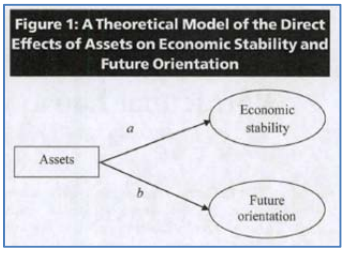
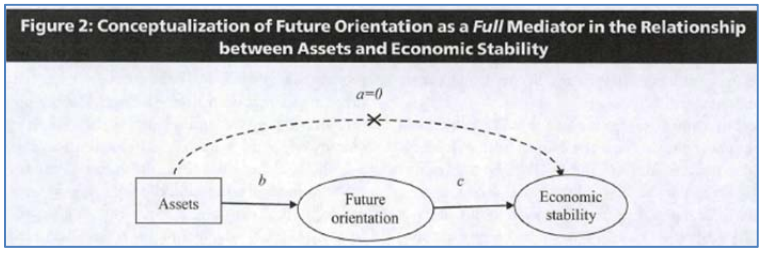
Examples of SEM in Various Fields of Study

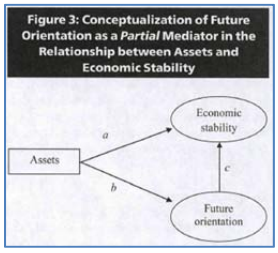
Public Policy

Anson, D., Chowa, G. A. N., & Grinstein-Weiss, M. (2013). Future orientation as a mediator between assets and perceived household economic stability: A structural equation modeling approach. *National Association of Social Workers, 37*, 147-158. DOI: 1O.lO93/swr/srtO12

Abstract: *This article tests the mediation effects of future orientation in the relationship between assets and perceived economic stability. The first model, proposed by Sherraden, presents the direct effects of assets on perceived economic stability without any intermediary role of future orientation. The second model presents a model of asset effects on perceived economic stability that is fully mediated by future orientation as proposed by Shobe and Page-Adams. The authors propose a third model with a partial mediation role of future orientation. Using structural equation modeling, the authors test these hypotheses and find that the full mediation hypothesis is a better fit. The authors present a discussion for the further development of asset theory.*







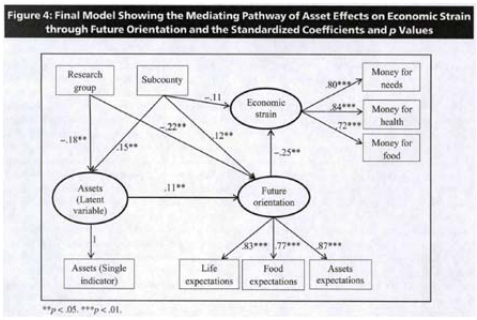
This article tests the following hypotheses:

1. *Original hypothesis (Sherraden's conceptualization): There is a direct effect of assets on both economic stability and future orientation (see illustration in Figure 1).*
2. *Alternative hypothesis (Shobe and Page- Adams's fuU mediation model): The effect of assets on economic stability is fully mediated by future orientation (see illustration in Figure 2).*
3. *Proposed hypothesis (partial mediation model); Controlling for future orientation, the effect of assets on economic stability is reduced but still significant (see illustration in Figure 3).* (p. 149)

Table 3: Model Fit Statistics

Model	χ^2	*df*	*p*	CFI	RMSEA	RMSEA 90% CI
Measurement model	10.54	8	.22	1	.03	0.00–0.069
Sherraden's model	32.51	22	.07	1	.04	0.00–0.058
Full mediation model[a]	27.12	22	.21	1	.02	0.00–0.051
Partial mediation model	24.31	21	.28	1	.02	0.00–0.049

Notes: CFI = comparative fit index; RMSEA = root mean square error of approximation; CI = confidence interval.
[a]Final model.



The purpose of this study was to test part of Sherraden's larger theorization of the welfare effects of assets and test and compare Shobe and Page- Adams's expansion of Shenaden's theory to the original hypothesis. In addition, this study proposed and tested the hypothesis that future orientation is a partial mediator in the relationship between assets and economic stability. The findings confirm the expanded hypothesis that the relationship between assets and economic strain may be fully mediated by future orientation, contrary to what Sherraden conceptualized as direct effects. It is important to note that even though Sherraden's hypothesis was rejected, part of his conceptualization (that is, direct effect from assets to future orientation) is consistent with the first part of the full mediation hypothesis in which assets directly affect future orientation. The theory of direct relationship between assets and future orientation is supported by a qualitative study of a savings account program for youths, which found that savings are positively associated with future orientation of youths (Scanlon & Adams, 2009). Support was found for the hypothesis that assets first affect future orientation after which future orientation affects perceived economic stability. (p. 155)

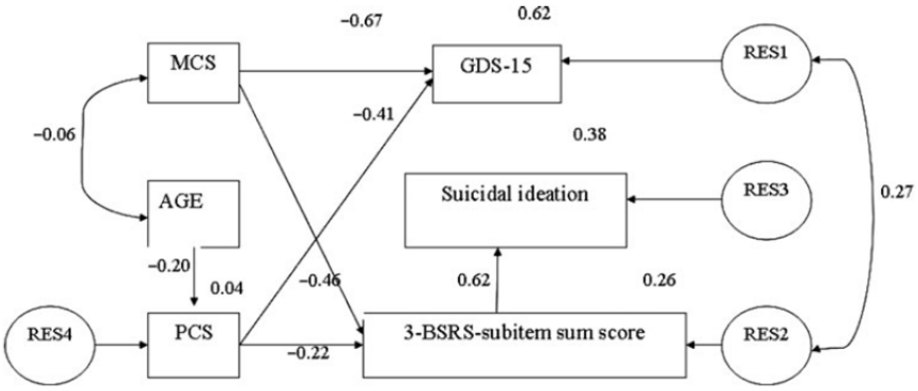
Examples of SEM in Various Fields of Study

Gerontology, Health Administration, & Policy

Chen, W. J., Chen, C. C., Ho, C. K., Chou, F. H., Lee, M., ... , & Sun, F. (2011). The relationships between quality of life, psychiatric illness, and suicidal ideation in geriatric veterans living in a veterans' home: a structural equation modeling approach. *American Journal of Geriatric Psychiatry, 19*, 597-601. DOI: 10.1097/JGP.0b013e3181faec0e

Abstract: Objective: *This study tested a structural model and examined the relationships between age, suicidal ideation, and scores on the 5-item Brief Symptom Rating Scale (BSRS-5), the 15-item Geriatric Depression Scale (GDS-15), and the Medical Outcome Study Short Form-12 (MOS SF-12) in a sample of veterans' home residents.* Methods: *Of the 266 individuals recruited, 226 completed the questionnaires, resulting in a response rate of 84.9%. Participants completed the BSRS-5, GDS-15, MOS SF-12, and a demographic survey. Analysis of Moment Structures, Version 7.0, was used to test the structural relationships of the model with a structural equation modeling analysis and a maximum likelihood ratio estimation. Patient subitem scores, which ranked their feelings of depression, hostility, and inferiority, were summed to determine their 3-BSRS-subitem sum scores.* Results: *The measures of model fitness were as follows: goodness-of-fit ($\chi 2 = 12.03$, $df = 7$, $p = 0.1$), goodness-of-fit index (0.98), adjusted goodness-of-fit index (0.95), comparative fit index (0.99), parsimony ratio (0.47), and root mean square error of approximation (0.06). All indices suggested that the final model fit the data well. Age was inversely related to physical component summary, which was inversely related to the 3-BSRS-subitem sum score. Mental component summary was inversely related to the 3-BSRS-subitem sum score and the GDS-15. Physical component summary was inversely related to the GDS-15. The 3-BSRS-subitem sum score correlated with suicidal ideation.* Conclusions: *The data reveal a significant relationship between quality of life and suicidal ideation, which may be affected more by the 3-BSRS-subitem sum score than by the GDS-15. The proposed model has the potential to help healthcare professionals effectively design and implement their suicide prevention programs.*

FIGURE 1. **Significant pathways in the final model using the *z*-test to determine whether each of these slopes is significant. The goodness-of-fit indices are as follows: $\chi^2 = 12.03$; $p = 0.10$; $df = 7$; GFI = 0.98; AGFI = 0.95; CFI = 0.99; P-ratio = 0.47; RMSEA = 0.06. AGFI: adjusted goodness-of-fit index; CFI: comparative fit index; df: degrees of freedom; GFI: goodness-of-fit index; and RMSEA: root mean square error of approximation**



To our knowledge, this study is the first to use SEM to outline the relationship between QOL and suicidal ideation in geriatric veterans. The use of SEM permits the simultaneous evaluation of the effects of QOL and psychiatric illness on suicidal ideation within the model. The present study shows a significant relationship between QOL and suicidal ideation, which may be mediated by the 3-BSRS-subitem (depression, inferiority, and hostility) sum score to a greater extent than that by the GDS-15. The better the clarification of the relationships between QOL, psychiatric illness, and suicidal ideation of geriatric veterans, the better healthcare professionals can develop their suicide prevention programs. (p. 601)

Examples of SEM in Various Fields of Study

Biology

Wu, X., Berkow, K., Frank, D. N., Li, E., Gulati, A. S., & Zhu, W. (2013). Comparative analysis of microbiome measurement platforms using latent variable structural equation modeling. *Bioinformatics, 14* (79), 1-11. DOI: 10.1186/1471-2105-14-79

Abstract: Background: *Culture-independent phylogenetic analysis of 16S ribosomal RNA (rRNA) gene sequences has emerged as an incisive method of profiling bacteria present in a specimen. Currently, multiple techniques are available to enumerate the abundance of bacterial taxa in specimens, including the Sanger sequencing, the 'next generation' pyrosequencing, microarrays, quantitative PCR, and the rapidly emerging, third generation sequencing, and fourth generation sequencing methods. An efficient statistical tool is in urgent need for the followings tasks: (1) to compare the agreement between these measurement platforms, (2) to select the most reliable platform(s), and (3) to combine different platforms of complementary strengths, for a unified analysis.* Results: *We present the latent variable structural equation modeling (SEM) as a novel statistical application for the comparative analysis of measurement platforms. The latent variable SEM model treats the true (unknown) relative frequency of a given bacterial taxon in a specimen as the latent (unobserved) variable and estimates the reliabilities of, and similarities between, different measurement platforms, and subsequently weighs those measurements optimally for a unified analysis of the microbiome composition. The latent variable SEM contains the repeated measures ANOVA (both the univariate and the multivariate models) as special cases and, as a more general and realistic modeling approach, yields superior goodness-of-fit and more reliable analysis results, as demonstrated by a microbiome study of the human inflammatory bowel diseases.* Conclusions: *Given the rapid evolution of modern biotechnologies, the measurement platform comparison, selection and combination tasks are here to stay and to grow – and the latent variable SEM method is readily applicable to any other biological settings, aside from the microbiome study presented here.*

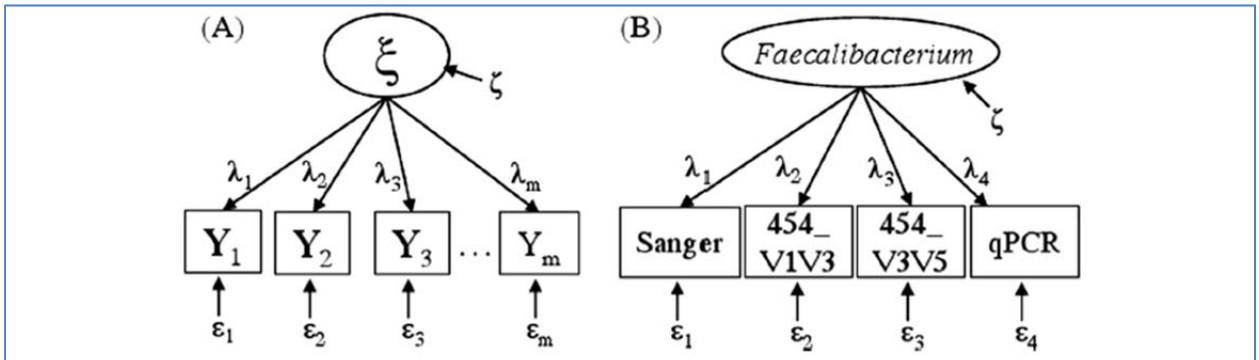


Figure 1 Path diagram for a latent variable SEM measurement model. (**A**) The general model with *m* measurements (observed variables) for one latent variable; (**B**) The measurement model with four measurements (Sanger, 454_V1V3, 454_V3V5 and qPCR) for the true (logit-transformed) relative frequency of *Faecalibacterium*.

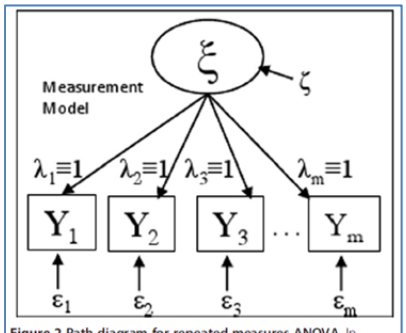


Figure 2 Path diagram for repeated measures ANOVA. In comparison to the latent variable SEM model (Figure 1A), repeated measures ANOVA assumes equal path coefficients for both the multivariate and univariate analysis approaches. In addition, for the univariate approach the measurement error variances, Var(ε_i), are assumed to be equal.

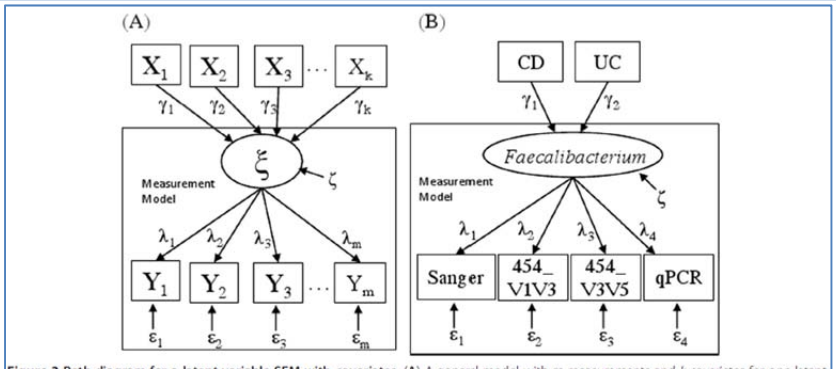


Figure 3 Path diagram for a latent variable SEM with covariates. (**A**) A general model with *m* measurements and *k* covariates for one latent variable ξ. (**B**) The model with four measurements (Sanger, 454_V1V3, 454_V3V5 and qPCR) and two covariates -- two binary disease indicators: CD (= 1 for subjects with Crohn's disease, and 0 otherwise), and UC (= 1 for subjects with ulcerative colitis, and 0 otherwise) for the true/latent (logit-transformed) relative frequency of *Faecalibacterium*.

Examples of SEM in Various Fields of Study

Biology (Cont'd.)`

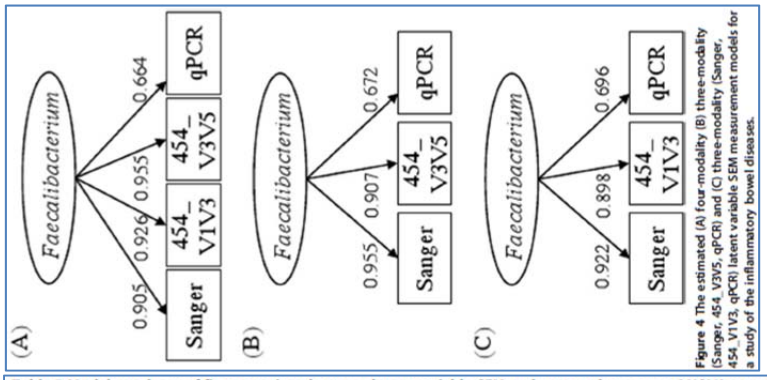


Figure 4 The estimated (A) four-modality (B) three-modality (Sanger, 454_V3V5, qPCR) and (C) three-modality (Sanger, 454_V1V3, qPCR) latent variable SEM measurement models for a study of the inflammatory bowel diseases.

Table 5 Model goodness-of-fit comparison between latent variable SEM and repeated measures ANOVA approach of *Faecalibacterium* based on four measurements (Sanger, 454 pyrosequencing V1V3, 454 pyrosequencing V3V5 and qPCR)

MODEL	MODEL CONSTRAINT	GOODNESS-OF-FIT	
A: Latent variable SEM	set only $\lambda_1 = 1$	Chi-square	5.089 (df = 2) Pr > χ^2: 0.079
		RMSEA	0.105
		CFI	0.994
B: Equivalent to repeated measures ANOVA (multivariate approach)	set all indicator path coefficient $\lambda_i \equiv 1$ (i = 1, 2, 3, 4)	Chi-square	129.955 (df = 5) Pr > χ^2: < .001
		RMSEA	0.421
		CFI	0.750
C: Equivalent to repeated measures ANOVA (univariate approach)	set all indicator path coefficient $\lambda_i \equiv 1$; set all indicator error variances to be equal, var $(\varepsilon_i) \equiv \sigma^2$ (i = 1, 2, 3, 4)	Chi-square	172.068 (df = 8) Pr > χ^2: < .001
		RMSEA	0.381
		CFI	0.671

In this work, we introduced the latent variable SEM as a versatile and effective analytical tool for measurement platform comparison and combination. While traditional SEM relied on the normality assumption for its parametric based inference, thanks to contemporary nonparametric techniques such as the bootstrap resampling method [22,24] and the rapid advancement of modern computers, one can readily perform non-parametric analysis of latent variable SEM when the data are not normal as we have shown in the analysis of a microbiome study of the human inflammatory bowel diseases. In the study of the gastrointestinal microbiome, we demonstrated that latent variable SEM can provide a robust means of integrating datasets derived from different experimental platforms. Moreover, it can gauge effectively the relative merits of different measurement platforms, in this example, Sanger sequencing, 454 pyrosequencing with two different target regions/windows, and qPCR. Joint panel studies [4] have shown that different 454 pyrosequencing windows may be optimal for different bacterial taxa. Their observations have been confirmed by our own analysis using the latent variable SEM measurement models (Table 4) based on the given IBD study – where the 454_V3V5 window are shown to be a better measurement platform for Proteobacteria, Actinobacteria, Bacteroidetes and Firmicutes/Bacilli in addition to the Faecalibacterium, while the 454_V1V3 window is found more reliable for Firmicutes/Clostridia/ Clostridiales/ LachnoIV. The joint study panel has also recommended sequencing microbiome with two 454 pyrosequencing windows such as V1V3 and V3V5 – which we can readily combine using the latent variable SEM for a unified joint analysis. Nevertheless, more works need to be done for a thorough treatment of the platform comparison problem. For example, we have yet to examine the rare taxa issue. Given that data from rare taxa will feature near zero counts and artificially low or suspiciously high variances, a robust version of the current latent SEM method needs to be developed for the occasion. (pp. 9-10)

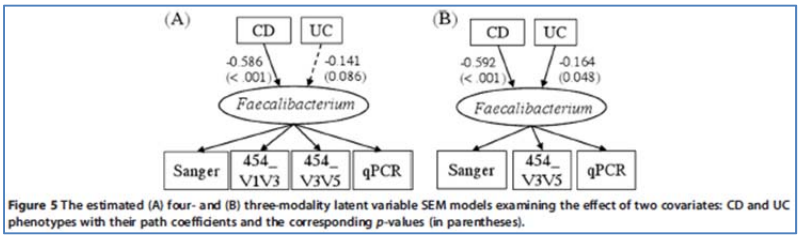


Figure 5 The estimated (A) four- and (B) three-modality latent variable SEM models examining the effect of two covariates: CD and UC phenotypes with their path coefficients and the corresponding *p*-values (in parentheses).

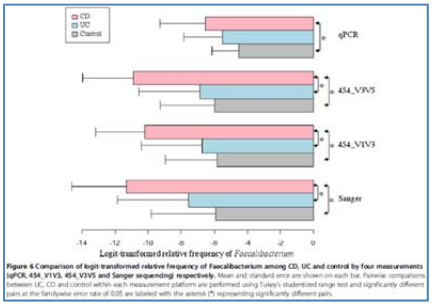


Figure 6 Comparison of logit-transformed relative frequency of Faecalibacterium among CD, UC and control by four measurements (qPCR, 454_V1V3, 454_V3V5 and Sanger sequencing) respectively. Mean and standard error are shown on each bar. Pairwise comparisons between UC, CD and control within each measurement platform are performed using Tukey's studentized range test and significantly different pairs at the familywise error rate of 0.05 are labeled with the asterisk (*) representing significantly different pairs.

Examples of SEM in Various Fields of Study

Language, Literacy, & Culture

Pishghadam, R., & Khajavy, G. H. (2012). Intelligence and metacognition as predictors of foreign language achievement: A structural equation modeling approach. *Learning and Individual Differences, 24*, 176-181. DOI:10.1016/j.lindif.2012.12.004

Abstract: *This study examined the role of metacognition and intelligence in foreign language achievement on a sample of 143 Iranian English as a Foreign Language (EFL) learners. Participants completed Raven's Advanced Progressive Matrices as a measure of intelligence, and Metacognitive Awareness Inventory as a measure of metacognition. Learners' scores at the end of the semester were aggregated as a measure of foreign language achievement. The findings revealed that intelligence accounts for 12.2% of the variance in foreign language achievement, and metacognition accounts for 17.6% of the variance. Although each of them had a unique impact on foreign language achievement, metacognition outweighs intelligence as a predictor of foreign language achievement. Finally, the pedagogical implications were discussed in light of foreign language achievement.*

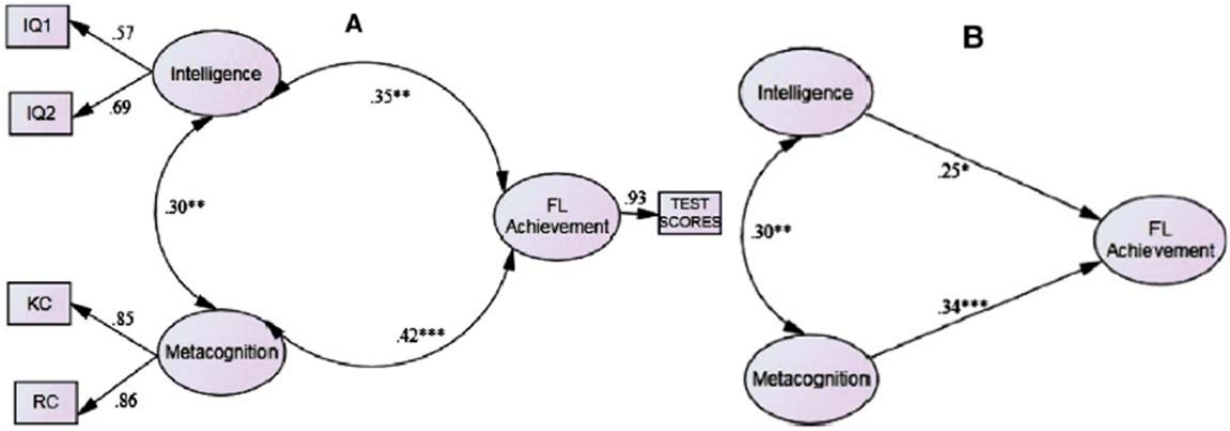


Fig. 1. Intelligence and metacognition as predictors of foreign language achievement. Observed variables for the model B is the same as for the model A. Note: KC=knowledge of cognition; RC=regulation of cognition. *pb.05.**pb.01.***.pb.001.

Table 2
Goodness of fit indices.

	χ^2	df	χ^2/df	GFI	TLI	CFI	RMSEA
Models A and B	5.52	3	1.84	.98	.97	.99	.06
Model B_1 ($\beta_{intelligence}=0$)	10.79	4	2.69	.97	.96	.98	.06
Model B_2 ($\beta_{metacognition}=0$)	11.66	4	2.91	.95	.95	.95	.05

Results of the study showed that intelligence and metacognition individually accounted for 12.2% and 17.6% of the variance in foreign language achievement, respectively. This finding shows that metacognition is a stronger predictor of foreign language achievement than intelligence. Taken together, intelligence and metacognition accounted for 23% of the variance in foreign language achievement, and each of them had a unique impact on foreign language achievement. Findings suggest that although metacognition predicts foreign language achievement stronger than intelligence, we cannot deny the unique role of intelligence as a determinant of foreign language achievement. Therefore, this study confirmed that the role of intelligence in language learning is the same as other skills, and one cannot ignore its unique contribution in this field. Results of this study also corroborated the mixed model in which metacognition contributed to learning (here foreign language achievement) on top of intelligence (Veenman, Wilhelm, & Beishuizen, 2004). It also confirms the claims of Chamot and O'Malley (1994) who stated that metacognition is one of the major factors in determining the effectiveness of individuals' attempts for learning another language. It shows that if L2 learners have a low level of intellectual ability, their metacognitive ability can compensate for this shortcoming. However, it should be mentioned that metacognition is achieved through observation and vicarious learning which highlights the role of others (peers, parents, and teachers) in this process. Prior studies had examined the mixed model in different tasks and fields (see Veenman et al., 2004), but L2 learning was not among them. Therefore, the present study confirmed that the mixed model can be generalized to L2 learning in EFL contexts. (pp. 179-180)

Examples of SEM in Various Fields of Study

This Page Left Blank Intentionally

Examples of SEM in Various Fields of Study

Information Systems and Human-Centered Computing

Misra, H. (2008, June). Users' computer human interface capabilities in information system development life cycle: An organizational perspective. *Proceedings of the Engineering Management Conference, 2008. IEMC Europe 2008. IEEE International, 2008,* 1-5. DOI: 10.1109/IEMCE.2008.4618039

Abstract: *Computer Human interaction (CHI) capabilities are critical for successful systems development life cycle (SDLC) in order to manage information systems (IS) effectively. CHI capabilities play crucial roles in interfacing information technology (IT) deployment with organisational goals. It is said that success of IT deployment is dependent on a successful process, usability, usefulness of IS products and services which are CHI centric. End-users in the organisation contribute the most towards CHI issues and their capabilities influence success of IT deployment projects. However, modern SDLC models are based more on organizational needs than understanding CHI capability needs. This incapability shows up in the form of poor reflection of user-intentions to use the services in post implementation stages. Insensitivities of IT acquirers towards end-users contribute to the gap between satisfying organizational needs, end-user deliveries and supporting organisational goals in the process. This problem can be addressed by carefully integrating end-user capabilities issues in the SDLC process to achieve a truly human-centered IS development. In this paper a framework is suggested to capture CHI capabilities in an acquiring organisation. The framework is tested for its fitness through structural equation modeling (SEM) with active participation from thirteen organizations. A case is discussed to appreciate application of the framework.*

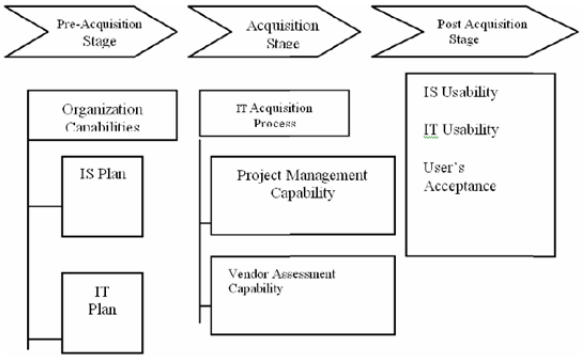


Fig. 1. The Framework

Table 1: Pre-Acquisition Stage

Activity	CHI Metrics
Understanding Organizational Issues	**IS strategy and planning:** -Functional teams' capability need to document possible systems, possible deliveries of systems -Strategy team's appreciation of IT intervention with a roadmap
Needs for IT Acquisition	**IT strategy, IT planning :** -IT Team's capability to scope the requirements of IT infrastructure -IT team capability to have knowledge on current tools, technology and trends Processes, Products, services - Understand the capability of IT suppliers
End-User Motivation	- Organisation Culture to encourage user affiliation -Attitude of end-user towards IT

Table 2: Acquisition Stage

Activity	CHI Metrics
IT Teams' Involvement	Project Management; feasibility, Project execution and project/ process deliveries, Component planning
User Involvement/ Vendor Capability	End-user interface designs; Menu, Forms, Reports, Queries

Table 3: Post Acquisition Stage

Indicators	CHI Metrics
Systems Usability	Least defects, User centered Applications
Technology Usability	Tools with user centered administration, Guaranteed Up-Time and SLA
User Acceptance	Increased Application usage Demand for user level transactions on-line

Examples of SEM in Various Fields of Study

Information Systems and Human-Centered Computing (Cont'd.)

Table 4: Dependency Matrix to display Relationship among Variables for First Group

Dependency	Explanation
OI= *d (PP, PM, UM)**	CHI in Pre-Acquisition stage would *depend* on planning and policy, Project management capability and user motivation
AQ= *d (AT, VC)**	CHI in Acquisition stage would *depend* on the capability of the IT department and vendor capability to manage projects
PAS= *d (OI, AQ)**	CHI in Post IT acquisition stage in the acquiring organization would *depend* on organization's CHI capabilities to acquire IT and manage the IT acquisition process

*** "*d*" denotes "Predictive Dependency";**

Organization's IT Acquisition Scenario (CHI capabilities in Post Acquisition Stage) = 0.45* (Organization's Pre-Acquisition CHI Capabilities) +0.53* (CHI Capabilities in Acquisition Process) + 0.024

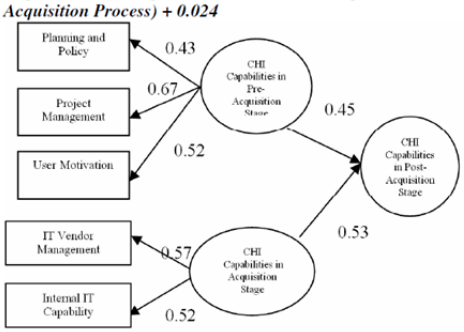


Figure 3: The CHI Management Model Fitness

It may be observed from the equation that pre-acquisition CHI capabilities of IT acquiring organisation is a critical issue (0.45) and this is possible through IS plan, IT plan, user motivation, project management capabilities and IT policy in the organisation. While agile software services are aimed at providing an opportunity to reassure the deliveries of a product or service, it is essential that organisations take note of users' view point, reflect all process requirements and provide a direction to the whole acquisition process. As discussed in section IIII, each phase has a specific contribution to understand CHI capabilities. It is therefore, essential to understand the contributions as detailed in the model (Figure 3). The model demonstrates role of key performing indicators to elicit CHI capabilities and their contribution to overall success in post acquisition stage (Tables 1, 2 and 3). In section VI a case is discussed to demonstrate applicability of the concept. The case measures the CHI capabilities through key indicators of the model and measurements are based on primary survey in the organisation. CHI capability management is a complex proposition and it is perhaps expected that acquiring organization should strategically plan these CHI capabilities. Software engineering process models provide tools to manage projects. But requirements elicitation and user involvement (CHI capability) are critical to success of an acquisition process. This acquisition process needs to be aligned with organizational processes. The usefulness of the proposed model developed is quite evident since it helps acquiring organization to assess its capabilities to manage user-led projects. (pp. 4-5)