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KNOWLEDGE TRANSFER IN PROBLEM BASED LEARNING TEACHING METHOD IN SOFTWARE ENGINEERING EDUCATION: A MEASUREMENT MODEL

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ABSTRACT

Problem Based Learning (PBL) is a teaching method that is able to transfer tacit knowledge from lecturers to students based on Socialization, Externalization, Combination and Internalization (SECI) model. However, the SECI model does not include the students' performance factor, which is an indicator to measure the effectiveness of teaching and learning processes. Hence, our study proposes a framework to evaluate the effectiveness of using PBL as a teaching method in Software Engineering (SE) education to transfer the tacit knowledge by enhancing the SECI model. This paper is a part of our study that purposely wants to evaluate a measurement model of knowledge transfer process in PBL teaching method in SE education. This study used survey as a method for data collection. The respondents were students who registered for System Analysis and Design (SAD) courses. The data was analyzed using Structural Equation Modeling (SEM) with Analysis of Moment Structures (AMOS). The results have shown that the measurement model fits the data. Therefore, the framework is suitable for PBL teaching method in SE education. Further, this study intends to identify the relationship between SECI model in PBL teaching method for SE domain.

Keywords: Knowledge transfer process, problem based learning teaching method, software engineering education.

INTRODUCTION

An Institution of Higher Education is a center for knowledge creation (Chen & Burstein, 2006), which refers to a center for creating new knowledge by the experts in respective fields through systematic and scientific studies and research as well as a center for creating new understanding and applications among the novices through teaching and learning processes. The creations of new knowledge involve experiments and tests by the experts in proving theories and models in understanding the nature and social processes. Meanwhile the creations of understanding and new applications involve experts sharing their accumulated knowledge and expertise by supervising novices or students. The experts in respected fields have wealth of knowledge which are divided into; 1) tacit knowledge, and 2) explicit knowledge. The process of sharing the knowledge is aimed at transferring the formed knowledge within the experts into their students involving interaction and transaction processes over the tacit and explicit knowledge iteratively until the knowledge is formed within the students. Common methods in knowledge sharing among novices and experts are through face-to-face medium such as giving tutorials, guiding in technical writing, and teaching in small groups.

Knowledge includes intention, ideas, rules, and procedures (Bhatt, 2000) that lead to reactions and decisions (Barreto & Eredita, 2004). (Polanyi, 1966) classifies the knowledge into two types; tacit knowledge and explicit knowledge. Tacit knowledge is difficult to be explained or transferred in an easily understood context (Arnett & Wittmann, 2014), (Hau, Kim, Lee & Kim, 2013). It is usually in the in the forms of intention and ideas. On the contrary, the explicit knowledge could be easily understood and explained which are transferred through words or numbers (Nonaka & Konno, 1998). (Brockmann & Simmonds, 1997) define tacit knowledge as the ability of making strategic decisions. In the online environment aspect, (Jialin, 2006) explains that tacit knowledge refers to personal knowledge which is difficult to be explained to others and are based on the contexts and problems. In terms of academic context, (Leonard & Insch, 2005) define the tacit knowledge as cognitive, technical, and social abilities that lead to learning and thinking strengths. Further, (Leonard & Insch, 2005) classify the abilities into more detail, in which cognitive abilities consist of self-motivation and self-organization; technical abilities in individual tasks and institutional tasks; and social abilities in interaction regarding the tasks and social interaction. Based on those views (Barreto & Eredita, 2004), (Brockmann & Simmonds, 1997), (Leonard & Insch, 2005), the tacit knowledge could be concluded as learning sophistication, thinking sophistication, and decision making sophistication in social context of teaching-learning processes.

Tacit knowledge can vary as well as it can be articulated and passed on from the senior to the apprentice (Busch, Richards & Dampley, 2003). In this paper, the tacit knowledge is referred to the SE knowledge that lecturers have gained and experienced through the years, which is difficult to transfer onto paper but to some extend it could be articulated in the classroom. Thus, the key success of leveraging tacit knowledge in the class environment is by using PBL teaching method that would help accelerate the students ability to solve problems.

PBL is a learning technique that uses inductive thinking approach based on the observation of a problem, analyze data and formulate the principles of the findings

(Savery & Duff, 1995). The students have the ability levels showed a positive outcome in the learning process through the inductive approach (Berg & Bergendahl, 2003), (Heywood, 1992).

One of the compulsory subject in Bachelor of Information Technology (BIT), Bachelor of Multimedia (BMM) and Bachelor of Education IT (BEduIT) curriculums in UUM is SAD. The SAD course is part of the SE program under School of Computing, UUM. The syllabus for SAD subject consists of theory, methodology, techniques as well as the practical aspects related to analysis and design phase during system development. The students need to have the skills to analyze the problem and design the solution. In addition, students are expected to go beyond the knowledge and skills obtained in the class in order to improve their competence as well as performance in system development practice. PBL has been applied as a teaching method for SAD subject to fill the gap between the theories and practices of SAD.

SAD course at UUM is implemented using the PBL technique for teaching method. The learning takes place in which the lecturers explain about the course. The ideas, views, and information are shared and revised with other learners and are documented for referencing. In gaining more knowledge, learners explore through the teaching materials and external resources provided by their lecturers. Based on the gathered information, learners refer to their lecturers and peers, to form their tacit knowledge or sharpening their existing skills. In PBL, the lecturers' tacit knowledge are transformed into group's explicit knowledge and organized into learners' tacit knowledge in a structured way.

Previous studies on SECI model in higher education have measured the relationships of four processes in the model - Socialization, Externalization, Combination, and Internalization (Ahmad, 2010), (Kuty & Aurum, 2007). Thus, the aim of this study is to proposed a framework that consists of five factors with an additional factor namely Performance as shown in Figure-1. Performance is an extension of the model. The original model of Nonaka and Takeuchi's had only four processes. In this study, our aim is also to determined wheather the four factors from the original model has any influenced on the fifth factor which is Performance.

Socialization is a process of transferring knowledge and experience from lecturer to student via email and forum. Externalization is a process of explaining the tacit knowledge into explicit knowledge in writing formats or sharing of knowledge between lecturer and student through online learning environment as the basis of new knowledge. The online learning environment will be measured by mode, system performance, social presence and media richness.

On the other hand, Combination refers to the process of collecting inconsistent explicit knowledge such as teaching material, external sources or via online system which consist of complex and systematic explicit knowledge. In the mean time, the process of Internalization is the experience acquired through previous process and then converted into a valuable knowledge for student in term of learning, thinking and decision making skills. Last but not least, Performance is measured based on the student results of final semester exam. In our study, we proposed a framework that represents a complete causal relationship, starting from Socialization to Externalization, Combination, Internalization and finally Performance, which is an indirect relationship from Socialization to Internalization influence of the students' performance.

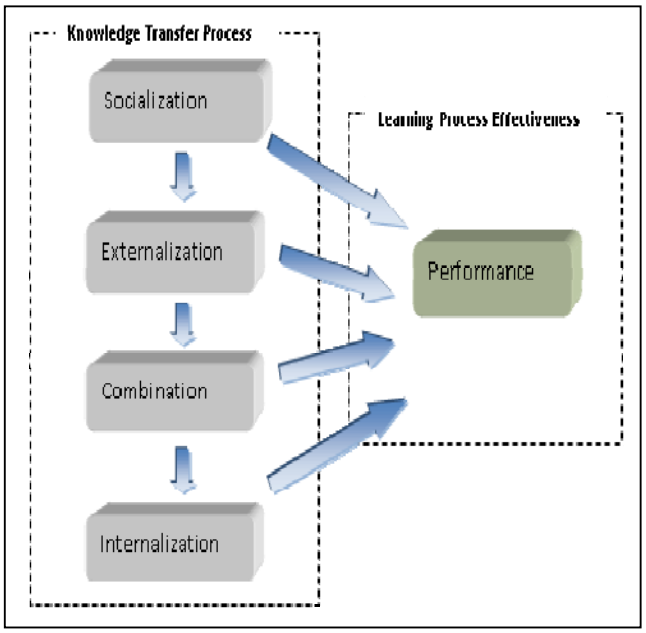

Figure-1. The Proposed framework.

Knowledge transfer process

(Nonaka & Takeuchi, 1995) propose four knowledge generation modes; Socialization, Externalization, Combination, and Internalization which is known as SECI model. It involves interaction and transaction between the tacit and explicit knowledge (Schiele, Laux & Connolly, 2013). The model is implemented in industries. In supports of the organizational goals, the processes in the SECI Model are combined in managing the within-organization knowledge.

According to (Nonaka & Takeuchi, 1995), socialization refers to the sharing of knowledge which creates the tacit knowledge such as the sharing of mental model and technical skills. Meanwhile, externalization refers to the processes of representing the tacit knowledge in writing formats or the explicit knowledge in any form of raw data so that they could be shared as the basis for new knowledge. Combination refers to the process of transforming the raw explicit knowledge into a group of complex and systematic explicit knowledge.

In the internalization process, the gathered experiences in earlier processes are transformed into

valuable values in views of the individuals and the organization. The cycle in the SECI model depicts the dissemination of knowledge among individuals and further the knowledge is expanded by other individuals in a dynamic knowledge creation environment. In particular, the dynamic knowledge creation begins when new knowledge created through a complete knowledge creation process functions as the basis for the creation of other new knowledge, and the basic knowledge grows gradually to higher levels (Nissen, 2006).

In relation, (Bhatt, 2000) states that the transformation of self-created knowledge needs continuous knowledge flow within individuals. Hence, knowledge transformation should stress on the importance of interaction and transaction among the tacit and explicit knowledge dynamically and consistently. The findings from (Ahmad, 2010) concluded that SECI model is capable for measuring knowledge transfer from lecturer as expert to student as novice via PBL teaching method.

It should be noted that this paper is a part of our study that focuses on knowledge transfer process in PBL teaching method for SE education. This paper discusses a study which attempts to answer question pertaining to the theoretical-based measurement model that fit the data collected at UUM, Malaysia. The knowledge transfer process in this study is divided into four main construct, which are Socialization, Externalization, Combination and Internalization. In the future, we will investigate the relationship of SECI model in PBL teaching method for SE education.

METHODOLOGY

This study used a survey as a method of data collection. An instrument for the survey is a set of questionnaire that focuses on how knowledge is transferred in Socialization, Externalization, Combination and Internalization. The instrument was adapted from SECI processes in educational context (Ahmad, 2010). For data collection, the questionnaires were distributed to the students who are currently registered for SAD course. A five-point Likert scale was used to tap into individual's perception, ranging from 1=Strongly Disagree to 5=Strongly Agree for all items. The data collected is analyzed using SEM with AMOS.

RESULTS AND DISCUSSIONS

The survey involves 79 respondents, comprising of 35 males and 44 females. The age of the respondents ranged between 20 years old to 23 years old. The majority were Malaysian (85% or n=67) and Non Malaysian (15%, n=12). The majority of the respondents were from BIT which consists of 49 students, 27 students from BMM and 3 students from BEduIT. In this present research, a more holistic approach to model evaluation was employed using SEM technique with AMOS. AMOS is used to determine the fitness of a model. Some indexes are used including Chi-square, Root Mean Square Error of Approximation (RMSEA) (Browne and Cudek, 1992), Comparative Fit Index (CFI) (Bentelr, 1973), Tucker Lewis Fit Index (TLI) (Tuucker, 1973), Normed Fit Index (NFI) (Reinard, 2006) and Chi Square/Degree of Freedom (Marsh and Hover, 1985). The chi-square index test is a reasonable measure of fit for model with about 75 to 200 cases (Information, 2012). In this study, the measure of fit is based on chi-square index as the sample is 79 and other indexes to determine the fitness of the measurement model.

In this study, the exploratory factor analysis (EFA) was not carried out because the constructs and indicators are based on an existing theory (SECI model). Meanwhile, the EFA was utilized to identify the variables in each construct in which the construct was determined through factor analysis (Hair, Anderson, Tatham & Black, 2006). The items in this study are categorized into five constructs (Socialization, Externalization, Combination, Internalization and Performance) which are formed based on the relationships among the elements in the PBL teaching method. The criteria for model fit assessment for both the Confirmatory Factor Analysis (CFA) and SEM are presented in Table-1.

Table-1. Criteria for model fit assessment

Name of category	Name of index	Index full name	Level of acceptance	Literature	Comments
Absolute fit	Chisq	Chi-square	P > 0.05	Wheaton *et al*. (1977)	Sensitive to sample size > 200
	RMSEA	Root Mean Square Error of Approximation	RMSEA<0.08	Browne and Cudeck (1993)	Range 0.05 to 1.00 acceptable.
	GFI	Goodness of Fit Index	GFI > 0.90	Joreskog and Sorbom (1984)	GFI = 0.95 is a good fit
Incremental fit	CFI	Comparative Fit Index	CFI > 0.9	Bentler (1989)	CFI = 0.95 is a good fit
	TLI	Tucker-Lewis Index	TLI > 0.9	Bentler and Bonett (1980)	TLI = 0.95 is a good fit
	NFI	Normed Fit Index	NFI > 0.8	Reinard (2006)	NFI = 0.95 is a good fit
Parsimonious	Chisq/df	Chi Square/Degree of Freedom	Chi square/df < 5.0	Marsh and Hocevar (1985)	The value should be below 5.0.

Measurement for model specification.

A group of goodness-of-fit indexes were used to determine the fit of the respective measurement models (variables) and overall measurement model in this study. These indexes include Chi-Squared (Chisq), Root Mean Square Error of Approximation (RMSEA), Goodness of Fit Index (GFI), Comparative Fit Index (CFI) and Chi-Squared/degree of freedom (Chisq/df). In this study, a combination of all fit indices was used to assess a model.

The CFA procedures for socialization.

Figure-2 shows the CFA procedures for Socialization. As the indicators, factor loading for each item is stated. Additionally, the goodness-of-fit indices for Socialization measurement model is also stated. According to (Hair et al., 2006), an acceptable factor loading (significant) is greater than 0.30. Then, Table-2 describes the Socialization measurement model. Hence, with reference to Figure-2, eight items have to be removed, because they have factor loadings less than 0.3. Having tested the new model, new values for goodness-of-fit indexes are depicted in Table-2. The new loadings for Socialization ranged from 0.3 to 0.9.

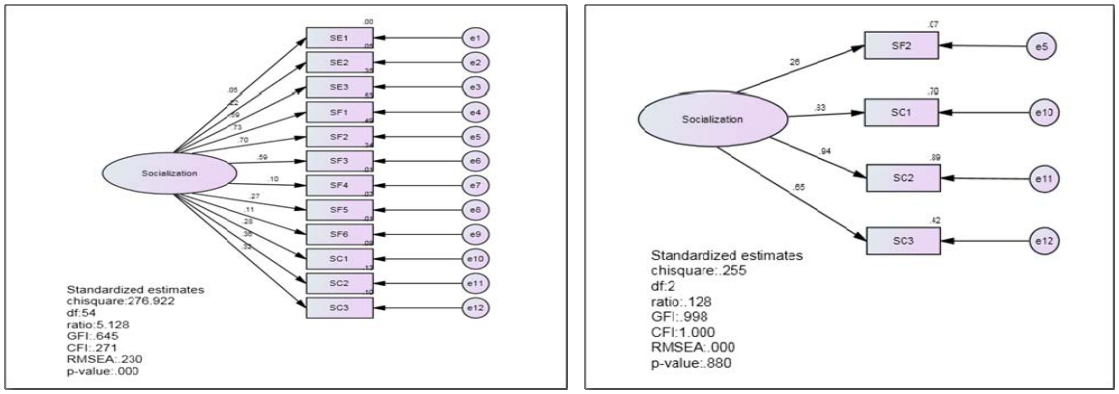

Figure -2. The socialization – CFA.

Table-2. The assessment of fitness for the socialization measurement model.

Fit Indices	Fit statistics	Recommended fit criteria	Conclusion
Absolute fit indices			
Chisq	0.255	P > 0.05	Satisfactory
RMSEA	0.000	RMSEA<0.08	Satisfactory
GFI	0.998	GFI > 0.90	Satisfactory
Incremental fit indices			
CFI	1.000	Over 0.90	Satisfactory
Parsimony fit index			
Chiq/df (Ratio)	0.128	Below 5	Satisfactory

The CFA procedures for externalization.

Figure-3 illustrates the CFA procedures for Externalization, which is described by Table-3. Figure-3 illustrates the factor loading for each item and goodness-of-fit indices for Externalization measurement model. Similarly, all (12) items that have factor loading less than 0.30 have been removed and new values for goodness-of-fit indices are summarized in Table-3. The new loadings for Externalization ranged from 0.5 to 0.8.

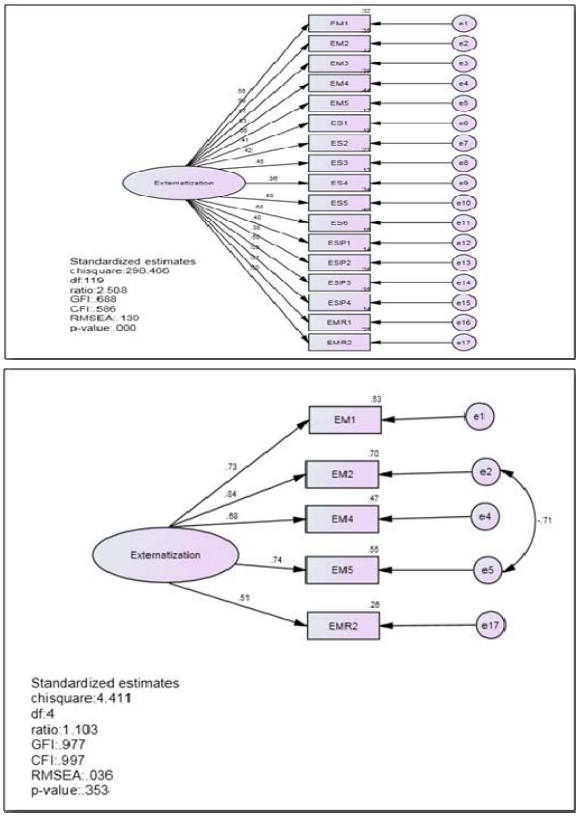

Figure-3. The externalization – CFA.

Table-3. The assessment of fitness for the externalization measurement model.

Fit indices	Fit statistics	Recommended fit criteria	Conclusion
Absolute fit indices			
Chisq	4.411	P > 0.05	Satisfactory
RMSEA	0.036	RMSEA<0.08	Satisfactory
GFI	0.977	GFI > 0.90	Satisfactory
Incremental fit indices			
CFI	0.997	Over 0.90	Satisfactory
Parsimony fit index			
Chiq/df (Ratio)	1.103	Below 5	Satisfactory

Table-4. The assessment of fitness for the combination measurement model.

Fit indices	Fit statistics	Recommended fit criteria	Conclusion
Absolute fit indices			
Chisq	0.751	P > 0.05	Satisfactory
RMSEA	0.000	RMSEA<0.08	Satisfactory
GFI	0.995	GFI > 0.90	Satisfactory
Incremental fit indices			
CFI	1.000	Over 0.90	Satisfactory
Parsimony fit index			
Chiq/df (Ratio)	0.375	Below 5	Satisfactory

The CFA procedures for combination

Further, the CFA procedures and measurement model for Combination is illustrated in Figure-4 with the new values for goodness-of-fit indices, described by Table-4. It is seen that eight items have factor loading less than 0.3. As a result, those items were removed and new values for goodness-of-fit indices are summarized in Table-4. Consequently, the new loadings for Combination ranged from 0.5 to 0.9.

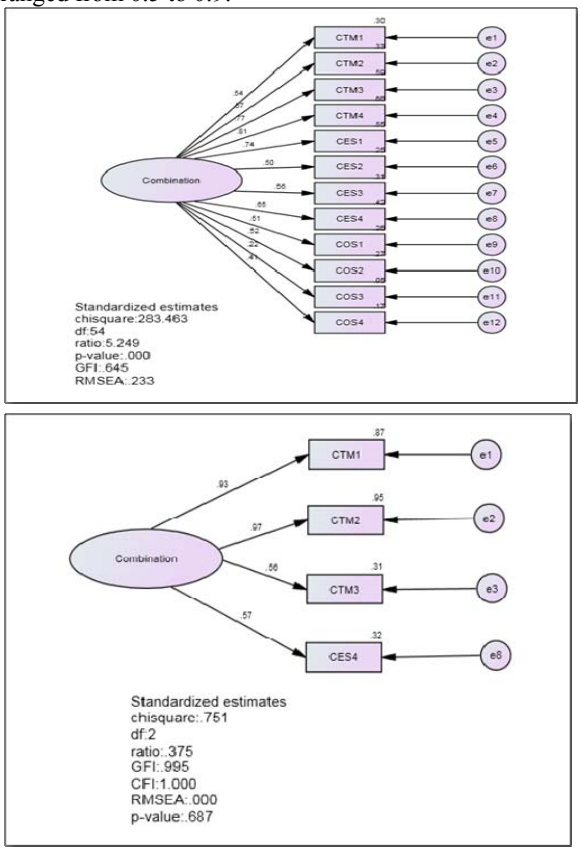

Figure-4. The combination CFA.

The CFA procedures for internalization

The CFA for Internalization and the measurement model are illustrated in Figure-5, described by Table-5. Figure-5 also states the factor loading for each item and goodness-of-fit indexes for Internalization measurement model. When all items with factor loading less than 0.3 have been removed, only six items remain in the model. Having run the test, their factor loadings range between 0.5 and 0.9. Eventually, the new values for goodness-of-fit indexes are summarized in Table-5.

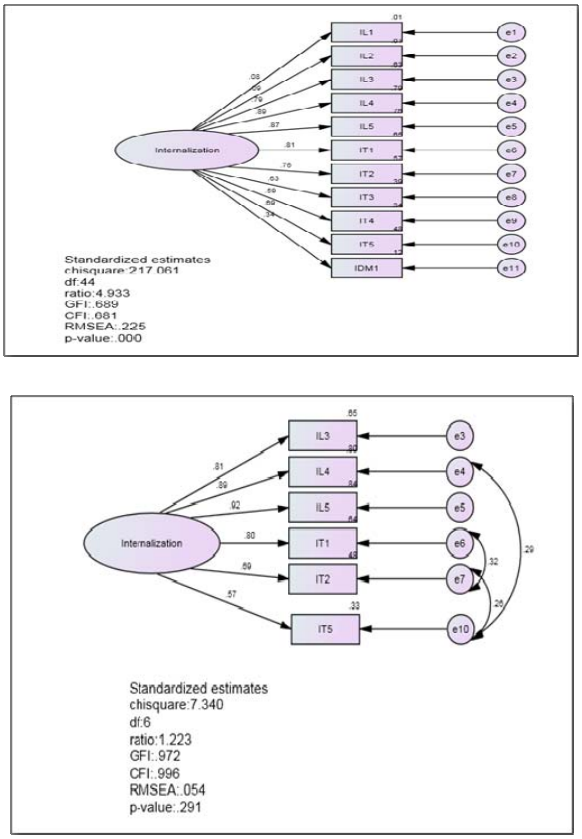

Figure-5. The internalization – CFA.

Table-5. The assessment of fitness for the internalization measurement model.

Fit Indices	Fit statistics	Recommended fit criteria	Conclusion
Absolute fit indices			
Chisq	7.340	P > 0.05	Satisfactory
RMSEA	0.054	RMSEA<0.08	Satisfactory
GFI	0.972	GFI > 0.90	Satisfactory
Incremental fit indices			
CFI	0.996	Over 0.90	Satisfactory
Parsimony fit index			
Chiq/df (Ratio)	1.223	Below 5	Satisfactory

The measure of validity and reliability of a measurement model. Once the CFA for the measurement is completed, the requirement for unidimensionality, validity and reliability are needed before analysis of correlation can be done (Awang, 2012). Hence, we list down requirements as suggested by (Awang, 2012) as follows:

- The requirement for unidimensionality that has been achieved through the item-deletion process and model re-specification.
- The requirement for validity that could be achieve through convergent validity, construct validity and discriminate validity.
  i. Average variance extracted (AVE) slightly above 0.50 might be acceptable - Convergent validity.
  ii. All fitness indexes for the model meet the requirement level - Construct validity.
  iii. All redundant items are either deleted or constrained, and correlation between exogenous construct is less and equal 0.85 - Discriminant validity.
- The requirement for reliability could be achieved through internal reliability, constructs reliability and average variance extracted.
  i. Cronbach alpha is greater and equal 0.60 - Internal Reliability.
  ii. Construct reliability (CR) greater and equal 0.60 - Construct Reliabilty.
  iii. AVE greater and equal 0.50 - Average Variance Extracted.

Table-6 shows the acceptable model fit that was obtained since all the chosen fit statistics was verified to the requirements. While all the factors have acceptable reliability value, each factor can also be measured individually depending on the nature of the research.

Table-6. The suggested CFA results reporting for measurement model.

Construct	Item	Factor loading	Cronbach alpha (above 0.6)	CR (above 0.6)	AVE (above 0.5)
Socialization	SF2	0.259	0.6420	0.7894	0.5189
	SC1	0.651			
	SC2	0.834			
	SC3	0.943			
Externalization	EM1	0.730	0.8470	0.8302	0.5001
	EM2	0.837			
	EM4	0.682			
	EM5	0.739			
	EMR2	0.508			
Combination	CTM1	0.934	0.834	0.8550	0.6114
	CTM2	0.972			
	CTM3	0.556			
	CES4	0.565			
Internalization	IL3	0.806	0.839	0.6742	0.6228
	IL4	0.893			
	IL5	0.918			
	IT1	0.800			
	IT2	0.692			
	IT5	0.573			

The diagonal values (in bold) are the square root of AVE while other values are the correlation between respective constructs, as presented in Table-7 below. The discriminant validity is achieved when a diagonal value in bold is higher than the values in its row and column. Before proceeding to the modeling the structural model, the normality assessment for the data needs to be examined. The value of skewness shows that all of the items have the skewness values that fall within the range of -1.0 and 1.0. This indicates that the data distribution is normally distributed.

Table-7. The Discriminant Validity Index Summary.

Construct	Socialization	Externalization	Combination	Internalization
Socialization	**0.7203**			
Externalization	0.602	**0.7072**		
Combination	0.336	0.398	**0.7819**	
Internalization	0.474	0.226	0.171	**0.7892**

CONCLUSIONS

This paper presented a study which was conducted to propose and evaluate a measurement model of knowledge transfer framework in PBL teaching method for SE education to understand the processes in transferring the tacit knowledge from lecturer to students. The study used a survey for data collection and the measurement model was tested using SEM with AMOS version 16.0. The study concludes that the framework is suitable for PBL teaching method in SE education. Therefore, the future work will concentrated on identifying the relationship of SECI model in PBL teaching method for SE education.

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