Modelling a Semantic Knowledge Management System for Collaborative Learning Environment Using a Structural Equation Modelling

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***Abstract*—Effective knowledge management system (KMS) should be able to deliver relevant knowledge to the right knowledge user at the right time. However, current KMS still largely relies on human efforts to access, extract and filter information pertinent to their knowledge need, resulted in inefficient process especially in collaborative learning environment. Effective KMS requires the identification of proper technology designed with the right system features to support the knowledge management (KM) activities to ensure that the goals of KM will be achieved. This study analyzed the proposed Semantic KMS Model for Collaborative Learning Environment using structural equation modelling (SEM) to test the effects of the model constructs in achieving the KM goals of KMS used in organizations. The model build upon comprehensive reviews of existing models in literature, and a prototype called Semantic Knowledge Management System for Collaborative Learning (SKMSCL) is developed to translate the constructs into KMS features. A post-implementation survey was conducted to assess the semantic KMS prototype in terms of the system quality, knowledge quality and the semantic KMS features identified, and how well the SKMSCL support the KM goals in comparison with the current KMS used in higher learning institutions (HLIs). Data was collected via questionnaire from a private university who participated in this study. Since there were no references can be found on the relationship between KMS knowledge quality, system quality and semantic KMS features and KM Goals, eleven research questions are derived from the model rather than hypotheses. In summary, findings indicated that seven out of eleven research questions tested are significant and supported by the findings.**

***Index Terms*—Knowledge Management; Knowledge Management System; Semantic Knowledge Management.**

I. INTRODUCTION

Today's dynamic environment require knowledge as one of the vital success factors for organizations' to survive. Organizations need to effectively apply knowledge management (KM) to ensure continuous knowledge creation for competitive advantage and survival [1]. The goal of KM is to connect relevant knowledge to people in the organization whenever they need the knowledge. KM involves the management of knowledge activities, practices, programs and policies in an organized and clearly defined manner within organizations [2].

Many organizations often tempted to believe that technology is the main solution for KM implementation. However, adopting information technology (IT) without carefully understanding its capability to suit the KM requirements and their organizations' KM needs may result in KM project failure. It is therefore very crucial to understand the capabilities of the technology that is properly aligned to the knowledge activities in the organization and to identify the critical features of the knowledge management system (KMS) to ensure that it achieves the KM goals of the organization.

Leveraging associated technology for dissemination and communication with the Semantic Web, the potential is enormous, especially in learning environment. Even though there are effective software systems to support knowledge work currently, however, current KMS is inadequate in several ways which resulted in inefficient process especially in collaborative learning environment. Successful KMS requires the identification of proper technology designed with the right system features to support the KM activities to ensure that the goals of KM will be achieved.

Much interest in the modern KM research fields has been inspired by the idea of recent Semantic Web technology for improved KM. The goal of Semantic Web is to provide a unified information medium that can be understood by human and machines, hence meaningful inferences can be made. The ability of machines to make meaningful inferences enable the automation or semi-automation of certain tasks [3]. This new idea has led to serious discussions on the impact of Semantic Web technologies such as XML and RDF for developing web-based KMS. This is where semantically enhanced learning objects and active documents with meaningful descriptions that can be understood by computers is very much needed to fully exploit the web technologies for supporting education's community of practice (CoP) [4].

In this research, a KMS model is formulated to support collaborative learning environment based on semantic technology. A comprehensive review was conducted to identify the important components of existing models in KM, KMS, semantic technology and collaborative learning, which resulted in a preliminary model for Semantic KMS for Collaborative Learning (SKMSCL) Environment. Detailed discussion on the preliminary model development can be found in [5]. This preliminary model was modified and the model's constructs are finalized based on the survey results distributed to higher learning institutions (HLIs) students and lecturers, and further examined by KM experts to verify the proposed semantic KMS components.

In addition, the post-survey results are analyzed using structural equation modeling (SEM) to assess the overall fit of the proposed model and to test the structural model. SEM can be used to evaluate the hypothesized structural linkages among constructs and also to assess the linkages that exist between a construct and its respective measures ([6], [7]). This paper shall discuss the proposed model testing using SEM.

II. THEORETICAL FRAMEWORK

The research model is proposed based on a model of KMS limitation factors proposed by [8]. Joo and Lee (2009) applied the reverse perspective of the popular IS success model by Delone and McLean (1992). They proposed system quality and information quality as important factors that affect user satisfaction and organizational performance. The model of KMS limitation provides the characteristics of KMS and suggested an approach in applying semantic to the KMS and proposed four factors related to system quality: 1) Time/Space; 2) Inconvenience, 3) Knowledge Search and 4) Knowledge Integration, and two factors related to knowledge quality: 1) incongruence/ incompleteness of knowledge and 2) untrustworthiness of knowledge.

As shown in Figure 1, there are five important variables synthesized from the LR and the survey conducted. The KMS needs to facilitate the KM Process to support the work in collaborative learning environment. The five main constructs are identified as critical elements for implementing KMS. The Ontology-based Knowledge Model realized the semantic KMS features such as semantic knowledge search, knowledge filtering and personalization. The semantic features of KMS have significant impact on the system quality which facilitate the KM processes hence achieve the KM goals. Similarly, the Ontology- based Knowledge Model also increase the knowledge quality in the KMS, which contributes to better utilization of knowledge in the KMS and facilitate the achievement of KM Goals. The entire collaboration processes are enhanced when the KMS is built on quality knowledge with semantic capabilities. The Knowledge Quality and System Quality influence the facilitation of the KM Process hence achieved the KM Goals of the specific organization.

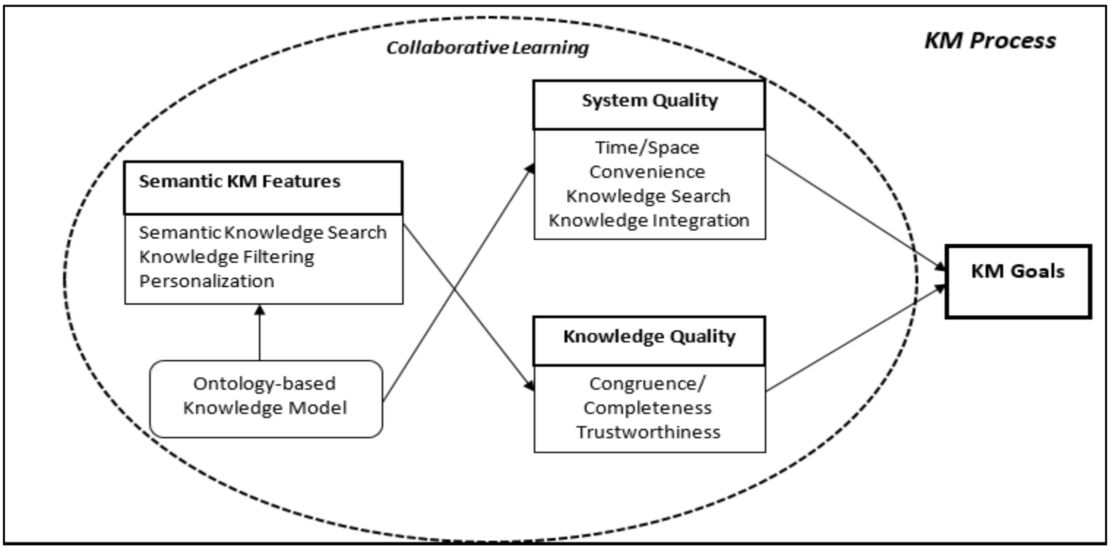

Figure 1: A Semantic KMS Model for Collaborative Learning Environment

III. RESEARCH MODEL AND RESEARCH QUESTIONS

Eleven research questions are derived based on the proposed research model. Since there were no references can be found on the relationship between KMS knowledge quality, system quality and semantic KMS features and KM Goals, the research questions are used rather than hypotheses. The approach had also been used by [6] in their study.

Q1: Does congruence and completeness of knowledge of the KMS has a positive impact on KM Goals?
Q2: Does trustworthiness of knowledge content in the KMS has a positive impact on KM Goals?
Q3: Does the time/space factor of the KMS has a positive impact on KM Goals?
Q4: Does the knowledge search feature of the KMS has a positive impact on KM Goals?
Q5: Does the knowledge integration feature of the KMS has a positive impact on KM Goals?
Q6: Does the convenience of knowledge provided by the KMS has a positive impact on KM Goals?
Q7: Does the semantic knowledge search feature of the KMS has a positive impact on KM Goals?
Q8: Does the knowledge filtering feature of the KMS has a positive impact on KM Goals?
Q9: Does the personalization feature of the KMS has a positive impact on KM Goals?
Q10: Does the knowledge integration feature of the KMS has a positive impact on semantic knowledge search?
Q11: Does knowledge filtering feature of the KMS has a positive impact on personalization?

To analyze the research model we used the Partial Least Squares (PLS) analysis using the SmartPLS 3.0 software [9] using two-stage analytical procedures: the measurement model is tested for validity and reliability measures, then the structural model is examined for the purpose of testing the hypothesized relationship [10]. To test the significance of the path coefficients and the loadings, a bootstrapping method (5000 resamples) was used [10].

IV. Research Methodology

This study comprised of five main phases and their research activities for each of the phases are described below:

A. Phase 1- Literature Review

The first phase of the study started with a literature review of important topics related to the study. The aim of these activities is to study the limitations of current KMS implemented to support teaching and learning processes at the HLIs and to identify important KM components to manage knowledge to support collaborative works in this setting. In depth review of literature covered on related topics such as KM, KMS, collaborative learning and Semantic technology. A comparison study has been performed on KM models/frameworks, KMS models/frameworks and semantic KMS model/frameworks to critically analyze and identify the important components of KMS.

B. Phase 2- Preliminary Study

A preliminary study is conducted among academicians as the knowledge providers and students as the knowledge users in HLIs in Malaysia. The preliminary study involves two-phased design: (i) Survey for academicians to identify the difficulties faced in managing teaching and learning activities and survey for students aim to identify the desired features of KMS to support teaching and learning in HLI; and (ii) Interview that provides the qualitative analysis about the problems to be solved.

C. Phase 3- Model Development

The model is formulated based on the identified components from literature review and empirical analysis performed in Phase 1 and also the findings from preliminary study performed in Phase 2 of research methodology. This preliminary model was modified and the model's constructs and variables are finalized based on the survey results distributed to HLIs students and lecturers, and further examined by KM experts to verify the proposed semantic KMS components. As a result, the proposed semantic KMS model consisted of seven important components to support collaborative works in HLI setting. These seven components are identified as critical elements for implementing KMS; Ontology-based Knowledge Model, KM Processes, Knowledge Quality, System Quality, Semantic KMS Features, KM Goals and Collaborative Learning Features to ensure successful implementation of KMS to support the goals of KM. Structural equation modeling (SEM) is then used to analyze the structural relationship between measured variables and latent constructs of the models. The details discussion on how the model is developed has been discussed in [5].

D. Phase 4: Prototype Development and Model Validation

A prototype, called Semantic KMS for Collaborative Learning (SKMSCL) was developed to illustrate how the model constructs and variables are supporting KM processes in collaborative works based on the formulated System Requirements Specifications (SRS). The SRS is discussed in [11]. To evaluate the KMS model constructs and variables, a post- implementation survey adapted from Joo & Lee (2008) was conducted to assess the semantic KMS prototype in terms of the system quality and knowledge quality of the system, and how well the SKMSCL support the KM goals in comparison with the current KMS used in HLIs.

To test the proposed model, a post-implementation survey of the developed prototype was conducted. The respondents are selected through convenience sampling technique to assess the prototype by answering the survey questionnaires. The respondents selected are the undergraduate students from University Tenaga Nasional. The students are given four weeks' time frame to explore and use the prototype. After the time frame ended, the students are gathered in a laboratory and an online survey is conducted in the laboratory to assess their perception on the effectiveness and efficiency of the system's features in supporting the KM goals. A four point Likert scale (strongly agree to strongly disagree) is used to assess the agreeable level of respondents for each of the items tested in the questionnaire. The questionnaires items are derived from literatures and also adapted from [8].

E. Phase 5: Model Evaluation and Discussion

The aim of this phase is to validate and demonstrate that the proposed semantic KMS model is indeed able to support collaborative work of knowledge users hence is useful in guiding the KM practitioners to develop an effective and efficient KMS to facilitate their KM initiative in organizations.

V. Measurement Model

For the measurement model, at first, the convergent validity which is the degree to which multiple items measuring the same concept are in agreement is examined. To assess convergent validity, factor loadings, composite reliability (CR) and average variance extracted (AVE) are extracted as suggested by [7]. Next, the discriminant validity is then assessed by using two measures: 1) Fornell and Larcker (1981) criterion [12], and 2) cross loading. A measurement model has discriminant validity when 1) the square root of the AVE exceeds the correlations between the measure and all other measures, and 2) the indicators' loadings are higher against their respective variable compared to other variables.

A. Convergent Validity

Factor loading for all items exceeded the recommended value of 0.5 suggested by [7] after deletion of four items due to low factor loadings (shown in Table 1). CR values which depict the degree to which the construct indicators indicate the latent construct ranged from 0.738 to 0.914 which exceeded the recommended value of 0.7 [7]. The AVE, which reflects the overall amount of variance in the indicators accounted for by the latent construct, were in the range of 0.414 and 0.842. The AVE for two constructs, KM Goals (AVE= 0.414) and Semantic Knowledge Search (AVE= 0.489) are less than 0.5 which is below the recommended value of 0.5 [7], whilst AVE for all other constructs are above 0.5.

An AVE of 0.5 or more indicate satisfactory convergent validity, as it means that the latent construct accounts for 50% or more of the variance in the observed variables, on the average. If the AVE is less than 0.5, the variance due to measurement error is larger than the variance captured by the construct. However, since all the CR > 0.7, the convergent validity is adequate [13]. Table 1 shows the detail results of the measurement model.

B. Discriminant Validity

The measurement model's discriminant validity is assessed by the [12] criterion. Factor and cross loadings of all items to their respective latent constructs are extracted and shown in Table 2. The results indicated that all items loaded: on their respective constructs from a lower bound of 0.643 to an upper bound of 0.918. The bolded elements in Table 2 represent the square roots of the AVE and the non bolded values represent the intercorrelation value between the constructs. All the off-diagonal elements are lower than the square roots of the AVE (bolded on the diagonal). Hence, the results confirmed that the Fornell and Larcker's criterion is met.

Table 1
Measurement Model

Constructs	Items	Loading	CR	AVE
Time/ Space	TSL1	0.941	0.903	0.824
	TSL2	0.873		
Convenience of Knowledge	IC1	0.938	0.914	0.842
	IC2	0.896		
Knowledge Search	KSL1	0.715	0.817	0.528
	KSL2	0.748		
	KSL3	0.718		
	KSL4	0.724		
Knowledge Integration	KI1	0.866	0.862	0.758
	KI2	0.875		
Congruence/ Completeness of Knowledge	IIK1	0.657	0.852	0.537
	IIK2	0.808		
	IIK3	0.775		
	IIK4	0.664		
	IIK5	0.747		
Trustworthiness of Knowledge	UWK1	0.811	0.843	0.642
	UWK2	0.853		
	UWK3	0.734		
Semantic Knowledge Search	SKS1	0.696	0.793	0.489
	SKS2	0.702		
	SKS3	0.696		
	SKS4	0.703		
Knowledge Filtering	KF1	0.742	0.815	0.595
	KF3	0.796		
	KF4	0.775		
Personalization	CP2	0.721	0.839	0.511
	CP3	0.719		
	CP4	0.655		
	CP5	0.795		
	CP6	0.676		
KM Goals	OKM1	0.644	0.738	0.414
	OKM2	0.613		
	OKM3	0.675		
	OKM4	0.640		

The second assessment is to examine the indicators' loadings with respect to all construct correlations. All measurement items loaded higher against their respective intended latent variable compared to other variables. Thus, the cross loading output confirmed that the second assessments of the measurement model's discriminant validity are satisfied.

Overall, the reliability and validity tests conducted on the measurement model are satisfactory. All the reliability and validity tests are confirmed where all indicators that are used in the measurement model for this study is valid and fit to be used to estimate the parameters in the structural model.

In addition, standardized root mean square residual (SRMR) was run to test the model fit. Although there are many measures of model fit, the only one which is available in Smart PLS is the SRMR. The SRMR is an absolute measure of fit and is defined as the standardized difference between the observed correlation and the predicted correlation. A value less than 0.08 is generally considered a good fit [14]. The SRMR value for the proposed model just very slightly missed the significance level (p=0.086), and is still consider fit for further analysis.

VI. STRUCTURAL MODEL

The validity of the structural model is assessed using the coefficient of determination (R2) and path coefficients. The R2 value indicates the amount of variance in dependent variables that is explained by the independent variables. Thus, a larger R2 value increases the predictive ability of the structural model. In this study, SmartPLS algorithm function is used to obtain the R2 values, while the SmartPLS bootstrapping function is used to generate the t-statistics values. For this study, the bootstrapping generated 500 samples from 145 cases. The result of the structural model is presented in Figure 2.

SmartPLS bootstrapping function is used to test the significant level, t-statistics for all paths. Table 4 lists down the path coefficients, observed t-statistics, and significance level for all hypothesized path. Using the results from the path assessment, the acceptance or rejection of the proposed research questions are determined.

Table 2
Discriminant Validity of Variable Constructs

Construct	1	2	3	4	5	6	7	8	9	10
1. Congruence/Completeness	**0.733**									
2. Convenience	0.544	**0.918**								
3. KM Goals	0.478	0.444	**0.643**							
4. Knowledge Filtering	0.472	0.501	0.555	**0.771**						
5. Knowledge Integration	0.372	0.433	0.438	0.398	**0.871**					
6. Knowledge Search	0.521	0.477	0.533	0.501	0.276	**0.727**				
7. Personalization	0.570	0.470	0.506	0.526	0.387	0.670	**0.715**			
8. Semantic Knowledge Search	0.490	0.460	0.515	0.550	0.277	0.564	0.693	**0.699**		
9. Time/Space	0.500	0.531	0.466	0.526	0.277	0.372	0.365	0.324	**0.908**	
10. Trustworthiness	0.399	0.306	0.373	0.426	0.233	0.455	0.409	0.326	0.379	**0.801**

First, we looked at the predictors of KM Goals, which were Congruence/Completeness of knowledge, Trustworthiness Time/Space, Convenience, Knowledge Search, Knowledge Integration, Personalization, Semantic Knowledge Search and Knowledge Filtering. Time/Space (β= 0.170, $p<0.05$), Knowledge Search (β= 0.216, $p<0.05$), Knowledge Integration (β= 0.213, $p<0.01$), Semantic Knowledge Search (β= 0.188, $p<0.05$) and Knowledge Filtering (β= 0.163, $p<0.05$) were all positively related to KM Goals explaining the 48.3% of the variance in KM Goals. Thus, Q3, Q5, Q6, Q8 and Q9 were supported. The R2 value of 0. 483 was above the 0.26 value as suggested by Cohen (1988) indicating a substantial model.

However, Congruence/Completeness of knowledge (β= 0.055), Trustworthiness (β= 0.03), Convenience (β= -0.037) and Personalization (β= -0.024) had non-significant influence on KM Goals. Thus, Q1, Q2, Q4 and Q7 were not supported by the findings.

Next, the predictor for Semantic Knowledge Search which was Knowledge Integration (β= 0.277, $p<0.01$) also positively related to Semantic Knowledge Search explaining 7.7% variance in Semantic Knowledge Search. Thus, Q10 was supported. The R2 value of 0. 276 was above the 0.26 value as suggested by [6] indicating a substantial model.

Lastly, the predictor for Personalization which was Knowledge Filtering (β= 526, $p<0.01$) also positively related to Semantic Knowledge Search explaining 6.6% variance in Personalization. Hence, Q11 was also supported. The R2 value of 0.077 was above the 0.02 value as suggested by [6] indicating a weak model.

Next, we also assessed effect sizes (f2) to determine the size of the effect. The f2 values is essential to be reported together with the P value. The effect size was measured using [6] which suggested 0.02, 0.15 and 0.35 to represent small, medium and large effects respectively [6] as shown in Table 3.

The results presented in Table 3 indicate that seven out of eleven research questions tested are significant and supported by the findings. The resulting KMS success model for collaborative learning is shown in Figure 2.

Table 3
Research Questions Testing

RQ	Relationship	Std Beta	Std Error	t-value	Decision	R^2	f^2
Q1	Congruence/Completeness -> KM Goals	0.055	0.090	0.615	Not Supported	0.483	0.003
Q2	Trustworthiness -> KM Goals	0.030	0.066	0.452	Not Supported		0.001
Q3	Time/Space -> KM Goals	0.170	0.082	2.073*	Supported		0.032
Q4	Convenience -> KM Goals	-0.037	0.096	0.386	Not Supported		0.001
Q5	Knowledge Search -> KM Goals	0.216	0.099	2.183*	Supported		0.042
Q6	Knowledge Integration -> KM Goals	0.213	0.074	2.880**	Supported		0.064
Q7	Semantic Knowledge Search -> KM Goals						
Q8	Knowledge Filtering -> KM Goals	0.163	0.098	1.654*	Supported		0.025
Q9	Personalization -> KM Goals	-0.024	0.115	0.209	Not Supported		0.000
Q10	Knowledge Integration -> Semantic Knowledge Search	0.277	0.070	3.955**	Supported		0.083
Q11	Knowledge Filtering -> Personalization	0.526	0.066	7.932**	Supported	0.077	0.382

**$p<0.01$, *$p<0.05$

VII. Discussions of the Findings

Based on the research findings, the facilitation of the KM goals by the KMS are found to be positively influenced by System Quality component and Semantic KM Features. Three of the constructs of System Quality which are Time/Space, Knowledge Search and Knowledge Integration are found to have significant impact on the KMS main goals; know-how, know-who, know-when, know-why and know-where. However, one of the construct (Convenience) in the

System Quality as proposed by [8] was found to be not significantly related to KMS performance in supporting the goals of KM.

Semantic Knowledge Search is found to be influenced by the Knowledge Integration construct, hence suggesting that the ability to integrate knowledge from different sources is important to allow more meaningful search by the knowledge users in collaborative environment. As KM Goals is also found to be positively influenced by Semantic Knowledge Search, consequently the Semantic Knowledge Search feature in KMS will facilitate the knowledge users to search for knowledge in KMS with minimal efforts required. KM Goals is also influenced positively by Knowledge Filtering. As large knowledge sources in KMS can be automatically filtered based on the user's profile, the efforts required from the knowledge users to find and search for relevant knowledge will be lesser and can be done much faster. This will lead to better utilization of knowledge in collaborative learning setting hence supporting the KMS goals. Contradict, KM Goals is not significantly influenced by Personalization features in the KMS.

The results also demonstrated that KM Goals is not significantly influenced by the Knowledge Quality of the KMS. Both of the variables namely Congruence/ Completeness of knowledge and Trustworthiness in the Knowledge Quality component are not supported by the results. In contrast, the literatures highlighted knowledge quality as one of the critical feature for better knowledge utilization in KMS. Hence, these results are questionable and this might be due to several reasons. The mean scores for both of the items used to measure these two variables are all above 3 (These two constructs might be important for KMS satisfaction level but not significantly important in terms of improving the performance of the KMS in achieving the KM Goals.

To conclude, seven research questions (i.e., Q3, Q5, Q6, Q8, Q9, Q10 and Q11) are supported by the empirical findings and four research questions (i.e., Q1, Q2, Q4 and Q7) are not supported.

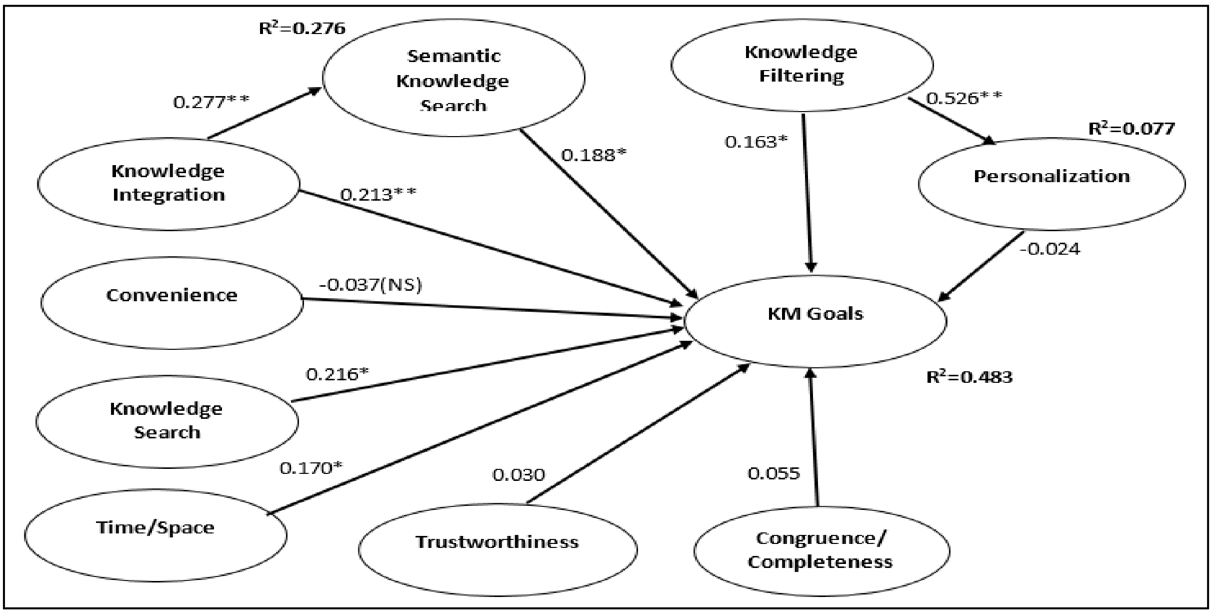

Figure 2: Structural Model Results

VIII. CONCLUSION

In summary, this paper proposed a conceptual model of a semantic KMS for collaborative learning environment. The relationship between the proposed model's constructs has been tested and the structural model results are presented. The concluding remark made is that all constructs are perceived important and determine the quality of the KMS to ensure that the KM goals are achieved. However, four of the research questions were found not significant hence not supporting the proposed relationship between the variables of the construct. This might be due to several reasons.

Since this study proposed a model of Semantic KMS, which is considered quite new area in KM field might explain this results. Whilst several studies have been conducted to propose semantic technology for KM, no effort has been found to address the impact of KMS features in supporting the KM main objective of connecting knowledge users and to promote knowledge sharing by providing the capability of the KMS deliver knowledge to the right user at the right time.

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