Original Research Article

STIB: THE SYSTEMIC THINKING INVENTORY FOR BUSINESS

Abstract

This article presents a scale, the Systemic Thinking Inventory for Business (STIB), which measures the systemic thinking of business learners. Based on literature related to cognitive styles, three dimensions of systemic thinking were identified – Divergent Thinking, Connected Thinking, and Creative Thinking. The scale's validity and reliability were assessed through an exploratory factor analysis of a 25-item instrument after which a confirmatory factor analysis of 12 items emerged that supports a three-dimensional structure. Scale validity and reliability along with convergent validity and discriminant validity were statistically significant with additional analysis on a holdout sample strengthening the support for using STIB to measure systemic thinking.

Keywords

Systemic thinking, Survey instrument, Reliability, Validity, Confirmatory factor analysis

Background

Management education is tasked with developing decision makers that can manage in a global and, often, turbulent environment. Given that managers coordinate people, ideas, and beliefs in implementing strategies, how these managers think will play a role in their decision making process and, ultimately, the organization's results. Systemic thinking, an approach to understanding reality, stipulates that systems have characteristics and patterns independent of their parts. As suggested by Allio (2003), "(Managers) have to understand how the interactions of the parts, and the parts with the whole and its environment, create the properties of the whole" (p. 3).

An exploratory study by Washington *et al*., (2014) measured the change in the level of systemic thinking of undergraduate students running a total enterprise business simulation. Using a rubric developed for the study, the researchers completed a content analysis of statements made by decision makers in an early and then later stage of the simulation. Using a scale ranging from 1 (low level of systemic thinking) to 7 (high level of systemic thinking) low levels were given for statements that addressed variables unrelated to the factor of interest (marketing, management, or operations). High levels were assigned to statements that presented a rationale for decisions that included all concepts asked about (marketing, management, or operations). Results showed an increase in the systemic thinking skills of students as they progressed through the exercise. In addition, higher levels of systemic thinking in early periods of running the simulation were positively related to subsequent firm performance ($p < 0.10$). Although insightful as to the importance and impact of systemic thinking on performance, this study had some limitations. First, the rubric developed for the study was specific to the simulation used which limited the generalizability of the findings. It was also impractical to suggest that a different rubric be developed for each simulation used in business schools to assess the systemic thinking skills of students. Second, while a rubric may be useful for assessing systemic thinking in a simulation environment it is not necessarily an appropriate methodology for assessment across different pedagogical approaches such as lectures, experiential exercises, and case analysis.

Subsequent research by Kurthakoti and Halpin (2016) addressed these issues by offering a comprehensive scale, the Systemic Thinking Inventory for Business (STIB), to assess systemic thinking in students running different simulations. The current research builds on those findings as it tests the validity and reliability of the scale and proposes its use across different pedagogical methods of teaching business concepts.

“Systems thinking is a way of understanding reality that emphasizes the relationship among various components in a process, rather than the independent constituents of the process” (Gregory and Miller, 2011, p. 259). Recognizing that a system has characteristics and patterns independent of its parts provides a rationale for business leaders to acquire skills that draw on their ability to view an entity in a holistic way (Allio, 2003; Henning and Chen, 2012). Systemic thinking integrates analysis and synthesis by an individual and is said to lead to greater understanding and better decision making. According to Laszlo (2012), “Analysis answers the questions ‘what’ and ‘how’…Synthesis answers the ‘why’ and ‘what for’ questions” (p. 97).

Research on individual cognitive styles provides a starting point for identifying key dimensions of systemic thinking. The manner in which one organizes and processes information is known as one’s cognitive style. When applied to how one completes a task or responds in a decision making situation, some individuals may focus on the individual parts of the task while others take the set of information and process it in a global context. These different methods of thinking are thought to be relevant in problem solving situations and may help predict the success rates of decision makers (Sadler-Smith and Badger, 1998). Sternberg and Wagner (1991) offered thirteen thinking styles and created a scale, the Mental Self-Government Thinking Styles Inventory (MSG), which categorizes individuals based on how they approach problem solving situations. They identified a number of tendencies in decision makers such as rule making, goal setting, and flexibility. Choi *et al.*, (2007) contributed further to our understanding of thinking styles with their Analysis-Holism Scale (AHS), which distinguishes between individuals who view the world in a holistic way and those with a focus on the world as a set of independent components. One of the four domains examined in their work, locus of attention, is of particular interest in the current study.

Business schools and programs seek to graduate students with the knowledge and skills to manage in a global economy. Facing increasingly complex environmental factors, solutions to problems today are neither obvious nor satisfactory (Caldwell, 2012). Given the current business climate, decision makers must arrive at solutions in shorter periods of time and with less than complete information (Noel and Erskine, 2013). Leaders who are systemic thinkers are thought to be able to adjust to time constraints and make sense of situations where relationships or patterns may not have occurred previously. This requires higher-order thinking such as analysis, synthesis, and evaluation as defined by Bloom *et al*., (1959) or, more recently, the ability to analyze, evaluate, and create (Krathwohl, 2002). From the perspective of management education, identifying teaching methods that strengthen the systemic thinking skills of students is a reasonable goal.

In today's learning environment with a variety of learning approaches available to instructors and learners, straight lecturing need not be the dominant teaching method used. A range of tools exists to effectively teach business concepts one of which is computer-based simulations. Business simulations allow students to work alone or in groups to test their decision making skills. Moschella and Motiwalla (1997) argue that strategic thinking skills are improved using a simulation by requiring participants to engage in goal setting, strategy formulation, and planning. Lovelace *et al*., (2015) found critical thinking skills improve in those completing different web-based simulations across different classes - business strategy, human resources, and organizational behavior. Understanding the range of business course requirements that exist, an argument could be made that the more complex the concepts being studied the more complex the simulation should be resulting in a more challenging exercise. A total enterprise simulation fits this category since students are expected to consider how marketing, operations, finance, and management factors influence one another and affect the overall performance of an organization. Strategies used by simulation participants that are consistent with the environment they face are thought to be indicators that learning is taking place (Wellington *et al*., 1998).

The Systemic Thinking Inventory for Business (STIB), first presented by Kurthakoti and Halpin (2016), proposed a scale-based metric approach to measuring systemic thinking in business learners. This method was viewed as a preferred approach over measuring the construct using content analysis as it had the potential to be used across teaching methods. An exploratory study using the scale with undergraduate students enrolled in two different business courses, an introductory class and capstone, responded to a survey prior to running a simulation and after. Performing an exploratory factor analysis, the authors concluded that systemic thinking is a multi-dimensional construct with three components. Two major limitations of this work were the small sample size and the use of exploratory factor analysis rather than confirmatory factor analysis.

Problem solving skills require an understanding of a situation and the ability to sort through vast amounts of data to select the most relevant and meaningful information (Moschella and Motiwalla, 1997). What we are interested in identifying is what a decision maker focuses on while making decisions. Some individuals pay more attention to the parts of a task when developing a response while others take the information and process it all within a holistic context (Sadler-Smith and Badger, 1998). Successful decision making by managers may also require an appreciation of the interconnectedness of the parts of a task or issue. This is a challenge for business leaders who are charged with identifying which elements of a situation are the most pressing and in need of attention (Moschella and Motiwalla, 1997). Organizations facing complex decision making situations can employ techniques such as chunking and specialization (Cannon, 1995) or mapping to visually represent the variables in a situation (Wallis and Wright, 2015; Essila *et.al*., 2021). Modeling helps individuals conceptualize the system they are trying to understand. Identified as conceptual knowledge this is what enables a learner to understand how a system functions, how the parts interact with one another, and how the properties of the parts differ from the properties of the whole (Krathwohl, 2002; Richardson, 2008; Eom and Ashill, 2018).

In addition to thinking in a holistic way and seeing the relationship between components of a task, a systemic thinker should also be creative and responsive to changing conditions while problem solving. This means having the ability and the will to adjust one's approach. In the context of organizational change, we often think of the term 'flexibility' which has a positive connotation and is thought to be a valued attribute (Dunford *et al*., 2013). We know decision making situations are not stagnant. They often involve changing environmental factors, the introduction of new information, and the development of alternative solutions. Experienced decision makers often create a range of possible responses to common problems they face. This is thought to improve a manager's decision making style and lead to a greater ability to be creative in developing solutions (Gioia and Poole, 1984). While maintaining the status quo is acceptable when decisions are routine this may not be the best approach when faced with novel situations (Dunford *et al*., 2013; Ford and Gioia, 2000). Novel situations, common in complex systems, require flexibility, adaptation, and creative problem solving. We expect that decision makers who lack flexibility may discount the change occurring in an environment and focus on traditional or linear thinking when being adaptive might yield a better outcome.

Understanding the thinking process of decision makers may help explain the quality of the solutions they offer and, ultimately, whether there is a relationship between thinking style and performance (Gioia and Poole, 1984). As schools of business are charged with developing managers with a broad perspective and an ability to make decisions in a complex world the use of experiential learning methods such as computer simulations may aid in this effort (Moschella and Motiwalla, 1997; Papenhausen and Parayitam, 2015). Based on this discussion and the results of the exploratory study by Kurthakoti and Halpin (2016), we believe that systemic thinking is a three dimensional construct. The focus of the proposed research is to answer two questions: (a) what factors explain the level of systemic thinking in business learners using a computer simulation program and (b) can we statistically confirm the reliability and validity of a survey instrument intended to measure this construct?

Methods

In this study we attempt to assess the systemic thinking skills of learners enrolled in capstone business courses that traditionally run a total enterprise simulation. Data were pooled from 258 participants (213 Undergraduates and 45 MBAs) at two northeastern universities in the US. We received 204 usable surveys (174 undergraduate and 30 MBA) resulting in a response rate of 79.07% (81.7% for undergraduates and 66.7% for MBAs). The two total enterprise simulation packages, Micromatic (Scott *et al*., 2013) and Capsim (Guide, C.S., 2010) are tools that teach decision making skills to users. These programs call on participants to integrate their knowledge of marketing, finance, and operations to successfully manage a for-profit enterprise.

Based on scales used in prior studies (Choi *et al*., 2007; Sternberg and Wagner, 1991) the instrument used in this study combined items from each and was introduced as the Systemic Thinking Inventory for Business (STIB) by Kurthakoti and Halpin (2016). Specific items from the AHS (Choi *et al*., 2007) and the MSG (Sternberg and Wagner, 1991) were adapted to reflect decision making in a management setting. We believed that the resulting 25 items had face validity to capture the essential dimensions of systemic thinking as discussed in the previous section. Using a 5-point Likert Scale (Strongly Agree to Strongly Disagree) individuals assess their level of agreement on items related to what they pay attention to when completing a task, how they view the interconnectedness of the parts of a task to the whole, and their level of creativity during the process. Examples of items included in STIB from Choi *et al*., (2007) include, "It is more important to pay attention to the whole rather than its parts." and "It is more important to pay attention to the whole context rather than the details of the task". From Stenberg and Wagner (1991) the instrument includes, "I see how the parts relate to the overall goal of the task." and "I prefer to have fixed rules to follow in order to complete a task."

As stated previously, the goal of the proposed study is to assess the structural validity of a systemic thinking inventory, STIB, when administered to business learners. The authors use an Exploratory Factor Analysis (EFA) followed by a Confirmatory Factor Analysis (CFA) to validate the factor structure. Testing for convergent and discriminant validity was completed along with a final CFA using a holdout sample not included in the development of the original model.

Results

Sample Pooling

Demographic profiles of participants were compared as well as average scores across the STIB items. Results showed the demographic profile of participants was comparable across universities and across programs (undergraduate and graduate). Levene's test as well as the ANOVA test for the items indicated no difference in group means or variances among the groups of students (across universities and program level) so the entire data set was pooled to boost sample size for the analysis.

Exploratory Factor Analysis

The first step in validating a construct is to perform an exploratory factor analysis (EFA). This was done on the pooled sample across the 25 items using SPSS software. EFA was performed using Principal Axis Factoring with Varimax Rotation[1]. Since the objective was to develop a scale for a multi-factor latent variable grounded in theory, the use of principal axis factoring approach is recommended over the principal components approach as the former allows for partitioning between shared, unique and error variance to reveal factor structure (Costello and Osborne, 2005).The number of factors was restricted to 3 as per our theoretical expectation. All cross loading and weakly loading items (those with a factor loading of less than 0.3) were removed after which an EFA was repeated (Hair *et al*., 2006). This resulted in the retention of 20 items from the original 25 (7 for Factor 1, 9 for Factor 2, and 4 for Factor 3). Each extracted factor had sufficiently high reliability as indicated by Cronbach's alpha (0.823 for F1, 0.848 for F2, and 0.697 for F3). Appendix A provides a list of the 20 items used in the EFA and the corresponding Factor Loadings and Cronbach's Alpha.

[1] A non-orthogonal extraction did not result in significant inter-factor correlations. In the interest of interpretation, orthogonal extraction using varimax rotation was retained.

Confirmatory Factor Analysis – Phase 1

With the promising results from the EFA, we proceeded toward a Confirmatory Factor Analysis (CFA) to theoretically validate the factor structure. CFA was performed on the data using SPSS AMOS® V23 software. Only the 20 items resulting from EFA were included as the initial seed for the CFA. Estimation of the CFA was done using the Maximum Likelihood method.

The initial CFA using 20 items resulted in a chi-square of 467.993 (167 df; $p < 0.001$) which indicated a poor fit. At first glance, this suggests a bad model fit for this initial effort. We will call this *Initial CFA*. Since it is well known that chi-square is usually statistically significant for large estimation samples on other indicators of model fit were evaluated. Subsequently, this model (Initial CFA) did not fare well on other fit indices. There was less-than-good fit on both CFI (0.786) and RMSEA (0.094), two commonly used fit indices (Bentler, 1991; Bagozzi and Yi, 1988). A CFI value of 0.9 or higher and a RMSEA value below 0.05 are said to indicate a very good fit. However, the cutoff points for RMSEA have been further discussed by MacCallum *et al*., (1996) who argue that an RMSEA of up to 0.08 indicates a reasonably good fit, a RMSEA in the range of 0.08-0.10 indicates a mediocre fit, and one greater than 0.10 indicates a poor fit. Based on these suggested cut off points our initial model had a mediocre to weak fit and needed further evaluation.

Confirmatory Factor Analysis – Phase 2

Recalling the objective of the study, to develop a scale to measure Systemic Thinking, we were committed to identifying a set of items for measuring this construct. With this goal in mind, we relied on guidance from the modification indices and residual analysis to iteratively purify and improve the factor structure (Anderson and Gerbing, 1988; Novak et al., 2000; Byrne, 2010).

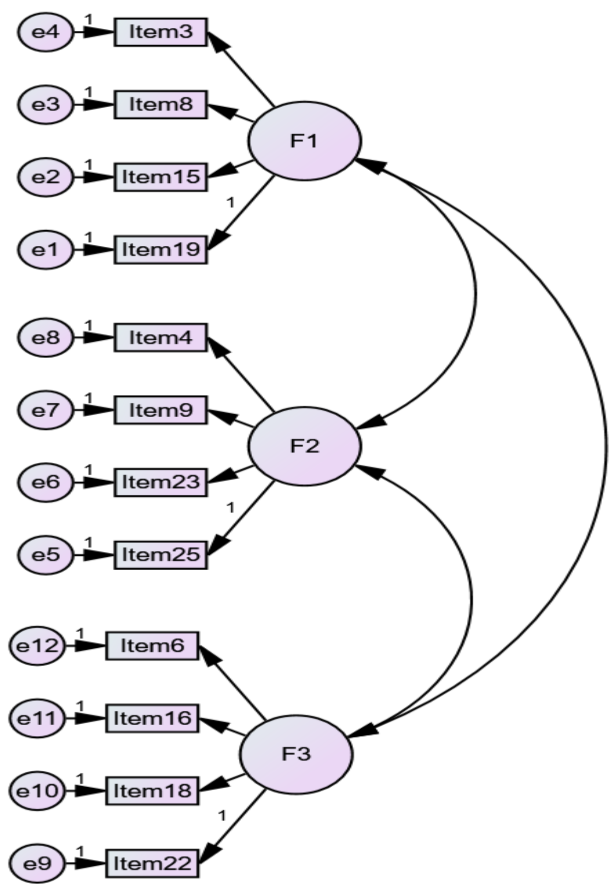
Indicator variables whose residuals were significantly correlated with other indicators were eliminated. Similarly, indicator variables that were suggested to be cross-loaded by the modification indices were eliminated as these items indicate lack of uni-dimensionality. This process of elimination resulted in the removal of eight indicator items after which a second CFA was performed using 12 items (See Appendix A - CFA Original Sample).

The statistics shown in Table 1 indicate that the 12-item scale (Final CFA) has both an acceptable CFI (0.931) and RMSEA (0.065). Further, the 90% confidence interval of the RMSEA is within the recommended range for an acceptable fit. The AIC value of 172.952 for Final CFA (12 items) is significantly lower than that of Initial CFA (20 items) and is, therefore, acceptable. Additional analysis indicates that all factor loadings are statistically significant with a p value of < 0.001. The factor structure for the 12 items is shown in Figure 1 with factor loadings for each provided in Appendix A.

TABLE 1: CFA Fit Statistics

	Initial CFA –20 Items (Modification of EFA)	Final CFA –12 Items (Modification of Initial CFA)	Holdout Sample CFA –12 Items
Sample Size (n)	204	204	112
Chi Square (df)	467.993 (167)	94.952 (51)	71.831 (51)
P value of the Chi Square test	< 0.001	< 0.001	< 0.05
Chi Square/DF	2.802	1.862	1.408
CFI	0.786	0.931	0.939
RMSEA	0.094	0.065	0.061
90% CI of RMSEA	0.084-0.104	0.044-0.085	0.020-0.091
AIC	553.993	172.952	125.831

Figure 1: Final Factor Structure and Standardized Factor Loadings of CFA2 (12 Items)



Anderson and Gerbing (1988) recommend using different samples for EFA and CFA to confirm factor structure. Given the limited sample size we started with, EFA and CFA were originally performed on the same dataset. However, to further confirm the robustness of the factor structure of STIB, a holdout sample analysis was performed. Data were collected from a new group of student respondents from two northeastern universities in the US for the holdout sample. There were no differences between responses from the two groups of students and so the data were pooled to boost sample size (total n=112, response rate 79.4%). On this holdout dataset, the final CFA model (12 items) was specified and analysis performed using SPSS AMOS® . The results of the CFA on the holdout sample are also presented in Table 1. As we can see, the model fit for this holdout sample is similar to the model fit of original sample (Final CFA) indicating a robust factor structure.

Testing Scale Validity and Reliability

Common Method Bias was tested using the single factor test to determine whether a single factor can explain the majority of the variance (White *et al*., 2012; Alumran *et al*., 2014). The chi-square difference test shows that the three-factor

model ($X^2 = 94.952$, df = 51, $p < .01$) is a significant improvement over the one-factor model ($X^2 = 344.148$, df = 54, $p < .01$). The difference between the chi-square of the two models (249.196, df = 3) is statistically significant at a .001 level indicating that a three-factor model is a significantly better fit and that there is no common method bias. Convergent Validity and Discriminant Validity were tested by comparing inter-factor correlations and item factor correlations. A factor is said to have convergent validity if the items related to a factor exhibit significant correlation with each other. Discriminant validity is supported if the items related to one factor are weakly correlated with the items related to other factors. Table 2 provides the comprehensive correlation matrix for all 12 measurement items. As shown on the table, items

Table 2: Inter-Item Correlations for Convergent and Discriminant Validity

	M	SD	1	2	3	4	5	6	7	8	9	10	11	12
Item 3 Factor 1	3.41	.976	1											
Item 8 Factor 1	3.09	.908	0.428	1										
Item 15 Factor 1	3.17	.912	0.441	0.464	1									
Item19 Factor 1	3.25	.883	0.487	0.514	0.529	1								
Item 4 Factor 2	4.07	.691	0.121	0.128	0.132	0.146	1							
Item 9 Factor 2	4.07	.729	0.138	0.145	0.149	0.165	0.499	1						
Item 23 Factor 2	4.02	.746	0.116	0.122	0.126	0.139	0.421	0.477	1					
Item 25 Factor 2	4.02	.684	0.127	0.133	0.137	0.152	0.459	0.52	0.438	1				
Item 6 Factor 3	3.56	.968	0.105	0.111	0.114	0.126	0.184	0.208	0.175	0.192	1			
Item 16 Factor 3	3.39	.820	0.109	0.115	0.118	0.131	0.191	0.216	0.182	0.199	0.309	1		
Item 18 Factor 3	3.99	.753	0.132	0.139	0.143	0.158	0.23	0.261	0.22	0.24	0.374	0.388	1	
Item 22 Factor 3	3.83	.833	0.122	0.129	0.133	0.147	0.214	0.242	0.204	0.223	0.347	0.36	0.435	1

related to each factor are highly correlated with each other and weakly correlated with items related to the other factors. This indicates convergent and discriminant validity (Lehmann, 1988).

Additional methods of testing for convergent and discriminant validity include Composite Reliability (CR), Average Variance Extracted (AVE), Maximum Shared Variance (MSV), and the Square Root of AVE. With regard to CR, factors are said to have convergent validity if the CR is more than 0.7 and is greater than the AVE. (Malhotra, 2009). More evidence of discriminant validity is if the square root of each AVE exceeds the corresponding correlations of the remaining factors (Fornell and Larcker, 1981; White *et al*., 2012). Additional support is if the AVE for each factor is more than its MSV (Alumran *et al*., 2014). The results of each of these assessments are shown on Table 3 and are at the recommended levels which confirm the final model has both convergent and discriminant validity.

Table 3: Validity Assessment using CR, AVE and MSV

	CR	AVE	MSV	F1	F2	F3
Factor 1	0.786	0.480	0.141	**0.693#**		
Factor 2	0.780	0.472	0.249	0.283	**0.687#**	
Factor 3	0.702	0.372	0.249	0.306	0.499	**0.610#**

Note: # is the square root of the AVE for each factor.

Discussion

Measuring systemic thinking has proved to be a challenge for researchers interested in this topic. Some have focused on qualitative analysis (content analysis, mental maps, etc.) possibly assuming that a quantifiable assessment of this construct is not possible. Results from the current study support the argument that levels of systemic thinking may very well be quantifiable. Three distinct components measure the degree to which an individual approaches a task in a systemic way. We have identified these as the following.

Factor 1, *Divergent Thinking*, is captured in the STIB instrument by four statements that assess what a person pays attention to while performing a task; e.g. When working on a task, I care more about the general picture than about details; I like tasks where I am dealing with general issues; not with nitty-gritty details. Systemic thinking requires a holistic approach to problem solving so higher scores on these items are desirable. Factor 2, *Connected Thinking*, is linked with four items that ask about how individuals perceive the relationship between the parts of a task and the whole; e.g. When working on a task, I like to see how what I do fits into the overall picture; Everything associated with a task is somehow related to each other. High scores on these items reflect an understanding of how each component of a task relates to the whole and provide evidence of systemic thinking. Factor 3, *Creative Thinking*, is captured by four items on the survey which assess the extent of an individual's rigidity in completing a task; e.g. When considering ways to complete a task, I tend to approach it in a traditional way; I like tasks where I know before starting the things I have to do and in what order. Lower scores on these responses reflect systemic thinking since they indicate a willingness to be flexible and to consider a range of solutions in a decision making situation.

Management education is aimed at developing decision makers who can successfully solve problems. Strengthening ways of thinking that are holistic are expected to lead to a better understanding of situations and an ability to offer solutions that produce successful outcomes. The use of computer simulation models in business education is thought to improve the thinking of future business leaders. STIB provides a tool to assess changes in levels of systemic thinking in both undergraduate and graduate students using this teaching tool. For those educators interested in administering the instrument, the survey along with instructions for scoring, are presented in Appendix B. We urge users to share results with learners and discuss the importance of each factor along with the significance of any change in score over time.

Suggestions for future research include the continued use of STIB to study changes in the systemic thinking skills of those using business simulations in the classroom. Not only should those using total enterprise simulations be evaluated but researchers can measure if thinking skills improve for those using discipline-specific simulations tied to marketing, finance, and operations. Beyond the use of simulations, identifying how other teaching methods such as case studies and experiential exercises develop the thinking skills of business learners would be valuable to leaders in management education. Two limitations of the current study are that the data were gathered from US-based institutions and the score on each measure was self-reported. Administering this at institutions around the globe would add to the richness of these findings and aid in our understanding of the generalizability of the instrument. In addition, perhaps some objective measures could be identified and used in conjunction with an individual's STIB results to verify the level of systemic thinking.

Other areas of interest would be to understand the relationship between levels of systemic thinking within and between groups and between group members. In addition, identifying a relationship between level of systemic thinking and performance on a simulation would provide some insight into the benefit of developing business leaders with a holistic approach to completing tasks. Additionally, explaining how one's level of systemic thinking may influence the choices made during a decision making situation would add an additional dimension to this construct. Other variables of interest in a simulation session might be use of information and time taken between decision periods. The potential for future studies using STIB is quite promising since scores from this scale could be used to compare, refine, and improve pedagogies within the business discipline.

Conclusion

This article reports the findings of a confirmatory factor analysis of a survey to measure systemic thinking in business learners. Over 200 business students participating in a total enterprise simulation rated themselves on how they complete tasks. The initial exploratory factor analysis included all 25 items of the survey but the cross loadings and weak loadings resulted in the removal of 5 items that loaded on the three factors. The high reliability of each of these factors, as indicated by Cronbach's alpha, led the authors to conduct a confirmatory factor analysis to validate the factor structure. When the initial model with 20 items did not offer a good fit, modification indices were used to eliminate cross loading and weak items resulting in a final model that had a good fit. The final 12-item scale, the Systemic Thinking Inventory for Business (See Appendix A) has both an acceptable CFI and RMSEA and all factor loadings are significant ($p < .001$). It also demonstrated convergent and discriminant validity which was confirmed through a series of tests. Analysis of a holdout sample using a different set of independently collected data demonstrated similar fit and factor loadings indicating the robustness of the scale.

References

Allio, R.J. (2003), "Russell L. Ackoff, iconoclastic management authority, advocates 'systemic'approach to innovation", *Strategy and Leadership*, Vol. 31 No. 3, pp.19-26.

Alumran, A., Hou, X. Y., Sun, J., Yousef, A. A. and Hurst, C. (2014), "Assessing the construct validity and reliability of the parental perception on antibiotics (PAPA) scales", *BMC public health*, Vol. 14 No. 1, p.73.

Anderson, J. C. and Gerbing, D. W. (1988), “Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach”, *Psychological Bulletin*, Vol. 103, pp.411-423.
Bagozzi, R. P. and Yi, Y. (1988), “On the Evaluation of Structural Equation Models”, *Journal of the Academy of Marketing Science*, Vol. 16, pp.74-94.

Bentler, P. M. (1991), “Comparative Fit Indices in Structural Models”, *Psychological Bulletin*, Vol. 107, pp.238-246.

Bloom, B.S., Englehart, M.D., Furst, E.D., Hill, W.H. and Krathwohl, D.R. (1959), *Taxonomy of educational outcomes: The classification of educational goals. Handbook 1: Cognitive Domain*, New York, NY: David McCay Company, Inc.

Byrne, B. M. (2010), *Structural Equation Modeling with AMOS – Basic Concepts, Applications and Programming*. Routledge Taylor and Francis Group, NY.

Caldwell, R. (2012), “Systems thinking, organizational change and agency: A practice theory critique of Senge’s Learning Organization”, *Journal of Change Management*, Vol. 12 No. 12, pp.145-164.

Cannon, H. (1995), “Dealing with the complexity paradox in business simulation games”, *Developments in Business Simulation and Experiential Learning*, Vol. 22, pp.96-102.

Choi, I., Koo, M. and Choi, J.A. (2007), “Individual differences in analytic versus holistic thinking”, *Personality and Social Psychology Bulletin*, Vol. 33, pp.691-705.

Costello, A. B. and Osborne, J. (2005), “Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis”, *Practical assessment, research, and evaluation*, Vol. 10 No. 1, p.7.

Dunford, R., Cuganesan, S., Grant, D., Palmer, I., Beaumont, R. and Steele, C. (2013), “Flexibility as the rationale for organizational change: A discourse perspective”, *Journal of Organizational Change Management*, Vol. 26 No. 1, pp.83-97.

Ford, C.M. and Gioia, D.A. (2000), “Factors influencing creativity in the domain of managerial decision making”, *Journal of Management*, Vol. 26 No. 4, pp.705-732.

Fornell, C. and Larcker, D. F. (1981), “Structural equation models with unobservable variables and measurement error: Algebra and statistics”, *Journal of Marketing Research*, Vol. 18 No. 3, pp.382-388.

Gioia, D.A. and Poole, P.P. (1984), “Scripts in organizational behavior”, *Academy of Management Review*, Vol. 9, pp.449-459.

Gregory, A. and Miller, S. (2011), “Waving or drowning? Re-evaluating the place of systems thinking in business and management learning and curricula”, Paper presented at the Organisational Learning, Knowledge and Capabilities Conference, Hull, UK.

Guide, C.S. (2010). Management Simulations, Inc. Northfield, Illinois.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E. and Tatham, R. L. (2006), *Multivariate statistics*. Pearson Education Inc., Upper Saddle River.

Henning, P.B. and Chen, W-C. (2012), “Systems thinking: Common ground or untapped territory?”, *Systems Research and Behavioral Science*, Vol. 29, pp.470-483.

Krathwohl, D.R. (2002), “A revision of Bloom’s Taxonomy: An overview”, *Theory Into Practice*, Vol. 41 No. 4, pp.212-218.

Kurthakoti, R. and Halpin, A.L. (2016), “STIB: The systemic thinking inventory for business”, *Developments in Business Simulation and Experiential Learning*, Vol. 43, pp.250-257.

Laszlo, K.C. (2012), “From systems thinking to systems being: The embodiment of evolutionary leadership”, *Journal of Organizational Transformation and Social Change*, Vol. 9 No. 2, pp.95-108.

Lehmann, D. R. (1988), “An alternative procedure for assessing convergent and discriminant validity”, *Applied Psychological Measurement*, Vol. 12 No. 4, pp.411-423.

Lovelace, K.J., Eggers, F. and Dyck, L.R. (2015), “I do and I understand: Assessing the utility of web-based management simulations”, *Academy of Management Learning and Education*, 2013, published ahead of print October 23, 2015.

MacCallum, R.C., Browne, M.W. and Sugawara, H.M. (1996), “Power analysis and determination of sample size for covariance structure modeling”, *Psychological Methods*, Vol. 1, pp.130-149.

Malhotra N. K. (2009). *Marketing Research an Applied Orientation*. 6th Ed., Pearson Publishing.

Moschella, P. and Motiwalla, L. (1997), “For today’s dynamic and changing world, business simulations need to be expanded to encompass much greater complexity (A demonstration)” *Developments in Business Simulation and Experiential Learning*, Vol. 24, pp.311-319.

Eom, S.B. and Ashill, N. (2018), “A System’s View of E-Learning Success Model”, *Decision Sciences Journal of Innovative Education*, Vol. 16:1, pp.42-76.

Essila, J.C., Alhourani, F., and Motwani, J. (2021), “Using Concept Maps in Teaching Operations Management Courses”, *Decision Sciences Journal of Innovative Education*, Vol. 19:1, pp.15-39.

Noel, T. and Erskine, L. (2013), "The silent story: using computer-aided text analysis to predict entrepreneurial performance", *Journal of Entrepreneurship*, Vol. 22 No. 1, pp.1-14.

Novak, T. P, Hoffman, D. L. and Yung, Y. (2000), "Measuring the Customer Experience in Online Environments: A Structural Modeling Approach", *Marketing Science*, Vol. 19, pp.22-42.

Papenhausen, C. and Parayitam, S. (2015), "Total enterprise simulations as a pedagogical tool to improve system dynamics thinking", *Business Education Innovation Journal*, Vol. 7 No. 2, pp.117-121.

Richardson, K.A. (2008), "Managing complex organizations: Complexity thinking and the science and art of management", *E:CO*, Vol. 10 No. 2, pp.13-26.

Sadler-Smith, E. and Badger, B. (1998), "Cognitive style, learning and innovation", *Technology Analysis and Strategic Management*, Vol. 10 No. 2, pp.247-265.

Scott, T.W., Kaliski, J.A. and Anderson, P.H. (2013). *Micromatic: A strategic management simulation*. Oak Tree Simulations, LLC.

Sternberg, R.J. and Wagner, R.K. (1991), "Mental self government thinking styles inventory manual" Unpublished manual.

Wallis, S.E. and Wright, B. (2015), "Strategic knowledge mapping: The co-creation of useful knowledge", *Developments in Business Simulation and Experiential Learning*, Vol. 42, pp.1-18.

Washington, M.L., Kurthakoti, R., Halpin, A.L. and Byrd. S. (2014), "Assessing systemic thinking in undergraduates: An exploratory study using a total enterprise business simulation", *Developments in Business Simulation and Experiential Learning*, Vol. 41, pp.53-63.

Wellington, W., Faria, A.J. and Whiteley, T.R. (1998), "Holistic cognitive strategy in a computer-based marketing simulation game: An investigation of attitudes towards the decision-making process", *Developments in Business Simulation and Experiential Learning*, Vol. 25, pp.246-252.

White, C. D., Campbell, K. S. and Kacmar, K. M. (2012), "Development and validation of a measure of leader rapport management: the LRM scale", *Journal of Behavioral and Applied Management*, Vol. 13 No. 2, p.121.

APPENDIX A – Items and Factor Loadings

Items	EFA (Principal Axis Factor)			Final CFA – Original Sample			CFA Holdout Sample		
	F1	F2	F3	F1	F2	F3	F1	F2	F3
#3 – When working on a task, it is more important to pay attention to the whole rather than its parts.	0.612			0.637			0.582		
#5 – When working on a task, I am not concerned with details.	0.529				Excluded			Excluded	
#8 – When working on a task, I care more about the general picture than about details.	0.768			0.672			0.680		
#10 – When considering ways to complete a task, the whole, rather than the parts, should be considered most important to understand.	0.592				Excluded			Excluded	
#15 – When considering ways to complete a task, it is more important to pay attention to the whole context rather than the details of the task.	0.677			0.691			0.826		
#19 – I like tasks where I am dealing with general issues; not with nitty-gritty details.	0.702			0.765			0.546		
#21 – I like tasks where I can focus on general ideas, rather than specifics.	0.550				Excluded			Excluded	
#1 – When working on a task, I like to		0.520			Excluded			Excluded	

do things in new ways not used by others in the past.									
#2 – When working on a task, I like when I need to pay attention to details.		0.629			Excluded			Excluded	
#4 - When working on a task, I like to see how what I do fits into the overall picture.		0.617			0.664			0.652	
#9 - When working on a task, I see how the parts relate to the overall goal of the task.		0.677			0.752			0.509	
#11 – When considering ways to complete a task, I like to be allowed to look at a situation from a new perspective.		0.617			Excluded			Excluded	
#20 – I like tasks where I can try novel (unique) ways of approaching things.		0.636			Excluded			Excluded	
#23 - Everything associated with a task is somehow related to each other.		0.590			0.634			0.678	
#24 - Even a small change in any element of a task can lead to significant alterations in other elements.		0.605			Excluded			Excluded	
#25 - In dealing with difficulties completing a task, I have a good sense of how important each element is and in which order to tackle each of them.		0.633			0.692			0.648	
#6 - When working on a task, I prefer to have fixed rules to follow in order to complete it (a task). (Reverse Coded)			0.513			0.546			0.621
#16 - When considering ways to complete a task, I tend to approach it in a traditional way. (Reverse Coded)			0.653			0.566			0.529
#18 - I like tasks where I can follow a specific set of steps. (Reverse Coded)			0.610			0.684			0.692
#22 - I like tasks where I know before starting the things I have to do and in what order. (Reverse Coded)			0.532			0.636			0.735

Appendix B

Systemic Thinking Inventory for Business (STIB)

The following survey is an attempt to gather information about how you think about completing tasks. In this course, you are expected to think about the world of business and about how businesses operate. Your style of thinking about completing tasks may play a role in how you view issues and situations in a business environment. This survey will be administered twice during the semester – first before you begin the simulation exercise and then a second time after the simulation is completed - at the end of the course.

Instructions:
Please read each statement carefully. Indicate how strongly you agree or disagree with each statement by circling the appropriate number to the right.

When working on a task,	**Strongly Agree**	**Agree**	**Neither Agree or Disagree**	**Disagree**	**Strongly Disagree**
1) …it is more important to pay attention to the whole rather than its parts.	**5**	**4**	**3**	**2**	**1**

2) …I care more about the general picture than about details.	**5**	**4**	**3**	**2**	**1**
3) …I like to see how what I do fits into the overall picture.	**5**	**4**	**3**	**2**	**1**
4) …I see how the parts relate to the overall goal of the task.	**5**	**4**	**3**	**2**	**1**

5) …I prefer to have fixed rules to follow in order to complete it (a task).*	**5**	**4**	**3**	**2**	**1**
When considering ways to complete a task,	**Strongly Agree**	**Agree**	**Neither Agree Nor Disagree**	**Disagree**	**Strongly Disagree**
6) …it is more important to pay attention to the whole context rather than the details of the task.	**5**	**4**	**3**	**2**	**1**
7) …I tend to approach it in a traditional way.*	**5**	**4**	**3**	**2**	**1**

I like tasks where	**Strongly Agree**	**Agree**	**Neither Agree Nor Disagree**	**Disagree**	**Strongly Disagree**
8) …I am dealing with general issues; not with nitty-gritty details.	**5**	**4**	**3**	**2**	**1**
9) …I can follow a specific set of steps.*	**5**	**4**	**3**	**2**	**1**
10) …I know before starting the things I have to do and in what order.*	**5**	**4**	**3**	**2**	**1**
Respond to the following statements.					
11) Everything associated with a task is somehow related to each other.	**5**	**4**	**3**	**2**	**1**
12) In dealing with difficulties completing a task, I have a good sense of how important each element is and in which order to complete it (a task).	**5**	**4**	**3**	**2**	**1**

Guidelines for Instructor Scoring:

Divergent Thinking: Sum Items 1, 2, 6, and 8 Total Score ______ Average Score______

Connected Thinking: Sum Items 3, 4, 11, and 12 Total Score ______ Average Score______

Creative Thinking: Sum Items 5*, 7*, 9*, and 10*   Total Score ______   Average Score______

Grand Total______   Grand Average_____

*Reverse Code