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The effects of gender, cognitive style and family socio-economic status on the performance of learning spreadsheets using a Problem-Based Learning strategy

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ABSTRACT: This study explores the effects of gender, cognitive style and family socio-economic status (SES) on the performance of learning spreadsheet using a Problem-Based Learning (PBL) strategy. The study comprised 95 students enrolled in a five-year junior college programme. The experimental design for this study was an experimental group only pre-test-post-test design. The instruments used for pre-test included personal information form, embedded figures test, spreadsheet learning attitude scale and achievement testing. The treatment of this study was ten weeks of problem-based spreadsheet learning. Post-test included spreadsheet leaning attitude and achievement testing. The findings can be summarised as follows: First, there was a significant difference in spreadsheet learning achievements and attitude, as post-test scores were better than pre-test. Second, the performance of spreadsheet learning for different cognitive styles were significantly different, although field-independence was better than field-dependence. Third, there were no significant differences between different family SES. However, there was a significant difference between genders: female was better than male. Fourth, the pre-test for learning achievement, gender and cognitive style helped to explain variations in learning achievements.

INTRODUCTION

Philip stated that educational programmes must focus more intensely on how to teach the necessary skills more effectively [1]. Problem-Based Learning (PBL) is a powerful instructional approach that is engaging and leads to the sustained and transferable learning of problem solving skills [2]. PBL uses authentic, complex problems as the impetus for learning and fosters the acquisition of both disciplinary knowledge and problem solving skills [3]. Because of its potential to enhance knowledge acquisition, PBL has become a popular method to deliver classroom instruction in education, and has been widely implemented in a variety of other academic environments [3].

Spreadsheets have been used for many years in business to keep track of expenses and other calculations. Microsoft *Excel* is the most widespread program for creating spreadsheets on the market today. It is very useful for organising and creating graphs for science, mathematics and business. Learning spreadsheet skills can make students face higher order cognitive tasks, take apart a problem into several little problems and solve the same problem utilising different methods. It is considered suitable for PBL.

Cheung and Kan found several student characteristics to be important in influencing learning performance, namely: gender, relevant learning experience and so on [4]. A number of recent papers indicate that this concern still exists. For example, the North Carolina report into student performance in computer skills reported that more female than male students passed the proficiency requirements [5].

The purpose of this study was to explore the performance of learning spreadsheet skills using a PBL strategy for *Excel* 2002 and to investigate the influence of learning strategy, gender, family socio-economic status (SES) and cognitive style on the performance of learning spreadsheet skills of freshman students enrolled in a five-year junior college programme in the Department of Business Administration at National Taichung Institute of Technology, Taichung, Taiwan.

SPREADSHEETS

The spreadsheet is a tool allowing one to organise information in rows and tables (which create cells), and use various formulae, functions and relationships with automatic calculations. Microsoft *Excel* is considered by many as the best and most powerful Windows spreadsheet. It is easy to use and allows the user to perform financial calculations and to store, manipulate, analyse data and plot graphs, providing maximum, minimum, average values, etc. *Excel* not only works with primarily numerical data, it also has basic database capabilities. It can keep track of numbers placed in cells and, by placing reference points in other cells, any changes made in one cell will be reflected in these referring cells. This means that if the data is changed, MS *Excel* automatically recalculates and redraws the graphs. Learning how to use MS *Excel* to analyse the data stored in rows and columns, perform calculations on data, and display data in a graph is considered a necessary skill for every business student.

PROBLEM-BASED LEARNING

Problem solving is regarded as one of the most important cognitive activities in everyday life and a primary goal of the education process [6]. It is defined as a complex interplay of cognitive, affective and behavioural processes for the purpose of adapting to internal or external demands or challenges [7]. Problem solving has a great deal of applicability for a broad range of practitioners, as they work to increase the problem solving effectiveness of a broad range of people [8]. Effective problem solvers are flexible, adaptable and are able to develop suitable methods to solve problems and reach personal goals.

Problem solving is very relevant for educators. Educators are often interested in increasing students' problem solving abilities; thus, the advent of PBL has made problem solving central to the educational process [8]. PBL, an instructional model based on constructivism, is the concept that learners construct their own understanding by relating concrete experience to existing knowledge where processes of collaboration and reflection are involved [9]. Posner and Rudnitsky gave scientific support for PBL, noting that *a crucial determinant of learning is students' thinking or cognitive processing, and this processing is directly influenced by the kind of tasks in which students actually engage* [10].

The stages of a generic PBL model can be described as follows: a problem situation is presented to students in the same manner that it would be in the real world, students work through the problem that challenges their abilities, necessary areas of learning are identified and are used as a guide to individualised study, the knowledge and skills that are learned are applied to the problem, and the learning is then integrated into the student's existing knowledge base [11].

PBL is an instructional method that challenges students to *learn to learn* and seek solutions to problems [12]. Students are presented with a loosely structured problem and the problem must be content relevant and represent a real world problem. The learning that takes place is in response to students' attempts in resolving the problem. It has been shown that, by using a PBL approach, complex and real problems motivate students to identify and research concepts and principles they need to know in order to solve such problems [13]. Using PBL, students acquire life-long learning skills that include the ability to find and utilise appropriate learning resources. Through such problems, students encounter concepts in contextually rich situations that impart meaning to those ideas and enhance their retention. In encouraging students to assess their own knowledge, to recognise deficiencies, and to remedy those shortcomings through their own investigations, PBL provides them with an explicit model for life-long learning [14].

COGNITIVE STYLE, GENDER AND SES

Cognitive styles are stable traits that influence the way an individual selects, organises and stores information. There are two major types of cognitive style: field dependent and field independent. Field-dependent individuals rely on external references, while field-independent persons rely on internal references [15]. A significant relationship has been found between the strength of field independence and problem solving performance [16].

Gender is one factor that has been associated with spreadsheet learning performance. Patrick, David and Janet reported that females like word processing, spreadsheets and typing more than males [17]. Launius also found a significant relationship between gender and student performance: female students outperformed their male counterparts [18].

Lilly reported that SES, including parents' occupations and education, had significant effects on students' attitudes towards computers. She showed that parental encouragement, parental gender views and SES affected their children's attitudes [19]. However, Wu and Morgan also found that SES exerted less influence than other factors on college students' computer performance [20].

METHOD

The experimental design for this study was an experimental group pre-test-post-test design. The samples of this study comprised 95 freshman students enrolled in a five-year junior college programme in the Department of Business Administration at National Taichung Institute of Technology who were learning spreadsheets and 15-18 years of age.

A pre-test was administered to all students in the first time of the experimental period. The pre-test, which consisted of a personal information form, cognitive style scale, spreadsheet learning attitude scale and spreadsheet achievement testing, collected personal information, measured students' cognitive style and spreadsheet learning attitude, as well as their learning achievement.

The content of the treatment of this study was computer mediated problem-based spreadsheet learning. A PBL environment was generated that provided the context for learning and authentic activities for students to engage in. This provided opportunities for students to engage in self-practice, auto correction and error hint, and allowed students to practice at their own pace. Treatments were applied for ten weeks, which is the normal period of time used during the semester to present spreadsheet concepts. A series of open-ended problems, which were carefully constructed with increasing levels of difficulty, constituted the core of this treatment. Even-numbered problems were solved by the instructor as he/she explained each step of the process. Odd-numbered problems were solved by students as they practiced each step. Because all new learning is based on previous learning, when relevancy and experience (from previous learning) are brought to the learning environment, transfer occurs.

In addition, for the purpose of collecting data, this study developed a spreadsheet learning attitude scale. The spreadsheet learning attitude scale was developed for assessing student's spreadsheet learning attitudes, consisted of 16 items and used a 4-point Likert-style response format. Four dimensions of attitudes were represented in terms of anxiety, confidence, liking and usefulness. The Cronbach alpha reliability coefficients for these sub-scales and total scale were 0.83, 0.89, 0.69, 0.64 and 0.88, respectively. The loading factors were 21.4%, 21.1%, 12.1%, 11.7%, respectively, yielding a total of 66.3%.

The spreadsheet learning achievement testing was used to assess student's learning achievements about spreadsheet learning. It was developed by the Chinese Computer Technical Foundation Association and extensively used in Taiwan. In this test, each student should test for 1 hour, including 20 multiple choice items and five manipulatable problems. After testing, the computer can automatically correct answers, give hints about what is wrong, and calculate and tally the total score. The post-test was administered after ten week's of problem-based computer assisted spreadsheet learning with teacher instruction. The post-test included the spreadsheet learning attitudes scale and achievement testing.

An embedded figures test was used to assess field dependence and field independence. The test measures an individual's ability to break up an organised visual field so that an embedded part or given shape in that field may be recognised and memorised as separate from the given shape in that field.

The main statistical procedures employed to analyse experimental data and test the research hypotheses were MANCOVA, t-test and regression procedures. MANCOVA was applied to investigate the performance of learning spreadsheets between different cognitive styles, gender and different family SES. An analysis of the covariance can improve the precision of a research design by employing a pre-existing variable that is correlated with the dependent variable [19]. Covariance analysis should match the same assumptions of variance analysis; it also needs to match the assumption of homogeneity of a within-class regression coefficient.

RESULTS

As listed in Table 1, the result of a paired-t analysis for pre-post testing of the performance of learning spreadsheets revealed significant differences. There was a significantly difference in spreadsheet learning achievement (t=-36.274, p<0.05), with the post-test (N=95, Mean=63.437) being better than the pre-test (N=95, Mean=4.62). There was also a significant difference found in spreadsheet learning attitude (t=-6.927, p<0.05), with the post-test (N=95, Mean=43.77) being better than the pre-test (N=95, Mean=38.77).

Table 1: Results of a paired-t analysis for the pre-post testing of students' spreadsheet skills.

		Learning Achievement			Learning Attitude		
	No.	M	SD	t	M	SD	t
Pre-test	95	4.62	1.85	-36.27**	38.77	2.72	-6.927**
Post-test	95	63.44	16.44		43.77	6.58	

** p<0.01

Table 2 shows the results of a multivariate covariance analysis of different cognitive styles for the performance of learning spreadsheets, indicating that students' cognitive styles did significantly affect the performance of learning spreadsheets (Wilks'Λ=0.816, P<0.05). An analysis of univariate covariance revealed a significant difference in spreadsheet learning achievements (F=10.719, p<0.05). The results of a post hoc comparison of different cognitive styles for learning spreadsheets found that field independence (N=34, Mean=67.382) was better than field dependence (N=29, Mean=54.621). However, there was no significant difference detected in spreadsheet learning attitude (F=1.953, p>0.05).

Table 2: Results of a multivariate covariance analysis of different cognitive styles for learning spreadsheets.

Source of Variance	Df	SSCP		Wilk's Λ	Univariate F	
		A	B		A	B
Constant	1					
Main Effect	1	$\begin{bmatrix} 2855.894 & 463.255 \\ 463.255 & 74.145 \end{bmatrix}$		0.816*	10.719*	1.953
Covariates	3	$\begin{bmatrix} 1256.773 & 627.193 \\ 627.193 & 389.280 \end{bmatrix}$		0.788*	1.572*	3.374*
Within	58	$\begin{bmatrix} 15453.584 & -261.544 \\ -261.544 & \text{[illegible]} \end{bmatrix}$				
Total	63					

*p< 0.05, A: spreadsheet learning achievement.
B: spreadsheet learning attitude.

Table 3 lists the results of a multivariate covariance analysis by gender concerning spreadsheet learning performance, identifying that gender did significantly affect students' performance of learning spreadsheets (Wilks'Λ=0.902, P<0.05). An analysis of univariate covariance found that there was, indeed, a significant difference in spreadsheet learning achievements (F=6.130, p<0.05). The results of a post hoc comparison by gender of students' learning achievements of learning spreadsheet shows that the female students (N=78, Mean=64.095) were better than their male counterparts (N=17, Mean=54.203). However, no significant difference was found regarding spreadsheet learning attitude (F=3.436, p>0.05).

Table 3: Results of a multivariate covariance analysis by gender of spreadsheet learning performance.

Source of Variance	Df	SSCP		Wilk's Λ	Univariate F	
		A	B		A	B
Constant	1					
Main Effect	1	$\begin{bmatrix} 1304.162 & 393.404 \\ 393.404 & 118.672 \end{bmatrix}$		0.902*	6.130*	3.436
Covariates	3	$\begin{bmatrix} 3767.171 & 860.734 \\ 860.734 & 733.529 \end{bmatrix}$		0.680*	5.903*	7.080*
Within	90	$\begin{bmatrix} 19146.478 & -143.922 \\ -143.922 & 3108.193 \end{bmatrix}$				
Total	95					

*p< 0.05, A: spreadsheet learning achievement.
B: spreadsheet learning attitude.

Table 4 gives the results of multivariate covariance analysis of different family socio-economic status (SES) regarding students' spreadsheet learning performance. This shows that family SES did not significantly affect students' performance in learning spreadsheets (Wilks'Λ=0.897, P>0.05).

Table 4: Results of a multivariate covariance analysis of different family SES on students' spreadsheet learning performance.

Source of Variance	Df	SSCP		Wilk's Λ	Univariate F	
		A	B		A	B
Constant	1					
Main Effect	4	$\begin{bmatrix} 1411.029 & 39.530 \\ 39.530 & 96.811 \end{bmatrix}$		0.897	1.711	0.692
Covariates	4	$\begin{bmatrix} 6407.652 & 1568.656 \\ 1568.656 & 970.372 \end{bmatrix}$		0.567*	7.768*	6.930*
Within	86	$\begin{bmatrix} 17735.449 & -183.452 \\ -183.452 & 3011.312 \end{bmatrix}$				
Total	95					

*p< 0.05, A: spreadsheet learning achievement.
B: spreadsheet learning attitude.

An all possible subsets regression analysis was used to compare the proportion of variance in spreadsheet learning achievements as explained by each variable. The analysis revealed that variables from each of the three domains were important predictors of spreadsheet learning achievements. Overall, the pre-test for spreadsheet learning achievement was the best predictor, explaining 15.7% of the variances in spreadsheet learning achievements. Gender explained 6.3% of variances, while cognitive style (4.7%) was the third predictor of variance.

DISCUSSIONS AND CONCLUSIONS

According to the results of the literature review, panel discussion, experimental instruction and opinions given in questionnaires, spreadsheet learning is a task that is well suited for PBL. The main findings of this study can be summarised into four parts, which are detailed below.

First, There was a significant difference in spreadsheet learning achievements, with post-tests revealing better student results than in the pre-test. There was also a significant difference found in spreadsheet learning attitude. As such, this study has implications for the design and practice of a PBL strategy. Indeed, PBL is an effective strategy when teaching spreadsheet skills to students. That is, teachers' adaptive instruction to match students' learning styles can improve students' motivation levels and allow students to reach their full educational potential [21].

Second, significant differences were found in the performance of spreadsheet learning for different cognitive styles, notably that field-independence is better than field-dependence. This reflects Pithers' research that field-dependence and field-independence may impact on learning and problem solving [16]. So, individuals need to develop self-awareness about their preferred cognitive style and be able to select and apply an information processing approach that best suits the problem or situation.

Third, no significant differences were detected between different family SES. However, there was a significant difference between genders, with female students proving better than males. The finding regarding the relationship between gender and performance was consistent with previous research; Launius found a significant relationship between gender and student performance [18]. Also, Patrick, Nolan and Janet's report found that females liked word processing, spreadsheet tasks and typing more than males [17].

Fourth, regarding the pre-test of spreadsheet learning achievements, it was found that gender and cognitive styles explained 26.7% of the variations detected.

Given the results described above, the following suggestions can be made. Problem-based computer assisted spreadsheet learning is necessary and can be implemented. Learners can also transfer their problem solving skills to attempt other real-life problems. One could also consider problem-based computer-aided learning software for other Microsoft Office software.

A follow-up study of PBL for spreadsheets should emphasise the method of qualitative research and compare the learning performance among different recognition behaviours. It is also of interest to investigate problem-based spreadsheet learning applied to learners of different ages, study stages and regions, and compare differences in performance.

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