Study on a Structural Equation Model of the Effects of E-learning Perceived by Elementary School Students

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Abstract

The purposes of this study are to create a Structural Equation Model for explaining the factors which influence the effects of e-learning perceived by elementary school students, to examine the model fit of the Structural Equation Model, and to explain the structural relationship among the factors.

To this end, the theoretical framework was developed to explain elementary students' perceived effects of e-learning, based on critical analysis of the previous studies. Second, the model fit of the measurement model based on the theoretical framework was tested, using the confirmatory factor analysis and structural equation modeling (SEM) analysis. Third, the hypothesized structural equation model was revised and refined as the final model for the most appropriate one. Finally, the paths and effect size of the factors which influence the students' perceived effects of e-learning were analyzed.

The result of the confirmatory factor analysis for measurement model pointed out that the fit of the AGFI did not satisfy the statistical criterion. Accordingly, Squared Multiple Correlations (SMC) was conducted, and 6 factors were eliminated to revise the measurement model. The second test for the revised measurement model was conducted. The result indicated that the fit of the indices in the SEM were higher than the previous model with $\chi^2=2,401.83$, df=979, GFI=0.913, AGFI=0.900, TLI=0.938, CFI=0.943, and RMSEA=0.036. Both credibility and validity were examined and turned out to be appropriate.

Next, the SEM analysis was also conducted to verify the appropriateness of the hypothesized structural equation model based on the revised measurement model. The result indicated that the entire model was appropriate, but GFI and AGFI still did not satisfy the desired statistical criterion. The result led to finding the more appropriate model than the present model. The hypothesized structural equation model, therefore, was revised according to both the previous studies and the modification indices, using AMOS 5.0. The revised model was eventually decided as final, indicating a more appropriate fit than the previous model. The model fit of the final structural equation model presented $\chi^2=2,776.39$ (p=0.000), df=999, $\chi^2$/df=2.779, GFI=0.900, AGFI=0.887, TLI=0.924, CFI=0.929, and RMSEA=0.039.

In conclusion, this study presented that the theoretical framework and the final structural equation model were found to be appropriate for explaining the factors which influence elementary students' perceived effects of e-learning. This study also added new findings to the relevant studies in that the characteristics of e-learning environments caused the effects of e-learning in the characteristics of the learners as a parameter.

Finally, the findings about the paths and effect size of the factors which influence the effects of e-learning in this study can be used to design e-learning service which is most appropriate to the students' abilities and to understand the processes of the elementary students' learning and perceived effects during e-learning.

Introduction

The term “e-learning” started to be widespread in Korean elementary and secondary education after it was used in the Education Ministry’s announced measures in 2004 to reduce private tutoring expenses by normalizing public education (The Ministry of Education and Human Resources, 2004). E-learning, therefore, has a relatively short history in the Korean education field.

Now there is a move to broaden the concept of e-learning in Korea as the government has been actively working to use e-learning in teaching and learning in elementary and secondary schools (Jang Sang-hyeon et al. 2004; Han Geon-woo, Song Gi-sang, Lee Yeoung-jun, 2005). This has caused varied terms such as cyber learning, online learning, and internet learning, commonly used in elementary and secondary schools, to be all replaced by the term e-learning (Byeon Yeoung-gye, Kim Gyeong-hyeon, 2003).

The trend has made e-learning a familiar teaching and learning method for the elementary and secondary education. As part of its policies, the Education Ministry is providing e-learning services nationwide including “EBS Lectures for the Scholastic Ability Test” and “Cyber Home Learning” for elementary and secondary school students. These services are aimed at expanding education beyond the classroom into cyberspace; enabling students to learn according to their own levels and have greater right to learning choices; and enhancing the quality of public
education by providing students with self-directed learning opportunities that enable them to study whenever necessary.

Despite the enthusiasm surrounding e-learning, few efforts are being made to prove the effectiveness of e-learning in elementary and secondary education. Some are even voicing concern about its effectiveness (Han Geon-woo, Song Gi-sang, Lee Yeoung-jun, 2005).

Park Innwoo (2004) said that e-learning, by nature, is self-directed learning. This means that a more careful and effective approach is necessary when providing e-learning service to elementary and secondary schools than to universities and companies as schoolchildren are less capable of directing their own learning than adults (Song Sang-ho et al., 2005). Han Geon-woo, Song Gi-sang, and Lee Yeoung-jun (2005) stressed the need to make constant efforts to enhance the effectiveness of e-learning in their research on “Ways to improve EBS lectures for the scholastic ability test for the good of the public education,” where they argued that the EBS lectures failed to take advantage of e-learning by conducting one-way lectures, and pointed out the lack of lecture information and evaluation. These points indicate the urgency of taking a systematic and comprehensive look at the effects of e-learning used in elementary and secondary education.

Theoretical Background

Every study has different yardsticks for measuring the effectiveness of e-learning. Many studies focusing on its academic effects adopted learners’ academic achievement as the major yardstick (Kang Ok-mi, 2001; Kim Se-eun, 2002; Lee In-sook, 2002; Moore & Kearsley, 2005; Neuhauser, 2002; Hiltz, 1990), while others used learners’ satisfaction (Park Seong-ik, Yoon Soon-geyong, 2000; Thurnond et al., 2002). Some studies took learners’ academic achievement, participation, and satisfaction into account to explain the effectiveness of e-learning (Kang Yeoung-hwan, 2004; Seo Hye-jeon, 2001; Lim Jeong-hoon, Lee Hang-nyeong, 2003; Yoo Pyeong-jun, 2003b).

This study defines the effectiveness of e-learning as individual learner’s comprehensive and subjective perception of the educational experience and benefits gained through e-learning, including their academic achievement, participation, and satisfaction. Based on this definition, it examines existing studies and relevant documents for the theoretical background to find that most studies on the effectiveness of e-learning dealt with individual learner’s characteristics and e-learning environmental characteristics as factors influencing effectiveness. The findings will be explained in detail below.

Kang Myeong-hee (2004) argued that computer-based learning is not suitable to all learners, and that benefits and level of satisfaction can vary according to learners’ characteristics. This means that learners’ characteristics determine whether e-learning is effective. Relevant studies focused the individual characteristics that affect the effectiveness of e-learning. The characteristics identified include learning motivation, achievement motivation, academic self-efficacy, computer self-efficacy, learners’ familiarity with technology, learners’ desire and ability to direct their own study, learners’ educational background or preliminary education, learners’ personality, learner’s interest, time management strategies, positive attitude, test anxiety, cognitive strategies, and meta-cognitive strategies (Kang Ok-mi, 2001; Kim Se-eun, 2002; Song Sang-ho, 2000; Yang Yeon-sook, Yoo Pyeong-jun, 2003; Eom Woo-yong, Choi Eun-hee, 2001; Lee In-wook, 2002, 2003; Lee Ji-yeon, 2004; Lim Jeong-hoon, Lee Hyang-nyeong, 2003; Yoo Pyeong-jun, 2003a; Cho Il-hyeon, Lim Gyu-yeon, 2002; Ju Yeoung-ju, Moon Ja-yeoung, 2004; Compeau & Higgins, 1995; Hasan, 2003; Houle, 1996; Kelsey, Lindner & Dooley, 2002; Moore & Kearsley, 2005; Oliver & Shapiro, 1993; Torkzadeh & Van Dyke, 2002).

Other studies found that the effectiveness of e-learning is dependent on e-learning environmental characteristics (Song Sang-ho, 2004). They focus mainly on design and operational elements of e-learning, and identify elements including composition of learning contents, learner support, convenience or ease of use, interaction such as teachers’ feedback and operators’ social role, user interface, teachers’ capability, various evaluation methods, preliminary education, interaction between learners, accessibility, and physical and psychological support (Park Seong-ik, Yoon Soon-Gyeong, 2000; Seo Shin-seok, 2003; Seo Hye-jeon, 2001, Lee Ji-yeon, 2004; Cho Il-hyeon, Lim Gyu-yeon, 2002; Choi Jeong-im, 1999; Harasim, 1986; Kelsey, Lindner & Dooley, 2002; Thurmond et al., 2002).

Purpose of the Paper

Although there are a number of theories and studies on the effectiveness of e-learning, few studies take a comprehensive look at various e-learning factors such as learners’ profile, general learning-related elements, web-based learning-related elements, learners’ satisfaction, learners’ academic achievement, and learners’ participation. As a result, Lee In-sook (2003) and Yoo Pyeong-jun (2003b) strongly raised the need to conduct comprehensive research taking all e-learning factors into account. This study aims to design a comprehensive theoretical model to explain the effectiveness of e-learning based on existing studies, which revealed the effectiveness of e-learning
according to learners’ characteristics and environmental characteristics, and to verify the model by measuring paths
between factors and effect size to identify factors contributing to the perceived effects of e-learning. This will help
us understand the elements that must be considered to enhance the effectiveness of e-learning.

**Research Questions**

The purposes of this study are to design a model that can explain factors affecting the perceived effects of
e-learning; to identify a structural relationship between those factors; and to assess the model fit of the structural
equation model. To that end, it has set up the following research tasks.

**Research Task I**: To design a theoretical structural model of factors influencing the effects of e-learning
perceived by elementary school students based on existing studies

**Research Task II**: To devise a provisional structural equation model based on the theoretical model, and
test the model fit of the equation model

**Research Task II-1**: To decide whether the provisional structural equation model based on the theoretical
model is the optimum model or not, and, if not, to identify the optimum model

**Research Task II-2**: To discover whether hypothetical paths between factors affecting the perceived effects
of e-learning are significant

**The Model**

This study used the Input-Environment-Outcome (I-E-O) model by Astin (1993) as the conceptual basis for
a structural model of factors influencing the perceived effects of e-learning. The I-E-O model has been used by
many researchers to verify the relationship between learner’s characteristics, e-learning environmental
characteristics, and e-learning effectiveness (Astin & Sax, 1998; Campbell & Blakey, 1996; House, 1999; Kelly,
1996; Knight, 1994a, 1994b; Long, 1993; Pace, 1976).

Adopting the ideas of Astin (1993), the study defined “input” as the characteristics of individual learners
participating in educational programs and “environment” as the practical experiences and activities educational
programs provide for students. Based on existing studies, “outcome” was defined as the learners’ academic
achievement and satisfaction through participation in learning (Kang Yeoung-hwan, 2004; Koo Gyo-jeong, 2005;
Figure 1 shows the theoretical structural model indicating the elements of each factor and hypothetical paths between them.

**Measurement Issues**

Table 1 shows the composition and sources of a survey tool to analyze a structural model. The questionnaire has three factor categories – e-learning environmental characteristics, learners’ characteristics, and e-learning effectiveness. The e-learning environmental characteristics category consists of four parts, which are the same as the four elements – composition of learning contents, learner support, usability, and interaction. The learners’ characteristics category also consists of four parts – intrinsic motivation, extrinsic motivation, academic self-efficacy, and computer self-efficacy – and the e-learning effectiveness category three parts – learners’ academic achievement, learners’ participation, and learners’ satisfaction.
The questionnaire is composed of 53 questions measured 1 to 5 according to a Likert-type scale, with 1 meaning “strongly disagree”; 2 “disagree”; 3 “neither agree nor disagree; 4 “agree”; and 5 “strongly agree.” The questions were created based on existing studies to verify a provisional structural model devised on the basis of a theoretical structural model. In relation to the question items, a validity test by experts and a reliability test were conducted. For the reliability test, a preliminary survey was also carried out on 130 sixth-graders in elementary schools in Seoul from Apr. 5-7, 2006, to compute Cronbach’s $\alpha$ of the questionnaire. The reliability of the questionnaire was .94, which is fairly high.

### Data Analysis

The survey for the study was conducted on 1,500 sixth-graders in seven elementary schools in Seoul and Gyeonggi Province Apr. 18-29, 2006. Some 82.7 percent, or 1,241, out of the 1,500 questionnaires distributed were collected, and 1,154 of them were found valid for statistical analysis.

With the collected data, a confirmatory factor analysis of a measurement model based on the theoretical structural model was carried out using AMOS 5.0. The analysis included the assessments of the model fit index and construct reliability, and calculation of the variance extracted index to evaluate if the scales of the measurement model are representative of the factors concerned. A discriminant validity test was also conducted using a correlation matrix analysis of constructs. An analysis of a measurement structural equation model based on the measurement model showed that AGFI, a model fit index, was not high enough to be valid, and as a result, six measurement variables were removed using squared multiple correlations, modifying the measurement model. A model fit test of the modified measurement model found that most of the model fit indices improved in the measurement structural equation model with the value of $\chi^2=2,401.83$, df=979, GFI=0.913, AGFI=0.900, TLI=0.938, CFI=0.943, and RMSEA=0.036. The reliability and validity of the measurement model were also assessed to be valid.

All the results of the confirmatory factor analysis were valid enough to next conduct an analysis of a structural equation model, which was carried out for a provisional model based on the measurement model modified. A model fit test of the provisional model showed a fairly good fit, but the values of GFI and AGFI were lower than acceptable, raising the need for a better model than the provisional model. After checking the modification index of the provisional model and the theoretical background of existing studies, two paths indicating a direct relationship between interaction and learners’ participation, and between composition of learning contents and learners’ participation, were added.
Table 2. Results of Model fit Test of Provisional Model and Modified Model

<table>
<thead>
<tr>
<th>Model</th>
<th>$\chi^2$</th>
<th>d.f.</th>
<th>P</th>
<th>$\chi^2$/d.f</th>
<th>GFI</th>
<th>AGFI</th>
<th>TLI</th>
<th>CFI</th>
<th>RMSEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provisional model (1)</td>
<td>2,949.59</td>
<td>1,001</td>
<td>0.000</td>
<td>2.947</td>
<td>0.895</td>
<td>0.882</td>
<td>0.916</td>
<td>0.923</td>
<td>0.041</td>
</tr>
<tr>
<td>Modified model (2)*</td>
<td>2,776.39</td>
<td>999</td>
<td>0.000</td>
<td>2.779</td>
<td>0.900</td>
<td>0.887</td>
<td>0.924</td>
<td>0.929</td>
<td>0.039</td>
</tr>
<tr>
<td>Model 1: Model 2</td>
<td>173.20</td>
<td>2</td>
<td>0.000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Modified model = Provisional model + (Interaction $\rightarrow$ Learners’ participation, Composition of learning contents $\rightarrow$ Learners’ participation)*

A model fit test of the modified provisional model showed an improvement of model fit with the value of $\chi^2=2,776.39$ ($p=0.000$), $\chi^2$/d.f=2.779, GFI=0.900, AGFI=0.887, TLI=0.924, CFI=0.929, and RMSEA=0.039. Thus, the modified model was chosen as the final model. Figure 2 shows the final modified model and path coefficients.

![Figure 2. Final modified model and path coefficients](image)

**Discussion**

Efforts to raise the effectiveness of e-learning are needed not only in elementary and secondary education but also in university and corporate education. Many studies have therefore been conducted to assess the effectiveness of e-learning and thus provide an effective e-learning service. This study aims to design a model explaining the effects of e-learning perceived by elementary school students and assess the paths and effect size of various factors influencing the effectiveness of e-learning. This is expected to promote in-depth understanding of how elementary school students learn in e-learning and enable creation of an e-learning service that suits the needs of child learners.

The following conclusions can be reached based on the study results.

First, the final structural equation model was proved valid to explain factors influencing the effects of e-learning perceived by elementary school students through the confirmatory factor analysis and structural equation model. The model fit test of the final model showed a fairly good fit with the value of $\chi^2=2,776.39$ ($p=0.000$), $\chi^2$/d.f=2.779, GFI=0.900, TLI=0.924, CFI=0.929, and RMSEA=0.039. This means that the final structural equation model is a proper structural model to explain the effects of e-learning perceived by elementary school students.
Second, unlike models in past studies, the model in this study showed that e-learning environmental characteristics influence the effectiveness of e-learning through the mediation of learners’ characteristics. For example, in the composition of learning contents, an element of the e-learning environmental characteristics that affect academic achievement, the effect size was significant at .447, even when taking into account indirect effects alone that take place through the mediation of intrinsic motivation, computer self-efficacy, and learner’s participation. Learner support also showed a significant effect size of .228 toward academic achievement, even taking into account indirect effects alone that took place through the mediation of intrinsic motivation and computer self-efficacy. These results indicated that e-learning environmental characteristics can have indirectly influence the effectiveness of e-learning through the mediation of learners’ characteristics. This study is distinguished from past studies by its interest in the mediating effects of e-learning environmental characteristics and learners’ characteristics on the effectiveness of e-learning (Seo Hye-jeon, 2001; Koo Gyo-jeong, 2005; Chung Jae-sam, Lim Gyu-yeon, 2000).

Third, it was found that e-learning environmental characteristics have positive effects on learners’ characteristics. In the case of intrinsic motivation, learner support, composition of learning contents, and usability had positive effects in that order, with the effect size being .475, .378, and .207, respectively. Learner support (.319) had a positive effect on extrinsic motivation. On academic self-efficacy learner support (.641) had a positive effect, and on computer self-efficacy learner support (.907) and usability (.121) had a positive effect. This showed that e-learning characteristics influence the effectiveness of e-learning in combination with specific learners’ characteristics.

Fourth, an analysis of learners’ characteristics influencing the effectiveness of e-learning found that extrinsic motivation and academic self-efficacy do not have a significant effect on learner’s academic achievement, participation, or satisfaction. This goes against existing study results: Wlodkowski (1999) and Chung Jae-sam and Lim Gyu-yeon (2000) said that extrinsic motivation had a direct impact on learners’ academic achievement and participation in e-learning, and Lee In-sook (2002) found that academic self-efficacy was a major factor affecting learners’ academic achievement. The results suggest that the structural model could include another element of e-learning effectiveness on which extrinsic motivation and academic self-efficacy have indirect impact, or a new path.

Fifth, the effect size of each factor influencing the effectiveness of e-learning can be compared by analyzing indirect, direct, and total effect size. Of factors affecting learners’ academic achievement, intrinsic motivation had the biggest effect size with .919. Composition of learning contents came second with .447, followed by learners’ satisfaction (.346), and learner support (.228). In relation to learners’ participation, composition of learning contents showed the biggest effect size with .267, followed by interaction with .203. In the case of learners’ satisfaction, intrinsic motivation was found to have the biggest impact with the effect size being .879. Composition of learning contents came in second with .439 followed by learners’ participation (.179) and learner support (.160). This suggests that to raise the effectiveness of e-learning, that is, learners’ academic achievement, participation, and satisfaction, it is essential to actively work on development of factors found to affect it most and take child learners into account when doing so.

**Future Research**

Based on the study results, some suggestions can be made in relation to future study on the effectiveness of e-learning. First, the study showed that it is intrinsic motivation, a learner’s characteristic, that has the greatest influence on learners’ academic achievement. This indicates that when developing a new e-learning service for child learners, the focus in a new service needs to be placed on ways to increase intrinsic motivation, which makes learners feel rewarded and pleased with their learning activity. This is in contrast to existing services, which focus on ways to boost extrinsic motivation, like providing cyber prize money, prizes, gifts, and vouchers.

Second, as mentioned earlier, the e-learning service for elementary and secondary school students needs to be more carefully thought out and effective than that for university students and corporate workers because children are less capable of regulating their own study than adults (Song Sang-ho et al., 2005). This raises the need for serious study on the differences in characteristics between child and adult learners. This study produced some results that go against past studies. Previous studies, in many cases, have focused on adult learners and thus failed to reflect the characteristics of child learners in e-learning. Many other studies on ways to enhance the effectiveness of e-learning have also failed to present the differences in e-learning environments for children and adults. Therefore, as Kim Do-il et al. suggested (2003), it is necessary to work to increase in-depth understanding of the e-learning environment optimized to suit the level of child learners, who analyze, use, and understand information in a different way from adults due to difference in cognitive ability.
Concluding Comments

E-learning is a comprehensive cyber learning space where various environmental factors and factors related to learners’ characteristics play a major role. As such it is essential to identify those various factors and study in depth what role they play in raising the effectiveness of e-learning. Existing studies on the effectiveness of e-learning have usually applied one or two factors for evidence, but future studies should look at all e-learning composition factors in a comprehensive and complete way. While it is important to study how each e-learning factor influences the effectiveness of e-learning, it is more important to establish a systematic relationship between e-learning factors, and discuss ways to operate e-learning effectively and make the e-learning environment more learner-friendly.

References


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