Therefore, service quality is an important performance measure of excellent education, as well as a major strategic variable for universities in providing quality service to increase their market share in the international education market.

The aim of this study is to discover the dynamics attracting foreign students to pursue higher education in Taiwan with a novel approach, the Fuzzy Importance-Performance Analysis (FIPA). The method has often been used in various industries such as tourism and hospitality (Go & Zhang, 1997), education (Alberty & Mihalik, 1989), and health care (Dolinsky, 1991) to measure customer satisfaction. Here it was used here to identify international student satisfaction. This study will contribute to understanding factors which attracts students from developing or developed countries to choose a developing country for higher education study.

LITERATURE REVIEW

Higher education as a global industry

The international higher education market, which is concerned with market share, productivity, return on investment and the quality of services offered to foreign customers, has become attractive to universities (de Jager & Gbadamosi, 2010; Hou, 2010). Menna (2012) suggested that recruiting international students not only helps universities in decreasing the financial reliance from the government subsidies but also effectively induces different cultures on campus, thereby, helping domestic students to blend into the international job markets. Through the mechanism of demand and supply, administrative efficiency and service quality are improved and can accurately reflect the demands of international students. Thereby, internationalization (i.e. recruiting foreign students) has become the compulsory choice of educational development for many universities.

University education falls into the domain of services, where service performances are considered situation-specific (Schoefer & Ennew, 2005) and services cannot be treated as identical if they are performed in different settings and by different individuals (Hou, 2010; Lovelock, Patterson, & Walker, 2003). Given the student diversity, differences in learning styles, previous life experiences and the variation in service facilities offered by universities, the perceptions of the overall service performance will be different, thus challenging universities to maintain a uniform standard of service performance (Dawson & Conti-Bekkers, 2002; de Jager & Gbadamosi, 2010; Hou). According to de Jager and Gbadamosi, student perceptions of the service performance can be either positive or negative judged by their expectations of the delivery of such service performance. Positive WOM (word of mouth) promotion, student retention and loyalty are achieved if a positive attitude is formed, but the opposite can occur if a negative attitude is formed (Hou, 2010; Kau & Loh, 2006). In order for students from developing or developed countries to form a positive attitude, prospective universities in developing countries need to recognize the fact that students who had prior experience in a university service environment are to evaluate service performance delivered by a newly chosen educational institution.

Student mobility in relation to pull-push factors

A significant body of literature has focused on the dynamics behind student mobility in the international education environment. In general, these studies used pull-push terminology to explain student mobility (Hou, 2010; Li & Bray, 2007), which suggested that there were factors in the host countries pulling the students to choose particular destinations and/or push factors in home countries pushing the students to choose a particular host country. Take Taiwan for example. Like many students of developing countries who choose to undertake higher education in countries like the United States, the United Kingdom, Canada, Australia, Singapore, etc., students in Taiwan are pulled to the western countries to enhance their English ability as well as to increase their competitive advantages in the job market. On the other hand, there are many international students who seek higher education in Taiwan. Recognized graduation diplomas, scholarships, work permits, and the ability to find jobs in the country of education are the pulling factors which attract students to pursue further education in Taiwan (Tsai, 2008).

Pull-push factors causing student mobility also include increased availability of higher educational opportunities in source countries and reductions or constraints in local capacity (Arambewela & Hall, 2009). That is, the need for international education may arise from doubts whether the home country is able to provide the increased physical capacity required and train academics within a short period because the available educational resources may not be able to meet such demands.

The choice of a study destination is normally a two-stage process, whereby the student either chooses a country first and then an educational institution or chooses both the country and the educational institution separately and independently. Socio-economic and environmental factors/variables such as safety, lifestyle, cost of living, transportation, racial discrimination, visas and immigration potential, friends and family, climate and culture (Arambewela, 2003; Menna, 2012; Veloutsou, Paton, & Lewis, 2005) are the “pull factors” associated with the choice of a country as a study destination, and individual level factors/variables such as study programs and courses, fees, facilities and support services, intellectual climate, teaching quality, teaching staff and methods, recognition of courses, image and prestige of the university (Arambewela; Hou, 2010; Menna; Smith, Morey, & Teece, 2002; Veloutsou et al., 2005) are the “pull factors” associated with the choice of a university as a study destination.

Through literature review, seven constructs were extracted in this study: A) education (Enders, 2004; Teichler, 2003; Schmied & Shiba, 2007), B) social orientation (Arambewela & Hall, 2008; Kondakci & Van den Broeck, 2009), C) technology (Kondakci & Van den Broeck), D) economic considerations (Kondakci, Van den Broeck, & Yildirim, 2008), E) accommodation (Kondakci, Van den Broeck, & Yildirim), F) safety (Kondakci, Van den Broeck, & Yildirim), and G) image and prestige (Massey, Arango, Hugo, Kouaouci, Pellegrino, & Taylor, 1993; Kondakci & Van den Broeck). The seven constructs were further broken down in into 19 attributes (Table 1).

Table 1
Strategic factors that international students use in selecting a Taiwan college

Dimensions	Items
	A1 Valuable feedbacks from lecturers
A) Education	A2 Good access to lecturers
	A3 High standards of teaching by qualified lecturers

(Continuous)

B) Social orientation	B1	Counseling services
	B2	Customs and traditions in host country
	B3	Close working relationships with all students
	B4	International student orientation programs
C) Economic considerations	C1	Part-time job opportunities
	C2	Cost of living
	C3	Opportunities for migration
D) Safety	D1	Low crime rate
	D2	Friendly, law-abiding citizens
E) Image and prestige	E1	Image and prestige internationally
	E2	Image and prestige in Taiwan
	E3	Image and prestige in home country
F) Technology	F1	Access to computing and IT facilities
	F2	Availability of modern teaching facilities
G) Accommodation	G1	Reasonable housing cost
	G2	Good standards of housing

METHODOLOGY AND RESEARCH DESIGN

This research used the Stratified Random Sampling Method and selected 130 international students from northern, southern and central Taiwan as a sample. Fuzzy Importance-Performance Analysis (FIPA) revealed the degree of importance and satisfaction of the international students with the chosen education environment.

Fuzzy Importance-Performance Analysis (FIPA)

The Importance-performance analysis (IPA) method is used in this study to measure international student satisfaction. First introduced by Martilla and James (1977) in the late 1970s, it is a simple and useful method to evaluate perceived importance and performance level. O'Sullivan (1991) emphasized that this method has simple characteristics and is convenient to use. It is an effective tool used in service industries mostly. Its effectiveness and simplicity makes it popular and important for researchers and industries to identify perceived importance and performance level. It is widely used in the various SWOT analyses of the manufacturing industries, service industries, tourism, and retail businesses (Chapman, 1993; Kozak, & Nield, 1998; Chu, & Choi, 2000). Martin (1995) used IPA to examine the perceptions of customer expectation by service providers in the hotel industry. Duke and Persia (1996) used the IPA method to examine the performance of national escorted tours. Zhang and Chow (2004) used IPA to assess the performance of tour guides in Hong Kong as perceived by Mainland Chinese outbound visitors. Jang, Ha, and Silkes (2009) used IPA to identify the relative positions of Asian foods in the minds of American customers.

Although IPA is a valuable and efficient method, there are still some limitations. The IPA method treats a sample as a homogenous group, which may decrease in the accuracy of the results when customers differ in terms of the importance ratings they allocate to the product or service attributes (Vaske, Beaman, Stanley, & Grenier, 1996). The limitation of IPA was noted by scholars. For example, Guandagnolo (1985) suggested the use of demographic and situational characteristics when applying the IPA method, and Hendricks, Schneider, and Budruk (2004) suggested the use of benefit segmentation to examine the motives and benefits sought by participants in outdoor recreation.

While IPA identifies which product or service attributes a firm should focus on to enhance customer satisfaction (Matzler, Fuchs, & Schubert, 2004), the objectives of FIPA are to systemize complex problems and differentiate the differences in importance and actual performance of the various attributes, clearly defining their degree of importance and customer satisfaction, thereby helping strategists to choose the best solving cases by scheduling the priorities of the resources (Wang, Tai, Chen, & Yang, 2010). Generally, surveys examining customer perceptions of satisfaction or service quality have used questionnaires in which respondents indicate their feelings with reference to selected linguistic terms. Human judgments of events may vary significantly, however, according to the subjective perceptions or personality of individuals, even when the same linguistic term is used (Chiou, Tzeng, & Cheng 2005). Thus, when using fuzzy numbers to represent specific linguistic terms, researchers can consider the differences among survey respondents. FIPA has been applied as an effective means of evaluating a firm's competitive position in the market, identifying improvement opportunities, and guiding strategic planning efforts (Hawes & Rao, 1985; Myers, 1999). Therefore, this study adopts the fuzzy importance-performance analysis (FIPA) method to examine the satisfaction level of international students currently studying in the universities in Taiwan.

Procedure

This research gathered 130 international students of colleges in northern, central and southern Taiwan and used them as the survey targets. These students' personal data were provided in Table 2.

Table 2
Summary of the interviewed students

Variable	Category	Frequency	Percentage
Gender	Male	78	60%
	Female	52	40%
Age	18- 25 years old	108	83.1%
	26-30 years old	17	13.1%
	31 years old and above	5	3.8%
Region	Northern Taiwan	4	44.5%
	Central Taiwan	2	22.2%
	Southern Taiwan	3	33.3%
School type	Public	5	50.0%
	Private	5	50.0%
Department	College of Medicine	44	33.8%
	College of Management	31	23.8%
	College of Engineering	38	29.2%
	College of Business	13	10.0%
	Others	4	3.2%

The seven dimensions in Table 1 were developed into a 19-item questionnaire and then were put to a pretest for validity and reliability. The Cronbach α values of the pretest were between 0.74~0.86, and the overall scale was 0.93 (> 0.7 recommended by Nunally and Bernstein (1994)). The results of the pretest thus show that the questionnaire was reliable. Our research continued factor extraction via Principle Component Analysis; furthermore we also adopted Varimas to carry out orthogonal rotation for extracting critical factors. The eigenvalues were between 1.469~4.365 (>1 recommended by Cooper and Emory (1995)), and the explained variances were between 45.96% and 60.38%, which confirmed the reliability and validity of our questionnaire.

The research design of our study includes the following steps:

(1) Identify 7 constructs, out of which 19 attributes are further defined. (Table1).
(2) List 19 attributes of the service items and develop them into questionnaire questions.
(3) Allow international students to appraise the degrees of "importance" and "performance" to these attributes. The degree of importance indicates the importance the participants give to the activities of the attributes (expectations) whereas the degree of performance indicates the performance of the attributes given by the providers (practical experience).
(4) Apply FIPA to the data and a diagram was generated (Figure 1).
(5) The degree of importance is placed on the vertical axis and the degree of performance is placed on the horizontal axis. The values of the various attributes of the degrees of importance and performance are viewed as the coordinates and are shown in two-dimensional spaces.
(6) The total average of the coordinates of the various attributes is used as the separation point and the spaces are divided into four quadrants.
(7) Conduct random post-questionnaire interviews with international students to probe into possible explanations for the research results.

The results of the fuzzy importance-performance analysis are summarized in the following Table 3.

Table 3
FIPA analysis of the "strategic factors used by international students in selecting a Taiwan university

IPA dimension	Service items and contents
Quadrant I "Keep up the good work"	A2 Good access to lecturers A3 High standards of teaching by qualified lecturers B3 Close working relationships with all students C2 Cost of living D1 Low crime rate D2 Friendly, law-abiding citizens F1 Access to computing and IT facilities F2 Availability of modern teaching facilities

(Continuous)

Quadrant II “Concentrate here”	A1	Valuable feedbacks from lecturers
	G2	Good standards of housing
Quadrant III “Set low priority”	B1	Counseling services
	C1	Part-time job opportunities
	C3	Opportunities for migration
	E1	Image and prestige internationally
	E3	Image and prestige in home country
	G1	Reasonable housing cost
Quadrant IV “Possibly overkill”	B2	Customs and traditions in host country
	B4	International student orientation programs
	E2	Image and prestige in Taiwan

RESULTS AND DISCUSSION

The results of the fuzzy importance-performance analysis of this research influenced the relationship between importance-performance aspects of the educational factors of the international students. The factors are divided in four quadrants (Figure 1).

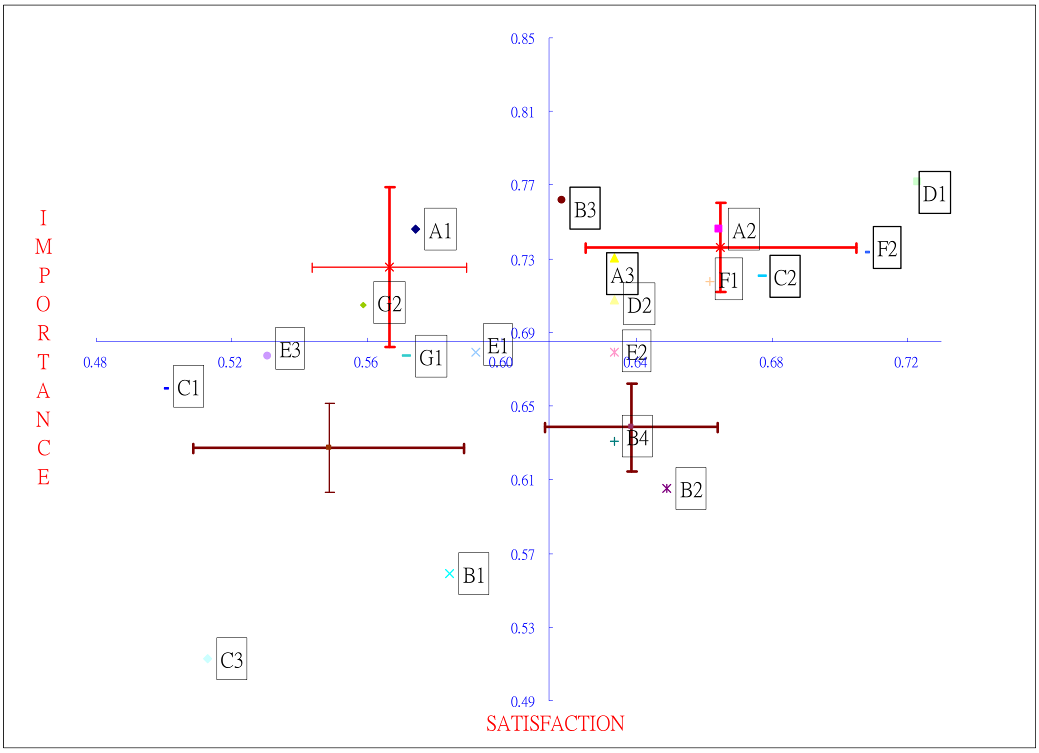


Figure 1. Importance-performance diagram of the influence of the educational factors on international students

(1) First quadrant (“Keep up the good work”)

Factors in the first quadrant receive high degrees of both importance and satisfaction given by the international students. In other words, the measure for the various items in this quadrant should be “keep up the good work.” The analysis results show the following eight items in the first quadrant: *A2 Good access to lecturers*, *A3 High standards of teaching by qualified lecturers*, *B3 Close working relationships with all students*, *C2 Cost of living*, *D1 Low crime rate*, *D2 Friendly, law-abiding citizens*, *F1 Access to computing and IT facilities*, and *F2 Availability of modern teaching facilities*. “Keep up the good work” reveals the niche advantages and merits of the educational environment in Taiwan. *D1 Low crime rate* received the most approval from the students and the degrees of importance and satisfaction are 0.723 and 0.772 respectively, which are apparently higher than the other measures in the same quadrant. The continuous maintenance of these items can maintain the competitive edge of Taiwan in attracting international students (Table 3).

(2) Second quadrant (“Concentrate here”)

The second quadrant shows the general recognition of high importance given to the measures in this quadrant by the international students, but their satisfaction results are not up to the mark. It means the expectations of *A1 Valuable feedback from lecturers* and *G2 Good standards of housing* from the international students are high, but the degree of agreement is low. Therefore, Taiwan universities should “concentrate here” and the resources invested in this quadrant should be rapidly increased. Measures located in this quadrant, i.e. *A1 Valuable feedbacks from lecturers* and *G2 Good standards of housing* require improvement and the prioritized investment of resources must be immediately improved.

(3) Third quadrant (“Set low priority”)

Measures in the third quadrant show a low degree of both importance and satisfaction given by the international students. The result suggests that the expectations of the international students are low, and the degree of agreement is also low. This means that although international students are dissatisfied with the practical performance of *B1 Counseling services*, *C1 Part-time job opportunities*, *C3 Opportunities for migration*, *E1 Image and prestige internationally*, *E3 Image and prestige in home country*, and *G1 Reasonable housing cost*, the needs of the students for these measures were low anyway. The measures apparently are not urgent for Taiwan universities to improve, and they can be set with “low priority” on the improvement list. It can be appropriately incorporated into the secondary priority list for improvement after Taiwan universities have successfully dealt with the measures from the second quadrant.

(4) Fourth quadrant (“Possibly overkill”)

Measures in the fourth quadrant have low expectations but high satisfaction. It means the expectations of *B2 Customs and traditions in host country*, *B4 International student orientation programs*, and *E2 Image and prestige in Taiwan* from the international students are low but the degree of university performance is high in these factors, so this quadrant is aptly called the “possibly overkill” domain. Since the related measures in this quadrant are not considered to be important/influential factors by interviewed students but Taiwan’s universities have already been able to satisfy the needs of the international students in these regards, the universities should not put any more efforts into them.

Research conclusion

1) International students consider that *Low crime rate* has the highest degree of importance and satisfaction

This research found that *D1 Low crime rate* is the most important strategic item when international students select the country they want to study in, as it receives the highest degree of satisfaction. This shows the niche advantage of Taiwan’s higher educational institutions when attracting international students and is worth fostering. Moreover, due to the unfamiliarity of the place, international students give some importance to their affinity of the teachers (*A2 Good access to lecturers*), and this item also belongs to the advantage list of the research. F*2 Availability of modern teaching facilities* also belongs to one of the important factors for effectively attracting international students. Moreover, *B3 Close working relationships with all students* is worth attention. Compared with the other factors’ location in the first quadrant, it has the lowest degree of importance, which means it should be strengthened in order to attract international students even though is included in this quadrant.

2) *Valuable feedbacks from lecturers* and *Good standards of housing* require strengthening and improvement

According to international students’ opinions, *A1 valuable feedbacks from lecturers* and *G2 good standards of housing* require improvement. In the second random interview results, it was found that some of the international students were passive in their interactions with classmates and teachers because of their inability to communicate orally as well as their inability to write and read. This may affect the international students’ satisfaction level with the present *valuable feedbacks from lecturers*. Moreover, some international students come from countries where the standards of living are lower than those in Taiwan; therefore, most of them are dissatisfied with the higher living cost in Taiwan. Take rental for example. The high housing cost plus their inability neither to communicate effectively nor to read the rental contracts made them dissatisfied with the living in Taiwan.

3) *Opportunities for migration* is secondary for improvement; *customs and traditions in host country* are oversupplied.

A possible reason why international students choose Taiwan for study may be the opportunities of finding a job or the probability of immigration after graduation. The research results showed, however, that the present law does not approve so, so international students list it as a secondary area for improvement. This also provides references to business units in their future strategies. Moreover, *B2 customs and traditions in host country* is oversupplied and this requires attention. It may be because many international students are already prepared when they choose the place to study and friendship and love among their own can assist the international students to adapt to the new environment. This measure is already saturated and oversupplied.

CONCLUSION

Global competition has forced people to enter higher education abroad. Globalization is the challenge that universities must face. In this study, the FIPA is used to measure the international student satisfaction in different universities in Taiwan. Generalized from the locations of the factors in Figure 2, the present advantages of Taiwan include *D1 Low crime rate* and *F2 modern teaching facilities*, which are located at the far right side of the diagram. On the other hand, “A1 valuable feedbacks from lecturers” and *G2 good standards of housing*, located in Quadrant II, are important items that require immediate improvement. The findings could help the higher educational institutions to better focus on the dynamics behind student mobility to Taiwan and hence attract more students worldwide to study at universities in Taiwan.

REFERENCES

Alberty, S., & Mihalik, B. (1989). The use of importance-performance analysis as an evaluative technique in adult education. *Education Review*, *13*(1), 33-44.

Arambewela, R. A. (2003). *Post-choice satisfaction of international postgraduate students from Asia studying in Victorian universities.* Unpublished doctoral thesis, Victorian University, Melbourne.

Arambewela, R., & Hall, J. (2008). A model of student satisfaction: International postgraduate students from Asia. *European Advances in Consumer Research, 8*, 129-135.

Arambewela, R., & Hall, J. (2009). An empirical model of international student satisfaction. *Asia Pacific Journal of Marketing and Logistics 21*(4), 555-569.

Chapman, R.G. 1993. Brand performance comparative, *Journal of Products & Brand Management, 2*(1), 42-50.

Chiou, H. K., Tzeng, G. H., & Cheng, D. C. (2005). Evaluating sustainable fishing development strategies using fuzzy MCDM approach. *Omega, 33*, 223-34.

Chu, R. K. S., & Choi, T. (2000). An importance-performance analysis of hotel selection factors in the Hong Kong hotel industry: A comparison of business and leisure travellers, *Tourism Management, l21*, 262-377.

Cooper, D. R., & Emory, C. W. (1995). *Business Research Method* (5th Ed.). Homewood, IL: Richard D. Irwin.

Dawson, J., & Conti-Bekkers, G. (2002). Supporting international students' transitional coping strategies. Focusing on students. *Proceedings of the Annual Teaching Learning Forum, Edith Cowan University, Perth*, 5-6 February.

de Jager, J., & Gbadamosi, G. (2010). Specific remedy for specific problem: Measuring service quality in South African higher education, *High Education, 60*, 251–267.

Dolinsky, A. L. (1991). Considering the competition in strategy development: an extension of importance-performance analysis. *Journal of Health Care Marketing*, *11*(1), 31-36.

Duke, C. R., & Persia, M. A. (1996). Performance–importance analysis of escorted tour evaluations. In D. Fessenmaier (Ed.), *Recent advances in tourism marketing research* (pp. 207–223). New York: The Haworth Press.

Enders, J. (2004). Higher education, internationalization, and the nation state: Recent developments and challenges to governance theory. *Higher Education, 47*(3), 361-382.

Go, F., & Zhang, W. (1997, Spring). Applying importance-performance analysis to Beijing as an international meeting destination. *Journal of Travel Research*, 42-49.

Guadagnolo, F. (1985). The importance-performance analysis: an evaluation and marketing tool. *Journal of Park and Recreation Administration*, *3*(2), 13-22.

Hawes, J. M., & Rao, C. P. (1985). Using importance-performance analysis to develop health care marketing strategies. *Journal of Health Care Marketing*. *5*, 19-25.

Hendricks, W., Schneider, L., & Budruk, M. (2004). Extending importance-performance analysis with benefit-based segmentation. *Journal of Park and Recreation Administration*, *22*(1), 53-74.

Hou, A. Y. C. (2010). Quality assurance at a distance: International accreditation in Taiwan higher education, *High Education*, 61, 179–191

Jang, S., Ha, A., & Silkes, C. A. (2009). Perceived attributes of Asian foods: from the perspective of the American customers. *International Journal of Hospitality Management*, *28*(1), 63-70.

Kau, A.K., & Loh, E. W. Y. (2006). The effects of service recovery on consumer satisfaction: A comparison between complainants and non-complainants. *Journal of Service Marketing, 20*(2), 101-111.

Kondakci, Y., & Van den Broeck, H. (2009). Institutional imperatives versus emergent dynamics: A case study on continuous change in higher education. *Higher Education, 58*, 439-464.

Kondakci, Y., Van den Broeck, H., & Yildirim, A. (2008). Challenges of internationalization from foreign and local students' perspectives: The case of management school. *Asia Pacific Education Review, 9*(4), 448-463.

Kozak, M., & Nield, K. (1998). Importance-performance analysis and cultural perspectives in romanian black sea resorts. *Anatolia, 9*(2), 99-116.

Li, M., & Bray, M. (2007). Cross-border flows of students for higher education: push-pull factors and motivations of mainland Chinese students in Hong Kong and Macau. *Higher Education, 53*, 791-818.

Lovelock, C. H., Patterson, P. G., & Walker, R. H. (2003). *Service Marketing: An Asia-Pacific Perspective*. Sydney, Australia: Prentice-Hall/Pearson Education.

Marginson, S. (2006). Dynamics of national and global competition in higher education. *Higher Education, 52*, 1–39.

Martilla, J. A., & James, J. C. (1977). Importance-performance analysis. *Journal of Marketing*. *41*(1), 77- 79.

Martin, D. W. (1995). An importance-performance analysis of service providers' perception of quality service in the hotel industry. *Journal of Hospitality and Leisure Marketing*, *3*(1), 5-17.

Massey, D. S., Arango, J., Hugo, G., Kouaouci, A., Pellegrino, A., & Taylor, J. E. (1993). Theories of international migration: A review and appraisal. *Population and Development Review, 19*(3), 431-466.

Matzler, K., Fuchs, M., & Schubert, A. K. (2004). Employee satisfaction: Does Kano's model apply? *Total Quality Management & Business Excellence, 15*(9/10), 1179-98.

Menna, A. (2012). Linking quality of life and standard of living priorities with rates of return in education: Implications for Ontario's community colleges. *Community College Journal of Research and Practice, 36*, 453-457

Myers, J. H. (1999). *Measuring Customer Satisfaction:*

Hot Buttons and Other Measurement Issues. Chicago, IL: American Marketing Association.

Naidoo, V. (2006). International education, a tertiary level update. *Journal of Research in International Education, 5*(3), 323-45.

Nunally, J. C., & Bernstein, I. R. (1994). *Psychometric theory*. NY: McGraw-Hill.

O'Sullivan, D. (1991). DSM High-performance Fiber Attracts Growing Interest. *Chemical & Engineering News,* 69, 20-23.

Rhoads, R. A. (2005). University reform in global times: Opportunities and challenges. *Proceedings of 2005 Annual Seminar of Chinese Comparative Education Society—Taipei*, 20-31. [Retrieved May 28, 2010, from http://www.ced.ncnu.edu.tw/ccest/seminarC/seminarC.htm]

Schmied, L. A., & Shiba, K. E. (2007). Internationalizing the curriculum: Bringing the world to east Tennessee. *International Education, 36*(2), 70-82.

Schoefer, K., & Ennew, C. (2005). The impact of perceived justice on consumers' emotional responses to service complaint experiences. *Journal of Service Marketing*. *19*(5), 261-270.

Smith, G., Morey, A., & Teece, M. (2002). *How international students view their Australian experience: A survey of international students who finished a course of study in 1999*. Special Report, DETYA. Canberra, Australia: Australian Education International.

Teichler, U. (2003). Mutual recognition and credit transfer in Europe: Experiences and problems. *Journal of Studies in International Education, 7*(4), 312-341.

Tsai, M.G. (2008). Coping with the impacts of low birthrate on the educational system. *Learning information, 25*(5), 101-108.

Vaske, J., Beaman, J., Stanley, R., & Grenier, M. (1996). Importance performance and segmentation: where do we go from here? *Journal of Travel & Tourism Marketing*, *5*(3), 225-240.

Veloutsou, C., Paton, R. A., & Lewis, J. (2005). Consultation and reliability of information sources pertaining to university selection. *International Journal of Educational Management, 19*(4), 279-291.

Wang, R., Tai, D. W. S., Chen, J. S., & Yang, K. L. (2010). Holistic effectiveness of e-learning systems using fuzzy importance-performance analysis (IPA) in uncertainty. *World Transactions on Engineering and Technology Education, 8*(2), 156-161.

Zhang, H.Q., & Chow, I. (2004). Application of importance-performance model in tour guides performance: Evidence from mainland Chinese outbound visitors in Hong Kong. *Tourism Management*, 25, 81-91.

AUTHORS

Yow-jyy J. Lee is currently Assistant Professor of Department of Applied English at National Taichung University of Science and Technology, Taiwan. She received her Ph.D. degree from Yale University, USA. Her recent research interests include strategies in public speaking, English language teaching, CALL, and *kansei* engineering.

David Wen-Shung Tai is Chair Professor and Dean of College of Management at Hungkuang University, Taiwan. He earned his M.S. degree from the Dept. of Industrial Technology at the Univ. of Wisconsin-Platteville. He also earned his M.S. degree from the Dept. of Computer Science at Iowa State University and his Ph.D. from the Dept. of Industrial Education and Technology at the same University in 1987. Prof. Tai's research experience includes engineering drawing, computer-assisted learning, spatial ability and problem solving. His latest projects included the study of promoting spatial abilities and problem solving abilities in college students.

Ray Wang, Ph.D., is Associate Professor at Hungkuang University, Taiwan. A consultant for industry from Bureau of Employment and Vocational Training, he also serves as Auditor of the senior vocational high school for Ministry of Education, Taiwan. He is interested in human resource development and research of hospitality training programs. Wang is the corresponding author and can be reached at ketr501215@hk.edu.tw

Int. J. Technol. Eng. Educ.
2012, Vol.9, No.1

Assuring Educational Quality in Taiwan's Universities of Technology

Ray Wang *, & Eppie E. Clark **

* Associate Professor, Hungkuang University, No.34 Chung-Chie Rd., Sha Lu, Taichung City 443, Taiwan
** Associate Professor, Industrial Engineering Dept, De La Salle University, Manila 1004, Philippines

ABSTRACT

Since the quality of education has a direct impact on the effects of education, the educational system is an important focus of social and political attention. In order to effectively control educational quality, university administrative departments undertake regular evaluations. However, quality criteria are interdependent and the formulation of weight values for them is complex. Moreover, the relevance of various criteria is also an issue when evaluating educational quality. This study uses a new approach to evaluate educational quality; the Decision Making Trial and Evaluation Laboratory (DEMATEL) combined with the KANO model. The purpose of this new methodology is to determine the crucial educational quality factors for Taiwan's universities of technology as well as identify critical items for improvement. Using this method, the causal relationships and the level of relevance between each criterion may be calculated and the relationships among the various criteria clarified. The two dimensions of quality can confirm the satisfaction/dissatisfaction of customers when preparing or not preparing the attributes of a given quality characteristic. Based on the research findings, suggestions are provided for the design of educational quality evaluations and for further research.

Keywords: Educational quality, quality criteria, Decision Making Trial and Evaluation Laboratory (DEMATEL), KANO model

INTRODUCTION

Promoting educational quality is considered an effective tactic for strengthening the competitiveness of schools (Palmer, 1998; Menna, 2012) as well as the economic development of society (Lawrence, 2006). However, there is no scholarly consensus on the best way to achieve that goal (Gallagher, 2006; Oliveira, Oliveira & Costa, 2012). Danielson and McGreal (2000) and Smith (2010) believed educational evaluation can promote educational quality. However, a review of the literature on educational quality evaluation shows that scholars have largely focused on discussing educational evaluation methods and their application (Fetterman, 2000; House & Howe, 2000; Cronbach, 2000; Smith, 2010; Oliveira, Oliveira & Costa, 2012). Most evaluation processes are distinct from one another based on educational quality criteria and lack holistic estimation. Furthermore, few studies investigate the diversity of the importance of educational quality criteria that are suitable for technical universities. These studies have generally ignored the mutual influences among the criteria. Thus, comprehensive and appropriate educational quality evaluation methods and criteria for universities of technology are lacking.

The Decision Making Trial and Evaluation Laboratory (DEMATEL) excels in social science problem analysis toward relevance and the cause-and-effect for every element. This method is different from the intuition of nonlinear systems because it can quantify complex questions and calculate the direct and indirect relationships among the variables.

Considering the changes in the external environment of Taiwan's technological universities and the mutual influence of various direct and indirect elements, this study uses DEMATEL to explore the key educational quality attributes of higher education and to confirm the critical criteria of educational quality in higher education. It will then discriminate the correlation of criteria from important differences and identify how educational quality may be improved.

To date, customer satisfaction has largely been seen as a one-dimensional construction: the higher (lower) the perceived product value, the higher (lower) the customer's satisfaction. However, fulfilling individual product requirements does not necessarily imply a high level of customer satisfaction. Perceived product quality must be first defined, since it defines customer satisfaction. Extending Kano's model of customer satisfaction, this study introduces a methodology for determining the effects of the components of products and services on customer satisfaction. The authors also demonstrate how the results of a customer survey may be interpreted and how conclusions may be drawn and used for the management of customer satisfaction. Consequently, this study contributes to both the scholarly discourse on and administrative needs of higher education.

LITERATURE REVIEW

Education criteria

In recent years, interest in the quality assurance of higher education has increased. Many institutes for higher education have initiated evaluation activities, but these experiences have not always been successful (Altbach, 2004). Higher education institutions in Taiwan are facing the same transformational expectations as higher education elsewhere in the world. Around the world, the public expects that control and evaluation procedures are transparent, and that the results of monitoring have a positive influence on educational practices (Bolotov & Efremova, 2007).

The educational quality index is an important basis for measuring the present situation of education. A good educational quality index must be feasible, effective, and practical in data collection. Oakes (1986) and Shavelson, Mcdonnell & Oakes (1991) used input, process, and output as the basis for evaluation. Input indicators include finance and other resources, professional teachers, and the students' background. Educational process indicators include school background and organization, courses and teaching quality. Output indicators include student achievement, dropout rate, attitude, and ambition.

The range of educational evaluation of this study includes the student-centric system. It involves school educational resources as the input level (the quality of teachers and students), the process level (teaching, courses, and teaching methods), and the output level (student achievement). In addition, it is also necessary to consider the environment, social trends, and industry trends in the education system. Therefore, evaluation needs to involve the background of the education system. Thus, it combines the interaction between the industry, the community, and parents. Based on the work of previous scholars (Altbach, 2004; Bolotov & Efremova, 2007), the educational quality categories and criteria used in this study are listed in Table 1.

Table 1
Educational quality category and criteria

Quality category	Quality criteria item
Educational Research	C1. Curriculum planning C2. Teaching materials selection and teaching methods C3. Laboratory and course arrangement C4. Student achievement assessment C5. Quantity of teachers' papers
Administrative Service	C6. Administrative support for teaching C7. Attitude of administrators C8. Administrative efficiency and correctness
Community Interaction	C9. Interaction with students' parents C10. Communication skills with local people C11. University-industry cooperation and association
Learning Achievement	C12. Medium and long-term development goals of the school C13. Salary of graduates C14. Employment of graduates C15. Graduates' outstanding performance C16. Employers' satisfaction with graduates

The Decision Making Trial and Evaluation Laboratory method (DEMATEL)

The DEMATEL method can prioritize the criteria based on the type of relationships and the strength of their influences on one another. Criteria having a greater effect on other criteria are assigned a higher priority and called cause criteria. Those receiving a greater effect from other criteria are assigned a lower priority and are called effect criteria (Seyed- Hosseini, Safaei, & Asgharpour, 2006).

The DEMATEL method has been successfully applied in risk assessment (Sankar & Prabhu, 2001; Seyed- Hosseini et al., 2006), air transportation management (Liou & Tzeng, 2007), R&D project selection (Lin & Wu, 2008), and portal sites (Wang, 2011). Wu (2008) considered a large number of complex factors as multiple evaluation criteria and proposed an effective solution based on a combined analytic network process (ANP) and DEMATEL approach to evaluate and select knowledge management strategies. Wu and Lee (2007) explored how to enrich global managers' competencies by segmenting some portions to facilitate competency, and proposed an effective method to solve this issue involving the vagueness of human judgments by combining fuzzy logic and DEMATEL. Tzeng, Chiang and Li (2007) evaluated e-learning using a large number of interrelated criteria and developed a multi-criterion decision-making model suitable for e-learning evaluation. Finally, the evaluators identified the aspects of the e-learning experience that needed improvement.

Kano two dimensional model

In its initial stages, research on the recognition of quality attributes emphasized quality as a single dimensional attribute and argued that when the quality elements are (in)sufficient, customers will be (un)satisfied. Herzberg's (1959; 1993) "Motivation-Hygiene Theory" changed the field by Kano (1984) and elaborated Herzberg's work to formulate a two dimensional quality model and divided the quality attributes into five categories, which are shown in Figure 1.

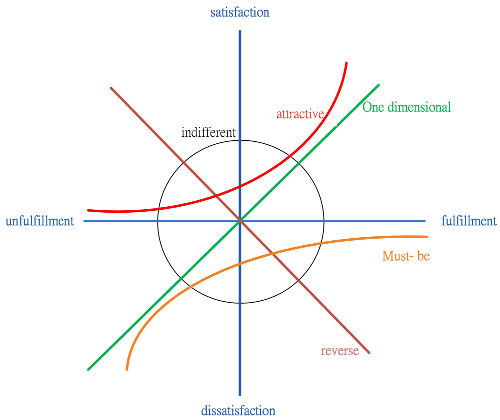


Figure 1 Kano's two dimensional quality model

Many customers seldom complain when a product or service quality is not up to expectation, such customers simply switching to a competitor or alternative product/service to fulfill their needs at the next opportunity (Shen, Tan, & Xie, 2000). One way to attract and retain customers is to develop a model to characterize the attributes of a product or service based on how well they are able to satisfy customer needs (Tan & Pawitra, 2001). Kano's model uses the relationship of the availability of quality characteristics and customer satisfaction to understand service quality attributes and satisfy customer requirements and expectations (Kano et al., 1984). In order to understand the cognition and preferences of customers toward the service quality characteristics, a paired survey design method must be used (Lee, Yen & Tsai, 2008). Customer emotional levels are classified as: (1) I like it that way; (2) It must be that way; (3) I am neutral; (4) I can live with it that way; and (5) I dislike it that way. From the answers of the customers, the attributes of service quality characteristics can be understood using the matrix analysis approach. According to Kano's model, the quality characteristics that have an impact on customer satisfaction are divided into five categories:

1. Attractive quality element (red line): when this quality element is sufficient, then the customers will be satisfied. If it is not sufficient, customers will accept it, but will not be satisfied.
2. One-dimensional quality element (green line), also known as the linear quality element. When this quality attribute element is sufficient, then customers will be satisfied. If not, customers will be dissatisfied.
3. Must-be quality element (yellow curve): when this quality attribute factor is sufficient, customers consider that they deserve it. The degree of satisfaction does not necessarily increase with the increase in the sufficiency of the quality attribute. If there is insufficiency, then customers will be dissatisfied.
4. Indifferent quality element (black circle): whether the quality attribute element is satisfactory or not, customer satisfaction will not be affected.
5. Reverse quality element (purple line): when this quality attribute element is sufficient, customers will be dissatisfied. If it is insufficient, customers will be satisfied.

Kano's two dimensional quality model is generally fleshed out with data from questionnaire surveys to understand customer satisfaction with the quality attributes of a given product or service. After calculating the results from the questionnaire data, the two dimensional quality characteristics of each quality attribute are categorized based on Kano's two-dimensional model of quality attributes. The various quality attributes will then yield different cumulative frequencies for the two-dimensional quality categories, and the quality attribute with the highest frequency will then be designated the two-dimensional quality of the quality attribute. When the cumulative frequency is the same, the prioritization of the category will be M>O>A>I (CQM, 1993). Kano's questionnaires are designed as a paired question of direct and reverse direction (when the quality attribute is sufficient or insufficient). Answers include like, deserve, indifferent, acceptable, and dislike. As a reference for improving service quality, Matzler and Hinterhuber (1998) developed a modified two dimensional quality element categorization table and used a customer satisfaction coefficient to confirm whether there is an increase in the degree of customer satisfaction or a decrease in the degree of customer dissatisfaction when improving a given quality attribute element,. The calculation of the coefficient is shown in equations (1) and (2).

Coefficient of increasing customer satisfaction:
(A+O)/(A+O+M+I)...(1)
Coefficient of decreasing customer dissatisfaction:
(O+M)/(A+O+M+I)×(-1).......................................(2)
A: attractive quality; O: Single-dimensional quality; M: Must be quality; I: Indifferent quality

METHOD

As discussed above, educational quality is influenced by educational research, administrative service, community interaction and learning achievement, and sixteen quality items. This study used purposive sampling to choose teachers whose teaching experience in universities of technology exceeded six years, as the targets of the pilot study. A total of 10 colleges were selected, with 5, 2, and 3 colleges from northern, central, and southern Taiwan, respectively. 56 questionnaires were sent to each college. Respondents totaled 560 (shown in table 2).

Table 2
Participants

Items	Gender		Total
	Male	Female	
Northern area	112	80	192
Central area	100	75	175
Southern area	110	85	195
Total	322	240	560

The effective return rate was 53.6%. The internal consistency of the three subscales in the pilot study ranged from .82 to .91 and the overall Cronbach's α was .93 with total variance accounted for of 62.98%. Since the reliability of the various quality dimensions exceeded 0.7, this scale has appropriate reliability and validity (Nunnally, 1978). Moreover, the total accumulated factor load of the quality dimensions was 61.292%. The value of the KMO (Kaiser-Meyer- Olkin) test was 0.909. Barlett's spherical test showed the same results. Details are given in Table 3.

Table 3
Consistency results

Dimension	Items	Cronbach's á
Curriculum and teaching	C1. Appropriate curriculum planning C2. Teaching materials selection and teaching methods C3. Laboratory and course arrangements C4. Students' achievement assessment	0.91
Administration and alliance	C5. The condition that administrators support teaching C6. The condition of university-industry cooperation and association C7. The medium and long-term development goals of the school	0.86
Students' achievements	C8. Employment condition C9. Graduates' outstanding performance C10. Employers' satisfaction toward graduates	0.89
Total number of questionnaires		0.93
Total variance accounted for		62.98 %

The effectiveness of the content of the educational quality criteria discussed in this study was confirmed by expert meetings. All the involved people were teaching professionals with sufficient knowledge, skills and practical experience. Through brainstorming and Nominal Group Technique (NGT) methods, the experts determined the risk factors and criteria of educational quality, while the meaning of each criterion was defined in detail (Muralidharan, Anantharaman & Deshmukh, 2002). To avoid the complexity caused by too many criteria, educational quality criteria were limited to three to five items in each dimension.

The main tool of this study was the questionnaires required to develop DEMATEL. All the questions in the questionnaire were drafted based on the aforementioned educational quality criteria.

Each item was defined and a pair comparison method was used for the respondents to fill in the degree of influence that one item has on the other items. These were scored from 0 to 3. 0 represents "no effect," 1 "marginal effect," 2 "influential," and 3 "great impact."

This study issued 250 questionnaires, 134 of which were effective. After conducting the survey, Microsoft Office Excel 2007 was used to analyze the data and separately calculate the direct and indirect relationship matrix of the various evaluation criteria. This was followed by the plotting of a causal diagram. The data analysis was divided into two stages. The DEMATEL method was first used to choose the criteria with D+R values greater than the total mean (8.106). The two-dimensional quality attributes were then used to confirm the categorization of the quality of the various evaluation criteria.

RESULTS AND DISCUSSION

This study used the DEMATEL method to analyze the data from the collected questionnaires. Taking the original influence evaluation between each question to build a direct relationship matrix, the value relationship matrix was then normalized in order to calculate the total effect relationship matrix. Furthermore, the statistics of the columns and rows were compiled to obtain the correlation value of the cause (D) of each question. According to the center degree, the empirical results are shown below.

Center degree (D + R)

The sum of each row and the sum of each column was added in the determinant to calculate the D+R (center). When the value of the D+R is higher, the importance of the item (factor) in the overall evaluation factor is higher. There were ten factors with D+R values greater than the mean (8.106). Thus, the importance of each decision evaluation factor of educational quality in the technical universities in descending order is: the medium and long-term development goals of the school (C12); graduates' outstanding performance (C15); university-industry cooperation and association (C11), employers' satisfaction with graduates (C16), laboratory and course arrangements (C3), employment (C14), administrative support of teaching (C6), teaching materials selection and teaching methods (C2), students' achievement assessment (C4), and appropriate curriculum planning (C1). Details are given in Table 4.

Table 4
Total Effect Relationship Matrix of Educational Quality in Technical Universities

Sum of Row D		Sum of Column R		D+R		D-R	
Item	Value	Item	Value	Item	Value	Item	Value
C12	4.951	C12	5.018	C12	9.964 *	C5	0.769
C3	4.659	C15	4.997	C15	9.389 *	C10	0.443
C2	4.501	C11	4.671	C11	9.155 *	C2	0.412
C11	4.489	C16	4.646	C16	9.121 *	C3	0.285
C16	4.480	C6	4.642	C3	9.034 *	C8	0.239
C14	4.427	C14	4.560	C14	8.982 *	C9	0.174
C15	4.397	C3	4.380	C6	8.744 *	C1	0.057
C4	4.157	C4	4.186	C2	8.591 *	C4	-0.024
C6	4.107	C2	4.094	C4	8.338 *	C12	-0.061
C1	4.098	C13	4.067	C1	8.138 *	C14	-0.129
C13	3.736	C1	4.045	C13	7.798	C16	-0.161
C8	3.516	C7	3.625	C7	6.943	C11	-0.176
C10	3.463	C8	3.282	C8	6.794	C7	-0.297
C9	3.432	C9	3.263	C9	6.690	C13	-0.326
C7	3.323	C10	3.025	C10	6.484	C6	-0.530
C5	3.150	C5	2.387	C5	5.532	C15	-0.595

Analysis of the Kano model

The questionnaire data was used to define the categorization of the service quality two-dimensional quality attributes of technological universities in order to examine the ability to increase customer satisfaction and decrease customer dissatisfaction at the same time (prior to improving the service quality attribute). The analyzed results showed that customers categorized two items of the service quality attributes of the technological universities as attractive (items 3 and 10), three items as must be quality (items 1, 4, and 7) and the remaining items as indifferent quality. No items were categorized as reverse quality. The results of the categorization are shown in Table 5.

Table 5
Two-dimensional quality attribute comparison, categorization and customer satisfaction coefficient of the various quality attributes in Kano's questionnaires

Categorized items	M	O	A	I	R	Q	Category	CS	DS
C1	42%	26%	3%	26%	0%	3%	*must be*	0.300	-0.700
C2	26%	6%	16%	45%	6%	0%	indifferent	0.241	-0.345
C3	16%	23%	32%	23%	3%	3%	**attractive**	0.586	-0.414
C4	39%	23%	3%	26%	0%	3%	*must be*	0.286	-0.679
C5	10%	32%	10%	35%	3%	3%	indifferent	0.481	-0.481
C6	26%	10%	19%	32%	0%	6%	indifferent	0.333	-0.407
C7	19%	32%	3%	32%	3%	3%	***must be***	0.407	-0.593
C8	10%	32%	10%	35%	3%	3%	indifferent	0.481	-0.481
C9	3%	13%	16%	58%	3%	0%	indifferent	0.321	-0.179
C10	6%	32%	19%	35%	3%	0%	**attractive**	0.552	-0.414

A: attractive; O: one dimension; M: must be; I: indifferent; R: reverse
CS: coefficient of customer satisfaction ; DS: coefficient of customer dissatisfaction

In order to effectively increase customer satisfaction and decrease customer dissatisfaction, the mean values of the coefficient of customer satisfaction and the coefficient of customer dissatisfaction were used as the center axis to plot the coefficient of customer satisfaction diagram (Figure 2). The portion of the grid where improvements can greatly increase customer satisfaction or decrease customer dissatisfaction is situated at "effectively improve service quality attribute". Figure 2 shows that "C3 Laboratory and course arrangements" and "C10 Employers' satisfaction toward graduates" are the effectively improved service quality attributes of technological universities.

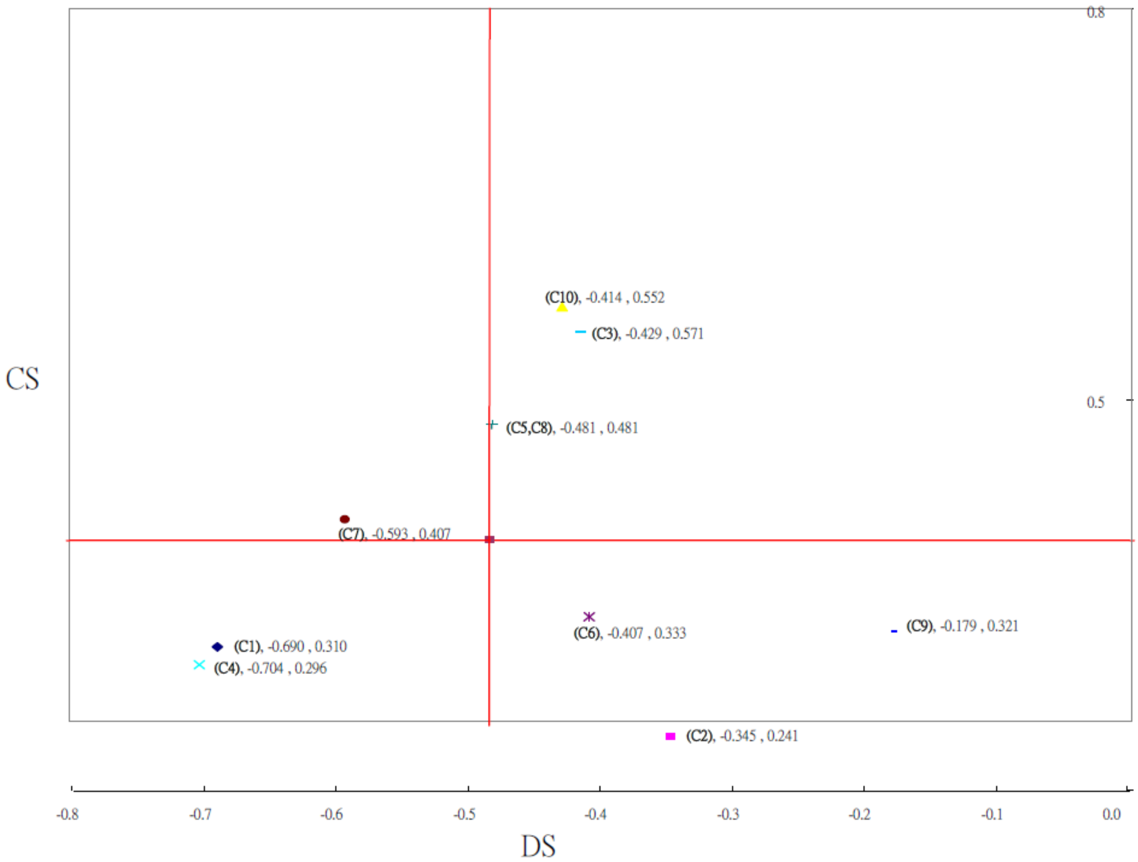


Figure 2 Diagram of Customer Satisfaction Coefficient

CONCLUSION AND RECOMMENDAT-IONS

Traditionally, the studies on customer satisfaction have used the questionnaire method for investigation. Researchers treat the quantitative scale data of the priority level as continuous for analysis. However, these models have problems, including: (1) the assumption of the linear relationship of performance and customer satisfaction; and (2) the quality criteria are independent variables and have no causal relationship. This study combined Kano's model and DEMATEL and described the nonlinear relationship of the quality attributes. It classified the criteria of educational quality and further analyzed the improvement effectiveness of the criteria of educational quality. Since Kano's model does not discuss the interaction between the criteria of educational quality, this study used the DEMATEL method to consider the causal relationship between the criteria of educational quality and integrated Kano's model and DEMATEL to establish a new decision-making analysis methodology.

Conclusions

The following two major conclusions may be derived from the study:

1. Educational quality evaluation factors for universities of technology consist of ten items

The results of this study yielded ten factors which influence the educational quality of universities of technology. These include the medium and long-term development goals of the school, graduates' outstanding performance, university-industry cooperation and association, employers' satisfaction with graduates, laboratory and course arrangement, employment, administrative support of teaching, teaching materials selection and teaching methods, student achievement assessment, and appropriate curriculum planning. Using these items, the cause and effect relationship of the decision evaluation for educational quality of technical universities were constructed. It shows that the quality of graduates is the most important index for educational quality evaluation. Therefore, to promote educational quality in universities of technology, the top priorities should be to identify the medium and long-term goals of the school, and implement them, and to train students to help them find employment easily and to obtain recognition from industry.

2. Laboratory and course arrangement and employers' satisfaction with graduates are the service quality attributes of universities of technology which can directly influence student satisfaction

This study used the importance value of the various evaluation criteria in the DEMATEL to determine the total mean value. The 10 factors that influence the educational quality of the universities of technology were analyzed using a two-dimensional quality model. The results showed that when laboratory and course arrangements and employers' satisfaction with graduates are poor, students will be dissatisfied.

Limitations and Recommendations

Facing vigorous competition from the external environment, higher education in Taiwan has already moved toward market mechanisms of providing a good service. In addition to playing the role of traditional knowledge instruction, schools must accept the different views of students regarding the educational process. This is consistent with the argument of Hsieh and Liu (2002) and is also similar to the new trend of “market governance” of university management (Mok, 2005).

The various universities of technology set strict requirements for academic research and thesis presentation for teachers who provide knowledge to students in technological universities, so as to conform to the evaluation of the educational department as well as the requirements of various grants. However, students do not really care about the knowledge production capability of professors, but instead view them as sources of knowledge and training. For students, the customers of the educational system, teacher actions that increase employability, such as internship facilities and resources, directly influence their degree of satisfaction. Therefore, given limited resources, the provision of directly related service attributes to students can increase the measure of customer satisfaction.

A limitation of the present study was its low response rate of 53.6 percent. Although the problem of low response rates is by no means unique to this study (Groves & Peytcheva, 2008), it certainly poses the question of potential bias and whether the results of the present study can be considered valid and representative of the population.

ACKNOWLEDGEMENTS

The authors are grateful for the financial support from the National Science Council (NSC 100-2511-S-241 -003).

REFERENCES

Altbach, P. (2004). Globalization and the university: Myths and realities in an unequal world. *Tertiary Education and Management*, 103–125.

Bolotov, V.A., & Efremova, N.F. (2007). *Russian Education and Society*, 49(1), January, 6- 23.

CQM(1993). A special issues on Kano’s methods for understanding customer-defined quality, *Center for Quality Management Journal*, 2, 3-35.

Cronbach, L. J. (2000). Course improvement through evaluation. In D. L. Stufflebeam, G. F. Madaus, & T. Kellaghan (Eds.), *Evaluation models: Viewpoints on educational and human services evaluation* (2nd ed., pp.235-247). Boston: Kluwer Academic Publishers.

Danielson, C., & McGreal, T. L. (2000). *Teacher evaluation to enhance professional practice*. New Jersey: Educational Testing Service.

Fetterman, D. M. (2000). *Empowerment evaluation*. London: Sage.

Gallagher, D. J. (2006). If not absolute objectivity, then what? A reply to Kauffman and Sasso. *Exceptionality*, 14, 91-107.

Groves, R. M., Peytcheva, E. (2008). The impact of nonresponse rates on nonresponse bias – A meta-analysis. *Public Opinion Quarterly*, 72(2), 167-189.

HAMPTON, G.M., (1993). Gap analysis of college student satisfaction as a measure of professional service quality. *Journal of Professional Services Marketing*. 9(1), 369–80.

Herzberg, F., Mausner, B., and Snyderman, B. B. (1959). *The motivation to work*. Wiley, New York.

Herzberg, F., Mausner, B., and Snyderman, B. B.(1993). *The motivation to work: with a new introduction by Frederick Herzberg*. Transaction Publishers, New Brunswick, New Jersey.

House, E. R. & Howe, K. R. (2000). Deliberative democratic evaluation. In K. E. Ryan & L. DeStefano (Eds.), *Evaluation as a democratic process: Promoting inclusion, dialogue, and deliberation* (pp. 3–12). New Directions for Evaluation, No. 85. San Francisco: Jossey-Bass.

Hsien, A. P., Liu, L. L. (2002). Marketization: selection of universities and going beyond. Contained in Tai, H. S., Mo, C. H., Hsieh, A. P. (editor), *Higher education and marketization: Comparison of the trends in Taiwan*. Hong Kong and China (pp. 4-39). Taipei city: Higher education.

Kano, N., Seraku, N., Takahashi, F. & Tsuji, S. (1984). Attractive Quality and Must-be Quality. *Hinshitsu Quality, the Journal of Japanese Society for Quality Control*, 14, 39-48.

Laurence, P.L. (2006). The Death and Life of Urban Design: Jane Jacobs, The Rockefeller Foundation and the New Research in Urbanism, 1955-1965. *Journal of Urban Design*, 11, 145-172.

Lee, Y.C., Yen, T.M., & Tsai, C.H. (2008). The study of an integrated rating system for supplier quality performance in the semiconductor industry. *Journal of Applied Sciences*, 8, 453-461.

Lin, C. J., & Wu, W. W. (2008). A causal analytical method for group decision making under fuzzy environment. *Expert Systems with Applications*, 34, 205- 213.

Liou, J. J. H., & Tzeng, G. H. (2007). A non-additive model for evaluating airline service quality. *Journal of Air Transportation Management*, 13, 131-138.

Matzler, K. and Hinterhuber, H. H.(1998). How to make product development projects more successful by integrating Kano’s model of customer satisfaction into quality function deployment, *Technovation*, 18(1), 25-38.

Menna, A. (2012). Linking quality of life and standard of living priorities with rates of return in education: implications for ontario’s community colleges. *Community College Journal of Research and Practice*, 36, 453-457.

Mok, Ka-ho. (2005). Globalization and educational restructuring: university merging and changing governance in china. *Higher Education*, 50, 57-88.

Muralidharan, C., Anantharaman, N. & Deshmukh, S.G., (2002). A multi-criteria group decision-making model for supplier rating, *The Journal of Supply Chain Management*, 22-33.

Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.

Oakes, J. (1986) *Educational indicators: A guide for policymakers*. New Brunswick, NJ: Center for Policy research in Education.

Oliveira, C. G., Oliveira, P. C., & Costa, N. (2012). Students' and teachers' perspectives about quality of engineering education in Portugal. *European Journal of Engineering Education*, 37(1), 49-57.

Palmer, J. (1998) *Environmental Education in the 21st Century: Theory, Practice, Progress and Promise*. London: Routledge.

Peterson, K. D. (2000). *Teacher evaluation- a comprehensive guide to new directions and practices*. Thousand Oaks, CA: Sage Publications.

Sankar, N. R., & Prabhu, B. S. (2001). Modified approach for prioritization of failures in a system failure mode and effects analysis. *International Journal of Quality Reliability Management*, 18(3), 324-335.

Seyed-Hosseini, S. M., Safaei, N., & Asgharpour, M. J. (2006). Reprioritization of failures in a system failure mode and effects analysis by decision making trial and evaluation laboratory technique. *Reliability Engineering and System Safety*, 91(8), 872-881.

Shavelson, R., McDonnell, L., & Oakes, J. (1991). Steps in Designing an Indicator System. (*ERIC Document Reproduction Service No. ED338700*)

Shen, X. X., Tan, K. C. and Xie, M (2000) An integrated approach to innovative product development using Kano's model and QFD. European Journal of Innovation, 3(2), 91.

Smith, K. (2010). Assuring quality in transnational higher education: a matter of collaboration or control? *Studies in Higher Education*, 35(7), 793-806.

Suwignjo, P., Bititci, U.S., & Carrie, A.S.(2000). Quantitative models for performance measurement system. *International Journal of Production Economics*, 64, 231-241.

Tan, K. C. and Pawitra, T. A. (2001) Integrating SERVQUAL and Kano's model into QFD for service excellence development. Managing Service Quality, 11(6), 418-430.

Tzeng, G. H., Chiang, C. H., & Li, C. W. (2007). Evaluating intertwined effects in e-learning programs: A novel hybrid MCDM model based on factor analysis and DEMATEL. *Expert Systems with Applications*, 32(4), 1028-1044.

Wang, R. (2011). Study on the Cause-Effect Relationship of the Service Quality Evaluation Criteria of Portal Sites. *African Journal of Business Management*, 4(10), 2432-2444,

Wu, W. W. (2008). Choosing knowledge management strategies by using a combined ANP and DEMATEL approach. *Expert Systems with Applications*, 35(3), 828-835.

Wu, W. W., & Lee, Y. T. (2007). Developing global manager's competencies using the fuzzy EDEMATEL method. Expert Systems with Applications, 32, 499-507.

APPENDIX(extract)

Criteria	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
A1.Appropriate curriculum planning	N															
A2.Teaching materials selection and teaching methods		N														
A3			N													
…																

AUTHORS

Eppie E. Clark , Ph.D., is Associate Professor at De La Salle University, Philippines. She is a consultant for industry (National Work Productivity Council) and other private firms, and the technical panel for Eco-labeling of Philippine Restaurants. Professional service includes being Guest Editor of the Philippine Institute of Industrial Engineers, and a reviewer for the Team Performance Management International Journal. She has received a M.S. in Industrial Engineering from De La Salle University, a Ph.D. from The University of Manchester, United Kingdom and a Postgraduate Certificate for Academic and Professional Practice from The University of Warwick, United Kingdom. Interests include sustainability issues in manufacturing and service industries, lean production/service system implementation, human resource development, and instruction in higher education.

Ray Wang, Ph.D., is associate Professor at the HungKuang University. He is a consultant for industry (Bureau of Employment and Vocational Training), and auditor for senior vocational high school (Ministry of Education). Professional service includes Quality Engineering (1987–96) and president consult (2004–05) of MyEnamel. He has received a M.S. and Ph.D. from the University of Changhua of Education, both in College of Technology and Vocational Education. He is interested in human resource development and research into hospitality training programs.

Address: No.34 Chung-Chie Rd., Sha Lu, Taichung City 443, Taiwan (R.O.C.)
Tel.: 886-4-26318652 Fax:886-4-26310744
E-mail address:ketr501215@sunrise.hk.edu.tw
Tel.: 00632-4827793; 00632-5244611 local 220

Int. J. Technol. Eng. Educ.
2012, Vol.9, No.1

Using Technology in Students' Daily Life to Teach Science

Yu-Liang Ting*, & Yaming Tai**

*Department of Communication Engineering, Oriental Institute of Technology, Taiwan

**Department of Children English Education, National Taipei University of Education, Taiwan

Abstract

This study presented an analysis of how technology in students' daily-life can motivate students to learn science in school contexts. Technology-rich environments already provide a range of affordances that can facilitate science learning. However, technology itself has not been adopted as a subject of teaching even though it is related to various science concepts and phenomena. By reviewing the characteristics of daily-life experience and technology, this study explicated the educational potential of daily-life technology in science education and proposed a teaching model. The teaching model was supplemented with a sample practice design, and then validated by an experiment. Experimental group students began their science learning with daily-life technology, while control group students learnt in a traditional manner. Students' attitudes toward science learning before and after the activity were collected and analyzed. Results showed that the proposed teaching method improved significantly students' attitude toward science learning. The finding supports this study's assertion in teaching science with technology in students' daily life in the modern world filled with advanced technology

Keywords: daily-life technology, science education, teaching model

INTRODUCTION

Traditional science instruction in high schools and universities is topic-based and usually involves teaching all theories and principles before introducing real-world tasks or problems for students to work on. This kind of instruction involves theoretical introduction and explanation whose sequences are mostly based on the knowledge structure of the field. The reason for this type of teaching may be that the goal of school education is to provide students with coherent logic for generalizibility, and build up their knowledge for generic situations (Bereiter, 1997).

However, this types of teaching may not work for some students who have not been immersed in the joy of exploring and understanding science, as well as for students who are unable to experience the effects of the new information by their own noticing and understanding **(**Fraser & Tobin, 2003)**.** Under such circumstances, the instruction will lose students' attention at the very beginning, and scare them away with the abstract science concepts or social issues, which have never existed in their immediate life experiences. To cope with such life-irrelevant instruction, science educators have advocated the integration of Science, Technology and Society (STS), which uses social issues to engage students in science learning. However, Rubba *et al.* (1991) reported that, in the STS reform, occasional reference to societal issues did not improve students' understanding of the related science concepts. As most science teaching is decontextualized and does not take much students' personal experience and background into account (Lester *et al*., 2006), the curriculum seems to be unrelated to the world in which students live (Bulte *et al*., 2006; Osborne & Collins, 2001). Therefore, science courses continue to be viewed as a means of pushing students into the world of scientists rather than as a way of helping them cope with their own living worlds (Roth & Lee, 2004).

On the other hand, Stinner and Williams (1998) proposed 'Science for Everyone', which argues that science is comprehensible to most students when it is related to their everyday life and experience. This may refer to the constructivist position, which asserts that meaningful learning can only occur when the student is able to relate the new information to their existing experience and knowledge. In addition, when a science curriculum is related to students' life-world experiences, it engenders them to possess more positive attitude toward school science (Osborne *et al*., 2003; Tuan *et al*., 2005). As a matter of fact, researches find that learning environment needs not be big or glamorous, and low-key experiences that connect directly to the life experience would suit students better (Cronin, 1993; Gulikers *et al*., 2005).

The above two types of teaching, one addressing students' everyday experience and one focusing on generic science knowledge, need to be balanced as the contemporary science educators have claimed that science instruction should be personally meaningful as well as academically responsible (Cross & Price, 1999; Lester *et al*., 2006). Hence, there should not be dichotomy between these two types of teaching. Instead, they should be viewed as a continuum of Authenticity and Generalizibility proposed by Chen and Hung (2002). Learners should be scaffold along such a continuum, or should be in the context-process authenticity, in order to gain richer and deeper understanding of a subject or domain. This study aimed to find out how to strike a balance between incorporating students' experience into the teaching and helping students acquire science knowledge for generic situations.

The use of students' everyday contexts in science teaching has been reported, classified, and discussed (Kasanda *et al*., 2005; Jegede & Aikenhead, 1999). Their use often follows theoretical exposition or teacher questioning (Kasanda *et al*., 2005). This study asserts that such contexts should play a more active role in motivating students' science learning. That is, students should be attracted by the presentation related to their daily-life experience at the beginning of teaching and guided subsequently towards the generic science content they need to learn. Although similar idea has been discussed in Chemistry education as the context-based approach or *Salters Advanced Chemistry* (Bennett *et al.*, 2005), the current study intended to explore further the principles for complete instruction and verify a sample design for practical reference. Moreover, the impact of using students' everyday experiences on their learning has systematically studied in Chemistry, Physics, and Biology only (Bennett *et al.*, 2005; Bennett *et al.*, 2007). Regarding the advanced development of Information and Communication Technology (ICT) and its numerous applications to people's life, Godwin-Jones (2009) claimed that the current generation of students are already equipped with quite sophisticated technology skills and habits. This study assumed that these related experiences can be pedagogically solicited to facilitate students' ICT-related science learning.

The experience about daily-life technologies includes using special glasses to watch 3D movies, using TV remote control to select programs, and using navigation device to provide direction. These experiences are related to science knowledge of light and electromagnetic waves. In addition, such experience is a result of active use of a specific technology or tool to achieve certain purpose and benefit in living, instead of passive observation. Students nowadays should have preference or emotional commitment, basic understanding and knowledge, and appreciate the value about the usage of daily-life technologies. These daily-life technologies are developed from and related to science knowledge. Students' everyday experiences, daily-life technologies, and science knowledge may then be pedagogically bridged together to make science learning more interesting and comprehensible.

Inspired by Gee's (2003) observation in game learning, where players often get motivated by the current game they play to explore the background knowledge and the context of the game, this study aimed to engage students in science learning through the technologies in their daily lives. This idea is different from that of Pivec (2007), who suggested that opportunities should be provided for students to employ their ICT experience and knowledge in technology use to mediate their learning. This study also explored how these experiences and knowledge can be pedagogically solicited to facilitate their science learning.

Role of daily-life technology

Different from that in traditional instruction, the role of daily-life technology proposed in this study is not just a referential scientific application. Most traditional teachers use technology in students' daily lives as an analogy to explain or supplement a scientific phenomenon. However, this study took a further step to make daily-life technology play a more active role in motivating and guiding students in their exploration of abstract and challenging scientific contents. Researchers argue that, by using daily-life experience to access science knowledge, students can feel confident, and find science learning interesting and valuable (Stinner & Williams, 1998; Aikenhead, 2006; Osborne *et al*., 2003). Daily-life experience in this study refers to the use of daily-life technology. With regard to students' interest, Renzulli *et al*. (2004) claimed that a real-life experience has a personal frame of reference, which involves an emotional or internal commitment to the part of those involved. When such frame of reference is mentioned, students' interest will be aroused. For example, students have personal preference for the TV programs they like and they use Infra-Red (IR) technology to select programs they prefer to watch using the remote control. Hence, demonstrating how the IR technology is adopted in TV should arouse students' personal frame of reference and attract their attention.

Regarding confidence, students' life experiences provide some of their prior (science) knowledge (Tsai & Huang, 2002), upon which they can access the new science knowledge (Merrill, 2001; Zohar, 2006) and feel confident in learning science (Lawrence, 1999; Norman & Hyland, 2003). The teaching may use daily-life technology to make students recall their prior experiences related to that technology and science under discussion. With these experiences, students can access the science knowledge and feel confident in learning. Hence, technology in students' daily life may be pedagogically utilized to help students build up their confidence in science learning.

Finally, researchers argue that, because students can make utilitarian meaning out of their personal lives, if the learning content is related to their life experience, they value more the learning content (NRC 1996; Tuan *et al*., 2005). Daily-life technologies are used by today's students and bring much benefit and enjoyment to their life. Hence, by relating explicitly daily-life technologies to the science content, students can see an obvious and direct utilitarian meaning out of their personal lives, and should value the content of learning.

AUTHENTICITY VS. GENERALIZIBILITY

When teaching begins with a scientific application such as a daily-life technology, it is a trend of contextual learning (Huang *et al*., 2008; Huang *et al*., 2012), which recognizes that learning is best when the student is shown authentic examples rather than being taught with generalities. The authenticity here means how the science knowledge and scientific phenomenon are implemented as technology in human life. In this way, the constructed concepts have their basis on experiential schema and are organized through associations with only limited coherence. However, the required concepts in the science domain should be established from rules and follow a coherent logic (Reif & Larkin, 1991; Kasanda *et al*., 2005). Sloman (1996) addressed such difference by positing that the knowledge in everyday domain requires only “associative thought”, whereas in science domain, it is strictly “rule-based”. Moreover, as the coherent logic for generalizibility is the major goal of teaching in school (Bereiter, 1997), students can then apply knowledge from principles to more scenarios of real-life problems. That is the reason why current education in schools still emphasizes mental thinking rather than manipulation of tools; engaging students in manipulation of symbols rather than contextualized reasoning; and aiming to teach general skills rather than specific competencies (Hung & Tan, 2004; Resnick, 1987).

To reach the learning goal of generalizibility even though teaching is proposed to start with authentic daily-life technology, this study adopted the idea of continuum of Authenticity and Generalizibility (Chen & Hung, 2002). Hung and Chen argued that learners should be scaffold along such a continuum, or should be in context-process authenticity, in order to gain richer and deeper understanding of a subject or domain. When teaching and learning is from Authenticity to Generalizibility, students should be explicitly instructed about the connection for their construction of general knowledge (Goldstone & Son, 2005; Uttal *et al*., 1997). Hence, in this study, the technologies chosen from students’ daily lives should be associated with appropriate instruction to faithfully reflect the science to be presented such that students can make a connection between their daily-life technologies and science. To cope with such a challenge, the use of logistic causal relationship between science and technology is suggested. That is, the scientific facts interpret the world and provide the potential for engineers to change the world in a predictable manner (Bhaduri, 2003). When the potential of science is transformed into an actual reality, it is called a technology. According to this relationship, there must be technical features inherited from the science phenomena. These features constitute the specific characteristics of a technology used in daily lives and contribute to people’s everyday experience. This understanding as the content knowledge not only can be employed to reason how a technology is developed from scientific phenomena, but may also reveal a trace of teaching as instructors’ pedagogical content knowledge in facilitating students to approach the science behind that technology. For example, IR may serve as a short-range and directional point-to-point wireless communication technology. When it is adopted in TV for remote control, watchers can point the remote control device at the TV for channel selection. Students may be perceptually familiar with the act of pointing the remote control device at the TV without being conceptually aware of the scientific feature of IR. Hence, there should be some appropriate manipulatives and pedagogies of augmenting the features of technologies in students’ daily lives to facilitate their science learning.

Finally, as students can perceive the utilitarian meaning for the learning content, the instructor may ask them what can be done when the daily-life technology does not work under a specific circumstance. Such instruction for students is more than mere reproduction of the delivered knowledge. Students are encouraged to rely on their current understanding to generate and test hypotheses and predictions in a tailored situation regarding the daily-life technology. This would foster their explorative learning attitude toward the topics taught through solving a problem for their own good in daily life. For illustration of the proposed approach, a sample practice design is presented below.

SAMPLE PRACTICE DESIGN

For a practical reference, this study proposed a sample practice design. The subject chosen was IR because IR in the modern society is one of the widely deployed sciences and technologies in daily lives, and one of its many applications is the TV. Moreover, because IR is a kind of wave, and the abstract concept of spectrum is important for understanding various kinds of waves in the natural world, spectrum was introduced as the generalized knowledge of IR and was tailored into this learning practice. Hence, the sample practice design is to use the daily-life applications of TV to teach students about IR, especially where the IR is located in the wave spectrum. In accordance with the teaching model, five phases of a learning practice are illustrated: 1) introduction of daily-life technology, 2) connecting daily-life technology with science knowledge, 3) presentation of science knowledge, 4) various applications of science knowledge, and 5) solving daily-life problems with acquired science knowledge.

Phase 1

The first phase involves using daily-life technologies to raise students’ interests and demonstrate features of technologies related to the subjects of science learning. Students are asked how often they watch TV and what their favorite TV programs are to arouse their personal frame of reference. The next question is about how they use the TV remote control. Is the TV remote control a wireless technology? Do they point the remote control device at the TV and why? These questions are meant to help students recall their prior experience related to the subject of learning.

Phase 2

The second phase is to demonstrate how IR is related to the use of TV remote control. A piece of paper is employed to block the line-of-sight transmission of IR light from the TV remote control, and the control operation is interrupted. Students then realize that IR light can be blocked by paper. Using these vivid and concrete presentations, the instructor can explain how the IR technology works. Moreover, students become aware of their lack of knowledge about IR in TV. IR applied to TV remote control is a type of communication technology, whose features include the direction and the available distance of communication. These demonstrations and explanations should be attractive and comprehensible to students.

Phase 3

In this phase, the instruction moves from the explanation of students' daily-life experience in authentic context of daily-life technology to the introduction of generalized knowledge concerning the abstract concept of spectrum. This phase of instruction involves finding supplementary manipulatives under the topic of spectrum. The spectrum of rainbow seems to be appropriate. The rainbow's spectrum is caused by the dispersion of daylight as it goes through raindrops. Since this optical and meteorological phenomenon that causes a spectrum of light to appear in the sky is difficult to manipulate in the school setting, the proposed manipulative is the graphical representation of the color spectrum of dispersed visible light. After introducing the concept of spectrum, the next presentation is to associate the visible light spectrum with the comprehensive wave spectrum (Figure 1). These manipulatives are selected and arranged in sequence for presentation according to the proposed principle of authenticity to generalizibility, and they should facilitate students to create mental entities that serve as the basis for their new concept of spectrum.

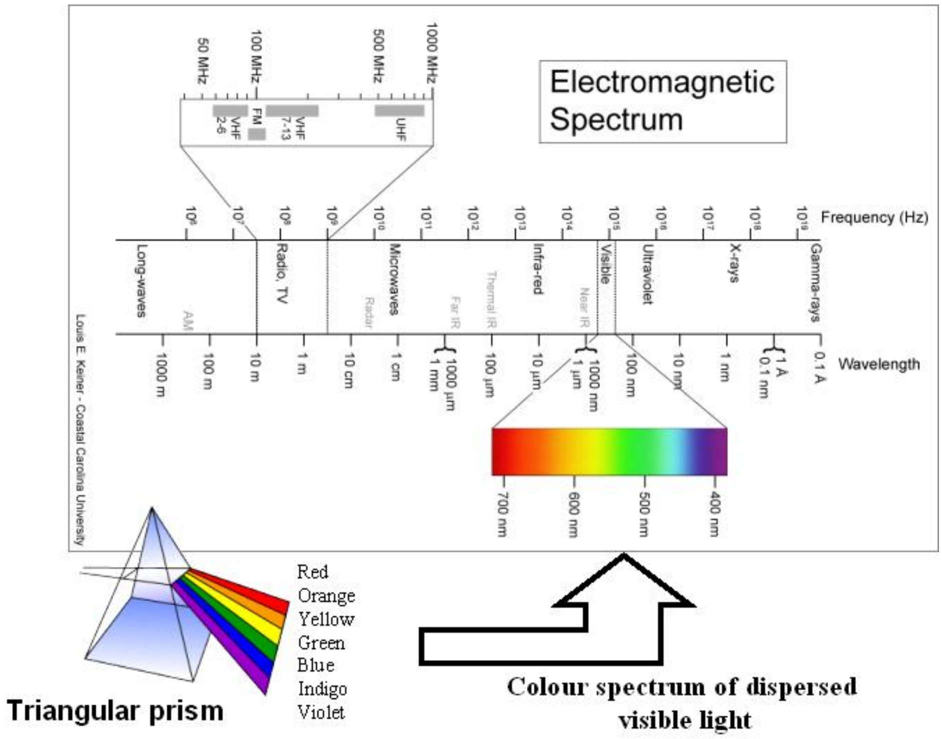


Figure 1. Association of visible light spectrum with the comprehensive electromagnetic spectrum (Diagrams are adopted from NASA JSC Web and Wikipedia)

As instruction progresses to indicate that the location of IR in the spectrum is right next to the visible light of the color red, students can then learn the new facet of IR in its association with the spectrum, and in its manner of generalizibility as an abstract science concept.

Phase 4

After students are presented with the generic knowledge of the categorization of IR and other various electromagnetic waves along the spectrum in addition to IR, the applications of these waves in the human world are then introduced. Students begin to understand that waves of different wavelengths or frequencies have different characteristics, which support various applications. The instructor may ask students to explain the characteristics of these applications according to their prior experience and current understanding of the spectrum. As students are asked to interpret their new observations of these applications with which they are familiar to a certain extent, more opportunities are offered to students for them to reason, justify and share their understanding.

For example, most students have a mobile phone, whose radio wave in the spectrum has a lower frequency than that of IR. In comparison with the TV remote control, students are asked whether they need to point the mobile phone at the Radio Base Station on the tower or the top of the building. The answer is obviously no. Hence, students should realize that these two daily-life applications employ different wireless technologies. As students activate their prior live experiences to synthesize currently presented theories, they should have deeper understanding of different wireless technologies in the spectrum.

Phase 5

Instruction of this phase aims to foster students' explorative attitude toward the topic of science learning. The suggested activity is to ask students what can be done if the sensor bar (IR emitter) in Wii does not work. Wii is a popular and interesting game, and Wii-related questions should engage students. In Wii, players wave physically the Wii remote control to embody virtually the simulated player or avatar in the digital game. Most students are only aware of the interactional relationship between the player's remote control and the avatar without knowing the supporting IR technology behind it. If students can be reminded that, in the spectrum, the red light is right next to the IR and that the red light of a candle can emit a signal of similar wave length as the sensor bar does. Then, the answer is to use a candle to replace the broken sensor bar. The next step is to demonstrate such solution approach. This instruction not just proves the scientific facts, but, more importantly, enables students to be aware of the significance of the spectrum and how it can be utilized to solve daily-life problems. Then students will not view the concept of spectrum as a purely scientific fact. Instead, they will realize that if they can master the science concept of spectrum, they will be knowledgeable and able guys like MacGyver in an American adventure television series.

EXPERIMENT

This study proposed using daily-life technologies as a starting point to teach science. Although this proposal is supported by learning theories and reasoned argument, an investigation still needs to be conducted because empirical evidence is needed in order for an educational research to be complete (Mayer, 2000). Hence, a corresponding experiment was carried out to verify whether students could feel interested and confident about, and value the science learning content under the proposed teaching approach.

A pre-post comparison study design that involves an experimental group and a control group was used. Students' attitude toward science learning was examined. The material and teaching method for the experimental group had been described in the proposed model previously, while those for the control group will be explained in the next section.

At this point, it can be argued that students' attitudes towards science learning are consistent and stable with time. This may refer to the fact that people's attitudes tend to have features of some stability and tend to lead to certain relatively consistent patterns of behavior (Reid, 2006; Roediger *et al.,* 1984). Nonetheless, there are some mechanisms by which attitudes do change and develop, relating the general stability of attitudes with the situations when change is possible (Reid, 2006). By using precise curriculum strategies developed according to established social-psychological principles, this study attempted to explore and justify such possibility in science learning.

Teaching material and method for the control group

The materials for the control group were developed according to the traditional instruction method to provide comparison of students' responses with those obtained by the proposed teaching method. The content and structure in Wikipedia regarding IR is adapted. In Wikipedia, the introduction of IR is presented in the following structure: Overview, Origins of the term, Different regions in the infrared, Applications, and History of infrared science. Such structure is domain-based, just like the traditional instruction. The important concept of wave spectrum is described in the section of "Different regions in the infrared". Moreover, some contents in Wikipedia which will not be addressed in the material taught to the experimental group are removed to make the learning material of these two groups as identical as possible.

The teaching material for the control group contains 23 slides and takes 40 minutes to lecture; while that for the experimental group contains 31 slides and takes 60 minutes for presentation and demonstration of daily-life technology. Teaching materials for both groups are designed and taught by the author of this study to ensure greater objectivity in the content presented.

INSTRUMENT

Students' attitudes are measured in terms of interest, confidence, and value, and a corresponding questionnaire is designed with reference to Pintrich and De Groot's (1990) study. Regarding these three aspects of measurement, they have proposed a framework and a questionnaire for conceptualizing and measuring students' attitude upon a learning task, and the framework has: (a) an affective component, which includes students' emotional reactions to the task, (b) an expectancy component, which includes students' beliefs about their ability to perform a task, and (c) a value component, which includes students' goals and beliefs about the importance and interest of the task. The learning task is specified as science learning task in this study. The revised questionnaire comprises three items regarding interest, five items regarding confidence, and four items regarding value (see Appendix A).

Because the measurement of students' expressed preferences and feelings towards a learning activity is a relative scale (Osborne *et al.*, 2003), this study measured students' pre- and post-activity opinions to gain an understanding of the variation of students' responses attributed to the proposed learning practice. In addition, to obtain more objective responses in the survey, the pre-activity survey will be held three weeks before the learning activity, as suggested by Kopcha and Sullivan (2008), and the post-activity survey will be held right after the activity. Reviewed by an expert in the field of educational measurement and instructional design, the questionnaire is found to have validity. Finally, to ensure the validity of students' response to the questionnaire, one trick question with meaning opposite to that of another item in the questionnaire is included.

Interview

The use of multiple methods and data sources (Mathison, 1988) are needed to produce more reliable evidence for identifying the assumed learning benefits in this study. Hence, this study conducted interviews with students. Participants of the experimental group were randomly selected after filling out the questionnaire to provide further comments, if any, regarding their answers and the experimental activities in an open manner. The interview was held in a focus group format for the following reasons. Most of the participants are expected not to actively provide their teaching-related opinions in the one-to-one interview, and they have been classmates for one semester already. Hence, the focus group method is employed to obtain multiple interactions among all participants in the group and enhance data quality (Krueger & Casey, 2000). That is, the method is expected to provide students' in-depth reflection on their experience and to gain an understanding of the finer-grained aspects of students' perceptions during the group discussion.

For a better understanding how each phase of instructional activity affects students' attitude toward science learning, an open-ended questionnaire was employed to guide them in identifying which phase of instruction made them feel interested and confident, and find science learning valuable. Questions on any additional personal comments and suggestions for the proposed experimental method of teaching science then followed. The interview responses were transcribed and coded to trace any specific opinions upon the activity and possible instructional implications.

PARTICIPANTS

The participants are 40 freshmen recruited from the Department of Engineering of a private college-level institute. They are randomly and separated evenly into two groups, namely, the control group and the experimental group. For this institute, only 10% of the seniors are pursuing further degree after graduation. Such statistics show that most of the students are not academic-oriented, and their purpose in learning is to apply acquired knowledge to their work right after graduation. Hence, the school mission is to motivate them to study contemporary technology and science, and help them utilize their acquired knowledge in the field.

RESULTS

Questionnaire

Students' attitude toward using daily-life applications for science learning was measured by the students' self-evaluation of their quantitative response to the questionnaire. The questionnaire consists of 13 items on interest, confidence, and value. The items are ranked on a five-point Likert scale, which ranges from strongly agree, agree, neutral, disagree, to strongly disagree at score 1 to 5, respectively.

All 40 students (20 for each group) completed both pre- and post-activity questionnaires. The number of valid responses for the experimental and control group s are 17 and 19, respectively. The Cronbach's coefficient alpha for this study scale in interest, confidence, and value are at the acceptable level of 0.79, 0.65, and 0.77, respectively in the pre-activity measurement result.

One-way analysis of variance was employed to analyze the pre-activity survey results of both control and experimental groups. No significant differences were found between them in the dimensions of interest, confidence, and value (p = 0.509, 0.611, and 0.080, respectively). The means and standard deviations for these dimension measurements in pre-activity survey of experimental and control groups are presented in Table 1.

Table 1
Students' attitudes pre-test (between groups)

		N	Mean	Std.	t	df	Sig. (2-tailed)
Interest	Control	19	2.11	0.40	-0.695	34.000	0.509
	Experimental	17	2.25	0.84	-0.671	22.409	
Confidence	Control	19	2.92	0.49	-0.520	34.000	0.611
	Experimental	17	3.01	0.61	-0.514	30.636	
Value	Control	19	2.18	0.65	1.785	34.000	0.080
	Experimental	17	1.82	0.55	1.802	33.909	

p<.05 *

As to the difference between groups in the post-activity survey results, the experimental group was found to have much better attitude of interest and value toward science learning, at the average of 1.80 and 1.71 than the control group, with the average of 2.30 and 2.09, respectively. These difference are significant at p = 0.013

and 0.047, respectively. The means and standard deviations for these dimension measurements in post-activity survey of experimental and control groups are presented in Table 2.

Table 2. Students' attitudes post-test (between groups)

		N	Mean	Std.	t	df	Sig. (2-tailed)
Interest	Control	19	2.30	0.54	2.618	34.000	0.013 *
	Experimental	17	1.80	0.59	2.605	32.735	
Confidence	Control	19	2.74	0.43	0.356	34.000	0.724
	Experimental	17	2.68	0.49	0.354	32.315	
Value	Control	19	2.09	0.64	2.064	34.000	0.047 *
	Experimental	17	1.71	0.46	2.101	32.683	

$p<.05$ *

As to the difference between pre- and post-activity responses, according to one sample *t*-test analysis result, the experimental group improves significantly their interest from 2.25 to 1.80 (p = 0.014) and their confidence, from 3.01 to 2.68 (p = 0.005). The means and standard deviations for these dimension measurements in pre- and post-activity survey of experimental group are presented in Table 3.

Table 3
Differences of experimental group students' attitudes (within group)

	N	Mean	Std.	t	df	Sig. (2-tailed)
Interest	17	0.45	0.68	2.749	16	0.014 *
Confidence	17	0.33	0.42	3.249	16	0.005 *
Value	17	0.12	0.10	1.224	16	0.239

$p<.05$ *

Regarding the control group, their attitude toward science learning under the traditional instructional method show no significant change in the dimension of interest, confidence, and value (p = 0.200, 0.190, and 0.505, respectively). The means and standard deviations for these dimension measurements in pre- and post-activity survey of control group are presented in Table 4.

Table 4
Differences of control group students' attitudes (within group)

	N	Mean	Std.	t	df	Sig. (2-tailed)
Interest	19	-0.19	0.63	-1.332	18	0.200
Confidence	19	0.18	0.57	1.361	18	0.190
Value	19	0.09	0.59	0.680	18	0.505

$p<.05$ *

The survey results show that, within the context of teaching science with daily-life technology, the proposed teaching method does improve students' attitude toward science learning. Among these three dimensions of science learning attitude, interest has the most significant improvement according to analysis results of both between and within groups.

Interview

Six participants in the experimental group are randomly selected for the interview. Their responses to the phase of instruction that makes them feel interested, confident, and valuable about science learning are summarized in Table 5.

Table 5
Summary of interview responses concerning Phases 1 to 5 instruction.

Student	A	B	C	D	E	F
Interesting	2	2	1,2,4	2,5	1,2,5	5
Confident	5	4	1,2,4,5	5	1,2,5	5
Value	5	4,5	1,3,4,5	4,5	1,2,4,5	2,5

According to Table 5, Phase 5 instruction showing how the science knowledge can help students solve their daily-life problems is the most preferred, followed by Phase 2 instruction of how daily-life technology is related to the science knowledge. Students do not favor much Phase 1 instruction with daily-life technologies shown in classroom. It should be noted that Phase 3, presenting science knowledge, is only preferred by one of the six interviewed students. Because most of the students are not pursuing further academic degree; hence, they have little interest in science knowledge.

After answering the interview questions, these six students were asked to provide further comments in an open manner according to either their answer to previous questions or the experimental activity. A student describes that "Teachers always give us the examples which are out of date…It is better if they show something more related to me in the classroom…" Another student states that " I am going to find a job after graduation, and I need to know how to apply the knowledge learned in the classroom. Hence, I prefer Phase 4 instruction on various applications of science knowledge." The third student gave reason for preferred phase of instruction saying, "I value what I learn if it can be applied in my life and future career...that will be interesting to me…and I feel confident and like to study it." The fourth student says, "Showing the candle (in Phase 5) makes me feel curious, and I want to understand it…that makes me feel confident about it [the learning]." In addition to the qualitative support of the proposed teaching method, two themes can be drawn from these comments. One is that nowadays students who are looking for jobs after graduation value the science knowledge taught in classroom in a way that requires teachers to help them see the connection between the curriculum and their daily lives and career. The other is that, for these students, when the instructional activity makes them feel interested, they will feel confident in the corresponding learning.

DISCUSSION

This study tackled the challenge faced by today's science educators regarding students' attitude toward learning, and proposed using technologies in students' daily lives to begin the science teaching. According to the responses collected through questionnaire survey and interview, students showed improvement in their learning attitude in the aspects of interest, confidence, and value. This finding echoes previous literature in addressing how students' experience in their daily lives can be related to students' attitude of learning. That is, when learning is related to students' everyday experience, it will make students feel interested in and confident about, and value the learning content. This study took a further step in showing how to use students' experience about daily-life technologies in a classroom setting to improve their attitude toward science learning. The results are also in line with the comment of Osborne *et al*. (2003) that when a science curriculum relates to students' life-world experiences, it engenders students' more positive attitude to school science. The results also supplement the study of Bennett *et al*. (2005) in providing the proof of students' positive responses to context-based approach, in addition to the previous survey of teachers' view.

Moreover, the results show that students of the experimental group had significantly greater interest in learning. The finding also echoes that of Schraw *et al.* *(*2001) that when students' personal frame of reference is mentioned in an educational setting, their interest for learning can be aroused.

As to students' confidence, the results support the theory that when the science content is related to their everyday lives, their prior experience and knowledge may help them build up their ability in understanding the content (Merrill, 2001; Stinner & Williams, 1998; Tsai & Huang, 2002; Zohar, 2006), and foster their confidence. Such result also supports this study's pedagogy in showing how daily-life technologies and their corresponding life experiences may be pedagogically utilized to improve students' confidence in learning science.

Furthermore, the results show that students of the experimental group value science learning more, thus supporting the argument that students will value the science taught when they can make personal utilitarian meaning out of the learning content (Aikenhead, 2006). As this study uses daily-life technology to make students see the direct connection between the curriculum and their life, the results show that they do value the science learnt.

Another finding is related to students' confidence in science learning. During the interview, two students mentioned that their confidence is aroused by curiosity and interest, respectively. It is beyond what is revealed in previous studies that confidence can be built up by the ability to deal with a task (Lawrence, 1999; Norman & Hyland, 2003). The task here is to understand the science learning content, and it can be facilitated by students' prior experience and knowledge (Merrill, 2001; Tsai & Huang, 2002; Zohar, 2006). Although this finding needs further investigation, it does provides an alternative view of students' confidence and additional aspect of instruction in helping today's youngsters build up their confidence in learning.

As to the analysis of how students view the proposed five phases of instruction, showing how the daily-life technology is related to science knowledge (Phase 2) and how the acquired knowledge can be utilized to solve their daily-life problems (Phase 5) were considered important by most students in providing them interest, confidence, and value in learning. This qualitative evidence shows that students prefer the instruction which makes explicit connection between daily-life technology and science learning content. On the other hand, the instructional phase of showing daily-life technologies is not of much interest to most students interviewed, revealing that sugar-coating (Dewey, 1990) the learning content is neither favored by these youngsters, nor improves their attitude toward learning the science content. Hence, when instructors design activity to attract students in classroom learning, they need to think more deeply. That is, getting students' attention is an essential step, but this cannot improve students' learning attitude in a long run. Similar concern has been mentioned in Moyer's (2002) study, which finds that mathematics teachers often use advocated manipulates to generate fun rather than to foster students' interest in mathematics. To a certain extent, these teachers use interest-catching techniques that are irrelevant to the subject matter. Hence, from the aspect of using manipulates, for example, daily-life technologies, to improve students' attitude toward learning, the instruction effort should be devoted to the type of instruction of great relevance to the subject matter, or in Dewey's terms, psychologizing the learning content.

In addition, according to the summary of interview responses, only one of the six interviewees shows preference for the instructional phase of showing the science content in a factual manner as the general mode of knowledge presentation. On the contrary, interviewees show significant preference for the instructional phases of showing how the science is utilized as a technology and as a solution to daily-life problems as the authentic mode of knowledge presentation. Such evidence echoes the assertion that learning is more motivating in an authentic context (Resnick, 1987; Soloway, 1996). This result also assures the need of traditional science education reform advocated in the science-technology-society (Ziman, 1980) and History and Philosophy of Science (Stinner & Williams, 1998). Although the proposed teaching model is successful in improving students' attitude toward science learning in general, the general mode of presenting science knowledge is still a challenging issue for these youngsters.

IMPLICATIONS

This study provides a practice design for reforming the traditional science teaching at the levels of content and pedagogy. The content level is to situate the science curriculum in the context of students' lives; that is, the use of students' daily-life technology as the curriculum. The pedagogy level is the beginning of teaching with that curriculum. The curriculum is within the context of students' personal experiences, and the teaching is learner-centered. Such design is to ensure students' motivation for science learning. Meanwhile, the implemented continuum of Authenticity and Generalizibility serves as the pedagogic strategy teachers can use to support the *border crossing* (Jegede & Aikenhead, 1999) through the matching of three domains – everyday life, school, and science domains.

With reform of both levels, the proposed teaching approach echoes the call from Kasanda *et al.* (2005) for more learner-centered science teaching in bringing learners' experiences into the classroom. They reported that most of the everyday contexts are introduced after a more conventional use of abstract theoretical terms, which has been unsuccessful in helping students provide meaning to their learning. The contexts of students' everyday experiences are used as a remedial strategy, not as a teaching approach. Such type of teaching are still subject-centered rather than learner-centered (Kasanda *et al.*, 2005).

In the present study, the proposed teaching approach harmonizes the abstract science with the students' concrete life-world experiences, and supports the learning process of *enculturation* instead of *assimilation* (Contreras & Lee, 1990; Jegede & Aikenhead, 1999). It therefore should overcome the challenge of parallel *collateral learning* (Jegede & Aikenhead, 1999), in which students use scientific knowledge only in school, never in their everyday world, as a result of segregation of school science content within the minds of students.

Finally, this study uses the example of IR in the domain of ICT. The rationale behind this study is that if teaching begins with students' everyday experience, their attitude toward learning will be improved. Such proposal should not be treated as unique and inapplicable to other domains. For example, the young like to dye their hair, color their nails or tattoo their skin with fancy logos; the science of chemistry can play an important role in these. Tracing what the students' care about in their daily lives and exploring the possible curricula for teaching the intended science topics are the suggested instructional rationale for instructors nowadays.

CONCLUSION AND FURTHER STUDY

This study proposed using technologies in students' daily lives to teach science taking into consideration students' personal frame of reference, prior experience and knowledge, and foreseeable value of learning. The proposed learning begins with authentic practice, and adopts the continuum of Authenticity to Generalizibility to fulfill schools' goals of learning. To make the proposal clear and practical, a sample practice design was presented. To evaluate whether the assumed values of daily-life technologies in science learning are perceived as beneficial in the eyes of students, an experiment was been conducted. The results obtained support this study's argument that using daily-life technologies to begin science teaching is a valuable approach in science education.

However, observation of an ICT technology in people's daily lives tends to cause misconceptions. Webb (2002) cautioned that widespread use of ICT in today's society together with the hidden nature of the mechanisms of many ICT devices is likely to result in misconceptions. How to probe students' misconceptions and help them accept new concepts is a challenging issue. In addition to making the new concept understandable, believable and fruitful (Bryce & MacMillan, 2005; Duit & Treagust, 2003; Posner *et al.*, 1982), students' dissatisfaction with a prior concept is required (Posner *et al.*, 1982; Strike &Posner, 1985; Tsai, 2000). Hence, in addition to the use of daily-life technologies in the proposed teaching method, future study can explore how to elicit students' misconceptions and how to demonstrate the selected technologies in a specific way to make students dissatisfied with their previous knowledge, which is not correct.

As this study values science learning in taking account of different types of life experiences, one issue needs to be noted is some indigenous or minority groups might have their own unique living experiences in some countries. Kidman *et al.* (2011) and McConney *et al.* (2011) examine the perspectives of indigenous science learners and debate about the nature of science and the science curriculum. They call educators to make school science more culturally responsive or relevant to students from indigenous or minority groups. As to this study, when applying the proposed teaching, since the perspectives of indigenous science learners might much differ from the current study, the teaching design should be modified accordingly.

REFERENCES

Aikenhead, G. S. (2006). *Science education for everyday life: Evidence-based practice*, Teachers College Press, New York.

Bennett, J., Gräsel, C., Parchmann, I. & Waddington, D. (2005). Context-based and conventional approaches to teaching Chemistry: Comparing teachers' views. *International Journal of Science Education*, 27, 1521–1547.

Bennett, J., Lubben, F. & Hogarth, S. (2007). Bringing science to life: A synthesis of the research evidence on the effects of context-based and STS approaches to science teaching. *Science Education*, 91, 347-370.

Bereiter, C. (1997). Situated cognition and how to overcome it. In D. Kirshner & J.A. Whitson (Eds.). *Situated Cognition: Social, semiotic, and psychological perspectives*. Mahwah, NJ: Lawrence Erlbaum Associates, 281-300.

Bhaduri, S. (2003). Science, society, and technology—three cultures and multiple visions. *Journal of Science Education & Technology*, 12(3), 303-308.

Bryce, T. & MacMillan, K. (2005). Encouraging conceptual change: the use of bridging analogies in the teaching of action–reaction forces and the 'at rest' condition in physics. *International Journal of Science Education*, 27(6), 737-763.

Bulte, A. M. W., Westbroek, H. B., de Jong, O. & Pilot, A. (2006). A research approach to designing chemistry education using authentic practices as contexts. *International Journal of Science Education*, 28(9), 1063–1086.

Chen D.-T. & Hung, W. L. D. (2002). Two kinds of scaffolding: the dialectical process within the Authenticity-Generalizibility (A-G) continuum. *Educational Technology & Society 5(4), 148-153.*

Contreras, A. & Lee, O. (1990). Differential treatment of students by middle school science teachers: Unintended cultural bias. *Science Education*, 74, 433-444.

Cronin, J. F. (1993). Four misconceptions about authentic learning. *Educational Leadership*, 50(7), 78–80.

Cross, R. T. & Price, R. F. (1999). The social responsibility of science and the public understanding of science. *International Journal of Science Education, 21*(7), 775–785.

Dewey, J. (1990). *The school and society and the child and the curriculum*. Chicago: University of Chicago Press (Two book volume; original work published 1900 and 1902, respectively).

Duit R. & Treagust D.F. (2003). Conceptual change: a powerful framework for improving science teaching and learning. *International Journal of Science Education*, 25(6), 671-688.

Gee, J. P. (2003).*What video games have to teach us about learning and literacy*. New York: Palgrave Macmillan.

Godwin-Jones, R. (2009). Emerging technologies personal learning environments, *Language Learning & Technology*, 13, 3-9.

Goldstone, R. L. & Son, J. Y. (2005). The transfer of scientific principles using concrete and idealized simulations. *Journal of the Learning Sciences*, 14(1), 69-110.

Gulikers, J. T.M., Bastiaens, T. J. & Martens, R. L. (2005). The surplus value of an authentic learning environment. *Computers in Human Behavior*, 21, *509-521*.

Huang, Y.-M., Kuo, Y.-H., Lin, Y.-T. & Cheng, S.-C. (2008). Toward interactive mobile synchronous learning environment with context-awareness service. *Computers & Education*, 51, 1205–1226

Huang, Y.-M., Huang, Y.-H., Huang, S.-H. & Lin, Y.-T. (2012). A ubiquitous English vocabulary learning system: Evidence of active/passive attitudes vs. usefulness/ease-of-use. *Computers & Education*, 58, 273–282.

Hung, D. & Tan. S. C. (2004). Bridging between practice fields and real communities through instructional technologies. *International Journal of Instructional Media*. 31(2), 167-174.

Jegede, O. J. & Aikenhead, G. S. (1999). Transcending cultural borders: Implications for science teaching, *Research in Science & Technological Education*, 17, 45-66.

Kasanda, C., Lubben, F., Gaoseb, N., Kandjeo-Marenga, U., Kapenda, H. & Campbell, B. (2005). The role of everyday contexts in learner-centred teaching: the practice in namibian secondary schools. *International Journal of Science Education*, 27(15), 1805-1823.

Fraser, B. J. & Tobin, K. G. (2003). *International handbook of science education*, Kluwer Academic.

Kasanda, C., Lubben, F., Gaoseb, N., Kandjeo-Marenga, U., Kapenda, H. & Campbell, B. (2005). The role of everyday contexts in learner-centered teaching: The practice in Namibian secondary schools, *International Journal of Science Education*, 27, 1805–1823.

Kidman, J., Abrams, E. & McRae, H. (2011). Imaginary subjects: school science, indigenous students, and knowledge–power relations, *British Journal of Sociology of Education*, 32, 203-220.

Krueger, R. A. & Casey, M. A. (2000). *Focus Group Interviews: A practical guide for applied research*. 3d ed. Thousand Oaks, CA: Sage.

Kopcha, T. J. & Sullivan, H. (2008). Learner preferences and prior knowledge in learner-controlled computer-based instruction, *Educational Technology Research and Development*, 56, 265–286.

Lawrence, D. (1999) *Teaching with confidence: a guide to enhancing teacher self-esteem* (London, Paul Chapman Publishing Ltd.).

Lester, B. T.; Ma, L.; Lee; O. & Lambert, J. (2006). Social activism in elementary science education: a science, technology, and society approach to teach global warming. *International Journal of Science Education*, 28 (4), 315-339.

Mathison, S. (1988). Why triangulate? *Educational Researcher,* 17(2), 13–17.

Mayer, R. (2000). What is the place of science in educational research? *Educational Researcher, 29*(6), 38–39.

McConney, A., Oliver, M., Woods-McConney, A. & Schibeci, R. (2011). Bridging the gap? A comparative, retrospective analysis of science literacy and interest in science for indigenous and non-indigenous Australian students, *International Journal of Science Education*, 33, 2017-2035.

Merrill, M. D. (2001). First principles of instruction. *Journal of Structural Learning & Intelligent*

Systems, 14(4), 459-466.

Moyer, P. S. (2002). Are we having fun yet? How teachers use manipulatives to teach mathematics. *Educational Studies in Mathematics*, 47, 175–197.

National Research Council (1996). *National Science Education Standards.* Washington, DC: National Academy Press.

Norman, M. & Hyland, T. (2003) The Role of Confidence in Lifelong Learning. *Educational Studies*, 29 (2/3), 261-272.

Osborne, J., & Collins, J. (2001). Pupils' views of the role and value of the science curriculum: A focus-group study. *International Journal of Science Education, 23*(5), 441–467.

Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education***,** 25(9), 1049-1079.

Pintrich, P. R. & De Groot, E. V. (1990) Motivational and self-regulated learning components of classroom academic performance, *Journal of Educational Psychology*, 82, 33-40.

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology*, 95(4), 667-686.

Pivec, M. (2007). Editorial: Play and learn: potentials of game-based learning. *British Journal of Educational Technology*, 38(3), 387-393.

Posner, G. J., Strike, K. A., Hewson, P.W. & Gertzog,W. A. (1982). Accommodation of a scientific conception: toward a theory of conceptual change. *Science Education,* 66: 211-227.

Reid, N. (2006) Thoughts on attitude measurement**,** *Research in Science & Technological Education,* 24(1)*, 3–27.*

Reif, F., & Larkin, J. (1991). Cognition in scientific and everyday domains: Comparison and learning implications. *Journal for Research in Science Teaching, 28*(9), 733–760.

Renzulli, J. S., Gentry, M. & Reis, S. M. (2004). A time and a place for authentic learning. *Educational Leadership*, 62(1), 73-77.

Resnick, L.B. (1987). The 1987 presidential address - Learning in school and out. *Educational Researcher*, 16(9), 13-20.

Roediger, H. L., Ruston, J. P., Capaldi, E. D. & Paris, S. G. (1984) *Introduction to Psychology* (Boston, Little-Brown).

Roth, W.-M. & Lee, S. (2004). Science Education as/for Participation in the Community. *Science Education*, 88(2), 263-291.

Rubba, P., McGuyer, M., & Wahlund, T. (1991). The effects of infusion STS vignettes into the genetics unit of biology on learner outcomes in STS and genetics: A report of two investigations. *Journal of Research in Science Teaching, 28*(7), 537–552.

Sloman, S. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin, 119*(1), 3–22.

Soloway, E. *et al*. (1996) Technological Support for Teachers Transitioning to Project-Based Science Practices. In T. Koschmann (Ed.), *CSCL: Theory and Practice of an Emerging Paradigm*. (pp. 269-307). NY: Lawrence Erlbaum Associates.

Stinner, A. & Williams, H.: (1998). 'History and Philosophy of Science in the Science Curriculum', in B. Fraser & K. Tobin (eds), *International Handbook of Science Education*, Kluwer Academic Publishers, Dordrecht, pp. 1027–1045.

Strike, K. A. & Posner, G. J. (1985). A conceptual change view of learning and understanding. In L. H. T. West and A. L. Pines, (eds), *Cognitive structures and conceptual change* (Orlando, FL: Academic Press), 211-231.

Tsai, C.-C. (2000). Enhancing science instruction: the use of 'conflict maps'. *International Journal of Science Education*, 22(3), 285-302.

Tsai, C.-C. & Huang, C.-M. (2002). Exploring students' cognitive structures in learning science: a review of relative methods. *Journal of Biological Education*, 36(4), 163-169.

Tuan, H.-L., Chin, C.-C. & Shieh, S.-H. (2005). The development of a questionnaire to measure students' motivation towards science learning. *International Journal of Science Education*, 27(6), 639-654.

Uttal, D. H., Scudder, K.V. & DeLoache, J. S. (1997). Manipulatives as symbols: A new perspective on the use of concrete objects to teach mathematics. *Journal of Applied Developmental Psychology*, 18, 37–54.

Webb M. E. (2002). Pedagogical reasoning: issues and solutions for the teaching and learning of ict in secondary schools. *Education and Information Technologies*, 7(3), 237-255.

Ziman, J. (1980) *Teaching and learning about science and society*. Cambridge: Cambridge University Press.

Zohar, A. (2006). Connected knowledge in science and mathematics education. *International Journal of Science Education*, 28(13), 1579-1599.

Appendix A
Questionnaire for measuring students' attitude toward science learning

Interest

1. It is interesting to study science.
2. It is interesting to participate in science learning activities.
3. The information regarding science knowledge can often attract my attention.

(Continuous)

Confidence		
	1.	I am confident in understanding the content of science learning in class.
	2.	I believe I can perform well in science courses.
	3.	Participating in science courses makes me nervous.
	4.	I am confident in answering related questions during science learning science.
	5.	I always feel pressured when I participate in science learning activities.
Value		
	1.	It is useful to study science.
	2.	Regardless of my future occupation, science knowledge is important to me.
	3.	Learning (Understanding) science knowledge can help me deal with different problems in my daily life.
	4.	Science knowledge is important and useful for people in modern society.

AUTHORS

Yu-Liang Ting is currently teaching at the department of communication engineering, Oriental Institute of Technology, Taiwan. He acquired his Ph.D degree from the University of Texas at Austin in 1999. His major research interest is mobile learning and its innovative design in science and technology learning, and the use of information and communication technology in facilitating English as foreign language learning.

Yaming Tai is an associate professor of Department of Children English Education at National Taipei University, Taiwan. Her recent research focuses on EFL teacher training and integration of technology into English as a foreign language teaching.

Phone: (+886) 2-27321104 ext. 55222
Fax: (+886) 2-87323557
Email: yaming@tea.ntue.edu.tw

Int. J. Technol. Eng. Educ.
2012, Vol.9, No.1

Creativity Learning through Blended Teaching for Designing Amphibious Vehicles

Chih-Chao Chung*, Wei-Yuan Dzan, Ru-Chu Shih***, Huei-Yin Tsai****, & Shi-Jer Lou*******

*National Kaohsiung First University of Science and Technology, Kaohsiung, Taiwan
**National Kaohsiung Marine University, Kaohsiung, Taiwan
***National Pingtung University of Science and Technology, Pingtung, Taiwan
****National Kaohsiung Normal University, Kaohsiung, Taiwan
*****National Pingtung University of Science and Technology, Pingtung, Taiwan

Abstract

This study aims to explore the effect of applying blended creativity teaching to cultivate students' creativity learning in order to be in accordance with the demand of the digital age as well as to cultivate students' abilities in independent thinking, novelty, and flexibility. This study summarized and analyzed literature relating to blended learning and creativity, and then used fuzzy Delphi method to analyze the expert questionnaire and then to establish blended creativity teaching indicators. A total of 72 students participated in this study for an eight-week experimental teaching session in creative design of amphibious vehicles. This study further developed the blended creative learning achievement scale, which contains four dimensions and 23 evaluation indicators: (1) creative character traits; (2) abilities in the creative process; (3) innovative product design, and (4) teaching environment for creativity. The findings of the study reveal that after most students underwent the blended creativity teaching session, their learning achievements in creativity were significantly enhanced. Finally, the findings of this study may provide suggestions on school creativity curriculum planning, teacher design of teaching for creativity, and student creativity learning in order to effectively enhance student creativity and in turn enhance national competitiveness.

Keywords**:** blended creativity teaching, creativity learning, fuzzy Delphi method, amphibious vehicles

RESEARCH BACKGROUND

Creativity can be enhanced through engaging in actual creative thinking activities (Treffinger, County, Gifted, & Talented, 1980). If creative thinking abilities are blended in courses, students can have creative ideas, increase imagination, and think about issues from different perspectives in order to cultivate problem-solving ability (Maisuria, 2005). Thus, if students can personally experience and sense creativity, it would be the key to inspiring personal creativity. The usage of diverse and flexible instructional strategies has been proven to cultivate student creativity (Michaela, 2001). In terms of instructional strategies, with the development of digital technology, there are also new instructional strategies and tools. However, the application of information technology is not the guarantee for instructional effects and quality; it is also necessary to consider curricular content, learner characteristics, and the internet environment. Thus, the application of blended learning in education has received increasing attention. Blended learning combines physical classroom classes and internet virtual courses, breaking through the restrictions of time and space, effectively realizing the advantages of internet learning, covering face-to-face and collaborative learning, and emphasizes teacher guidance and student autonomous learning (Akkoyunlu & Yılmaz-Soylu, 2008). As a result, this study incorporates the spirit and concrete methods of teaching for creativity into blended instruction in order to inspire the potential creativity of students. Meanwhile, diverse instructional methods and strategies were used to guide student problem-solving ability and strengthen their abilities in real work, in turn elevating creativity learning achievements to achieve instructional objectives. There are three research purposes in this study, including (1) to establish blended creative learning achievement indicators; (2) to develop a blended creative learning achievement scale; and (3) to explore the effect of blended teaching for creativity learning achievements.

LITERATURE REVIEW

The purpose of this study aims to explore the effect of blended teaching for creativity on creativity learning achievements, thus the literature on blended learning, teaching for creativity, and creativity evaluation is reviewed and summarized as follows.

Blended learning

Blended learning refers to the blending of two or more different learning methods or media tools, integrating traditional instruction and internet instruction, integrating the media and tools of internet learning, and integrating the usage of instructional methods and instructional technology (Oliver and Trigwell, 2005). Blended learning combines face-to-face instruction and remote instructional transmission systems to seek the optimal combination and balance between the two. Thus, blended learning can effectively integrate different transmission models, instructional models, and learning methods (Procter, 2003). In teacher construction of the blended learning environment, there are six reachable purposes, including: 1) educational richness; 2) knowledge can be stored and accessed; 3) social interactivity; 4) personal representativeness; 5) can save costs; 6) easy to modify (Osguthorpe and Graham, 2003). According to Mortera-Gutierrez (2006), in the blended learning context, the combination of traditional instruction and information technology can create infinite possibilities in education to reflect the richness of education. In other words, the content of blended learning integrates different instructional methods, media, and instructional materials, combining internet learning and face-to-face learning methods to accommodate individual differences of students, teacher experiences, and instructional purposes through using the most appropriate learning environments and tools for instruction as well as to achieve the purpose of instruction and learning. Thus, this study employed diverse instructional technology in blended learning, complemented by related instructional strategies, so that students can efficiently engage in online learning of creativity, face-to-face learning, and autonomous learning in order to achieve the effects of students' creativity learning achievements.

Integration of teaching for creativity and platforms

According to Starko (2009), teaching for creativity refers to teachers adding specific behaviors in the instructional process to develop student creative thinking or develop creative personality traits. Also, creativity can be cultivated, and it is a continuous construction, deconstruction, and reconstruction process unique to humans(Gagne, Yekovich, and Yekovich, 1997). Prior studies also have pointed out that practice can be used to construct and develop personal potential in creativity(Zimmerman, 2006). Thus, the effective usage of diverse and variable instructional strategies has been proven to cultivate student creativity(Michaela, 2001). In terms of teaching for creativity and platform integration, Lou, et al.(2012) integrated the opinions of various experts to propose the function correlation chart for blended creativity learning platforms, including (1) purpose delineation, (2) system design, (3) system mechanisms, (4) system support, in the construction of blended TRIZ creativity learning platforms (Lou, Chung, Chao, Tseng, & Shih, 2012). This study employed the blended creativity learning model proposed by Lou et al. (2012) as the foundation for integrating blended learning and learning for creativity and effectively using the advantages of information technology and diverse and variable instructional strategies in order to promote the effects of students' creativity learning outcomes.

Evaluation of creativity

Creation is a composite and holistic activity, and creativity is the overall composite performance of the individual. Rhodes (1961) proposed 4Ps: person, process, products, place or press. Sternberg and Lubart (1995) pointed out that creativity comes from six resources: wisdom, knowledge, thinking forms, personality, motivation, and environmental contexts. Wu and Fan (2011) further proposes that when establishing and implementing educational policy in creativity, the content can differ based on nation and region, but should cover the 4Ps. With the evaluation of the times, creativity research still focuses on 4Ps, which shows that the 4Ps has fully covered the overall performance of creativity. In summary, in order to enhance student creativity learning achievements, this study refers to the content of the 4P as proposed by Rhodes, and slightly modifies them to (1) creative character traits, (2) abilities in the creative process, (3) innovative product design, and (4) environment of teaching for creativity, referring to these as the blended creative learning the 4P dimension (henceforth BCL-4P), as shown in Figure 1, which are explained as follows.

(1) Creative character traits: Barron and Harrington (1981) suggested that traits exhibited by creative people include preference for complexity, autonomous self-confidence, and tolerance for difference between oneself and others. Many studies suggested that highly creative individuals should have the following character traits: strong active learning motives, perseverance, enjoyment of fun from work itself, sharing creativity, preference for independent thought, high levels of work enthusiasm, curious, enjoyment for inquiry, wide interests, willingness to grow, endless pursuit for advancement, ambitious, hope for affirmation, full devotion to work, pursuit for distant goals, preference for complex and challenging work, willingness to take risks, boldness in expressing one's own views and talents, boldness in trying difficult work, preference for solving problems, strong will, open-mindedness, tolerance for uncertain contexts, robust character, sensitive intuition, demand for evidence, independence and autonomy, optimistic and forward-looking, doubt for tradition, and not being constrained by biases and old methods (Amabile, 1997; Feldhusen, 1995; Sternberg, 1988; Torrance, 1988). The researchers of this study believe that performance of individual creative activity is creative character traits. To conclude, creative character traits are summarized as imagination, originality, knowledge-seeking, independent challenge, proactive, flexibility, association, and conciseness. Cultivation of creative personal traits can enhance student learning achievements in creativity.

(2) Abilities in the creative process: Wallas (1926) pointed out that the psychological process in creativity includes preparation phase, incubation phase, illumination phase, and verification phase. Creative thinking is a sequential process, including perceiving shortcomings in the problem and discovering the gap in knowledge, in turn perceiving the difficulty, seeking answers, proposing hypotheses, testing hypotheses, and finally reporting the results. In sum of scholarly views and research, the production of creativity must have the following abilities: producing new concepts (fluency), discovering problems, sensitive observation, identifying problems, imagination, originality, insight, flexibility, reflection, adaptation, resolution of conflict, professional capabilities, self-adjustment to conform to environmental

needs, problem-solving techniques, clear thinking, high degree of wisdom, effective decision, logical thinking, objective determination, clear expression, and verification (Amabile, 1996; Ripple, 1989; Runco, 1996; Sternberg & Lubart, 1996). This study integrates the abilities required for creativity in the creative process proposed by Wallas (1926), applying blended teaching for creativity so that students can engage in the complete creative process from the preparation phase, to the incubation phase, illumination phase, and the ultimate verification phase, in a series of course activities to cultivate student creativity, in order to enhance student achievements in creativity.

(3) Innovative product design: The creative results need originality, quality, and value (Gilchrist, 1972). There are two traits in creative work: originality and usefulness(Mayer, 1999). Thus, the created products should be original and have clear objectives (Gruber, 1988). Thus, students' innovative product design must conform to theme requirements, with value, and can apply new concepts to design products that are unlike others. This study believes that blended teaching for creativity must be able to clearly plan for the important points in innovative product design, so that students can clearly understand them, innovative product design must have effectiveness, originality, and flexibility, to design and innovate in correct directions and enhance student learning effects in creativity.

(4) Teaching for creativity environment: Environment has a decisive effect on creativity(Csikszentmihalyi & Csikszentmihalyi, 1975). Classroom atmospheres and teacher behaviors that benefit student creativity include encouragement of creative thinking, question techniques that can inspire curiosity, democratic interaction, safe atmosphere, student-centered, activities of collaborative learning, non-lecture instructional methods, response to student needs, encourage of student speaking, giving students opportunities for independent exploration, giving students choices in learning, acceptance of different student opinions, elevation of self-confidence, providing support and resources(de Souza Fleith, 2000; Hamza & Nash, 1996; Marjoribanks, 1994; Morgan & Forster, 1999). Cropley (1997) and Fleith (2000) suggested that a learning environment that encourages creative thinking and exploration can benefit the cultivation of student creative thinking. The environment mentioned in this study is primarily the learning environment at school for students, including the instructional methods provided by teachers, the learning atmosphere constructed, and collaborative learning among peers. In view of this, referring to Cropley (1997) and related literature, blended teaching for creativity should create an environment that is flexible and open, with collaborative discussion, inquiry, rewards and support, independence, reflection and challenge, interest and motivation, and evaluation to facilitate student learning for creativity, in order to enhance student learning achievements in creativity.

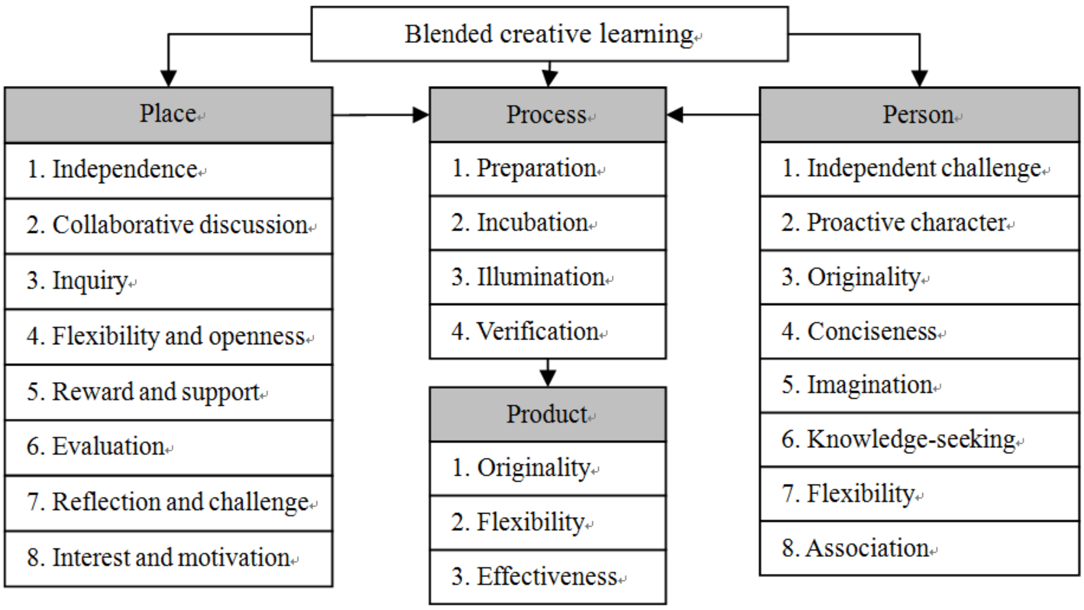


Figure 1 Blended creative learning design diagram

RESEARCH DESIGN AND IMPLEMENTATION

The research methods and implementation procedures in this study are described as follows,

(1) To explore literature on blended learning, creativity evaluation, and teaching for creativity to summarize the important points in BCL-4P instruction.

(2) To use fuzzy Delphi method expert questionnaire survey, to ascertain the BCL-4P learning achievement indicators.

(3) Based on the indicators, conduct design of blended

teaching for creativity, and develop the BCL-4P learning achievement scale.
(4) Conduct case study and administer BCL-4P learning achievement evaluation.
(5) Analyze BCL-4P learning achievements.
(6) Ascertain BCL-4P learning achievements.

Fuzzy Delphi method expert questionnaire survey

Fuzzy Delphi method is derived from the traditional Delphi method. Delphi method is a method of expert prediction and is a method of group decision-making (Noorderhaven, 1995), which has the advantages of questionnaire survey and meetings (Linstone, 1978; Rowe, Wright, & Bolger, 1991). On the whole, compared to the traditional Delphi method, fuzzy Delphi method has the following advantages: (1) can save time and cost in investigation; (2) the individual opinions of experts can be clearly expressed without distortion; (3) the semantic structure of the predictive items can be clearly expressed; (4) consider the unavoidable fuzziness in the investigation process; (5) simple calculation process, can deal with multi-level, multi-character, and multi-option decision problems (Hsu, 1998). Thus, this study uses the results of research review on creativity, as well as the expert professional ability and familiarity with the research topic as the consideration for expert selection. 10 experts in creativity evaluation, teaching for creativity, innovative product design, and blended learning fields are selected for fuzzy Delphi method expert questionnaire survey, to achieve the effect of group thinking, in turn integrating the opinions of scholars and experts, to obtain the analytical results that best conform to the trends of the times and to the topic.

Results of the fuzzy Delphi method expert questionnaire survey point out that the BCL-4P learning achievement indicators are: 1) creative character traits; 2) abilities in the creative process; 3) innovative product design, and 4) environment of teaching for creativity, which receive scores of .7577, .6894, .6914, and .7081, respectively, with 23 detailed indicators. This is used to carry out design of the activity of blended teaching for creativity, and develop student BCL-4P learning achievement scale. The results of the scale reliability analysis are: the Alpha coefficients of the four sub-scales are .840, .844, .832, and .870, and the results of the Alpha coefficient of the overall scale are: .881, which is above .80, showing that the scale has obtained good reliability.

Research Design and Implementation Procedures

The eight-week “amphibious vehicle” creative design unit is designed based on the BCL-4P learning achievement indicators. The theme activities use blended teaching for creativity to construct the instructional environment and cultivate and inspire character traits. Design of activities in the creative process is used to guide students in production of innovatively designed products. The implementation procedures contain asking students to use the existing materials, such as rechargeable batteries, motors, and gear sets, and creating a multifunctional amphibious vehicle to cope with global warming and rising ocean levels. The research subjects were 72 first and second year students at a girls’ high school in Taiwan, who voluntarily participated and formed 18 teams in the study. According to the principles and characteristics of blended teaching for creativity, face-to-face courses along with the internet platform are used to carry out blended instruction. The process integrates teaching strategies for creativity to guide student learning, and collaborative learning conducted through groups. The “Blended Creativity Internet Interactive Platform” is constructed by the research team. The online learning resources of the platform can provide students online learning and extended learning. The chat room and discussion forum offer students and teacher places to have discussions and knowledge sharing asynchronously and synchronously. Its data uploading function can provide team members to upload data and discuss outcomes freely. This study used the creative process to design four tasks, such as asking students to complete and upload the tasks on time, in order to have a grasp student progress as a reference for adjusting teaching strategies for creativity. The content of the tasks in each stage is: (1) “preparation phase task”: after blended learning, students are asked to collect related data, to discuss and analyze them to verify professional knowledge relating to amphibious vehicles; (2) “incubation phase task”: use the professional knowledge in the first stage as the multiple departure points for designing amphibious vehicles, use team imagination and collaborative discussion to draw the project framework, consider the functions, production flow, steps, and possible obstacles that may be encountered in amphibious vehicles; (3) “illumination phase task”: detailed description of solutions or steps for each problem, and complete the preliminary amphibious vehicle project based on the solution, and to provide a brief introduction and explanation of the characteristics; (4) “verification phase task”: refers to the preliminary task completed in the third stage for final testing and modification, and the processes and reflections in the testing and modification are expressed in words, for project briefing and achievement reports. Finally, the posttest was implemented after the activity followed by student interviews. The data collected from questionnaire, interview, the internet platform, and students’ projects were analyzed to understand how creativity were discussed, conveyed, shared, and applied as well as how they used the thinking model in verifying the problem and proposing solutions.

In sum, in the process of teaching for creativity, this study uses the online discussion content from teams, student tasks, and physical products of creative design for a basis in modifying and adjusting teaching strategies for creativity. This is supplemented with “BCL-4P learning achievement scale” to evaluate student effects of creative learning. The perspectives of the four aspects of creativity are used to understand student learning achievements in creativity.

RESULTS AND DISCUSSIONS

The findings of the study are divided into the two dimensions of student learning explanation and analysis of creativity learning achievements, which are discussed as follows.

Explanation of student learning conditions

The instructional environment and character trait cultivation and inspiration were constructed according to the expert suggestions for the design indicators of blended teaching for creativity. Design of the creative process was used to guide student production of innovatively designed works. The following explains the four creative process stages of tasks uploaded by students, including their creative works, and team reflections, projects, and interview in order to explore students' learning achievements in creativity.

Cultivation of student ability in the preparation phase

The diverse learning channels in blended instruction enhance student curiosity and learning motivation. A high desire for knowledge promotes students to autonomously investigate the project activity, amphibious vehicles, so they can actively consult with experts to gain professional knowledge. With integration and new and old knowledge, students were able to obtain in-depth understanding of the activity topic. In this way, students' attitudes for active learning and abilities for collecting data through different channels were hence cultivated.

Cultivation of student ability in the incubation phase

Design of teaching for creativity can guide students in their creative thinking about amphibious vehicles from different perspectives. For instance: the topic objectives, functionality, appearance, and material characteristics. Then, the parts were connected. In the process, many connective problems are discovered, such as connection between ocean sailing functions and land mobile functions, the connection between a rectangular appearance and oval boat body, float and loading capacity and speed considerations, and the selection and combination of materials. Group discussion was used to think about the possibilities of problem-solving, and seeking suitable and feasible solutions. The discussion results were expressed concretely through text and images, as shown in Figures 2, to serve as the construction blueprints for the teams. Then, students were able to collect more data and engage in collaborative discussion for the gaps in knowledge. Finally, the creative thinking diagrams were uploaded to the internet platform. These processes may effectively cultivate students' diverse and creative thinking, collaborative learning, and pre-work planning ability.

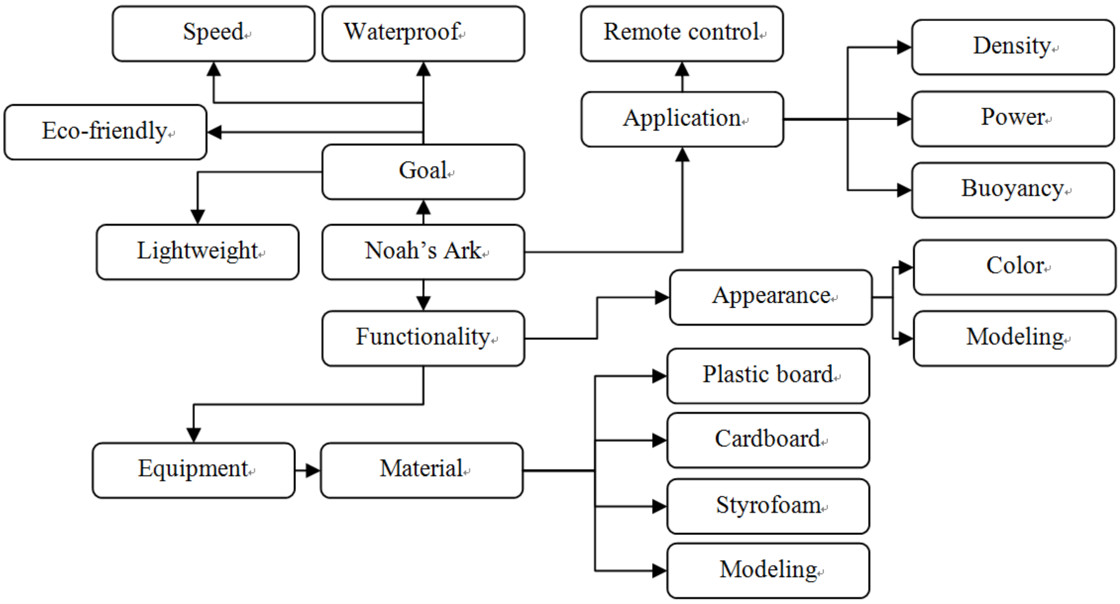


Figure 2 Blended creative learning design diagram

Cultivation of student ability in the illumination phase

Based on the results of team creative thinking, students produced the projects, as shown in Figure 3, to complete the connection of the electrical and drive systems. In testing, they found problems such as lack of drive and stability in sailing, for which students searched for data on the platform and discussed in groups to propose several solutions. For instance, adding a solar power system, adding flippers to the axle to increase power, and adding diffuser plates at the bottomo f the boat to enhance the stability in sailing, as shown in Figures 4, and 5. The teams kept testing to fix these problems to find the optimal improvement strategy, in turn completing the assembly and testing of the boat body, as shown in Figure 6. The solutions in the tasks in each stage were uploaded to the internet platform. Thus, this stage can enhance student ability in working with their hands and in problem-solving, and learn related knowledge and capabilities.

Figure 3 Wield the electrical system

Figure 4 Adding flippers to the axle

Figure 5 Adding diffuser plate at the bottom of the boat

Figure 6 Test on wat

Cultivation of student ability in the verification phase

As in Figures 7 and 8, a reporting conference was held. The teams were first invited to share their creative process, explain how they came up with creative ideas, solved problems, and verified improvement results, so that the innovative designs of the teams could concretely be presented, producing multifunctional creative amphibious vehicles. Then, the product innovative design ideas and appearances were evaluated, and the works compete against each other with their effective functions, as shown in Figure 9. The diverse evaluation items were used to find outstanding creative works, so that students could observe and learn from each other. Finally, the project reports and photos of creative works from each group were uploaded to the internet platform, so students can view them, achieving the purpose of sharing knowledge and exchange.

Figure 7 Presentation and exchange of accomplishments

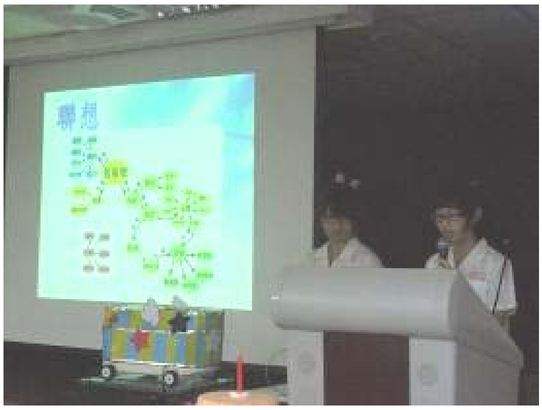


Figure 8 Reports on the creative production process

Figure 9 Functional competitions

Student explanation of ideas in innovative design and sharing of reflections

This section provides explanations of projects from 3 groups, as shown in Table 1. Blended teaching for creativity allowed students to proceed sequentially based on the guidance of activities in the creative process. From the beginning, there were many wild ideas, such as: rise of ocean levels, garbage floating on the ocean and polluting the environment, fighting over life resources, causing wars, and expanding to new habitats in the universe. These connect to issues on current materials, including combination of two or more functions to create the external form and the vehicular body as well as creative design in the vehicular body. Students discussed and resolved these problems to design multifunctional amphibious vehicles as a team, such as amphibious garbage boat, amphibious military vehicle, and universe Noah's Ark. The reflections shared by students show that unexpected issues often arise in the production process, which are resolved by the thoughts of students in the same group. They learned how to communicate and coordinate, and experienced the importance of dividing work for cooperation, and at the same time they could successfully complete amphibious vehicles based on innovative ideas.

Thus, the blended teaching for creativity in this study effectively integrated the 4P of creativity. It actively constructed an instructional environment conducive to do development of student creativity, which effectively cultivated student creative character traits, providing students with a comprehensive creative process, and guiding students to produce works rich in creative design.

Table 1
Student ideas in innovative design and sharing of reflections

Creative work (a)

Vision in innovative design: Global warming leads to rise in ocean levels, which not only shrinks the human habitat but "garbage" would also damage the environment. Thus, it is necessary to design an "amphibious garbage boat," to clean the garbage on land and on the ocean. Balsa wood is the material, which is light and easily formed. For instance, the shovel-shaped device in the front can pick up garbage on the ocean, and on the back there is a large hole like on a garbage truck into which to throw garbage. In addition, the boat body is fitted on the bottom by tenon, which is not only easily disassembled but also would not fall off.

Reflections: In this competition, even though the work was hard, we built solid camaraderie. We learned the importance of "work division and cooperation" and "time distribution," so that we had new experiences, and learned what we could not learn from classrooms, and we found that team members had a lot of expertise that we did not know about. We thank them for their contribution, so that we could smoothly complete production of the amphibious vehicle.

Creative work (b)

Vision in innovative design: Design a "Noah's Ark" that can sail in the universe to transport people to settle on other planets. The large capacity and war blue and yellow colors give people a calming feeling. The principles of density and floatation are used to achieve the objectives of waterproofing, wideness, solidness, and environmental-friendliness. For speed, we use corrugated boards as the main material. On the top of the boat is a small door that can be opened upwards for control of the motor. In addition, a set of wings is placed on the outside, to better conform with the concept of traveling in the universe.

Reflections: In the process, we encountered many new challenges and unpredictable failure, such as: poor wielding resulting in broken circuits. We understand that even though it is just a small boat, it applied many principles, such as: floatation, kinetic energy, and electricity. We thought we were familiar with these principles, but after actually working with our hands, we found that even a seemingly unimportant screw can affect the forward motion of the entire boat! Thus, we maintained strong perseverence and will and worked hard to complete this. The joy and sense of accomplishment makes us more mature and fulfilled.

Creative work (c)

Vision in innovative design: In the future, there will be new climate patterns on earth, which would cause continous heavy rains, resulting in floods, and people would need to move and avoid disaster. The mobile transportation tool we designed emphasizes speed and amphibiousness. Thus, each level in the front has a curve the reduce air resistance. On the back, there is a Styrofoam tail, increasing stability and decreasing weight. The deck and the structure at the bottom of the boat are completely connected to be waterproof.

(continuous)

Reflections: This meaningful activity creates cohesion among the team members, when we discuss the direction for innovative design. Sometimes we have different opinions, but discussion usually results in better ideas. Even though the process is difficult, we learned a lot of what we lacked, and we could spend this time with our partners. This gave us a chance to improve ourselves so that we can advance ourselves.

Analysis of creativity learning achievements

This study used "blended creative learning achievement scale" to evaluate student creativity learning achievements before and after the experiment. The means of scores in each indicator among students was used as the score for the indicator. Also pre-test and post-test, and t-test were conducted to analyze the scores. Below, evaluation results of creative character traits, abilities in the creative process, innovative product design, and environment of teaching for creativity were used for analysis and explanation.

(1) Analysis of creative personal trait learning achievements

The t values of pre-test and post-test for creative character traits are: independent challenge is 7.302, proactive character is 8.739, originality is 8.935, conciseness is 7.269, imaginativeness is 8.675, seeking knowledge is 9.266, flexibility is 6.350, and association is 6.804, which all reach the level of significance of .05, which shows that students have significant differences in their creative character traits indicator scores before and after blended teaching for creativity; after the blended teaching for creativity activity, the creative character traits indicator evaluation scores are significantly better than scores before instruction, which shows that blended teaching for creativity can help inspire student creative character traits. Among them, there are greater differences in seeking knowledge, originality, proactive character, and imaginativeness before and after instruction, which explains that after students undergo the blended teaching for creativity activity, in seeking knowledge, student curiosity and strong learning motivations are enhanced, so that they can actively explore their interest. In terms of originality, the personal styles of students, their original thought, and the ability of using their own values and standards to determine matters are cultivated. In terms of proactive character, student learning enthusiasm, proactive attitudes, pursuit of self-affirmation, and diligence toward innovative breakthroughs are cultivated. In terms of imaginativeness, students are trained to have broad ideas and observational angles, to strengthen their observational abilities.

(2) Analysis of learning achievements in abilities in the creative process

The t values of pre-test and post-test in abilities in the creative process are: preparation phase is 10.301, incubation phase is 9.117, illumination phase is 8.611, and verification phase is 9.400, which all reach the level of significance of .05, which shows that students have significant differences in their abilities in the creative process indicator scores before and after blended teaching for creativity; after the blended teaching for creativity activity, the abilities in the creative process indicator evaluation scores are significantly better than scores before instruction, which shows that blended teaching for creativity can help cultivate student abilities in the creative process. Among them, there are greater differences in preparation phase and verification phase, which explains that after students undergo the blended teaching for creativity activity, in the preparation phase they learn how to collect data in diverse channels, understand the truth of the problem, and enhance their ability in integrating old and new knowledge to serve as the motivating force for innovative ideas. In addition, the verification phase helps students understand the importance of concretizing their ideas and verifying them, and experience the difference between ideas and physical production, as they use their hands to produce creative physical works.

(3) Analysis of learning achievements in innovative product design

The t values of pre-test and post-test in abilities in innovative product design are: originality is 7.115, flexibility is 8.654, and effectiveness is 8.340, which all reach the level of significance of .05, which shows that students have significant differences in innovative product design indicator scores before and after blended teaching for creativity; ; after the blended teaching for creativity activity, the innovative product design indicator evaluation scores are significantly better than scores before instruction, which shows that blended teaching for creativity helps students verify the important points in innovative product design. Among these, flexibility and effectiveness have greater differences, which mean that after students undergo blended teaching for creativity activity, in terms of flexibility, they learn how to think on different dimensions, break though constraints of thought, and can consider using different materials to complete creative works. In terms of effectiveness, student works can develop with value and effectiveness, conforming to the requirements of the topic.

(4) Analysis of environment of teaching for effects of creative learning

The t values of pre-test and post-test in environment of teaching for creativity are: flexibility and openness is 5.329, collaborative discussion is 7.086, inquiry is 9.899, reward and support is 2.323, independence is 7.722, reflection and challenge is 6.650, interest and motivation is 3.934, and evaluation is 3.020, which all reach the level of significance of .05, which shows that students have significant differences in the environment of teaching for creativity indicator scores before and after blended teaching for creativity; after the blended teaching for creativity activity, the environment of teaching for creativity indicator evaluation scores are significantly better than scores before instruction, which shows that blended teaching for creativity is conducive to the formation of an environment of teaching for creativity. Among them, students sense greater differences in inquiry, independence, and collaborative discussion in the instructional environment. In terms of instruction, diverse inquiry techniques and methods are used to guide student thinking, encouraging them to express opinions and diverse views, and can emphasize student questions and suggestions. In personal learning, students are encouraged to learn independently, autonomously seek answers to question, and cultivate their attitudes for active learning. In group cooperation, students are encouraged to learn through group cooperation, discuss, share, and jointly solve problems.

CONCLUSION AND SUGGESTIONS

Based on the findings of the study, conclusion and suggestions are presented as follows:

Conclusion

(1) Blended teaching for creativity can effectively integrate the four aspects of creativity

In forming an environment of teaching for creativity, blended teaching for creativity contributes to the cultivation of student creative character traits. With comprehensive creative process design, student abilities in the creative process can be cultivated. Beginning with the preparation phase, the active learning attitudes and data collection abilities of students are cultivated; the incubation phase guides students to think with diverse creativity and strengthening their ability in pre-work planning; the illumination phase actively cultivates student ability in working with their hands to solve problems, while learning related knowledge and capabilities; finally, the verification phase allows students to use creative ideas to solve problems and verify the effects, in turn completing the physical creative works. This effectively integrates the four aspects of creativity, allowing students to obtain practical experiences in the comprehensive creative process, producing innovatively designed works, which enhances student learning achievements in creativity.

(2) Blended teaching for creativity can significantly enhance student creative character traits

Blended teaching for creativity can effectively inspire student creative character traits such as imaginativeness, originality, seeking knowledge, independent challenge, proactive character, flexibility, association, and conciseness, resulting in significant elevation of learning achievements in creative character traits. Concretely speaking, after the blended teaching for creativity activity, students have significantly enhanced learning motivation, resulting in active and forward-looking attitudes. This also strengthens student insight as they work hard for innovative breakthroughs. It also inspires student creative character traits, which effectively enhances student learning achievements in creativity.

(3) Blended teaching for creativity can significantly enhance student abilities in the creative process

Blended teaching for creativity is used to design a series of comprehensive creative process activities to cultivate student abilities in the preparation phase, the incubation phase, the illumination phase, and verification phase, and significantly enhance learning achievements in abilities in the creative process. Concretely speaking, after the blended teaching for creativity activity, students learn to use diverse channels to collect data, and integrate new and old knowledge for innovative ideas, further concretizing and verifying ideas to produce creative physical works. This cultivates necessary abilities in the creative process for students, which effectively enhances student learning achievements in creativity.

(4) Blended teaching for creativity can significantly enhance student innovative product design

Blended teaching for creativity can lead students in designing works that are original, effective, and flexible, thereby elevating learning achievements in innovative product design. Concretely speaking, after the blended teaching for creativity activity, students learn how to think in different directions, break through constraints, and use different materials to complete a creative work that is valuable and effective, while conforming to the topic. This allows student to gain practical experience in innovative design and effectively enhances student learning achievements in creativity.

(5) Blended teaching for creativity can significantly enhance the construction of environment of teaching for creativity

Blended teaching for creativity can be used to actively construct an environment suited for student learning for creativity that is flexible and open, with collaborative discussion, inquiry, rewards and support, independence, reflection and challenge, interest and motivation, and evaluation; it can significantly improve the environment of teaching for creativity. Concretely speaking, the flexible and open learning environment of blended teaching for creativity can guide student thinking, encourage student expression, and focus on student problems. On one hand, it cultivate active learning attitudes, and on the other hand, students can use group collaborative learning to jointly solve problems. It provides for a diverse learning environment to effectively enhance student learning achievements in creativity.

Suggestions

Based on the research findings, some suggestions are presented as follows:

(1) Schools should promote blended teaching for creativity in course design relating to creativity

Blended teaching for creativity can effectively integrate the four aspects of creativity, including creative character traits, environment of teaching for creativity, abilities in the creative process, and innovative product design, so that students can obtain practical experiences in the overall creative process. Thus, schools can promote blended teaching for creativity, comprehensively consider the four factors of creativity, as the primary basis of course design relating to creativity.

(2) Teachers should implement blended teaching for creativity in practical courses

Blended teaching for creativity positively affects the construction of the environment of teaching for creativity, inspiration of student creative character traits, cultivation of student abilities in the creative process, and guidance for students' innovative product design, which shows that it can contribute to student effects of creative learning. This is because blended instruction is not constrained by time and space, its own functions and characteristics can enrich the diversity of instruction, and can enhance student learning achievements in practical courses. Thus, it is suggested that teachers should implement blended teaching for creativity in practical courses, such as: innovative product design, project creation, and others; this can be promoted and implemented.

(3) Students should engage in self-evaluation to establish important points of development for creativity

The learning for creativity achievement scale developed in this study can effectively evaluate student learning achievements in the blended teaching for creativity, focusing on the 4P of creativity to comprehensively evaluate learning achievements in student creativity. In the current age that focuses on efficiency and actively striking out, it is suggested that students should evaluate themselves using this creativity scale. Students should evaluate their own learning conditions in terms of creativity and discuss with teachers to establish important points in developing creativity, and actively enhance their own creative abilities.

REFERENCE

Akkoyunlu, B., & Yılmaz-Soylu, M. (2008). Development of a scale on learners' views on blended learning and its implementation process. *The Internet and Higher Education, 11*(1), 26-32.

Amabile, T. M. (1996). Creativity and innovation in organizations. *Harvard Business School, 5*(9), 396-239.

Amabile, T. M. (1997). Entrepreneurial creativity through motivational synergy. *The Journal of Creative Behavior, 31*(1), 18-26.

Barron, F., & Harringtion, D. M. (1981). Creativity, intelligence, and personality. *Annual Review of Psychology, 32*, 439-476.

Cropley, A. J. (1997). Fostering creativity in the classroom. *The creativity research handbook*, 83-114.

Csikszentmihalyi, M., & Csikszentmihalyi, I. (1975). *Beyond boredom and anxiety*: Jossey-Bass Publishers San Francisco, CA.

de Souza Fleith, D. (2000). Teacher and student perceptions of creativity in the classroom environment. *Roeper Review, 22*(3), 148-153.

Feldhusen, J. F. (1995). Creativity: A knowledge base, metacognitive skills, and personality factors. *The Journal of Creative Behavior, 29*(4), 255-268.

Fleith, D. (2000). Teacher and student perceptions of creativity in the classroom environment. *Roeper Review, 22*(3), 148-153.

Gagne, E. D., Yekovich, C. W., & Yekovich, F. R. (1997). *The cognitive psychology of school learning*. New York: Addison Wesley Longman Inc.

Gilchrist, M. (1972). *The psychology of creativity*: Melbourne University Press Melbourne.

Gruber, H. E. (1988). The evolving systems approach to creative work. *Creativity Research Journal, 1*(1), 27-51.

Hamza, K., & Nash, W. R. (1996). Creating and Fostering a Learning Environment That Promotes Creative Thinking and Problem Solving Skills.

Hsu, T. H. (1998). Fuzzy Delphi Analytic Hierarchy Process Method. *Journal of the Chinese Fuzzy Systems Association 4*(1), 59-72.

Linstone, H. A. (1978). The Delphi technique. *Handbook of futures research*, 273-300.

Lou, S. J., Chung, C. C., Chao, L. C., Tseng, K. H., & Shih, R. S. (2012). Construction of a Blended TRIZ Creative Learning Platform. *International Journal of Engineering Education, 28*(1), 37 - 47.

Maisuria, A. (2005). The turbulent times of creativity in the National Curriculum. *Policy futures in education, 3*(2), 141-152.

Marjoribanks, K. (1994). Families, Schools, and Children. *International Journal of Educational Research, 21*(5), 439-555.

Mayer, R. E. (1999). *Fifty years of creativity research* (Handbook of creativity ed.). Cambridge: Cambridge University Press.

Michaela, D. (2001). Fostering creativity in business education: Developing creative classroom environments to provide students with critical workplace competencies. *Journal of Education for Business, 77*(1), 28-33.

Morgan, S., & Forster, J. (1999). Creativity in the classroom. *Gifted Education International, 14*(1), 29-43.

Mortera-Gutiérrez, F. (2006). Faculty best practices using blended learning in e-learning and face-to-face instruction. *International Journal on E*

Learning, 5(3), 313 - 337.

Noorderhaven, N. G. (1995). *Strategic decision making*: Addison-Wesley Wokingham.

Oliver, M., & Trigwell, K. (2005). Can'Blended Learning'Be Redeemed? *E-learning and Digital Media, 2*(1), 17-26.

Osguthorpe, R. T., & Graham, C. R. (2003). Blended Learning Environments: Definitions and Directions. *Quarterly Review of Distance Education, 4*(3), 227-233.

Procter, C. (2003). Blended learning in practice. *Education in a changing environment. University of Salford*.

Rhodes, M. (1961). An analysis of creativity. *The Phi Delta Kappan, 42*(7), 305-310.

Ripple, R. E. (1989). Ordinary creativity. *Contemporary educational psychology, 14*(3), 189-202.

Rowe, G., Wright, G., & Bolger, F. (1991). Delphi: a reevaluation of research and theory. *Technological Forecasting and Social Change, 39*(3), 235-251.

Runco, M. A. (1996). Personal creativity: Definition and developmental issues. *New Directions for Child and Adolescent Development, 1996*(72), 3-30.

Starko, A. J. (2009). *Creativity in the classroom: Schools of curious delight*: Taylor & Francis.

Sternberg, R. J. (1988). 5 A three-facet model of creativity. *The nature of creativity: Contemporary psychological perspectives*, 125.

Sternberg, R. J., & Lubart, T. I. (1995). *Defying the crowd: Cultivating creativity in a culture of conformity.* New York: Simon & Schuster Inc.

Sternberg, R. J., & Lubart, T. I. (1996). Investing in creativity. *American psychologist, 51*(7), 677.

Torrance, E. P. (1988). The nature of creativity as manifest in its testing. *The nature of creativity*, 43-75.

Treffinger, D. J., County, V., Gifted, N. S. L. T. I. o. t., & Talented, t. (1980). *Encouraging creative learning for the gifted and talented: A handbook of methods and techniques*: Ventura County Superintendent of Schools Office.

Wallas, G. (1926). *The art of thought*. New York: Harcourt Brace.

Wu, J. J., & Fan, H. L. (2011). The Policy and Practice of Creative Education in Taiwan. *Journal of Creativity, 2*(1), 5-28.

Zimmerman, E. (2006). It takes effort and time to achieve new ways of thinking: Creativity and art education. *The International Journal of Arts Education, 3*(2), 74-87.

AUTHORS

Chih-Chao Chung is a Ph.D. Candidate in the Graduate Institute of Engineering Science and Technology at National Kaohsiung First University of Science and Technology, Kaohsiung, Taiwan. Email: 9915916@nkfust.edu.tw

Wei-Yuan Dzan is an Assistant Professor in the Department of Naval Architecture and Ocean Engineering at National Kaohsiung Marine University, Kaohsiung, Taiwan. Email: dwydanel@mail.nkmu.edu.tw

Ru-Chu Shih is an Associate Professor at National Pingtung University of Science and Technology, Pingtung, Taiwan. Email: vincent@npust.edu.tw

Huei-Yin Tsai is a Ph.D. student in the Department of Industrial Technology Education at National Kaohsiung Normal University, Kaohsiung, Taiwan. Email: b8859024@gmail.com

Shi-Jer Lou is a Professor in the Graduate Institute of Technological and Vocational Education at National Pingtung University of Science and Technology, Pingtung, Taiwan. Email: lou@mail.npust.edu.tw. (Corresponding author)

Authors Index

Submission Guidelines

International Journal of Technology and Engineering Education (*IJTEE*) is a biannual journal published in every June and December. Papers to be considered for inclusion in the *IJTEE* should be submitted directly to the Association of Taiwan Engineering Education and Management (ATEEM). Original papers, not previously published, will be considered for publication on the basis of referee reports from at least two independent international referees. Authors of papers accepted will be required to transfer copyrights to the publisher. All contributions must be in English and adhere to the guidelines published in *Publication Guidelines of the American Psychological Association* format (APA 6 Edition). Papers will be fully edited and English corrected to ensure standard English form and expression. The publisher reserves the right not to return original manuscripts submitted for publication. Contributions in the form of a paper should comprise a PDF file and an MS Word file on a CD diskette suitable for an IBM PC. In preparing papers, authors are kindly asked to strictly adhere to the instructions for authors.

INSTRUCTIONS FOR AUTHORS

The ATEEM aims to produce a volume of the *International Journal of Technology and Engineering Education* with as uniform an appearance as possible and it is therefore requested that you conform to these instructions when preparing our article. These instructions are following APA style.

1. A **PDF file** and an **MS WORD file** must both reach ATEEM.

1. Please submit your papers by IJTEE online submission system. *Website: http://ijtee.org/ijtee/*
2. send your files to the following e-mail address:

   Ray Yueh-Min Huang
   huang@mail.ncku.edu.tw

2. LENGTH OF ARTICLE

The length of article is about **eight to ten (8-10)** pages**,** arranged on white paper, A4 size (210 x 297 mm).

3. TYPEFACE AND LINESPACING

Those with laser printers should select a Times New Roman font of 10-pt size on 12-pt line spacing (6 lines per inch). Papers must be justified, with the text in single-line spacing, and one-line spacing between paragraphs. Do not indent paragraphs. In preparing your paper you may use the Word style file on the attached disk, designed for an IBM or compatible computer. When keying in your paper use the page-layout view option to get a better view of the page layout. When transferring the file of your paper to the supplied style file on the disk, the computer may change the page layout settings. The correct page layout settings are as follows:

Margins	***From Edge***	***Format***
Top: 3 cm	Header: 1.5 cm	Single Column
Bottom: 2 cm	Footer: 1.5 cm	
Left: 2 cm		
Right: 2 cm		

4. TITLE, AUTHOR AND ABSTRACT

The title should be in the style as indicated in the sample (only capitalize the first letters of proper names). Author(s), affiliation(s), city and country should use first capital letter and lower case. Do not abbreviate the affiliation.

5. ABSTRACT

Please write a 75-100 word abstract (with keywords) of your paper, which should include your main idea and your major points. You also may want to mention any implications of your research. Place the abstract on its own page immediately after the title page. Center the word "Abstract" and then follow with the paragraph.

6. THE TEXT (please follow APA style)

Arrange the text of the paper in two columns. The text (or first heading) of the paper must start two lines beneath the abstract. The second and consecutive pages must start from the top of the new page. Do not leave space at the top of the new page. Make sure that left-hand and right-hand columns of text are balanced, top and bottom. Please ensure that the columns on the last page of the paper are evenly balanced.

7. IN-TEXT CITATION (please follow APA style)

When using APA format, follow the author-date method of in-text citation, and a complete reference should appear in the reference list at the end of the paper. APA style requires authors to use the past tense or present perfect tense when using signal phrases to describe earlier research. E.g., Jones (1998) found or Jones (1998) has found**...**

8. REFERENCE (please follow APA style)

Authors are named last name followed by initials; publication year goes between parentheses, followed by a period. The title of the article is in sentence-case, meaning only the first word and proper nouns in the title are capitalized. The periodical title is run in title case, and is followed by the volume number which, with the title, is also italicized or underlined.

Author, A. A., Author, B. B., & Author, C. C. (Year). Title of article. *Title of Periodical, volume number* (issue number), pages.

9. BIOGRAPHICAL SKETCHES

Each author of an accepted article is asked to submit a biographical sketch of about 150 words and the author's photograph. Your sketch should identify where you earned your highest degree, your present affiliation and position, and your current research interests. The first author should include an e-mail address which is optional for the other authors.

International Journal of Technology and Engineering Education
Process of Paper Evaluation

I. Papers will be evaluated by reviewers come from *International Journal of Technology Engineering Education* publication committee and related experts/scholars.

II. While receiving submitted paper, editor consults with publication committee about papers' fields.

III. Each academic paper will be evaluated by two reviewers（double-blind）, reviewers will write down their opinions in the comment paper.

IV. *International Journal of Technology Engineering Education* will send the reviewers' comment to the papers' authors and express accept, modify or refuse paper.

V. The process of paper evaluation as following:

Process of Evaluation			**Second Reviewer**				
			5	4	3	2	1
			Refuse (under 69)	Modify & Re-evaluate (70-74)	Modify (75-79)	Accept (80-89)	Accept (above 90)
First Reviewer	5	Refuse (under 69)	Refuse	Refuse	Third Reviewer	Third Reviewer	Third Reviewer
	4	Modify & Re-evaluate (70-74)	Refuse	Modify & Re-evaluate	Modify & Re-evaluate	Modify & Re-evaluate	Modify & Re-evaluate
	3	Modify (75-79)	Third Reviewer	Modify & Re-evaluate	Modify	Modify	Modify
	2	Accept (80-89)	Third Reviewer	Modify & Re-evaluate	Modify	Modify (Will be published)	Modify (Will be published)
	1	Accept (above 90)	Third Reviewer	Modify & Re-evaluate	Modify	Modify (Will be published)	publish

* If two reviewers opinions are too much difference (up to 15 points), the paper will be evaluated by third reviewer.

* Publication committee have right to determine accept, modify or refuse by reviewers comments.

<table>
<tr><td colspan="4">International Journal of Technology and Engineering Education</td></tr>
<tr><td colspan="3">Topic:</td><td>Field:
□ Engineering Education
□ Vocational Education
□ Technological Education</td></tr>
<tr><td colspan="2">First Author:</td><td colspan="2">Organization and phone number</td></tr>
<tr><td colspan="2">Second Author:</td><td colspan="2">Organization and phone number</td></tr>
<tr><td colspan="2">Third Author:</td><td colspan="2">Organization and phone number</td></tr>
<tr><td rowspan="3">Contact Person</td><td colspan="3">(O)</td></tr>
<tr><td colspan="3">(H)</td></tr>
<tr><td colspan="3">(Mobile)</td></tr>
<tr><td>E-Mail</td><td colspan="3"></td></tr>
<tr><td>Address</td><td colspan="3"></td></tr>
</table>

Assoication of Taiwan Engineering Education and Management
TEL: +886-2-77343440
E-mail: ftseng@ntnu.edu.tw
Website: http://www.ateem.org.tw
Address: 129, Heping East Road Section 1, Taipei, Taiwan

NO. 2009301744

IJTEE

International Journal of Technology and Engineering Education