A Confirmatory Factor Analysis of the Computer-Mediated Communication Questionnaire (CMCQ) for Online Social Presence

Abstract

Social presence is a vital affective learning factor that influences online interaction. Valid instrument to measure online learners’ degree of social presence is not available. The purpose of this study is to conduct a confirmatory factor analysis (CFA) of the scores generated from the Computer-Mediated Communication Questionnaire (CMCQ), using Structural Equation Modeling (SEM), to assess the consistency between the empirical data and the hypothesized factor structure of the CMCQ in the proposed model, which was specified according to the theoretical framework and past research. This study concluded that the target model based on educational framework was valid and accepted; however, it is deserved to continue to refine text items and developing new items to measure Online Communication factor.

Introduction

Social presence is a vital affective learning factor that influences online interaction (Gunawardena & McIsaac, 2003). It is the degree of feeling, perception and reaction of being connected by computer-mediated communication (CMC) to another intellectual entity through electronic media (Tu & McIsaac, 2002). Based on media comparison study, higher teacher social presence would generate a significantly higher quality of knowledge acquisition (Weidenmann, Paechter & Schweizer, 2000). Additionally, Polhemus, Shih, and Swan (2001) found that a high degree of social presence would initiate and maintain a greater quantity of interactions and promote deeper interactions. Contrarily, the lack of social presence would lead to a high degree of frustration, an attitude critical of the instructor's effectiveness (Rifkind, 1992), and a lower level of affective learning (Hample & Dallinger, 1995).


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The Computer-Mediated Communication Questionnaire (CMCQ) (Tu, 2002) was developed to measure online social presence. The purpose of this study is to conduct a confirmatory factor analysis (CFA) of the scores generated from the Computer-Mediated Communication Questionnaire (CMCQ), using Structural Equation Modeling (SEM), to assess the consistency between the empirical data and the hypothesized factor structure of the CMCQ in the proposed model, which was specified according to the theoretical framework and past research. An adequate fit between the proposed model and the empirical data will lend support to the tenability of the hypothesized factor structure underlying the scores of the CMCQ.

Dimensions

The study by Short and his associates (1976) is cited most frequently in discussions of the social presence theory. He introduced the theory in face-to-face and closed-circuited TV environments and concluded social presence was determined by the “quality of the medium.” This single dimensional aspect did not take into account individual differences, task, social context (Biocca, Harms, & Gregg, 2001), and social relationships among communicators. Biocca, Harms, and Gregg (2001) and Rettie (2003) argued that Short et al. (1976, p.65) simply defined social presence from the dimension of the quality of medium: “attitudinal dimension of the user, a “mental set towards the medium,” and as the “subjective quality of the communication medium.” It did not consider user’s social context: the judgment of users’ experiences and the judgment of other participants. In other words, it is suggested that social presence is multi-dimensional.

Biocca, Burgoon, Harms, and Stoner (2001), Danchak, Walther, and Swan (2002), and Tu and McIsaac (2002) went beyond the uni-dimensional, attributes of the medium, and examined
other possible dimensions, such as social relations and behaviors in virtual environments and online learning environments. These studies identify the factors of social presence from multiple dimensions, attributes of the medium, communicators’ feelings/experiences, and social relationships, and communicators’ virtual behaviors. Biocca (2002) stated the critical factors as form, behaviors, and sensory while Tu and McIsaac (2002) classified the elements of social presence as social context, online community technology, and interactivity for an online learning environment.

**Educational Framework**

Based on the results of the factor analysis and qualitative data analysis, Tu and McIsaac (2002) proposed a social presence framework for educational learning environment. Furthermore, four dimensions of social presence (i.e., social context, online communication, interactivity, and privacy) were extracted in an exploratory factor analysis (Yen & Tu, 2004) to indicate the degree of feeling/relations, perceptions, media used, and reaction/behavior to another intelligent being in online communication.

“Social context” is constructed from the CMC users’ characteristics and their feelings toward the CMC environment and another intelligent being. Social contexts, such as task orientation (Steinfield, 1986), users’ characteristics and perception of online environments (Steinfield), recipients/social relationships (Williams & Rice, 1983), trust (Cutler, 1995; Kumar, & Benbasat, 2002), availability of CMC, and CMC access locations, social process (Stacey, 2002), contribute to the degree of social presence. This dimension refers to users’ feeling and experiences.
“Online communication” is the users’ perception on the use and attributes of online communication technology. CMC media contain two major characteristics that previous media do not, synchronicity vs. asynchronicity and communication channel partition (text, audio, and video). Text-based communications are traditionally used as asynchronous communication media; however, CMC has the capability to be used either synchronously and/or asynchronously. Communication channel partition is the second characteristic of CMC media. Stein and Wanstreet (2003) concluded that provided with (a)synchronicity and communication channel partition, students are able to select different CMC media to collaborate comfortably and to improve their levels of social presence.

The text-based format of CMC requires that users possess some level of computer literacy such as typing, reading and writing; otherwise they may experience communication anxiety (Gunawardena, 1991); therefore, users may perceive different CMC technologies with different quality for sociality. This is particularly true for students who are not culturally accustomed to the use of the computer keyboard, people not accustomed to using written communication. Perceptions of CMC media are influenced by both communicators’ actual CMC skills and their own perceived communication skills.

“Interactivity” includes the active communication and learning activities in which CMC users engage and the communication styles they use, including such variables as response time, communication styles (Norton, 1986), task types, topics (Argyle & Dean, 1965; Walther, 1992), and size of groups. In other words, this dimension refers to behavioral interaction as an element of social presence. The potential for feedback from another contributes to the degree of salience of another person in the interaction. Gunawardena (1995) differentiated interactivity and social
presence, and suggested that social presence required users to add one more step to awareness of interactivity; in short, when users notice (awareness), appreciate (connectedness), and react to it (social presence), there is social presence. As recommended by Gunawardena, social presence should incorporate the dimension of reacting to others as one of its dimensions.

The literature strongly supports that “privacy” should be considered a critical factor influencing social presence (Tu & McIsaac, 2002; Witmer, 1997); however, privacy has been an unstable variable factor to social presence. Generally speaking, if one perceives CMC with a high degree of privacy, the social presence is higher. In Tu and McIsaac’s (2002) study, they concluded that students perceived CMC with a low level privacy; however, students also demonstrated a high level of social presence. This might be explained as a risk-taking phenomenon (Witmer, 1997). Naturally humans like to take risks. With more comprehensive understanding of social presence and, perhaps, the relationship between social presence and privacy will be lucid.

Method

Instrument

The Computer-Mediated Communication Questionnaire (CMCQ) was revised from its earlier version (Tu, 2002) to measure the construct of Online Social Presence. On the first part of the CMCQ, twenty-four test items were developed to measure a respondent’s self-perception of his or her online social presence in different. Those twenty-four items were on the five-point Likert scale (1: strongly disagree; 2: disagree; 3: uncertain; 4: agree; 5: strongly agree) to indicate the differential intensities of a respondent’s self-perception of online social presence.
The results in a previous validation study (Yen & Tu, 2002) lent support to the internal consistency and content validity of the test items on the CMCQ. In addition, four factors (i.e., Social Context, Privacy, Interactivity, and Online Communication) representing different aspects of Social Presence were extracted from the scores of the CMCQ and indicated by different subsets of test items on the CMCQ (see table 1). For the purpose of current confirmatory factor analysis (CFA) study, only scores of the test items listed in Table 1 were analyzed.

Participants

Participants \((N = 210)\) were recruited from the graduate programs in a private, four-year university in the area of Washington, DC by inviting them to respond to the Computer-Mediated Communication Questionnaire (CMCQ) on a voluntary basis. They filled out the CMCQ in either online format or paper-and-pencil form. In this convenience sample, majority of the participants were female \((n = 154, 73.3\%)\). As to the ethnicity, the group of Caucasian-Americans was the predominant one \((n = 126, 60.0\%)\) and the Asian-American group was the second large one \((n = 45, 21.4\%)\). The rest of the participants were African-American \((n = 19, 9\%)\), Latino-American \((n = 6, 2.9\%)\), Native-American \((n = 3, 1.4\%)\), and Other \((n = 11, 5.2\%)\). The participants were also asked of their computer expertise levels. As a result, 154 (73.3%) of them self-rated as intermediate, 29 (13.8%) as expert, 26 (12.4%) as novice, and 1 as no experience (0.5%).

In light of the complexities and number of free parameters in the model proposed for the current study, a sample size of 210 should be sufficiently large to avoid the potential issues of convergence failure, improper solutions, and inaccurate estimation (Loehline, 2004; Kline, 2005)
Data Analysis

The Amos 5.0 program (Arbuckle, 2003) was used to implement the confirmatory factor analysis (CFA) using Structural Equation Modeling (SEM). The actual application of the CFA using SEM in this study consisted of the following procedures: (1) model specification, (2) model estimation, and (3) model fitting.

Model Specification. In SEM, a model represents a set of hypotheses regarding relationships among variables, either latent or observed (Klem, 2000). Model specification involves formulating the relationships among variables with a set of parameters, which are constants and indicate the nature and strength of those relationships (Hoyle, 1995).

For the current study, the target model, a second-order factor model (see Figure 1), was specified a priori, on the basis of past research (Yen & Tu, 2004), and the conceptual framework (Tu, 2002), to represent hypothesized factor structure underlying the scores generated from the Computer-Mediated Communication Questionnaire (CMCQ). In the proposed model, four first-order factors (i.e., Social Context, Privacy, Interactivity, and Online Communication), representing various dimensions of the second-order factor (i.e., Social Presence), were postulated to underlie the participants’ responses to the designated subgroups of test items on the CMCQ respectively.

Two other alternative models were also specified to compare with the target model. The first alternative model was a first-order factor model with four factors (i.e., Social Context, Privacy, Interactivity, and Online Communication) underlying the responses of different test items respective (see Figure 2). The other alternative model was a first-order factor model with one factor, Social Presence, to account for responses to the test items of the CMCQ (see Figure
3). It had been suggested as desirable by researchers (McDonald & Ho, 2002) that potentially plausible alternative models should be specified and compared with the target model in terms of their goodness of fit.

*Model Estimation.* In model estimation, optimal estimates of model parameters are found to minimize the discrepancy between the observed variance/covariance matrix and the model-implied variance/covariance matrix (Bentler, 1980). Most of the estimation methods in SEM assume the multivariate normality of which the violation may result in the inflated Type I error rates for the overall $\chi^2$ goodness-of-fit test and the significance test of individual parameter estimates (Kaplan, 1990; West, Finch & Curran, 1995). For the current study, the maximum likelihood (ML) method was adopted in parameter estimation due to the robustness of parameter estimates generated by the ML method against the violation of multivariate normality assumption (Kline, 2005).

*Model Fitting.* Model fit is concerning the ability of a model to reproduce the observed variance/covariance matrix of observed variables (Thompson, 2000). Researchers (Bollen & Long, 1993; Breckler, 1990) suggested that multiple criteria should be adopted to assess the different aspects of model fit. For the current study, the $\chi^2$ goodness-of-fit statistic, the ratio of $\chi^2$ to degrees of freedom, two absolute fit indices (i.e., goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI)), two incremental fit indices (i.e., normed fit index (NFI), and comparative fit index (CFI)), and one population-based fit index (i.e., root mean squared error of approximation (RMSEA)) were utilized to assess the model fit of the target model and two alternative model from different perspectives. Moreover, two predictive fit indices (i.e., expected cross-validation index (ECVI), and consistent Akaike information criterion (CAIC))
were also used to assess the expected model fit of the target model and two alternative models in samples randomly selected from the same population.

The test statistic of the $\chi^2$ goodness-of-fit test for the overall model fit to the data is directly derived from the fitting function, or discrepancy function (Chou & Bentler, 1995; Hu & Bentler, 1999). The value of the fitting function and the derived $\chi^2$ value will equal zero, if a model fits the data perfectly. Therefore, the $\chi^2$ goodness-of-fit test is actually a "badness-of-fit test". Contrary to traditional hypothesis testing, a statistically significant $\chi^2$ value suggests bad model fit and is not desirable in model fitting (Kline, 2005). The $\alpha$ level was set at .05 for the $\chi^2$ goodness-of-fit test. The ratio of $\chi^2$ to degrees of freedom was also assessed due to the sensitivity of the $\chi^2$ value to sample size (Kline, 2005). A ratio of $\chi^2$ to degrees of freedom as 2 was adopted as the cutoff for an acceptable fit.

Goodness of Fit Index (GFI) is analogous to the squared multiple correlation and indicates the proportion of observed covariance accounted for by the model-implied covariance (Tanaka, 1993). Adjusted Goodness of Fit Index (AGFI) is obtained by correcting the value of GFI downward for model complexities in terms of degrees of freedom. As a rule of thumb, if the value of the GFI is larger than .90, the model is considered to have a good fit (Kline, 2005). There is no cutoff of an AGFI for an acceptable model fit. Therefore, an AGFI not very different from the GFI will be indicating a good model fit.

Bentler-Bonett Normed Fit Index (NFI) indicates the proportion of overall model fit improvement relative to the null model which assumes no relationship among observed variables in the population (Kline, 2005). Comparative Fit Index (CFI) is interpreted the same way as the
NFI. If the value of a NFI or the value of a CFI is larger than .90, an acceptable model fit is indicated (Kline).

Root Mean Square Error of Approximation (RMSEA), an index of the badness-of-fit of a model, is population-based, and therefore, relatively insensitive to the effect of the sample size (Loehlin, 2004). A value of RMSEA less than .05 indicates a close model fit and a value less than .08 indicates a reasonable model fit (Kline, 2005).

Expected Cross-validation Index (ECVI), and Consistent Akaike Information Criterion (CAIC) are appropriate indices in the comparison of two nonhierarchical (i.e., non-nested) models and a model with lower values of them will have a better chance to fit the future samples from the same target population equally well as with the current sample (Kline, 2005).

Results

Descriptive statistics and correlation coefficients for test items selected for data analysis are presented in Table 2.

**Overall Model Fit**

The results of various fit indices for the target model and two alternative models are listed in the Table 3.

In those three models, the results of the $\chi^2$ goodness-of-fit test failed to support the model fit. In light of the sample size in the current study ($N = 210$), the above statistically significant results might largely result from the large sample size (Schumacker & Lomax, 2004). The ratios of $\chi^2$ to degrees of freedom did support an acceptable model fit in the target model (i.e., 1.688), and the alternative Model 1 (i.e., 1.541), but not the model fit in the alternative Model 2 (i.e., 2.216) and indicated an acceptable model fit.
As to two absolute fit indices (i.e., GFI, and AGFI), and the population-based fit index (i.e., RMSEA) they all lent support to a reasonable fit of three models in the current study. While scrutinizing actual values of indices for those three models, the alternative Model 1 seemed to be the best in terms of the fit to the data, then, the target model, last, the alternative Model 2. However, the differences of model fit indicated by the above three fit indices were not sizable between the target model and alternative Model 1. On the other hand, two incremental fit indices (i.e., NFI, and CFI) were lower than the cutoff (i.e., .900) for an acceptable model fit for all three models with the CFI for the alternative Model 1 as the only exception.

Relative to the other two models, the target model had the lowest value of the CAIC but the alternative Model 1 had the lowest value of ECVI. The results of two different predictive fit indices were not consistent regarding which model was more likely to have a fit to the future samples from the same target population as good as the fit to the current sample. On the other hand, in light of the results, it could be concluded that the model fit of the alternative Model 2 was least likely to replicate in future samples. Moreover, the differences between the target model and the alternative Model 1 in those two predictive indices were not sizable. Accordingly, the target model and the alternative Model 1 would be perceived as being equal on predictive model fit.

Based on the results of the overall model fit indices, the overall model fit of those three models were supported to some extent, by not definitely. Among them, the alternative Model 1 appeared to have a better fit to the data. Though, the differences of between the target model and the alternative Model 1 in the overall model fit were not obvious.
Model Parameters

The alternative Model 1 has the best model fit according to the results of various fit indices discussed previously. While examining correlation between various factors (see Figure 2), three factors, Social Context, Interactivity, and Online Communication were highly correlated and the above results suggested possible redundancies among those factors. Therefore, it may be desirable to consider a more parsimonious two-factor alternative model and test it with a new sample in the future. As to the standardized factor pattern coefficients between those four factors and test items which were equal to the standardized factor structure coefficients (i.e., correlations or loadings) due to the absence of cross-loading (Kline, 2005), two out of twelve were lower the cutoff for a poor loading (.32), two higher than the one for a poor loadings, six higher than the one for a fair loading (.45), and two higher than the cutoff for a good loading (.55) (Comrey & Lee, 1992). Those two perceived as poor loadings were for the test items #8 measuring Interactivity, and the test item #22 measuring Online Communication. Further inspection of those two test items is necessary and revision or removal will be possible options when necessary.

It is noteworthy that there is an offending estimate of correlation (i.e., 1.07) between Interactivity and Online Communication which fell outside the theoretically possible range of a correlation coefficient. The possible causes of an offending estimate are specification errors, nonidentification of the model, outliner cases, a combination of small sample sizes and only two indicators per factor, bad start values, and empirical underidentification (Chen, Bollen, Paxton, Curran, & Kirby, 2001). In the current study, one possible explanation for the offending estimate of the correlation coefficient could be the insufficiently large number of test items (i.e.,
2) specified to measure the factor Online Communication, though the definitive answer was wanting. But the above offending estimate did raise the question of the correct specification of the alternative Model 1, especially when the model fit of the alternative Model 1 was slightly better than the target model in terms of various fit indices.

While examining the standardized factor pattern coefficients in the target model, the differentiation between the second-order factor, Social Presence, and three first-order factors, Social Context, Interactivity, and Online Communication, seemed to be ambiguous in light of the high correlations among them. Accordingly, a more parsimonious model with less first-order factors may be adequate to account for the variance/covariance among test items. As to the standardized factor pattern coefficients between test items and various factors, two out of twelve were lower than the cutoff for a poor loadings (.32), two higher than the one for a poor loadings, six higher than the one for a fair loading (.45), and two higher than the cutoff for a good loading (.55) (Comrey & Lee, 1992). As in the alternative Model 1, the validity of the test items #8 the test item #22 to measure the designated factors was problematic.

Discussion and Conclusions

In this study, it appeared the alternative model 1 has better fit than the target model; however, the difference between two models is insignificant. The target model is based on the educational theoretical framework (Tu & McIsaac, 2002). It is concluded that the target model is valid to keep and continue refining although it didn’t appear the best fit. There are two items (item 8 and 22) appearing poor loading. These two items have raised the attentions for refining the item language, and objectives. Additionally, item 22 loaded on the Online Communication which has two items only. Two items factor is considered weak. It is necessary to continue to
speculate and develop new items to measure Online Communication factor. In the future study, the newer social presence instrument should be re-validated by followed valid instrument validation procedure since the instrument developed in this study to be refined.

Table 1

*CMCQ Test Items Measuring Different Aspects of Social Presence in the Target Model and Alternative Model 1*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Item content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Context</td>
<td>1</td>
<td>CMC messages are social forms of communication.</td>
</tr>
</tbody>
</table>
3  CMC messages convey feeling and emotion.
16  CMC allows me to build more caring social relationship with others.
20  CMC permits the building of trust relationships.

Privacy
4  CMC is private/confidential.
18  It is unlikely that someone might obtain personal information about you from the CMC messages.
24  It is unlikely that someone else might redirect you messages.

Interactivity
8  Users of CMC normally respond to messages immediately.
13  I am comfortable participating, even I am not familiar with the topics.
23  I am comfortable with the communication styles employed by CMC users.

Online Communication
10  It is easy to express what I want to communicate through CMC.
22  My computer keyboard skills allow me to be comfortable while participating in CMC.

Note. In alternative Model 2, all listed test items are measuring the factor of Social Presence.

Table 2

Descriptive Statistics and Intercorrelations Among Test Items (N = 210)

<table>
<thead>
<tr>
<th>Item #</th>
<th>M</th>
<th>SD</th>
<th>1</th>
<th>3</th>
<th>16</th>
<th>20</th>
<th>4</th>
<th>18</th>
<th>24</th>
<th>8</th>
<th>13</th>
<th>23</th>
<th>10</th>
<th>22</th>
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<tbody>
<tr>
<td>1</td>
<td>4.062</td>
<td>.825</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>3</td>
<td>3.295</td>
<td>.987</td>
<td>.312</td>
<td></td>
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<tr>
<td>16</td>
<td>3.043</td>
<td>.994</td>
<td>.189</td>
<td>.304</td>
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<td></td>
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<tr>
<td>Model</td>
<td>$\chi^2$</td>
<td>df</td>
<td>$\chi^2$/df</td>
<td>GFI</td>
<td>AGFI</td>
<td>NFI</td>
<td>CFI</td>
<td>RMSEA</td>
<td>CAIC</td>
<td>ECVI</td>
<td></td>
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<tr>
<td>Target</td>
<td>84.407*</td>
<td>50</td>
<td>1.688</td>
<td>.931</td>
<td>.897</td>
<td>.746</td>
<td>.871</td>
<td>.057</td>
<td>262.126</td>
<td>.672</td>
<td></td>
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Table 3

*Fit Indices for Different CFA Models*
<table>
<thead>
<tr>
<th>Alternative Model 1</th>
<th>73.962*</th>
<th>48</th>
<th>1.541</th>
<th>.941</th>
<th>.904</th>
<th>.778</th>
<th>.903</th>
<th>.051</th>
<th>264.376</th>
<th>.641</th>
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<tbody>
<tr>
<td>Alternative Model 2</td>
<td>114.789*</td>
<td>54</td>
<td>2.216</td>
<td>.910</td>
<td>.870</td>
<td>.655</td>
<td>.772</td>
<td>.073</td>
<td>267.119</td>
<td>.779</td>
</tr>
</tbody>
</table>

*Note.* GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; NFI = normed fit index; CFI = comparative fit index; RMSEA = root mean square error of approximation; CAIC = consistent Akaike information criterion; ECVI = expected cross-validation index.

*p* < .05.
Figure 1. Target model with standardized factor pattern coefficients.
Figure 2. Alternative Model 1 with standardized factor pattern coefficients.
Figure 3. Alternative Model 2 with standardized factor pattern coefficients.
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