Assessment of Human Robot Interaction-based R-learning Systems: A Preceding Study

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Abstract: With the development of information technologies, computers play an important role in education and have been widely used for after-school activities. The students are also able to use computer-aided learning content anytime and anywhere due to the development of computer network technologies. Recently, there are efforts in using robots as one of devices to assist learning activities. The r-learning system was developed for aiding students' learning activities in this research. In order to improve the contents and responses of the r-learning system, it is necessary to conduct research to find the important factors that affect the intention to use the system. This paper shows the results of a preceding study to find important factors. The analysis result on the basis of the Technology Acceptance Model (TAM) suggests that the information technology level of users is a significantly important factor on the intention to use the r-learning system. This research is a preceding study and further analysis with other variables will be conducted in order to find the significant factors affecting the intention to use r-learning users.
[Junseok Oh, Hye-Kyung Cho. **Assessment of Human Robot Interaction-based R-learning Systems: A Preceding Study**. *Life Sci J* 2014;11(7):559-563] (ISSN:1097-8135). http://www.lifesciencesite.com. 76

Keywords: Robot learning; R-learning; Technology acceptance model; Robot interaction

1. Introduction

Recently, information technologies, such as cloud computing and mobile networks, increase the development of computer-aided systems. In the education field, there are also efforts to develop computer-aided learning systems. Currently, students can use computer-aided learning contents anytime and anywhere because of the development of computer network technologies. Because of the lack of active responses of learning systems, robot technology is applied to the development of learning systems. Likewise with e-learning and m-learning, researches for robot-aided learning or r-learning has been conducted because of the development of robot technologies.

The representative research in r-learning in Korea is the development of an r-learning system that provides educational contents with Human Robot Interaction (HRI). In order to improve the quality of contents and functions for human interaction, it is important to find the significant factors that affect the intention to use. Various researches in e-learning and m-learning have found many significant factors on intention to use based on TAM. The research method can be applied in the r-learning domain but the information technology level of the user should be used for evaluating the TAM-based model in the r-learning field. This research is a preceding study to find the impact of information technology level on the intention to use the r-learning system.

2. R-learning Research

Robots are generally used for assisting language learning in the education field. Kanda et al (2004) found that study through interaction with robots improve the English skill of elementary school students. They showed that the interactive humanoid robot that has the voice and action for interactive tools will give students more interest to study and helps students memorize English words. Hyun (2008) evaluated the performance of the iRobiQ robot for language learning with children in Korea. By comparing the before-and-after study of using the iRobiQ and laptop, they found that the iRobiQ has a greater difference between before and after learning than the laptop computer. Robots have been used for special education as well. Kozima et al (2005) developed the 'Keepon' robot and used it for assisting autistic children. They suggested that the Keepon helped improve the interaction with autistic children. Also, two robots, 'CosmoBot' and 'Bandit', were developed for helping the treatment of autism.

Cheng et al (2005) defined the trend in learning support systems with information technologies. The authors described the development of learning systems from desktop-based system to the ubiquitous system. They also suggested that the new system does not replace the old system but contains the old one (Cheng et al, 2005). Refer to the research of Cheng et al, Han and Jo (2009) who defined the educational robot and r-learning paradigm. They insisted r-learning includes web, mobile and ubiquitous learning and is a new paradigm to replace

existing computer-aided learning system (Han and Jo, 2009).

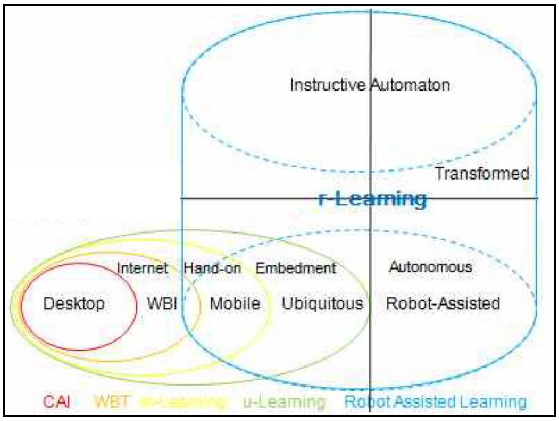

Figure 1. The scope of r-learning (Han and Jo, 2009)

However, u-learning can be defined by the learning environment in which users receive learning services by any device. Because the robot is a device to assist learning activities of users in the learning system, it can be one of devices in the ubiquitous environment. Therefore, r-learning can be defined as the learning environment that uses computer, network, and information technologies in a ubiquitous environment. The r-learning system, which was developed as a national project in Korea, is used for gathering data in this research. It includes multiplication quiz contents with an interaction scenario. The contents provide users the reaction by the open platform humanoid robot (DARwIn). The robot provides learning contents and questions to users and recognizes their reactions. The users input their answers by touch screen, voice and action, and the robot recognizes any type of reaction. Also, the control operator is able to intervene to increase the attention of users.

Figure 2. Use of r-learning system

The system consists of an Action Device, Contents Engine, and Human Intervention Device (HID) as shown Figure 3. The Action Device refers to the devices for the interactions between the r-learning system and the users. It includes the robot, display and speaker. The robot interacts with users by 11 voices and 15 motions. The display not only shows the contents but also receives the input information of the users. The Contents Engine consists of a Contents Manager, Action Module and Cognition Module. The Contents Manager manages the order of content scenarios and the other two modules in the engine. The Action Module controls the behaviors and input orders of the Action Device based on the behavior commands in the Cognition Module. The Cognition Module delivers cognition data which is defined in the Contents Manager to HID. It also plays the role of reading the ID of cognition data from HID and delivers the behavior commands to the Action Module. The HID provides the control operators a user interface. The interface shows the cognition information from the Contents Engine (Brisben et al, 2005; Wade et al, 2011)

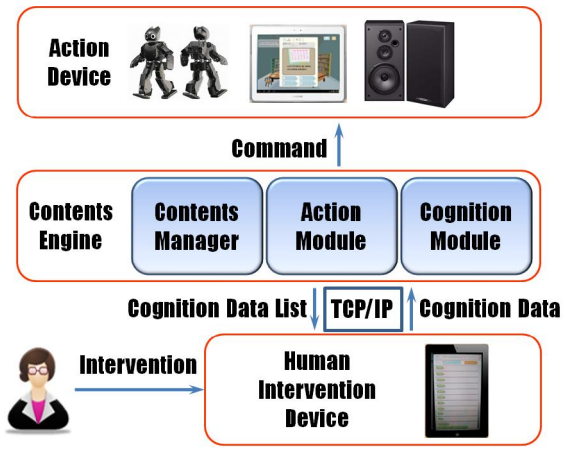

Figure 3. r-learning system architecture

To gather the data for user behavior research, a survey was conducted to students and teachers after they used the r-learning system or watched the video clips for using the system.

3. Research Model

The research model suggested in this paper is on the basis of TAM. It is theoretical model to estimate the intention to use computer-aided technologies (Legris et al, 2003). TAM was proposed by Davis in 1986 and is well accepted as a reliable model in the Management Information Systems (MIS) field. The model is the extension of Theory of Reasoned Action (TRA) which was proposed by Fishbein and Ajzen (Fishbein et al, 1975). TRA is the psychological theory that emphasizes behavioral attitude and subjective norms to estimate human behavior (Davis 1986). Davis suggested two variables, which are the Perceived Ease of Use (PEOU) and the Perceived Usefulness (PU), to measure the user behavior to information technologies (Davis 1986).

Also, TAM uses external variables as independent variables and the actual system use through behavioral intention to use as dependent variable.

TAM has widely been used in researches on the acceptance of computer-based learning systems. Grandon et al (2005) analyzed the effects of convenience and quality on the acceptance of the online learning system by TAM. Liaw (2008) found that system quality is an important variable that significantly affects learners' satisfaction, usefulness and effectiveness of the e-learning system. Chen and Huang (2010) researched the effects of the perceived ease of use and the perceived usefulness on the acceptance of the mobile learning system. Also, Abu-Al-Aish and Love (2013) found that the intention to use of mobile learning systems depends on mobile device experiences.

The r-learning system is able to be classified as an information system since it includes a computer-based engine and user interface in order to convey digital information. Therefore, this research used TAM for estimating the important factors for intention to use the r-learning system. This research focuses on the effect of the information technology level to intention to use the system. Since the proposed system is the computer-based learning system, the technology and contents of the system is substantially important. The user responses should be diverse according to their tendencies to the contents and the system quality. Their information technology level can affect the intention related to the quality. For instance, a student who has high-level knowledge for the information technology is able to evaluate the contents and the system quality is not good enough when they only experience touch screen type inputs and simple responses from the robot. Therefore, the Information Technology Level (INFTECH) is set as independent variable in this research in order to find its effect on the intention to use the r-learning system. Liaw (2007) considered e-learning satisfaction as an important variable to evaluate intention to use of the e-learning system. Almahamid and Rub (2011) also used the variable since it is a key factor for the use of the e-learning system. With mediators in TAM such as PEOU and PU, the User Satisfaction (SAT) variable is also used as mediators since the r-learning system has the features of an e-learning system.

4. Model Analysis Results

The questionnaires of the survey were distributed to elementary school teachers and university students but indirect interviews were conducted to elementary school students because the questionnaire contains terms that they cannot understand. The Likert scale is used for collecting sample data.

Table 1. Validity and reliability of constructs

Item	Factor Loading	KMO	$\chi 2$	p-value	Cronb' α
ITL1	0.859	0.88	509.478	0.000	0.897
ITL2	0.815				
ITL3	0.738				
ITL4	0.716				
ITL5	0.802				
ITL6	0.779				
ITL7	0.803				
USE1	0.887	0.893	418.952	0.000	0.922
USE2	0.879				
USE3	0.907				
USE4	0.823				
USE5	0.867				
EOU1	0.811	0.800	312.138	0.000	0.902
EOU2	0.900				
EOU3	0.904				
EOU4	0.901				
SAT1	0.903	0.896	622.978	0.000	0.953
SAT2	0.938				
SAT3	0.909				
SAT4	0.958				
SAT5	0.878				
BI1	0.911	0.822	398.782	0.000	0.931
BI2	0.942				
BI3	0.892				
BI4	0.893				

A total of 118 samples are collected for the research. The age of respondents is 9 to 45 with an average of 17. The sample includes 81 males and 37 females. Occupation data is also collected and it includes 10 teachers, 53 university students and 55 elementary students. The occupation data was included to find the differences of opinion between children and adults or that between students and teachers. However, the variable was excluded in the analysis because it does not show significant differences. Also, the data was collected on the basis of the interaction type of the robot in order to find the difference of the user intention in the type. The type is defined as interaction by the touch screen as type 1, and the interaction by voice and action as type 2. The total 59 samples are collected for both types.

Table 1 describes the results of validity and reliability of constructs. The factor analysis results show more than 0.6 of factor loading values. This shows that the items in each construct have the correlation. The Kaiser-Meyer-Olkin (KMO) test result shows the value from 0.795 to 0.896. This also shows that the items have strong relationships in each construct. The Bartlett test results show that the communalities of the constructs are secured. The Cronbach alpha values of constructs are greater than 0.8 which means the reliabilities of constructs are secured as well.

Table 2 shows the analysis results for acceptance of the r-learning system based on TAM. The INFTECH variable has a significant positive

effect (β=0.203, p=0.014) on the PEOU variable. The PU variable is positively affected (β=0.039, 0.398) by INFTECH and PEOU but only the PEOU (p=0.000) variable is significant to the PU variable. Also, PU has significant positive effects (β=0.921, p=0.000) on SAT while INFTECH has insignificant positive effects (β=0.084, p=0.138) on the SAT variable. The results show that a dependent variable of the model, Behavioral Intention to Use (BI), is positively affected by the INFTECH, PU and SAT variables (β=0.107, 0.148, 0.819) but it is negatively affected by the PEOU variable (β=-0.003). Since the SAT variable has a significant effect on the BI variable (p=0.000), it is only considered as an important variable to the dependent variable. According to the results of the interaction effects for the PEOU, PU and SAT variables with Age and Gender variables, the Gender variable has an insignificant effect on the BI variable but it has significant interaction effects with the PEOU and SAT variables on the dependent variable. However, the Age variable does not have any significant interaction effects on the BI variable but has the direct significant effects on the variable.

According to Baron (1986), the three relationship conditions have to be satisfied between the variables for the variable to have the mediating effect. First, the independent variable has significant impact on the dependent variable. Second, the mediator significantly affects the dependent variable. Third, in the relationship between the dependent variable and predictors, which are the independent variable and the mediator, the independent variable lost the significance or the impact of the independent variable is decreased. Table 1 shows that the research model satisfies Baron's conditions, so the PEOU, PU, and SAT variables have mediating effects of information technology level on the intention to use the r-learning system.

Also, the Gender variable has the moderating effect between SAT and PEOU variables, and the dependent variable according to Baron's method. This says the satisfaction and the ease of use variations affect the intention to use the r-learning system according to gender. The Age variable does not have the moderating effect, but rather it plays a role as the independent variable to the dependent variable. The result shows the increase of age affects the increase of intention to use r-learning system.

Figure 4 shows the summary of analysis results based on Table 1 results. The independent variable does not have a direct effect on the dependent variable but it has 0.061 indirect effects (0.203*0.398*0.921*0.819) on the dependent variable through significant path. Therefore, it is confirmed that the increase of information technology level significantly affects the increase of intention to use the r-learning system through the ease of use, usefulness and satisfaction. Also, this shows INFTECH is an important variable for the evaluation of user intention for the system.

Table 2. Analysis results of research model

Dependent Variable	Independent Variable	Coeff.	t-test	F-test
PEOU	Constant	4.985	13.485	6.259 *
	INFTECH	0.203	2.502*	
PUSE	Constant	2.782	4.069	7.691 **
	INFTECH	0.039	0.402	
	PEOU	0.398	3.709**	
SAT	Constant	-0.027	-0.076	159.501 **
	INFTECH	0.084	1.495	
	PUSE	0.921	17.520**	
BI	Constant	-0.327	-0.773	110.691 **
	INFTECH	0.107	1.963	
	PUSE	0.148	1.542	
	PEOU	-0.003	-0.041	
	SAT	0.819	8.676**	
BI	Constant	1.370	0.613	44.406 **
	PUSE	1.075	1.323**	
	PEOU	-0.047	-0.134	
	SAT	-0.237	-0.715	
	Age	-0.159	-2.068*	
	Gender	0.699	0.666	
	USE*Age	-0.018	-1.499	
	USE *Gender	-0.530	-2.115*	
	EOU*Age	0.019	1.603	
	EOU *Gender	-0.093	-0.601	
	SAT*Age	0.021	1.696	
	SAT *Gender	0.537	2.347*	

*p<0.05, **p<0.01

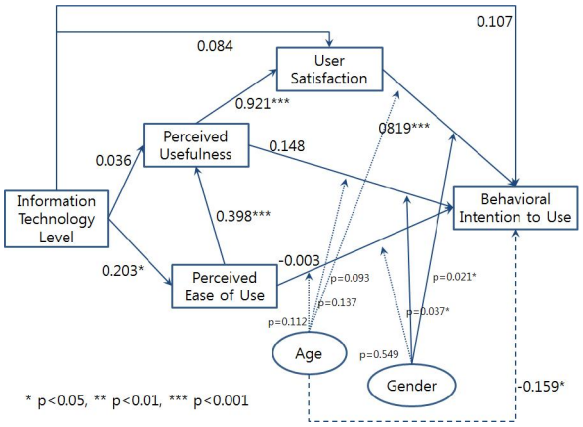

Figure 4. Summary of suggested model

5. Conclusions

This research is an advanced study to examine the acceptance of the r-learning system based on TAM. The system was developed to assist the increase in learning ability. Prior to widely using the r-learning system, it is necessary to improve the quality of the contents and functions in the system. The propensity of the system needs to be estimated for changing the contents or functions to satisfy different users. The TAM is applied for the estimation of user intention in this research. The information technology level variable has not been included in technology acceptance models in learning systems studies but it is included in this research because it is an important factor in human robot interaction. This research shows that the information technology level significantly affects the intention to use. It shows that the variable is an important factor in the estimation process for accepting the r-learning system. The estimation of intention to use the r-learning system will be conducted with the information technology variable and other variables which are generally used in the evaluation of e-learning systems.

Acknowledgements:

This work was supported by the Industrial Strategic Technology Development Program funded by the Ministry of Trade, Industry, and Energy (MOTIE, Korea)

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7/1/2013