Engineering Education: Measuring the Relationship between Knowledge and Confidence to the Student Performance

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Keywords: Engineering Education, Confident, Learning, Knowledge.

Abstract: The students can perform well in the study as well as in the practices if they learn to solve engineering problems. However, the gaps between the obtaining knowledge in school and skills in practices were still large. It is a challenge to find improvement in the education model so that the students can perform well both in school and future practices. This study aimed at investigating the relationship between knowledge and confidence to the engineering students' achievement through confidence-based testing. The survey was distributed to the students who were taking structural analysis course. The tests were scored and run using Partial Least Square Structural Equation Modelling to obtain the inter-relationship between all action. The results showed the confidence did not directly affect the students' achievement, but the knowledge did. The highly confidence can make students to gain highly or lower achievement. The highly confidence with the true knowledge developed potential from the students to get higher achievement. The findings showed highly achievement can be increased if the trainer can continuously make the students realize their false knowledge in their highly confidence. The highly confidence with the correct knowledge will impact in how the engineers behave in solving the engineering's problems.

1 INTRODUCTION

The current practices of engineering education are students require solving many engineering problems. By solving those problems, the students can perform well in the study as well as in the practices. However, the gaps between the obtaining knowledge in school and skills in practices are still large (Adams & W., 2009; Salehi & Sadighi, 2015). It is a challenge to find improvement in education model so that the students can perform well both in school and future practices.

The learning should be delivered in effective ways so that the students can gain an understanding of their knowledge. One of the struggles in education institution is to ensure the students have an appropriate level of knowledge acquisition, skills, and competency to perform in practices. The current practices of assessment, such as: traditional exam or quiz, can assess the obtaining knowledge of the students from taking the lecture and to motivate students to get good grade. However, the typical grading system tends to encourage the students to put some answers in hopes that they will get partial credit, which does not encourage a deeper understanding of their missing knowledge (Gardner-Medwin, 1995). Grading can interrupt understanding but the assessment is needed to measure the learning process of the students. Therefore, the assessment should be developed to become a productive way to help students succeed.

The most common assessments in engineering are essay-type written tests and oral examinations, but these methods are believed too subjective and unreliable (Salehi & Sadighi, 2015). Multiple Choice Question (MCQ) is also a common format

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Sulandari, N., Lesmana, C. and Setyana, C.
Engineering Education: Measuring the Relationship between Knowledge and Confidence to the Student Performance.
DOI: 10.5220/0010748400003113
In *Proceedings of the 1st International Conference on Emerging Issues in Technology, Engineering and Science (ICE-TES 2021)*, pages 227-232
ISBN: 978-989-758-601-9

for assessing knowledge and performance (Ben-Simon, Budescu, & Nevo, 1997), but this method sometimes leads to a bias whether the students make a decision because of the right answer based on their knowledge or whether they have a lucky guess to the right answer without having an exact knowledge (Kurz, 1999; Salehi & Sadighi, 2015). The confidence-based method has started with Information Reference Testing (Bruno, 1993) that introduced two metrics where mastery as a result of high confidence and knowledgeable. It has also developed with multiple levels of confidence, such as: three levels of confidence with a correct or wrong answer (Gardner-Medwin, 2006; Gardner-Medwin & Gahan, 2003), five levels of confidence (Khan, Davies, & Gupta, 2001), and simplification of the method (Reed & Reed, 2015). Although the method is not new, it needs to test for the different field of education such as engineering.

Table 1: Weighting for CBT.

	Absent	I don't know	Partially Confident		Confident	
			Wrong	Right	Wrong	Right
Knowledge	0	1	1	3	1	4
Confident	0	1	2	1	3	4

The linkage of confidence and knowledge in the learning process is not new. It The students who confident in learning new material will retain the knowledge better (Hunt, 2003). The confident students can develop their own solutions to any engineering problems. Students who have high self-confident to learn and put greater effort to overcome difficult situations and in contrary students with low-confident tend to give up hope easily (Busse & Walter, 2013; Stiggins, 2005). Confident and knowledge are the two important qualities for successful engineering education and practices. Knowledge as a product of reason can remain at rest if the students have no certain it is right. It is important that students can recognize how confident they are in solving problems (Bruno, 1993; Nelson & Webster, 2015; Reed & Reed, 2015). However, a confidence that driven by ignorance can lead to failure because students are being certain of own abilities without any supporting knowledge.

Students are expected to success in school, practices, and life so it is a challenge for every education institution to help the students develop to be independent to solve the problems with their knowledge.

This paper presents a confidence testing method through multiple choice and open-ended questions. The study examines the correlation between knowledge and confidence in performing the exam through the former method confidence-based testing that modified from Bruno (1993).

2 METHODS

2.1 Descriptions

This study used a survey questionnaire that integrated two types of questions: multiple choice and open-ended questions. A concept of the two axes of the knowledge and the confidence level that similar with the concept presented as Information Reference Testing (Bruno, 1993), Confidence-Based Assessment (Gardner-Medwin, 2006), and Confidence-Based Scoring (Reed & Reed, 2015) was adopted, but Confidence-based testing (CBT) was adding more condition if the students skip the class to the assessment of the students' performance.

From the method, confidence and knowledge are both variable that believe will affect the students' performance. As the students give their response on knowledge and confidence for each question, the answers lead to the true or false knowledge in the certain portion of confidence level. CBT was used for the knowledge from the answering questions and the selection of "confident" or "partially confident" or "no confident". The knowledge was measured by "right" and "wrong" answer to the questions. The summary of the weighting answers can be seen in Table 1. The best scenario was having right answer with confident. If students had the right answer but lacking confidence, they cannot get perfect score. The "no confident" answer was given if the students mark "I don't know" because it was assumed that the students had no knowledge on the material as well as no confident to try to answer the question. If the students had wrong answer in partially confident, the weighting knowledge was still low, but they assumed slightly confident than simply saying "I don't know". If the students' absent, they do not have any knowledge or confident to answer the questions so zero points are assigned. There three points that arise in this weighting system, the students with wrong answer were always having the lowest score of knowledge, knowing they do not know but they still try to answer the question were sort of good efforts in confident, and having right answer but partially confident was assumed similar with no confident because the students were not sure what they had known.

2.2 Participants

The participants of this study included 49 first semester undergraduate students majoring in civil engineering. The survey was distributed to the students who were taking a basic structural analysis course. To eliminate some bias, the valid data were taken only for students that took the class for the first time. The total of the respondents were 64 students, but 15 data were eliminated because too many data were missing, or the respondents had taken the same course before. The participants consisted of 31 males and 18 females. The following data included a total of 5 problems from 10 quizzes. The CBT method was integrated in every quiz, but not on any exams. The exam was the measurement of the outcomes from the learning process since it gave the grade for the students passed the course.

The students' performance is divided into three measurements before they lead to the final grade (FG), "pass" or "not pass". The three measurements are Mid Exam (ME), Final Exam (FE), and practices (Pr). There are two quizzes for Knowledge (K) and respectively confidence (C) in Mid Exam (ME) and eight quizzes for Knowledge (K) and respectively Confidence (C) in Final Exam (FE). The practice value is believed a result from knowledge and respectively confidence of the ten quizzes.

2.3 Analysis Methodology

After the collected data is coded and scored, the Partial Least Squares Structural Equation Modeling (PLS-SEM) is adopted to explain the variables. Structural equation modeling (SEM) is a statistical technique that very powerful in its ability to model latent variables, to consider various forms of measurement error, and to test entire theories. Partial least squares (PLS) is a path modeling that fully developed and widely used in the general system (Hair, Sarstedt, Ringle, & Mena, 2012; McDonald, 1996).

A number of researchers indicated that PLS is the most appropriate and powerful tool to avoid small sample size problems, such as: the assumptions of multivariate normality and interval scaled data that cannot be made, or the researcher's priority is the prediction of dependent variable (Birkinshaw, Morrison, & Hulland, 1995; Henseler, Ringle, & Sinkovics, 2009). The PLS path modeling avoids small sample size problems and even can be applied for situations that other statistical methods cannot, this method can be helpful for the investigation of the relationship between knowledge, confidence, and outcomes. From the statistic correlation, hypothesis is investigated to find the effect of knowledge, confidence, and outcomes.

PLS algorithm was conducted using SmartPLS (Ringle, Wende, & Will, 2005) to test reliability and validity of the research constructs. This test is demonstrated by an accumulation of evidence that should demonstrate using content analysis, correlation coefficients, factor analysis, to make sure the data is valid. Rule of thumbs for these three general indicators to evaluate the construct reliability and validity is 'greater than 0.50' for Average Variables Extracted – AVE (Fornell & Larcker, 1981; Götz, Liehr-Gobbers, & Krafft, 2010), and 'greater than 0.70' for both Composite

Table 2: Correlation Matrix for Relationship.

	AVE	C1	C2	K1	K2	Pr	FG	FE	ME
C1	0.545	**0.738**							
C2	0.661	0.377	**0.813**						
K1	0.637	0.641	0.430	**0.798**					
K2	0.533	0.363	0.784	0.358	**0.730**				
Pr	1.000	0.337	0.515	0.394	0.727	**1.000**			
FG	1.000	0.466	0.561	0.436	0.762	0.873	**1.000**		
FE	1.000	0.446	0.615	0.391	0.741	0.731	0.948	**1.000**	
ME	1.000	0.453	0.344	0.424	0.613	0.807	0.898	0.732	**1.000**

Note: The diagonal values are $\sqrt{AVE}$, the rest are R

Reliability – CR (Werts, Linn, & Jöreskog, 1974) and Cronbach's alpha (Nunnally, 1978). The correlations among variables should show acceptable validity results.

SmartPLS can generate t-statistics for significance testing of both the inner and outer model, using a procedure called bootstrapping (Hair, Sarstedt, Ringle, & Gudergan, 2017). The procedure includes a large number of subsamples that taken from the original sample with replacement to give bootstrap standard errors. In results, the analysis turn gives approximate the normality of data of t-values for significance testing of the structural path. PLS algorithm and bootstrapping was used for testing the research hypotheses. There are three stages of the basic PLS Algorithm: (1) iterative estimation of latent variable scores, (2) estimation of outer weights/loading and path coefficients, and (3) Estimation of location parameters. All path relationships required to indicate t-values higher than significance level of 1.96.

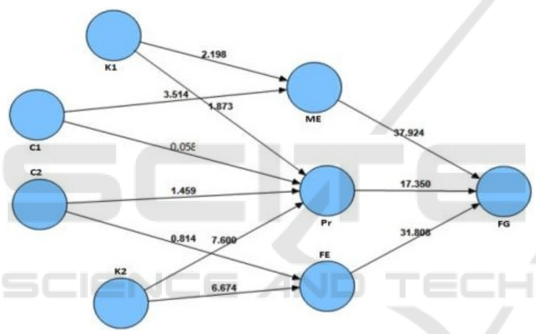

Figure 1: SmartPLS Model and Bootstrapping Results.

3 RESULTS AND DISCUSSION

Majority of the factor loading results were above the most common acceptance level of 0.6. After deleting the items of both constructs due to a low factor loading, the results show all acceptable results for Average Variables Extracted (AVE), Composite Reliability (CR), and Cronbach's alpha. Fornell and Laker method were followed to confirm the discriminant validity as the square root of AVE in each latent variable was used to establish discriminant validity if this value is larger than other correlation values among the latent variables (Fornell & Larcker, 1981). This validity test shows how much variance in the indicators that are able to explain variance in the construct (Afthanorhan, 2013). Numerical indications for correlation matrix are shown in Table 2, which the square root of AVE value is manually calculated and written in bold on the diagonal of the table while the correlations between the latent variables are copied from the "Latent Variable Correlation" between the respective constructs.

The correlation matrix in Table 2 shows that after some treatment of several items, the R value is lower than $\sqrt{AVE}$, which indicates the model has already acceptable since the discriminant validity is achieved when a diagonal value bold is higher than the value in its row and column. The SmartPLS framework model for path analysis in the first order analysis is shown in Figure 1. The detailed results are shown in Table 3 and Table 4.

Table 3: PLS-SEM Results for Relationship.

	Path coefficients	**SE**	**t-value**
C1 → Pr	0.002	0.137	0.058
C1 → ME	0.324***	0.086	3.514
C2 → Pr	-0.225	0.141	1.459
C2 → FE	0.102	0.117	0.814
K1 → Pr	0.198	0.113	1.873
K1 → ME	0.229*	0.104	2.198
K2 → Pr	0.839***	0.105	7.600
K2 → FE	0.662***	0.107	6.674
Pr → FG	0.197***	0.012	17.350
FE → FG	0.566***	0.018	31.806
ME → FG	0.325***	0.010	37.924

Note: significant at: * >1.96, ** >2.58, and *** >3.52 levels

Table 4: Overall Fit Assessment for Relationship.

Dependent variables	R-square	Redundancy
ME	0.257	0.119
Pr	0.626	0.037
FE	0.546	0.069
FG	1.000	0.306

From the relationship among K1, C1, K2, and C2 as the independent variables and ME, Pr, FE, and FG as the dependent variables, the coefficient of determination (R-square) is 25.7% for ME from K1 and C1, 62.6% for Pr from K1, C1, K2 and C2, 54.6% for FE from K2 and C2, and 100% for FG from ME, Pr, and FE as shown in Table 4. Since all the values of R-square are more than 10%, then all the dependent variables explain the variance in the independent variables

From path relationships, some of the paths indicate t-values lower than significance level of 1.96. The confidents, C1 and C2, are statically not significant to the Practical (Pr), while the confident, C2, is also statically not significant to the Final Exam (FE). Knowledge variables (K1 and K2) are statically significant to the exam, but confident variables tend not directly significant to the exam. Confident affects knowledge and knowledge affects confident as well. However, knowledge is statically significant to the performance of the students, but the confident is not statically significant to the students' performance. The confidence directs the students to gain more knowledge which it is an asset for doing the exam. However, in overall the interaction of knowledge and confident are positively significant associated with the final performance of the students (FG).

The purpose of the simulation is to demonstrate how the confidence-based testing can improve the students' performance by understanding the relationships between knowledge and confidence to the exam. The Partial Least Square Structural Equation Modeling (PLS-SEM) was used to study the parameters. Since the T-statistic values that greater than 1.96 show that the relationship both knowledge and confidence in the first set of quizzes to the mid exam is statically significant, so both knowledge (K1) and confidence (C2) are affecting the achievement of the Mid Exam (ME). However, the similar relationship cannot be found in the Final Exam (FE). The relationship of the confidence (C2) is not statically significant to the final exam, but the relationship of the knowledge (K2) is statically significant to the achievement of the final exam and practice (Pr) as well. Most of the relationship of the confidence are not statistically significant to the students' achievement so knowledge really affects the students' performance. Does the confidence really affect the students' performance?

Although the scoring of the CBT has accommodated the weight of the confidence and knowledge, the confidence is not really affecting the performance. Knowledge is acquired when the students learn. The exam is one of the methods to test how deep the knowledge of the students to the subject. The confidence does not directly affect to the students' performance, but it affects to how the students gain knowledge.

In the first term, the confidence seems has influenced to the students' performance but after several quizzes it seems no impact. The CBT method believed that confidence tends to motivate the students to gain more knowledge whether the knowledge is true or false. In the structural analysis course, the subject is in sequence from the session 1 to the final session as it is common in most of the engineering courses. As the students tend to learn false knowledge, the confidence led them to learn false knowledge, so in the beginning the knowledge and confidence are significant to the students' performance. However, as the students tend to learn more and more false knowledge with highly confidence, the confidence is not as significant as in the beginning of the students' achievement, since the confidence only leads to the false knowledge.

From the test of the relationship by the PLS-SEM, it can be observed that the combination of both confidence and knowledge will create an unstoppable force of human potential, but it can be destructive as well if it goes to the false direction. Knowledge is directly affecting the students' achievement and confidence seems to be a booster for the students to have higher achievement as well as lower achievement.

Although the CBT method can stimulate the reflection learning, the students' self-awareness along with the learning process, the deeper learning with the fairness of the assessment method only can be obtained if the trainer gives a continuously feedback to the students.

4 CONCLUSIONS

The unique confidence-based testing has been used by some scholars. The CBT method can increase the competencies of the MCQ exams to become an effective examination. The CBT stimulate the reflection for deeper learning among the students through the students ask to select the right answer as well as the level of confidence. The statistic results show that the knowledge is more significant to the student's achievement rather than the confidence level of the certain knowledge. The highly achievement of the exam can be increased by implementing the CBT if only the trainer can continuously make the students realize their false knowledge in their highly confidence.

ACKNOWLEDGEMENTS

We thank the undergraduate students at Department of Civil Engineering, Universitas Kristen Maranatha who participated in the Structural Analysis class and provided data for this study.

REFERENCES

Adams, T. M., & W., E. G. (2009). The importance of confidence in improving educational outcomes. In *Proceedings of the 25th annual conference on distance teaching and learning* (pp. 1–15).

Afthanorhan, W. M. A. B. W. (2013). A Comparison Of Partial Least Square Structural Equation Modeling (PLS-SEM) and Covariance Based Structural Equation Modeling (CB-SEM) for Confirmatory Factor Analysis. *International Journal of Engineering Science and Innovative Technology (IJESIT)*, *2*(5), 198–205.

Ben-Simon, A., Budescu, D. V, & Nevo, B. (1997). A Comparative Study of Measures of Partial Knowledge in Multiple-Choice Tests. *Applied Psychological Measurement*, *21*(1), 65–88. https://doi.org/10.1177/0146621697211006

Birkinshaw, J., Morrison, A., & Hulland, J. (1995). Structural and competitive determinants of a global integration strategy. *Strategic Management Journal*, *16*(8), 637–655. https://doi.org/10.1002/smj.4250160805

Bruno, J. (1993). Using testing to provide feedback to support instruction: A reexamination of the role of assessment organization. In D. L. & J. Burno (Ed.), *Item bank: Interactive testing and self assesment* (NATO ASI S, pp. 190–209). Berlin: Springer Verlag.

Busse, V., & Walter, C. (2013). Foreign Language Learning Motivation in Higher Education: A Longitudinal Study of Motivational Changes and Their Causes. *The Modern Language Journal*, *97*(2), 435–456. https://doi.org/10.1111/j.1540- 4781.2013.12004.x

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, *18*(1), 39–50. https://doi.org/10.2307/3151312

Gardner-Medwin, A. R. (1995). Confidence assessment in the teaching of basic science. *Research in Learning Technology*, *3*(1), 80–85.

Gardner-Medwin, A. R. (2006). Confidence-based marking: Towards deeper learning and better exams. *Innovative Assessment in Higher Education, Routledge*.

Gardner-Medwin, A. R., & Gahan, M. (2003). Formative and summative confidence-based assessment. In *Proceedings of the 7th International Computer-Aided Assessment Conference* (pp. 147–155).

Götz, O., Liehr-Gobbers, K., & Krafft, M. (2010). Evaluation of Structural Equation Models Using the Partial Least Squares (PLS) Approach. In V. Esposito Vinzi, W. W. Chin, J. Henseler, & H. Wang (Eds.), *Handbook of Partial Least Squares: Concepts, Methods and Applications* (pp. 691–711). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-32827-8_30

Hair, J. F., Sarstedt, M., Ringle, C. M., & Gudergan, S. P. (2017). *Advanced Issues in Partial Least Squares Structural Equation Modeling*: SAGE Publications.

Hair, J. F., Sarstedt, M., Ringle, C. M., & Mena, J. A. (2012). An assessment of the use of partial least squares structural equation modeling in marketing research. *Journal of the Academy of Marketing Science*, *40*(3), 414–433. https://doi.org/10.1007/s11747-011-0261-6 Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009).

The use of partial least squares path modeling in international marketing. In *New Challenges to International Marketing* (Vol. 20, pp. 277–319). Emerald Group Publishing Limited. https://doi.org/ doi:10.1108/S1474- 7979(2009)0000020014

Hunt, D. P. (2003). The concept of knowledge and how to measure it. *Journal of Intellectual Capital*, *4*(1), 100–113. https://doi.org/10.1108/14691930310455414

Khan, K. S., Davies, D. A., & Gupta, J. K. (2001). Formative self-assessment using multiple true-false questions on the Internet: feedback according to confidence about correct knowledge. *Medical Teacher*, *23*(2), 158–163.

Kurz, T. B. (1999). A review of scoring algorithms for multiple-choice tests. San Antonio, TX: Annual Meeting of the Southwest Educational Research Association.

McDonald, R. P. (1996). Path Analysis with Composite Variables. *Multivariate Behavioral Research*, *31*(2), 239–270. https://doi.org/10.1207/s15327906mbr3102_5 Nelson, L., & Webster, S. (2015). How Confident Are You- Using Knowledge Confidence to Learn Anatomy. *The FASEB Journal*, *29*(1 Supplement). Retrieved from http://www.fasebj.org/content/29/1_Supplement/689.10.abstract

Nunnally, J. C. (1978). *Psychometric theory*. McGraw- Hill. Retrieved from https://books.google.co.id/books?id=WE59AAAAM AAJ

Reed, G. Y., & Reed, K. B. (2015). Engineering Student Self-Assessment Through ConfidenceBased Scoring. *Advances in Engineering Education*, *4*(4), 1–23. Retrieved from http://advances.asee.org/category/summer-2015/ Ringle, C. M., Wende, S., & Will, A. (2005). SmartPLS v. 2.0M3. Retrieved from http://www.smartpls.de/

Salehi, M., & Sadighi, F. (2015). Comparing Confidence-based and Conventional Scoring Methods: The Case of an English Grammar Class. *The Journal of Teaching Language Skills*, *6*(4), 123–152. Retrieved from http://jtls.shirazu.ac.ir/article_3105_f12428f95f7587c998d08fcd1170f24f.pdf

Stiggins, R. (2005). From Formative Assessment to Assessment for Learning: A Path to Success in Standards-Based Schools. *Phi Delta Kappan*, *87*(4)

Werts, C. E., Linn, R. L., & Joreskog, K. G. (1974). Interclass reliability estimates: Testing structural assumptions. *Education and Psychological Measurement*, 34, 25-33. doi:10.1177/001316447403400104