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Shared Mental Models on the Performance of e-Learning Content Development Teams

Il-Hyun Jo
Department of Educational Technology, Ewha Womans University, 11-1, Daehyun-dong, Seodaemun-gu, Seoul, 120-750 South Korea // ijo@ewha.ac.kr

ABSTRACT
The primary purpose of the study was to investigate team-based e-Learning content development projects from the perspective of the shared mental model (SMM) theory. The researcher conducted a study of 79 e-Learning content development teams in Korea to examine the relationship between taskwork and teamwork SMMs and the performance of the teams. Structural equation modeling (SEM) was used to analyze the parameter estimations. As hypothesized, the results indicated that interaction among e-Learning ID team members led to higher SMMs (Ed- this acronym has already been defined above) which in turn improved the team performance. Meanwhile, the interaction decreased with the progression of ID projects and with the role differentiation. The implications of the findings and directions for instructional design (ID) practices are discussed.

Keywords
Shared mental model, role division, team performance, e-learning

Introduction

In real world instructional design (ID) situations, team-based approaches are common. In e-Learning ID projects where a variety of expertise – e.g., ID, graphic design, and programming - is required, it is often difficult or impractical to find an all-in-one expert instructional designer. In this regard, Jo (2008) suggested that an e-Learning content development project is a typically team-based, ill-structured problem solving task that involves a series of complex, problem solving activities. However, ID settings as considered by most traditional ID theories and models are more logical or individual than collaborative or team-based (Jo, 2008). Most ID theorists, regardless of their epistemological perspectives, assume that their typical research targets are individual designers, not teams.

This discrepancy between the theories and real world practices may generate severe challenges to the ID research in e-Learning. Without the provision of relevant theories that explain the team aspects of ID practices, our credibility as application scientists might be challenged. There is growing evidence that the existence of shared mental models (SMMs) among the members of a work team has a great impact on team processes and task effectiveness (Klimoski & Mohammed, 1994; Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005). SMMs are socially constructed cognitive structures that represent shared knowledge or beliefs about an environment and its expected behavior (Klimoski & Mohammed, 1994). They influence team member behavior and improve coordination by enabling members to anticipate one another's actions and needs (Cannon-Bowers, Salas, & Converse, 2005). This notion is particularly important when work events are unpredictable or when frequent communication is difficult (Mathieu et al., 2005), such as in the development of an e-Learning instructional design project (Jo, 2008). Some empirical studies have examined the relationship between SMMs and the team-based software design processes (e.g., Espinosa, Kraut, Lerch, Slaughter, Herbsleb, & Mockus, 2001). However, no reported research has investigated the effect of SMMs in team-based e-Learning ID projects.

The purposes of this study are; 1) to suggest a theoretical Model to explain the team-based ID processes in e-Learning content development project settings using the SMM perspective, and 2) to empirically validate the Model and investigate the path relationships among the Model's structural factors. The results will provide theoretical and practical implications to the increasingly popular team-based ID practices.

Literature review and hypotheses

Shared Mental Model (SMM) and Team Work

Humans create representations of their worlds that are simpler than the entities they represent (Johnson-Laird, 1983) in order to reduce uncertainty in their lives (Klimoski & Mohammed, 1994). These representations, which are called mental models, are cognitive structures that include specific types of knowledge humans use to describe, explain, and predict their surroundings (Rouse & Morris, 1986). Uncertainty is reduced through a heuristic function that individuals use to classify and retrieve the most salient pieces of information about situations, objects, and environments from their mental models (Cannon-Bowers et al., 1993). This process of identifying potential outcomes further reduces uncertainty. A collection of individuals working together as a team also needs mental representations, or SMMs, in order to effectively accomplish their assigned tasks.

Thus, the key for a team with diverse expertise to process information more effectively is to generate common understandings or SMMs. SMMs are `knowledge [and belief] structures held by members of a team that enable them to form accurate explanations and expectations for the task, and in turn, to coordinate their actions and adapt their behavior to demands of the task and other team members' (Cannon-Bowers et al., 1993; 228). These cognitive structures are expected to influence the way in which individuals cognitively process new information, both the content of what they process and the speed with which they are able to process it (Walsh, 1995). Thus, by shifting their focus from the individual level to the team level, team members can be better able to complete the project in a manner that is desirable for themselves, their teammates, and the organization.

Empirical studies that investigated the SMMs (e.g., Marks, Zaccaro, & Mathieu, 2000) suggest that team SMMs allow members to anticipate one another's actions and coordinate their behaviors, especially when time and circumstances do not permit overt and lengthy communication and strategizing among team members. Teams who share mental models are expected to have common expectations of the task and team, allowing them to predict the behavior and resource needs of team members more accurately (Cannon-Bowers et al, 2005).Under the team and task circumstances such as e-Learning content development projects, members in teams must rely on preexisting knowledge to predict the actions of their team members and respond in a coordinated fashion to urgent and novel task demands in order to be more productive (Jo, 2008).

Multiple SMMs: Taskwork and Teamwork

The theoretical literature on SMMs suggests that the members of a team are likely to hold not one, but multiple SMMs (Klimoski & Mohammed, 1994). Although there are many detailed breakdowns of mental-model types, these models can be viewed as reflecting two major content domains: those about taskwork and those about teamwork (Cooke, Salas, Cannon-Bowers, & Stout, 2000; Klimoski and Mohamed, 1994).

Taskwork encompasses all activities related to the execution of the task, while teamwork encompasses all activities necessary for teammates to work with each other. Each of these may have different effects on coordination depending on the task. A taskwork SMM describes the content and structure of the team's specific tasks. A teamwork SMM refers to how team members should interact with each other to accomplish the task and has been adopted by many researchers for representation because different types of projects have similar teamwork SMM content (e.g., Johnson & Lee, 2008). This division is also consistent with the idea that teams develop two tracks of behavior: a teamwork track and a taskwork track (McIntyre & Salas, 1995).

Research Hypotheses

As previous studies suggest, in project teams, members with different mental models about how tasks should be completed experience difficulty in coordinating their activities. To resolve these differences, team members need to exchange enough information in order to negotiate a mutually agreed upon solution and the means of achieving it. As information is accumulated through interactions such as observation, hearing others' explanations, or adapting one's own models, group mental models are thought to converge over time (Johnson-Laird, 1989; Klimoski & Mohammed, 1994; Mathieu et al., 2005).

Thus, researchers insist that interactions among members are a strong facilitator for the creation of the SMMs. The more team members communicate with each other, the more likely they are to form a common frame of reference and develop an SMM (Klimoski & Mohammed, 1994; Lurey & Raisinghani, 2001). Empirical research indicates that interactions among organizational members lead to similar interpretations of team- and task-events (e.g., Schein, 1992). In summary, relevant theories and empirical studies suggest that as team members develop experience with the task and with other team members through communication and shared interest, they develop SMMs. These research findings lead the researcher to formulate the following two hypotheses:

Hypothesis 1. Member interactions will facilitate the development of the teamwork SMMs.
Hypothesis 2. Member interactions will facilitate the development of the taskwork SMMs.

As hypothesized, interaction seems to be a facilitator for the SMMs. However, the tradeoff is that the team member workload increases with increased interaction. Research indicates that SMM influences team performance by decreasing the communication demands, thereby allowing team members to allocate cognitive load to the task at hand (Lagan-Fox, Anglim, & Wilson, 2004). According to Donnellon and colleagues, the SMM evolves as the team undergoes a complex, iterative process only until they converge to a point that allows the team to function as a collective (Donnellon, Gray, & Bougon, 1986). Thus, once team members develop SMMs to a sufficient degree, there is little incentive to continue interactions that consume precious time and cognitive load that would be better used for more taskwork purposes. The professional e-Learning content development teams that have certain levels of taskwork- and teamwork- SMMs through interactions should not require much time for their design projects except in the early stages, when members need to understand the uniqueness of the newly assigned project tasks. Therefore, for professional e-Learning ID team members, the researcher formulated the following hypothesis:

Hypothesis 3. Project progress by month will negatively predict member interaction

Instances of reduced interaction and communication within groups may inhibit the exchange of task- or team-focused information, and thus delay or otherwise interfere with the creation of team-level cognition. Such a situation can emerge when members decide to work independently of one another and have little role overlap. In group situations, the task structure or degree of role differentiation is a critical factor affecting the amount of interaction (Reichers, 1987), because team members communicate differently based on how their roles are structured (Rentsch & Hall, 1994).

As noted by Edmondson (1999), the reflection and discussion required for team learning might also reduce team efficiency, a necessity in short-term project teams working to meet a deadline. In this regard, Druskat and Kayes (2000) report an interesting phenomenon found in MBA team project groups. In their study, the requirement for MBA students to meet deadlines and achieve high performance in project teams resulted in short-term performance goals taking precedence over interactions and learning (Druskat & Kayes, 2000). In another study of the effects of structure on team interaction, teams in which every member had the opportunity to perform all of the subtasks interacted significantly more than teams in which the responsibilities for the tasks were divided among the members (Urban, Bowers, Monday, & Morgan, 1995). Since group interaction to coordinate work is partly a function of the type of structure or division of labor within it, there may be situations that are less conducive to the formation of SMMs. Hence, the researcher formulated the following hypothesis:

Hypothesis 4. Role differentiation in teams will negatively predict member interaction.

As the preceding discussion implies, SMMs in a team should improve task performance, other conditions being equal. However, few researchers have examined the influence of the two types of SMMs, teamwork and taskwork, on team performance. In a laboratory study of two-person teams, Mathieu and colleagues assessed the team members' SMMs and found that both taskwork and teamwork SMMs were significantly and positively related to team processes, which were in turn significantly related to team performance. However, the direct relationship between SMM and performance was not significant (Mathieu et al., 2000). In a similar, but more recent, laboratory-based study, Mathieu et al. (2005) showed that taskwork mental model similarity, but not teamwork mental model similarity, was significantly related to both team processes and team performance. Building on existing studies (e.g., Cannon-Bowers et al., 1993) and following the report of Mathieu et al. (2000, 2005), the researcher argues that both taskwork and teamwork SMMs enhance team performance. Thus, the researcher formulated the following hypotheses:

Hypothesis 5. Teamwork SMMs will positively predict the team performance
Hypothesis 6. Taskwork SMMs will positively predict the team performance

Based on the theoretical implications and empirical evidence, the researcher developed a theoretical Model to describe the causal relational structure of the variables previously discussed. The Model is depicted in Figure 1.

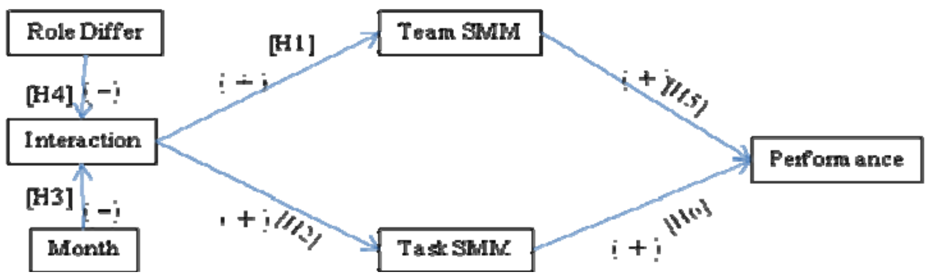

Figure 1. Research model and hypotheses

Method

Sample and procedure

The unit of analysis in the present study is the team, not the individual members. Seventy nine (79) e-Learning content development teams in Korea comprising 511 members participated in this study. Part-time employees or student interns were not included. The response rate of the survey was 85 % (523 out of 614). Twelve responses were not included in the analysis due to missing answers and/or obvious carelessness. The typical teams were composed of instructional designers, graphic designers, programmers, and system engineers. The average team size was 6.47 members with a range of 3 to 21. Of the respondents, 89% were full-time employees, 96% had college or advance degrees, 34% had education or educational technology degrees and 25% had computer science degrees.

The typical e-Learning ID projects in this study were corporate-oriented (vs. school-oriented) in terms of target audience, and were utilizing systematic approaches to ID in line with the recommendation from the Korean Ministry of Labor, which financially supports the ID projects by government policy.

The study used a single cross-sectional design (Fraenkel & Wallen, 2008; p.300) to investigate the changes in the observed variables with one-time data collection. Since a preliminary survey with the sample indicated that a typical e-Learning content development project takes about 3 months, the sample teams were categorized into three groups according to the month of the project progress: 32 teams were 0 to 1 month old, 37 were 1 to 2 months old, and 20 were in their third month. The levels of SMM, team performance, role differentiation, and member interaction were measured by the relevant instruments.

Measures

Shared mental models (SMMs)

To measure the SMMs of the participating teams, a translated version of the instrument developed by Levesque and colleagues (Levesque, Wilson, & Wholey, 2001) was used. The items ranged from assessments of the team's communication processes (`Most of our team's communication is about technical issues.'), to evaluations of the climate (`Voicing disagreement in this team is risky.'), and views of the team's structure (`Lines of authority in this team are clear.'). Items were assessed on a 5-point Likert scale. In addition, a number of questions were posed to make specific assessments of the team's progress, such as `What percentage of your project do you feel is complete?' The reliability and validity of the translated instrument was confirmed with an item internal consistency test using Cronbach’s alpha and confirmatory factor analysis using SPSS 15 and AMOS 7, respectively. Finally, 20 items, 10 for each of the teamwork and taskwork SMMs, were selected. Overall, post-hoc alpha and root mean square error of approximation (RMSEA) of the final instrument were .88 and .96, respectively.

Although SMMs have traditionally measured knowledge structures, it has been claimed that the construct should allow for the notion of evaluative belief structures (e.g., Johnson & Lee, 2008). The work on cognitive consensus can assist in this regard. Consensus is a different construct from consistency (Mohammed & Dumville, 2001). Measures of consistency are indices of reliability or the proportional consistency of variance among raters. Examples of consistency indices include the Pearson's correlation coefficient *r*. A high interrater reliability measured by *r* can be obtained if ratings by k judges are different but proportional. Specifically, consistency indices evaluate the similarity of rank orderings of judges' ratings. Therefore, high interrater reliability can be obtained even when there is little manifest agreement between judges. For example, one rater may use values 97 through 100, while another uses 1 through 4. Thus, a correlational analysis of these ratings calculated by Pearson's *r* would reveal perfect consistency or similarity in the patterns of the ratings, whereas an index of agreement would reveal minimum consensus.

To assess the extent to which SMMs had developed in each team, the researcher used a measure of intra-team similarity, instead of Pearson's *r*, as an overall index of the within-team consensus (Cooke et al., 2000) that evaluates the within-group agreement (r_{WG}) (James et al., 1984). R_{WG} is the most frequently used measure of agreement or consensus (Webber et al., 2000), and is represented mathematically as $r_{WG} = 1 - (S_{xj}^2 / \sigma_{EU}^2)$, where $r_{WG(1)}$ is the within-group interrater reliability for a group of k judges on a single item X_j, S_{xj}^2 the observed variance on X_j^2, and σ_{EU}^2 the variance on X_j that would be expected if all judgments were due exclusively to random measurement error (James, Demaree, & Wolf, 1984). R_{WG} controls for response biases, such as leniency and social desirability, that tend to inflate measures of group agreement (James et al., 2000).

Member role differentiation

Whereas the mental model measure looks at the level of perceptual agreement across a variety of variables, role differentiation measures the variance within group roles to determine the division of labor, i.e., how much the team members shared the duties of instructional analysis, storyboarding, media development, and organization of the team tasks. For instance, each team member's own contribution and each team member's contribution to the project role are measured using a 5-point scale. If a team's overall assessment is that every member made a `moderate' or `very small' contribution, the variance will be low, and the role differentiation will also be low (i.e., they shared the task among all members). If instead, a team has one member rated as contributing `a lot', and another as contributing `very little' to the same role, the division of labor in the group will be higher. As with the SMM measures, the r_{WG} value was used as the indicator of member role differentiation in this study.

Team interaction

Each participant was asked to rate how much they had worked with other members of their team during the period since their project had commenced using a 5-point scale that ranged from 1 (`not at all') to 5 (`a lot') for two different modes of interactions: face-to-face and electronic interaction such as email or internet chatting. The team interaction score was calculated for each team by taking the mean of its members' interaction scores.

Team performance

Board members of the e-Learning companies evaluated their content development teams, based on their weekly presentations, progress reports and the strategies they intended to use in the next period. Board members made their judgments by indicating their level of agreement with statements such as "The team is very likely to meet its instructional design quality objectives," "The team has predicted the reactions of its clients to its design strategy," and "Compared to other instructional design plans and storyboards that I have read, this one is … [5-point Likert scale, with endpoints of 'unacceptable' to 'outstanding']." The board evaluation score was calculated as the mean of multiple evaluation questions, averaged over all board members. The average reliability of this measure across all judges for a team was high for all three time-periods (alpha = .87, .89 and .91, respectively).

Data analysis

To test the model fit and the six individual hypotheses proposed, a structural equation modeling (SEM) analysis was conducted using AMOS 7. This analysis enabled the measurement error to be controlled for by fixing the random error variance to the product of the variance of the measured variable and the quantity one minus the estimated reliability for each variable. The quantity from the latent to the measured was fixed at one (1).

Before the hypotheses testing, preliminary analysis of the data revealed a few violations of normality measured by Shapiro-Wilk's univariate normality, and AMOS's multivariate normality index. In addition, the sample size was relatively small since the unit of analysis of the study was the team, not the individual. To deal with these issues, special care was required for the selection of parameter estimation method.

Thus, a maximum likelihood (ML) procedure with 2,000 iterations of bootstrapping option was used to estimate the model fit and other relevant parameter estimations. The rationale for using the ML procedure was two-fold: 1) ML estimation has been the most commonly used approach in SEM, and is therefore easily understood by the general readership, and 2) it has been found to be quite robust to a variety of less-than-optimal analytic conditions (e.g., small sample size, excessive kurtosis; Hoyle, 1995), as was observed in the present study. In addition, a bootstrapping procedure was selected as an option to overcome the study limitation caused by the relatively small sample size. Bootstrapping calculates the parameter estimates of interest resulting in an empirical sampling distribution. When the assumptions of the classical statistics such as a small sample size are severely violated, the empirical distribution that describes the actual distribution of the estimates made from this population will be substantially more accurate than the theoretical distribution.

Results

Descriptive statistics and correlation analysis

Descriptive statistics and correlation coefficients for all variables are reported in Table 1, which present a correlation matrix that permits the interested reader to recover the variance matrix. The reported data are rounded to three rather than the customary two decimal places to take full advantage of the precision offered by the SEM program, as recommended by Hoyle (Hoyle, 1995).

Table 1. Factor Correlations

Factor	Mean	SD	1	2	3	4	5
Month	1.971	.734	1				
Role Differentiation	.932	.595	.140*	1			
Interaction	6.232	3.891	-.070**	-3.09**	1		
Team-related SMM	4.017	.539	-.012	-.052	.168**	1	
Task-related SMM	4.654	.803	-.010	-.044	.144**	.024**	1
Team Performance	3.476	.741	-.011	.091	.114*	.767**	.203**

N=79 teams, *p<.05, **p<.01

Model fit

Major criteria fit indicators of the overall adequacy of the model fell within reasonable bounds. Table 2 summarizes the parameter estimates of the model fit accompanied by the major criteria indices. The fit criteria were referred from Hoyle (1995).

Table 2. Model Fit Indices

	NFI	CFI	RMSEA		
			Total	LO90	HI90
Observed	.912	.921	.091	.087	.114
Fit criteria	>.900	>.900	<.100	>.050	<.100

Individual hypotheses tests

Since the model fit was confirmed by the data, the individual hypotheses tests were allowed. All hypothesized relationships in the theoretical model were significant at the $p < .05$ level. The results are shown in Table 3.

Table 3. Hypotheses Test Results

Hypotheses	Standardized estimates	CR	*p*	Confirmed
H1. Interactions → (+) Team SMMs.	.078	2.606	.009	Yes
H2. Interactions → (+) Task SMMs.	.049	2.542	.011	Yes
H3. Progress by the month → (-) Interactions	-1.126	-3.119	.002	Yes
H4. Role differentiation → (-) Interactions	-2.150	-2.493	.013	Yes
H5. Team SMMs → (+) Performance	1.317	5.888	.000	Yes
H6. Task SMMs → (+) Performance	1.551	7.510	.000	Yes

Some Post-Hoc Observations

As reported previously, this study relied on data from self-reported surveys, which may be vulnerable to respondents' subjectivity and social desirability. To triangulate the interpretation of the main data, a follow-up group interview with the team leaders of 18 of the 79 ID teams and 3 board members from three different companies was conducted. The interview data provided some additional information. First, according to the interviewees, the respondents had enough time to carefully read the survey instrument, which provided a relevant level of engagement when answering the survey. The relatively high response rate (85%) supports this notion. Second, the interviewees unanimously agreed that the most relevant evaluator of the performance of the ID teams was the board member. In Korea, e-Learning development companies are relatively small, so that the board members, directors and CEOs usually have opportunities to personally review and evaluate the design processes and the products.

Discussion and conclusion

This study's major finding was that the Model developed on the basis of the SMM perspective was also relevant to a team-based e-Learning ID project's setting: like other team-based projects,e-Learning content development projects can be better understood by employing SMM perspectives. Professional e-Learning ID project is a collaborative activity which requires human resources and coordination among functionally diverse members. Some team members may work on one task/aspect of an instructional or performance solution (developing assessment measures, for example) while other team members may work on a different ID problem (for example, storyboarding specific lessons). ID activities may be accomplished at different times as well as at different locations. In short, ID for e-Learning is a complex, collaborative enterprise, requiring shared mental models in order for goals to be achieved (Spector & Edmonds, 2002). Despite today's advanced ID processes and development technologies, an ID team's performance was strongly influenced by human-social factors such as shared mental models, or organized knowledge that members share about things like the task, and each other. This result suggests that SMMs and the social aspects of the ID should be considered in the research field of IDs. In addition to the general recognition of the criticality of SMMs for successful ID projects, three specific findings were highlighted by the study results. First, member interaction was a prime facilitator for the development of SMMs. Increased interaction among the members increased their SMMs. Traditionally, instructional designers have been interested in student interactions. However, the present study results suggest that our attention should expand to include the interactions in ID teams as well. Thus, interventions that evaluate and facilitate member interactions in ID teams should be developed. Evaluation methods such as a social network analysis (Jo, 2008) and facilitating interventions such as team development sessions (Salas, Rozell, Mullen, & Driskell, 1999) may be worth of study in the future.

Second, the SMMs developed through member interactions contributed to the team performance - the ultimate goal of the teams and the organizations. Even expert instructional designers and developers who are individually equipped with knowledge of ID models and with experience in diverse projects still need to develop SMMs when they start to work on new ID projects as a team. This demonstrates the important effect on team performance of applying extra efforts, individual and organizational, to the development of SMMs. ,Shared mental model training (Rouse & Morris, 1986), which aims to the development of members' coordinated understanding of each other, shared goals and tasks, may be considered an effective intervention at an early developmental stage of the ID teams. In the long run, however, more systematic and structural approaches that involve knowledge collection and sharing of knowledge activities (such as needs assessment, goal definition, prototype development, resource allocation, and so on) are required (Spector & Edmonds, 2002). As Jo (2009) reports, knowledge management system for ID professionals should be beneficial for the performance enhancement of ID teams.

Third, the degree of interactions in the teams decreased as members' roles were differentiated by the division of labor. This finding is consistent with the reports of Druskat and Kayes (2000) and Urban et al (1995). For the Korean ID professionals participated in this study, the frequency of interactions with other members is negatively correlated with the level of role divisions. The present study findings suggest that such a short-term efficiency pursued by strict role division in teams has a negative influence on the amount of interactions that is critical for the knowledge sharing and reflection that occur in a team. This finding is consistent with research conducted by Langer (1997), which revealed that true collaboration is hindered by clearly mapped-out processes because team members reduce the level of mindfulness or the amount of thought and attention paid to the task processes. Thus, role division seems to be a double edged sword: it is necessary for highly standardized routines but not for ill-structured problem-solving tasks such as ID projects.

Fourth, the degree of interactions in these teams decreased as the projects progressed as well. This suggests that the time team members spent in meetings and other forms of communication decreased over the course of the project. For the Korean ID team members, interaction was instrumental for the development of SMMs but was cognitively costly as well. This finding is also consistent with Lagan-Fox et al (2004) and Donnellon et al (1986). Analyses of the present study left us with a number of implications that shared mental models help team members determine appropriate actions, form expectations of each other, explain how the team operates, describe the current state of the team, and predict its future state (Rouse et al., 1992). Organizations should attend to the shared, socially constructed causal connections that provide a blueprint for team action, and intervene early enough to mold these connections into effective shared mental models. The present analyses suggest that it is of particular importance that an e-Learning content development organization recognize the concrete and symbolic influence its culture and actions have on the ongoing development of shared mental models in teams.

The present research suffered a number of limitations. First, the study did not consider the 'accuracy' of the SMMs. Some theorists (e.g., Rentsch & Klimoski, 2001) have argued that shared and accurate SMMs enhance team performance. Second, the level of cross-validation was insufficient to strengthen the model validity. With a sample as small as that in the present study, even though the model fit indexes and *p* values met the set criteria, cross validation of the Model was necessary (Hoyle, 1995). Thirdly, politico-social mechanisms - power, authority, and norms – that could play a significant role in the collaboration processes were not included in this study. Fourthly, the study investigated the structure of the collaborations but not the regulation of the team interactions (e.g., Dillenbourg, 2002). Follow-up research will be required to answer practical question such as how the SMMs should be investigated. Lastly, due to the study context, the results may not be generalizable to non-Confucius cultures. Further studies are necessary with samples from other cultural contexts. Therefore, the study results must be interpreted cautiously.

References

Cannon-Bowers, J. A., Salas, E., & Converse, S. A. (1993). Shared mental models in expert team decision making. In N. J. Castellan, Jr. (Ed.), *Individual and group decision making: Current issues.* Hillsdale, NJ: Lawrence Erlbaum.

Cannon-Bowers, J. A., Salas, E., & Converse, S. (2005). Shared mental models in expert team decision making. In N. J. Castellan, Jr. (Ed.), *Individual and group decision making: Current issues*. Hillsdale, NJ: Lawrence Erlbaum.

Cooke, N. J., Salas, E., Cannon-Bowers, J. A., & Stout, R. J. (2000). Measuring team knowledge. *Human Factors, 42*(2), 151-173.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed). *Three worlds of CSCL. Can we support CSCL* (pp. 61-91). Heerlen, Open Universiteit Nederland.

Donnellon, A., Gray, B., & Bougon, M. (1986). Communication, meaning, and organized action. *Administrative Science Quarterly, 31*(2), 43-55.

Druskat, V. U., & Kayes, D. C. (2000). Learning versus performance n short-term project teams. *Small Group Research, 31*(3), 328-353.

Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly, 44*(2), 350-383.

Espinosa, J. A., Kraut, R. E., Lerch, J. F., Slaughter, S. A., Herbsleb, J. D., & Mockus, A. (2001). *Shared mental models and coordination in large-scale distributed software development*. 22nd International Conference on Information Systems, 513-518.

Hoyle, R. H. (1995). *Structural equation modeling: Conceptual issues, and applications*. Thousand Oaks, CA: SAGE.

James, L. R., Demaree, R. G., & Wolf, G. (1984). Estimating within-group interrater reliability with and without response bias. *Journal of Applied Psychology, 69*(1), 85-98.

Jo, I. (2008). Effects of social network measures on individual and team performance in a collaborative learning situation, *Journal of Educational Technology, 24*(4), 295-317.

Jo, I. (2009). Application of knowledge management system to collaborative instructional design activities. *Journal of Educational Information and Media design, 19*(3), 23-42.

Johnson, T. E., Lee, Y. (2008). The relationship between shared mental models and task performance in an online team-based learning environment. *Performance Improvement Quarterly, 21*(3), 97-112.

Johnson-Laird, P. N. (1989). Mental models. In Posner M.I. (Ed.), *Foundations of Cognitive Science*. Cambridge: MIT Press.

Klimoski, R, & Mohammed, S. (1994). Team mental model: construct or metaphor? *Journal of Management, 20*(2), 403-437.

Langer, E. J. (1997). *The power of mindful learning*. Reading, MA: Addison-Wesley.

Lagan-Fox, J., Anglin, J., & Wilson, J. R. (2004). Mental models, team mental models, and performance: Process, development, and future directions. *Human Factors and Ergonomics in Manufacturing, 14*(4), 331-352.

Lemieux-Charles L, Murray M, & Baker, G. (2002). The effects of quality improvement practices on team effectiveness: a mediational model. *Journal of Organizational Behavior. 23*(3), 533–553.

Levesque, L. L., Wilson, J. M., & Wholey, D. R. (2001). Cognitive divergence and shared mental models in software development project teams. *Journal of Organizational Behavior, 22*(2), 135-144.

Lurey, J. S., & Raisinghani, M. S. (2001). An empirical study of best practices in virtual teams. *Information & Management, 38*(3), 523–544.

Marks, M. A., Zaccaro, S. J., & Mathieu, J. E. (2000). Performance implications of leader briefings and team-interaction training for team adaptation to novel environments. *Journal of Applied Psychology, 85*(3), 971–986.

Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology, 85*(3), 273-283.

Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Cannon-Bowers, J. A., & Salas, E. (2005). Scaling the quality of teammates' mental models: Equifinality and normative comparisons. *Journal of Organizational Behavior, 26*(1), 37–56.

Mcintyre, R. M., & Salas, E. (1995). Measuring and managing for team performance: Emerging principles from complex environments. In R. Guzzo & E. Salas (Eds.), *Team effectiveness and decision making in organizations*. San Francisco: Jossey-Bass.

Mohammed, S. & Dumville, B. C. (2001). Team mental models in a team knowledge framework: expanding theory and measurement across disciplinary boundaries. *Journal of Organizational Behavior, 22*(2), 89-106.

Reichers, A. E. (1987). An interactionist perspective on newcomer socialization rates. *Academy of Management Review, 12*(3), 278-287.

Rentsch, J. R., Hall, R. J. (1994). Members of great teams think alike: a model of team effectiveness and schema similarity among team members. In Byerlein, M., & Johnson, D. (Eds.), *Advances in Interdisciplinary Studies of Work Teams*, Greenwich, CT: JAI Press.

Rentsch, J. R., & Klimoski, R. J. (2001). Why do 'great minds' think alike? Antecedents of team member schema agreement. *Journal of Organizational Behavior, 22*(2), 107-120.

Rouse,W. B., & Morris, N. M. (1986). On looking into the black box: Prospects and limits in the search for mental models. *Psychological Bulletin, 100*(2), 349–363.

Salas, E., Rozell, D., Mullen, B., & Driskell, J. E. (1999). The effect of team building on performance: An integration. *Small Group Research, 30*, 309-329.

Schein, E. H. (1992). *Organizational Culture and Leadership*. San Francisco. CA: Jossey-Bass.

Spector, M., & Edmonds, G. S. (2002). Knowledge management in instructional design, *ERIC Digest*, EDO-IR-2002-02.

Urban, J. M., Bowers, C., Monday, S. D., & Morgan, B. B. (1995). Workload, team structures, and communication in team performance. *Military Psychology, 7*(2), 123-139.

Walsh, J. P. (1995). Managerial and organizational cognition: Notes from a trip down memory lane. *Organization Science, 6*(3), 280-321.

Webber, S. S., Chen, G., Payne, S. C., Marsh, S. M., & Zaccaro, S. J. (2000). Enhancing team mental model measurement with performance appraisal practices, *Organizational Research Method, 3*(4), 307-322.