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Modelling Predictors of Students' Learning Gain - An Empirical Evidence using Structural Equation Modelling

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ABSTRACT

The abundance of literature on effective teaching that relates to student achievement bears witness to the ongoing quest for a better understanding of the effect of lecturers' characteristics and attributes (inputs) on students' learning gain. What is rarely looked at is how lecturers actually performs in the classroom and how that performance translates into students' learning advantage. The aim of this paper is to provide an in-depth analysis of the relationship between the lecturers' teaching contribution and students' learning gain. The methods of analysis start with establishing construct validity of the instrument through confirmatory factor analysis (CFA), using Analysis of Moment Structures software (AMOS). Data from this study were further analyzed with Structural Equation Modelling (SEM). All four dimensions of the lecturers' teaching attributes; namely rapport, clear explanation, preparation and organization, and feedback are considered as independent variables and students' learning gain as the dependent variable. The results of this study indicate that among the four teaching dimensions examined, the significant predictors of students' learning gain in the process of teaching and learning are clear explanation and lecturers' feedback.

Keywords: *Student Learning Gain, Effective Teaching, Confirmatory Factor Analysis, Structural Equation Modelling*

INTRODUCTION

To improve teaching and learning in universities, research on students' learning can be very helpful. The factors that influence students' learning gain are particularly useful for lecturers who want to understand their students' learning, and create learning environment which encourage students to achieve the desired learning outcomes. Sanders and Horn (1998) indicated that the single most important factor in determining students' academic success is the lecturer. Classrooms are complex systems where many factors influence students' learning,including tools, lecturers, and peers (Lampert, 2002). Reiser *et al.*(2001) argue that the role of lecturers is essential in structuring and guidingstudents' understanding of theories.

Marsh (1987) carried a definitive review of the massive literature on the use of student evaluations and their relation to teaching effectiveness. He identified workload, teachers' explanations, empathy (interest in students), openness, and the quality of assessment procedures (including quality of feedback), among his nine dimensions of effective instruction at university level. Similarly, Feldman's (1976) scheme included nineteen similar categories of instructional effectiveness, including stimulation of student interest, teacher sensitivity to class level and progress, clarity of course requirements, understandable explanations, respect for students and encouraging independent thought. According to Sherman *et al.*(1987), five characteristics had been regularly and consistently attributed to college instructors selected as excellent: enthusiasm, clarity, preparation/organization, stimulating, and love of knowledge.

Students who have higher quality outcomes normally adopt good approaches to learning under the following situations: the lecturer provides ample and useful feedback, makes clear the lesson objectives; the assessment criteria and what is expected of students, presents the significance of the course and endeavours to make it interesting, produces opportunities for questions and time for consultations, is good at explaining things and makes an attempt to understand students' complexity. The abundance of literature on effective teaching that relates to student achievement bears witness to the ongoing quest for a better understanding of the effect of lecturers' characteristicsand attributes (inputs) on students' learning gain. What is rarely looked at is how a lecturer actually performs in the classroom and how that performance translates into students' learning advantage.

The aim of this paper is to provide an in-depth analysis of the relationship between lecturers' teaching contribution and students' learning gain. All four dimensions of lecturers' teaching attributes i.e. rapport, clear explanation, preparation and organization, and feedback have different effects towards students' learning gain.

Rapport

It is vital that lecturers acknowledge students' personalities, exhibit stability of character, and build healthy relationships with the students. Lecturers would be able to motivate each student extensively once a mutually respectful and good rapport has been created. By developing a good relationship with their students, lecturers would be able to assist them regarding learning as a positive experience. One teaching method that is found to help enhance students' learning is collaborative learning as well as inculcating personal and social responsibility among students (Tony *et al.,* 2012). This method surely needs high rapport between students and lecturers in order to motivate students to participate.

Crosnoe *et al.*(2004) stress on the intergenerational connection between students and their teachers, such as how a student distinguishes his or her teacher (i.e. fair, caring, etc.), and investigate how that rapport influences the student's performance in school. A lecturer's job is not simply disseminating information. He or she could be a person with whom students need to feel trusting and confident. A robust bond between students and the lecturer is crucial for generating and upholding a productive and positive classroom environment. The entire learning system could easily descend if good communication is lacking between an educator and the students. On the contrary, if students and the lecturer maintain respect for each other, the students would feel safer and more comfortable; which would result in higher concentration on learning content.

Clear Explanation

According to Chin and Brown (2000), explanation refers to how or why an occurrence arises. Lee and Fradd (1998) highlight it as the notion of instructional congruencetopoint out the process of reconciling the nature of academic content with students' language andcultural experiences to make such content comprehensible, meaningful, and applicable forvarious

students. Lecturers should learn, both from experience and from other educators the best way in conveying the message and explaining to students in order to make them understand (Edge, 2002). Freeman (1993) proposes that expressing implicitly would give educators greater control in sharing their classroom practice through articulating the ideas in a professional and local language. With clearly articulated notions, it would maximize comprehension and promotes higher quality outcomes among students.

Preparation and Organization

Only highly professional individuals and people with the necessary teaching expertise should be trusted in the profession of teaching because the process is very important and complicated. As such, to be successful in their profession, lecturers must possess wide knowledge and background of other disciplines, such as pedagogy, psychology and methodology, significant features in disseminating knowledge to students. Part of the preparation for lecturers is getting themselves and their classrooms well organized. Lecturers who have made proper preparation and classroom management plans would tend to have well-managed classrooms. Organized educators and classrooms create a positive learning environment which encourages students to pay attention and work hard.Educators who are not well-managed are often ineffective in the classroom and they often report high levels of stress and have symptoms of burnout (Brouwers & Tomic, 2000).

Insufficient preparation is one of the major causal factors of classroom management problems faced by educators. Although the significance of effective classroom organization and behavior management is extensively acknowledged by educators, many failed to establish productive classroom environment (Baker, 2005).

Feedback on Continuous Assessment

Assessment is the process of attaining information needed in making educational decisions about students and providing feedback about their progress, strengths, and weaknesses. Assessment techniques comprise of formal and informal observations, qualitative analysis of pupil performance, paper-and-pencil tests, oral questionings and analysis of student records.

Jones and Jones (2007) recommends a feedback system that makes certain students receive attention and feedback from educators on their

progress. It would help promote effective classroom management and positive education environment. Lecturers could monitor students' work by praising, prompting, and then leaving or moving on to the next student. According to Hunter (1982), such practices enable educators to give first-rate feedback while verifying for students' understanding.

METHODOLOGY

The instrument was developed by Rohana *et al.* (2005). It consists of four dimensions of teaching which were established using exploratory factor analysis. The four dimensions together with the operational items are given below (refer to the Appendix for items under each dimension):

    X1. Rapport - Lecturers' ability to stimulate students' interest and establishing rapport.
    X2. Clear explanations - Lecturers' ability to explain clearly and sensitivity to students' level of progress.
    X3. Preparation – Lecturers' preparation and organization.
    X4. Feedback - Lecturers' feedback on continuous class assessments.

The research population is made up of all students of a Malaysian public university. From a total of 5000 students, a sample of 360 (Sekaran, 2003) was chosen using multistage sampling technique. Since students were assigned to lecturers, the first stage is to choose 20 lecturers from a total of 230 lecturers who were already stratified into 14 different programs. Since it is difficult to obtain an exact proportionate stratified sampling, a program with bigger number of students were represented by two lecturers, whereas a program with smaller number of students was represented by one lecturer. For each lecturer, 18 students were chosen randomly. In this way, the sample represents students from various programs, ranging from arts to science and technology. Questionnaires were personally distributed and a total of 359 were usable.

    The methods of analysis started with establishing construct validity of the instrument through confirmatory factor analysis (CFA), using Analysis of Moment Structures software (AMOS). The results from CFA indicate which variables best explained the four teaching dimensions and a latent variable named "students' learning gain". This variable is measured using four

operational items. Students were asked to rate their own perceivable learning gain by rating these items. The question is "Why use self reported learning gain?" One very common method to measure learning gain is to look at the students' performances in their examinations. A higher grade obtained would imply higher learning gain. But, did grades obtained in examinations correlate positively with students' rating of lecturers' performance in class? Areola (1995) tried to answer this question by reviewing 400 papers. The correlations recorded were mildly positive, zero, and even mildly negative, indicating that researchers had found that the relationship between students' examination grades and their ratings of lecturers' performance in class is weak. As an alternative method, it was suggested that students' self reported learning gain be used to validate students' ratings of lecturers' performances in class. A higher rating would imply higher learning gain (Scriven, 1995).

Three fitness indices were used to show the level of model fit. They are comparative fit index(CFI), goodness of fit index(GFI), and root mean square error of approximation (RMSEA). Internal reliability of the variables for each dimension and latent variable was investigated using Cronbach alpha.

Data from this study were further analyzed with Structural Equation Modelling (SEM), again using AMOS. The four dimensions of teaching are now considered as independent variables. The dependent variable is "students' learning gain" (Yi). This study examines the influence of each teaching dimension on students' learning gain. The objective is to determine which teaching dimension significantly influences students' learning gain. Mathematically, the equations are:

$$Yi = \beta0 + \beta1X1 + \varepsilon i \qquad (1)$$
$$Yi = \beta0 + \beta2X2 + \varepsilon i \qquad (2)$$
$$Yi = \beta0 + \beta3X3 + \varepsilon i \qquad (3)$$
$$Yi = \beta0 + \beta4X4 + \varepsilon i \qquad (4)$$

The theoretical framework of the study is represented in Figure 1.
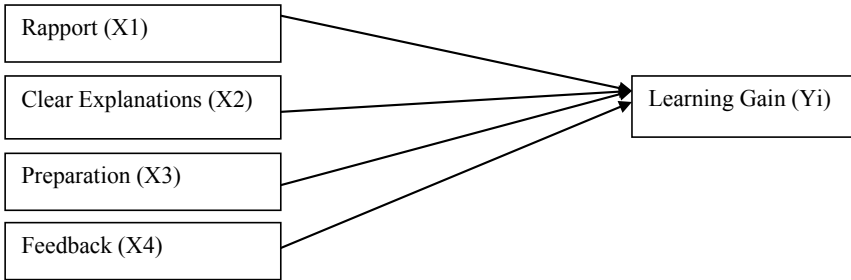
Figure 1: Theoretical framework of the study

RESULTS

In order to assess whether the data are suitable for confirmatory factor analysis (CFA), KMO and Bartlett's Test were run for both the independent and dependent variables. The results are shown in Table 1.

Table 1: KMO and Bartlett's Test for the Independent and Dependent variable

Variable	Kaiser-Meyer-Olkin Measure of Sampling Adequency	Bartlett's Test of Spherity		
		Approx. Chi-Square	Df	P-value
Rapport	.907	1425.587	21	0.000
Clear explanations	.902	1333.350	21	0.000
Preparation	.664	273.411	3	0.000
Feedback	.704	308.402	3	0.000
1. Feedback on tests, quizzes, assignments, and other graded materials helped students understand the material better.	.704	308.402	3	0.000

Based on the values as shown in Table 1, it is appropriate to continue with a CFA procedure on the data.

From the CFA, the results show that the number of items for dimensions Rapport and Clear Explanation are reduced (compared to the number of items shown in the Appendix). Whereas items for Preparation, Feedback, and Learning Gain remained the same. This is because items with the value of standardized regression weight below 0.6 (Rakowski *et al.*, 1997) were removed. Figures 2 to 6 illustrate the number of items in each variable after deleting or constraining the item having factor loading below 0.6 while Tables 2 to 6 show the fitness index of the model for each of the constructs.

Figure 2: The Path Diagram on the Confirmatory Factor Analysis for Rapport

Table 2: The Fitness Indices of The Model for Rapport

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI	RMSEA
Default Model	.983	.974	.993	.989	.993	.046

Items for Rapport are:

1. The lecturer was enthusiastic when teaching this course.
2. The lecturer praised students' efforts, where appropriate.
3. Sometimes, lecturer attracts students' attention with the use of humour.
4. The lecturer motivated you to do your best work.
5. The lecturer listened attentively to what students had to say.
6. Lecturer gave examples that clarified concepts.
7. Lecturer encouraged students to spend enough effort to acquire understanding of the material.

**Figure 3: The Path Diagram on the Confirmatory Factor Analysis
for Clear Explanation**

Table 3: The Fitness Indices of The Model for Clear Explanation

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI	RMSEA
Default Model	.977	.956	.985	.971	.985	.072

Items for Clear Explanation are:

1. The lecturer was able to answer questions clearly.
2. The lecturer presented material in an orderly manner.
3. The lecturer presented material at a level appropriate to the class.
4. The lecturer was able to recognize students' difficulties in understanding new material.
5. The lecturer changed approaches when the occasion demanded it.
6. The lecturer gave an overview at the start of a new topic.
7. Lecturer gave clear explanations
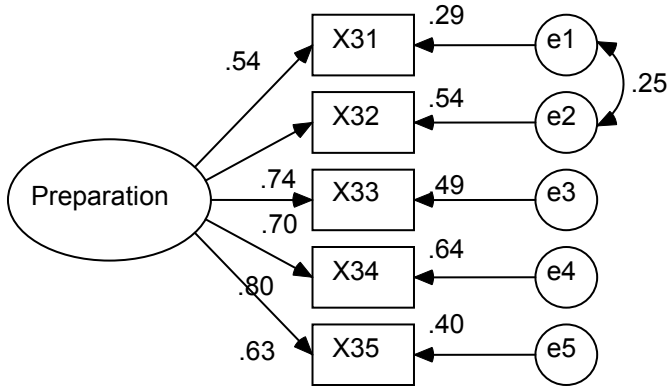
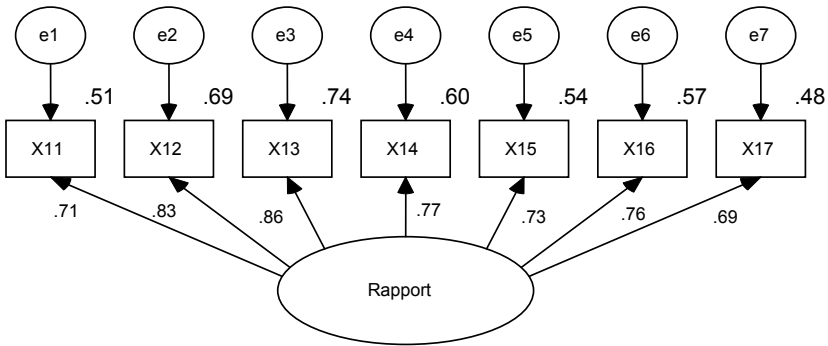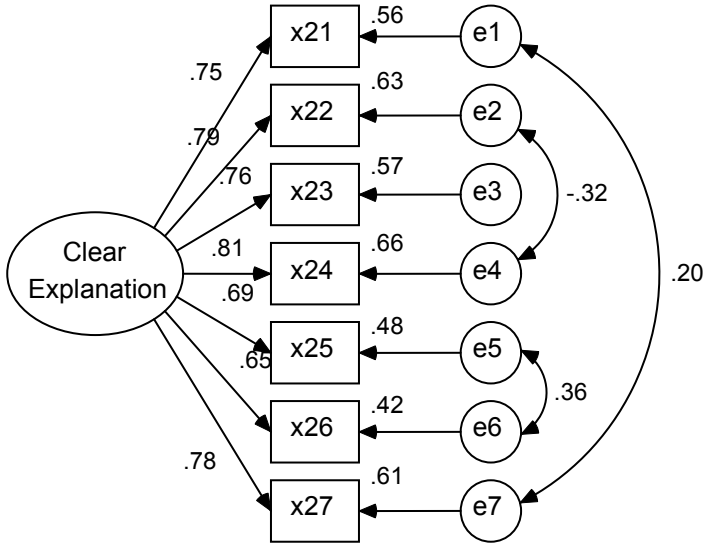**Figure 4: The Path Diagram on the Confirmatory Factor
Analysis for Preparation**

Table 4: The Fitness Indices of The Model for Preparation

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI	RMSEA
Default Model	.993	.981	.999	.999	.999	.015

Items for Preparation are:

1. There was considerable agreement between announced syllabus content and what was taught.
2. The lecturer was usually well prepared for class.
3. Lecturer used the class time effectively.
4. Lecturer encouraged students to complete their assignments (including tutorials) in a specified time.
5. Lecturer was usually punctual in starting class
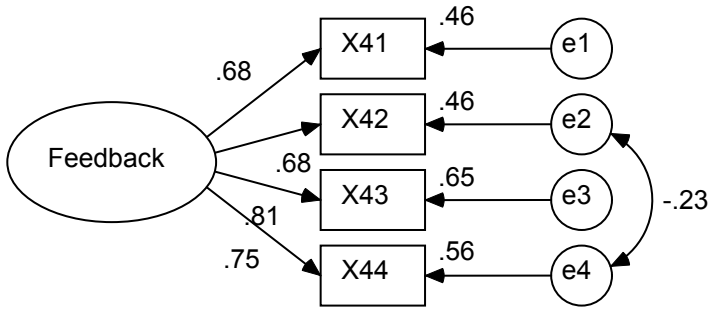
**Figure 5: The Path Diagram on the Confirmatory Factor
Analysis for Feedback**

Table 5: The Fitness Indices of The Model for Feedback

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI	RMSEA
Default Model	.995	.972	.998	.985	.998	.056

Items for Feedback are:

1. Feedback on tests, quizzes, assignments, and other graded materials helped students understand the material better.
2. The lecturer returned   tests and quizzes within a suitable period of time.
3. Tests, Quizzes and Assignments were well discussed afterwards
4. Tests, quizzes, assignments, and other methods of evaluating students, reflect contents of the course.
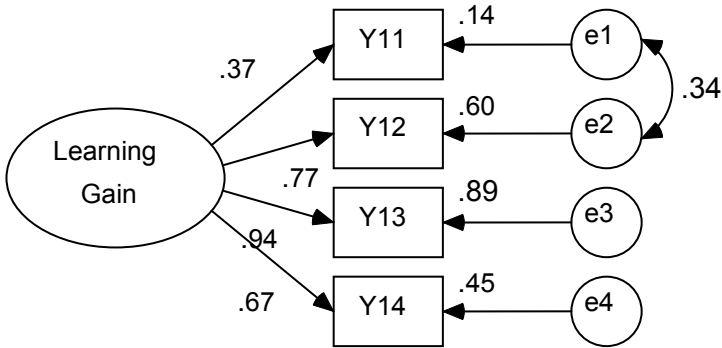
Figure 6: The Path Diagram on the Confirmatory Factor Analysis for Learning Gain

Table 6: The Fitness Indices of The Model for Learning Gain

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI	RMSEA
Default Model	1.000	1.000	1.002	1.011	1.000	.000

Items for Learning Gain are:

1. I found the course intellectually challenging.
2. I have learned someching which I consider valuable.
3. My interest in the course has increased as a consequence of learning the course.
4. I have understood the course material.

All fitness indices, namely the Goodness of Fit, Normed Fit Index, Relative Fit Index, Incremental Fit Index, Tucker Lewis Index, and the Comparative Fit Index are close to 1, which indicate that all the CFA models employed in the study are a good fit to the data (Bentler & Bonett, 1980; Bollen, 1989). According to Browne and Cudeck (1993), the value of RMSEA close to 0.05 will indicate a close fit of the model in relation to the degree of freedom. However the reasonable value for the RMSEA is about 0.08. Hence this also indicates that the model provides a good fit to the data.

Next, the reliability analysis using Cronbach's Alpha was conducted. The results in Table 7 show that all the values are greater than 0.6. According to Nunnally (1978), the measuring items are considered reliable.

Table 7: The Reliability Analysis for All Variables

Variable	Number of Item	Cronbach's Alpha
Rapport	7	.904
Clear explanations	7	.900
Preparation	5	.818
Feedback	4	.800
Learning Gain	4	.798

Once the reliability and construct validity of the instrument have been established, the next step is to study the relationship between the independent variables and the dependent variabe as pictured in the theoretical framework (Figure 1). Figure 7 shows the theoretical model in AMOS Graphic.
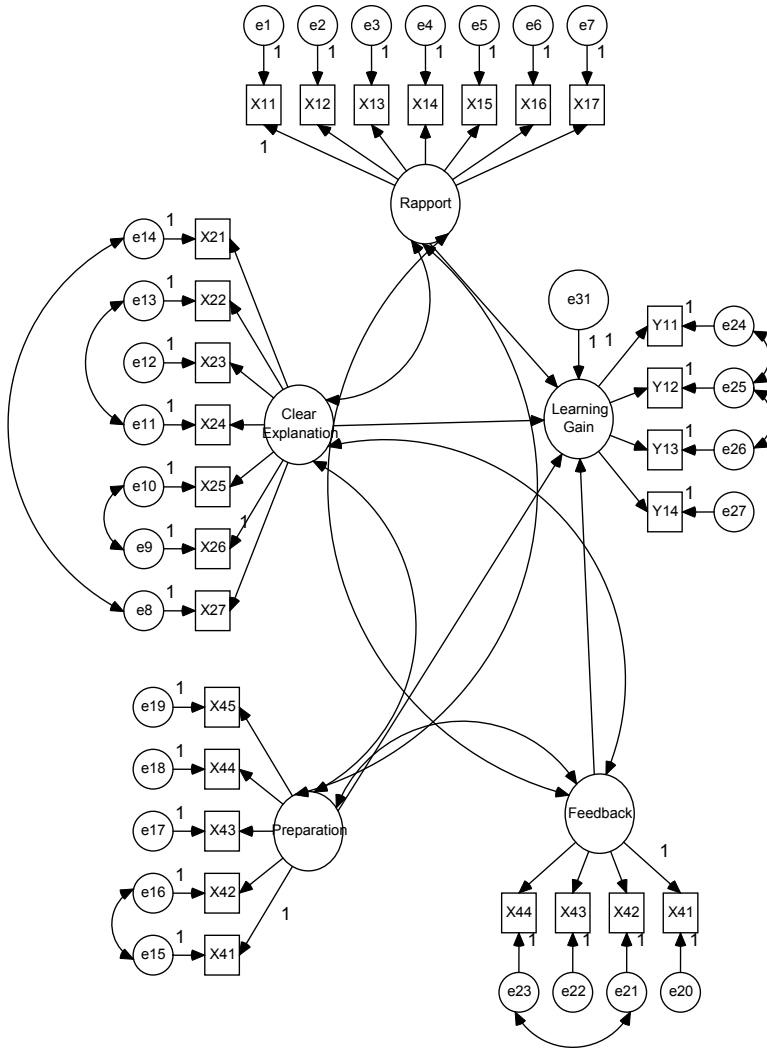
Figure 7: The Theoretical Model of the Study in AMOS Graphic

AMOS OUTPUT : THE UNSTANDARDIZED MODEL

The unstandardized model presents the regression coefficient linking the independent variables, the ordinary regression coeficient, the error

measurement of each independent variables and the significance level (p-value) for each relationship. The path analysis among all constructs and variables in the model is illustrated in Figure 8.
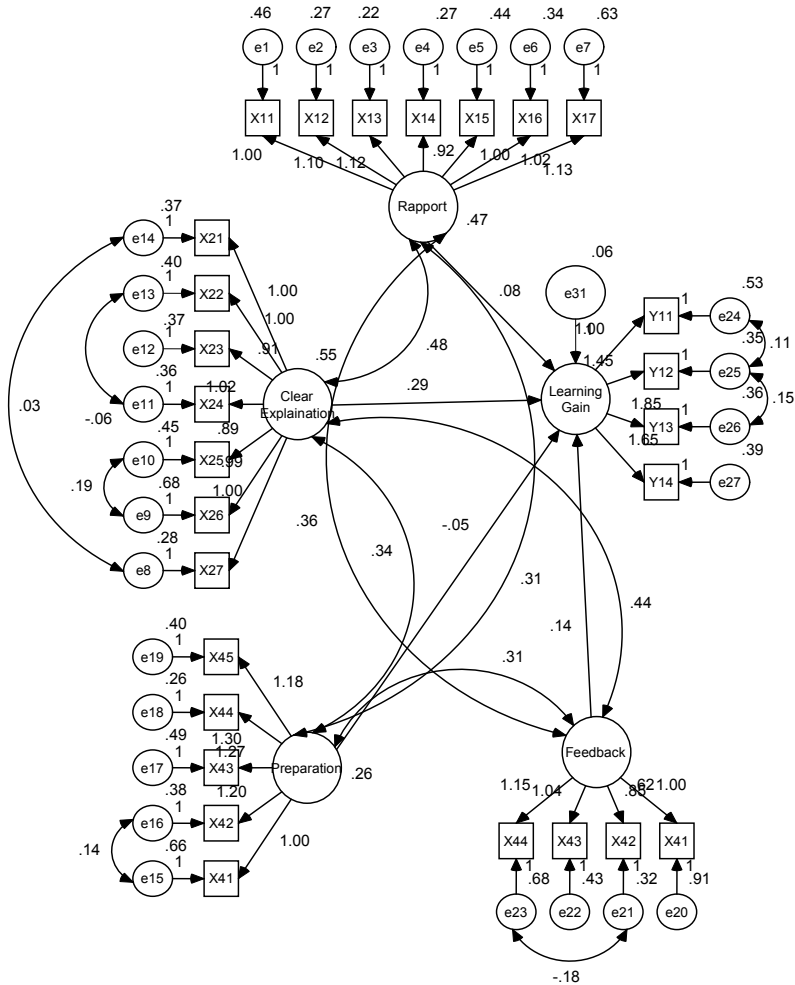
Figure 8: The Path Diagram Presents the Regression Coefficients among the Constructs

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MODEL FIT

The AMOS output showing the fitness indices for the model is given in Table 8.

Table 8: The Fitness Indices for The Model

Model	GFI	NFI Delta 1	RFI rho1	IFI Delta 2	TLI rho2	CFI
Default Model	0.854	0.869	0.850	0.913	0.900	0.912

From Table 8, all fitness indices namely the Goodness of Fit, Normed Fit Index, Relative Fit Index, Incremental Fit Index, Tucker Lewis Index, and the Comparative Fit Index are close to 1, which indicate that the model employed in the study is a good fit to the data (Bentler & Bonett, 1980; Bollen, 1989).

Table 9: The RMSEA

| Model	RMSEA
Default Model	0.070

The RMSEA of 0.070 (in Table 9) also indicates that the model provides a good fit to the data. The ideal value for RMSEA for the model should be 0.08 or lower. Hence, no further modification is required. The AMOS output showing the results concerning the hypothesized relationships among constructs is shown in Table 10.

Table 10: The Regression Weights and Corresponding Probability Values

Construct	Path	Construct	Estimate	S.E.	C.R.	P
Learning Gain	<---	Rapport	.083	.131	.630	.529
Learning Gain	<---	Clear Explanation	.285	.143	2.002	.045
Learning Gain	<---	Preparation	-.053	.144	-.369	.712
Learning Gain	<---	Feedback	.141	.056	2.544	.011

Based on Table 10, there is a significant relationship between Clear Explanation (p-value=0.045) and Feedback (p-value=0.011) with Learning Gain since the p-value are less than 0.05. Rapport and Preparation are both not significant. Thus, this study conclude that clear explanation and feedback from the lecturers have significant and positive direct influence on the students' learning gain.

CONCLUSION AND DISCUSSION

The results from this study indicate that among the four dimensions of teaching, the significant predictors of students' learning gain in the process of teaching and learning are clear explanation and lecturers' feedback. Recommendations by Edge (2002) and Freeman (1993) on the methods of imparting knowledge as well as suggestions by Jones and Jones (2007) and Hunter (1982) in giving first-rate feedback support the findings of this study.

In order to explain clearly, lecturers must be able to present materials in an orderly manner and at a level appropriate to the class. He or she must be able to recognize students' difficulties in understanding new materials and hence change the approaches when the occasion demanded it. Before starting a new topic, lecturers should also give an overview of the whole topic. Finally lecturers should be able to answer questions clearly.

Feedback on tests, quizzes, assignments, and other graded materials help students understand the materials better, especially when they reflect on the contents of the course and were returned within a suitable period of time. Lecturers should also later discuss the questions and answers well. If these aspects of teaching were implemented, we would expect students to be interested in and understood the course materials. Most importantly, students should have learned something which they considered valuable.

Scrutinizing the result of this study, it is in no way to suggest that lecturers can forget the other two dimensions of good teaching. It could be easily seen that the dimensions of clear explanation and feedback already encompass the other two dimensions, namely rapport and preparation. In order to be able to achieve the ability to explain clearly and to provide good feedback, lecturers must have done their own homework by reading, doing exercises and answering questions along with understanding and imagining the subtle confusion that might arise in the students' minds. By undertaking such efforts to prepare and organize the lecturers' own thought and notes

to be disseminated in class would enable lecturers to explain clearly the concepts and problems to their students. At the same time the ability to answer and explain any problem raised by students would naturally induce good relationship (rapport) between lecturers and students. Students' learning gain was found to significantly correlate with the fraction of class time spent doing student-centered activities (small group work, student presentation, computer work, and discussion) (Sandra et al., 2011). These activities demand that lecturers be the facilitators instead of preachers. Hence lecturers who are prepared would be more open and less defensive in conducting discussions in class and more often provide good and prompt feedback. They are more confident to respond to any problematic questions that students might raise. This in turn should command students' respect of their lecturers, which is an important component of any good and productive student-lecturer relationship.

So what does the significant predictor imply? The researchers would try to comprehend this finding, in the sense that whatever amount of preparation and good rapport with students, lecturers must give priority to their ability to explain clearly and provide good feedback to students so that students would attain higher learning gain in class.

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APPENDIX

(items for each dimension according to Rohana, Wan Karomiah, & Zokree (2005))

A.   Rapport
(Lecturers' ability to stimulate students' interest and establishing rapport)
1.   The lecturer was enthusiastic when teaching this course.
2.   The lecturer induced a relationship conducive to learning.
3.   The lecturer praised students' efforts, where appropriate.
4.   Sometimes, lecturer attracts students' attention with the use of humour.
5.   The lecturer motivated you to do your best work.
6.   The lecturer listened attentively to what students had to say.
7.   Lecturer spoke clearly.
8.   Lecturer gave examples that clarified concepts.
9.   Lecturer encouraged students to spend enough effort to acquire understanding of the material.
10.   Lecturer emphasized major points in lectures.
11.   The lecturer treated students with respect.
12.   The lecturer was receptive to questions.
13.   The lecturer showed an interest in helping students understand the material.

B.   Clear explanations
(Lecturers' ability to explain clearly and sensitivity to students' level of progress)
1.   Lecturer gave clear explanations.
2.   The lecturer was able to answer questions clearly.
3.   The lecturer presented material in an orderly manner.
4.   The lecturer presented material at a level appropriate to the class.
5.   The lecturer was able to recognize students' difficulties in understanding new material.

6. The lecturer changed approaches when the occasion demanded it.
7. The lecturer gave an overview at the start of a new topic.

C. Preparation
    (Lecturers' preparation and organization)
1. There was considerable agreement between announced syllabus content and what was taught.
2. Tests, quizzes, assignments, and other methods of evaluating students, reflect contents of the course.
3. The lecturer was usually well prepared for class.
4. Lecturer used the class time effectively.
5. Lecturer encouraged students to complete their assignments (including tutorials) in a specified time.
6. Lecturer was usually punctual in starting class

D. Feedback
    (Lecturers' feedback on continuous class assessments)
1. Feedback on tests, quizzes, assignments, and other graded materialshelped students understand the material better.
2. The lecturer returned tests and quizzes within a suitable period of time.
3. Tests, Quizzes and Assignments were well discussed afterwards