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Analysis on Acceptance and Use of Technology for Elementary School Teachers in Telepresence Robot-assisted Learning

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ABSTRACT

Telepresence robot-assisted learning can provide opportunities of education for students who are in vulnerable physical, intellectual, cultural or environmental conditions. It is to be applied in international virtual education for global citizenship education. To date, the study of acceptance model has been conducted only for preservice teachers, and post-intention for use is not considered. This paper identified whether there are significant differences by gender or years of experience from elementary school teachers on it and the basic factors that affect the acceptance intentions for it. Factors related to intention to use for a telepresence robot were investigated, and a questionnaire about post-intention for use was made after participants operated. The results showed that elementary school teachers did not have a significant difference in each factor by gender. The experienced teachers showed no difficulty in using it. It was shown that PU, ATT, PENJ, SI and Ttrust were all extremely significant factors to affect acceptance intentions. It will be possible to establish educational information policies based on the acceptance intentions of elementary school teachers on telepresence robot-assisted learning.

Keywords : Telepresence robot, Robot-assisted learning, Technology acceptance model, Intention to use, Post-intention to use

원격 로봇보조학습에 대한 초등교사의 기술수용도 분석

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요약

원격 로봇보조학습은 신체적 · 지적 · 문화적 · 환경적으로 취약한 학생들에게 교육의 기회를 제공할 수 있으며, 농산어촌 고교학점제의 어학관련 과목의 온라인교육과정을 대체하거나 세계시민교육을 위한 국제교류학습에 활용할 수 있으나, 현재까지 수용모델 연구는 예비교사를 대상으로만 이루어졌으며 사후사용의도 요인은 고려하지 않았다. 따라서 본 논문은 초등교사를 대상으로 원격 로봇보조학습에 대하여 사용의도와 사후 사용의도에 영향을 주는 기초 요인을 알아보았다. 연구 결과, 원격 로봇보조학습에 대하여 초등교사들은 성별에 의해 각 요인이 유의미한 차이가 없었으며, 경력이 많은초등교사들이 FC, PAD, PS, SP에서 더 긍정적으로 유의미한 결과가 나왔다. 또 수용의도에 영향을 주는 요인으로 PU, ATT, PENJ, SI, Ttrust 모두 매우 유의미 있게 나왔다. 이와 같은 원격 로봇보조학습에 대한 초등 교사들의 수용의도를 바탕으로 교육정보 정책 수립을 할 수 있을 것이다.

주제어 : 원격 로봇, 로봇보조학습, 기술수용모델, 사용 의도, 사후 사용 의도

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1. Introduction

Along with the rapid development of communication technology such as information devices and 5G, there is greater interconnection and reliability from the entire world, and there is an emphasis on the education that allows the students to have a sense of identity and belonging as a member of the global community. For this purpose, the International Virtual School (IVS) pan-globally operates an online international education. The national curriculum states that the students should have community competences, and the Ministry of Education and the Korea Education and Research Information Service (KERIS) is in charge of an online international cooperative education to improve the community competences of the students. There are implications found from studies by Shin and Han (2017) on real-time exchanges by using telepresence video conference system and telepresence robots for successful online exchange cooperative learning [11]. The results of investigating and analyzing the telepresence robot-assisted learning that uses the traditional screen-based telepresence video conference system and robots through experiment classes showed that there was more active interaction between the American student in the other side and the Korean students in robot-assisted classes.

Although the telepresence robot is controlled by a teacher or student from a remote place, there still exists a sense of coexistence as if they are physically at the remote location, and it can provide a social presence perceived from sharing emotions between students and remote-student. Therefore telepresence robot-assisted learning can mediate students who are physically, intellectually, culturally and environmentally vulnerable, and is used for studies on language education or disabled students [6,9,10,11].

To implement a new media to the education field, the most important factor is the awareness and attitude of the users, who are the teachers, and so there needs to be a study on the awareness and acceptance of teachers on the use of telepresence robots. This study will be a basic research to identify the factors that affect the acceptance of the Unified Theory of Acceptance and Use of Technology (UTAUT) by investigating whether there are significant differences by gender and experience of teachers for each factor.

2. Related Works

2.1 Telepresence Robot-Assisted Learning

Through the development of artificial intelligence and robotics, it is now possible to provide service in various areas such as medicine and education for those in remote places by using telepresence robots. Educational robots are largely divided into parish robots that are created and coded by children and intelligent educational service robots. Of the two, learning by educational service robots is defined as robot-assisted learning[7]. Robots that can be utilized in robot-assisted learning are divided into telepresence robots that can be controlled by a remote-operator and autonomous robots that have built-in artificial intelligence or that artificial intelligence is connected through a network[4].

The telepresence robot-assisted learning in this study is considered as a medium in the education field, major studies that have used this kind of robot is shown on <Table 1>.

<Table 1> Studies that have used telepresence robots in classes

	Study Contents
Weiss et al. (2001)	Implicated that using PEBBLES, a telepresence robot, to provide opportunities for regular education for isolated students suffering from diseases will minimize secondary problems from diseases and hospitalization such as educational, social and behavioral problems from Toronto[14]
Ryuji et al. (2013)	Conducted an experiment that focused on interpersonal relationships by using Telenoid,

	a telepresence android for students in elementary school classes and the elderly in nursing hospitals from Kyoto. It was possible to realize that telepresence robots contributed to facilitating cooperative work among peers and assisting communication for the elderly with dementia[15]
robohub.org, (2016)	Research teams from University of California at Irvine confirmed that VGo telepresence robots assisted children with cancer, cardiovascular diseases and immunodeficiency who cannot go to school to participate in school classes, and all of the participants showed great effects in the sense of belonging and satisfaction[9]
Shin & Han (2017)	Applied ROBOSEM, a telepresence robot and video imaging system. It was confirmed that learning methods that use telepresence robots allowed for recognition of social identity to lead to active and familiar interactions than telepresence video learning methods using large screens[11]

2.2 Technology Acceptance Model for Robot-Assisted Learning

The technology acceptance model that explains the acceptance of new information system or high technology products originated from studies by Davis (1986, 1989), Venkatesh & Davis (2000), and Venkatesh et al. (2003) as an integrated technology acceptance model, and increased the explanation power of acceptance by approximately 70%, and actual use by approximately 50% [2,3,12,13]. For the technology acceptance model for robot-assisted learning, Conti et al. (2017) considered those who were against using autonomous intelligence robot-assisted learning to develop the UTAUT model on autonomous intelligence robot-assisted learning for children's therapy and rehabilitation support by adding variables and age considered from the model developed by Heerink et al. (2009)[1,8]. Han (2018) developed the UTAUT model for preservice teachers for the telepresence-connecting robot-assisted learning that is increasing in the possibility of use recently [5]. This study is a basic analysis to identify the acceptance intentions of the UTAUT model of telepresence robot-assisted learning for elementary school teachers to identify the differences in gender and experience for each factor centered on the perceived usefulness and perceived ease of use, and identify the factors that affect the intention to use and post-intention to use.

3. Methods

3.1 Hypothesis

In this paper, the factors that influence elementary school teachers' acceptance of telepresence robot-assisted learning were selected as shown in <Table 2> from the previous studies.

<Table 2> Overview of factors in UTAUT model

ITU	Intention to use
PU	Perceived Usefulness
PAD	Perceived Adaptability
ANX	Anxiety
PEOU	Perceived ease of use
SI	Social influence
PENJ	Perceived enjoyment
ATT	Attitude towards technology
PS	Perceived sociability
SP	Social presence
FC	Facilitating conditions
TTrust	Trust
US	User Satisfaction
ME	Met Expectation
PITU	Post Intention to use

We considered the preliminary ones of the UTAUT model by including the pre-intention ITU and the post-use PITU as factors. In particular, this paper includes the user satisfaction and the met-expectation factors for the use after the experience of telepresence robot-assisted learning. To identify the acceptance intentions with 15 factors to elementary school teachers in telepresence robot-assisted learn-

ing, the following hypotheses were developed.

H1: Each factor for the technology acceptance model (ANX, ATT, FC, ITU, PAD, PENJ, PS, PU, SI, SP, TTrust, PEOU, US, ME, PITU) equal in average by the gender of elementary school teachers.

H2: Each factor of the technology acceptance model (ANX, ATT, FC, ITU, PAD, PENJ, PS, PU, SI, SP, TTrust, PEOU, US, ME, PITU) equal in average by the years of experience of elementary school teachers.

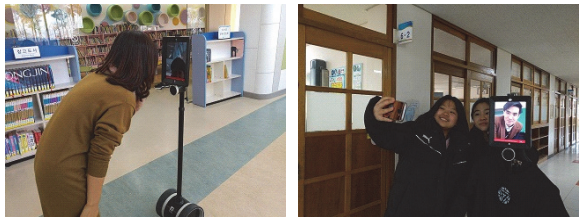
H3: The correlations between PU, PENJ, TTrust, ATT and SI to ITU for the acceptance intentions on the technology acceptance model of elementary school teachers on the telepresence robot-assisted learning equal to zero.

3.2 Participants and methods

First, pilot surveys are conducted with three elementary school teachers who have experiences in robot-assisted learning and reviewed the questionnaire questions.

We visited two elementary schools with more than 40 classes and conducted a questionnaire survey on 65 elementary school teachers who experienced direct manipulation and interaction with robots as shown in (Figure 1). The telepresence robot Double commonly used in research was a 150cm wheeled in (Figures 2). See in detail from doublerobotics.com.

(Figure 1) Controlling the telepresence robots



(Figure 2) Interaction to the telepresence robots

Out of the 65 elementary school teachers who have participated in the experiment, 50 were female (76.92%) and 15 were male (23.08%), and so the number of female teachers was 3.3 times greater than that of male teachers. According to the educational statistics from the Korea Educational Development Institute (KEDI) of 2018, 77.16% of the national elementary school teachers are female, which shows that the gender distribution of this study is similar with the national distribution. The number of elementary school teachers was 41 for less than 15 years and 24 for more than 15 years.

The obtained questionnaire data performed the Kolmogorov-Smirnov test and the Shapiro-Wilk test for the normality test for each factor. Since the assumptions of nomality were not satisfied, Mann-Whitney's U-test was used for the mean comparison of H1 and H2. Also, for causality between factors, Spearman's correlations were estimated and Kendall's Tau test for nonparametric regression analysis was performed.

4. Results

4.1 Comparisons of the Factors by Gender

First, Mann-Whitney U-test as a non-parametric test was performed on the mean and standard deviation as shown in <Table 3> to confirm the results of the significant differences by factors according to gender. First, to identify the results of the significant differences for each factor by gender, the means and the standard deviations.

There was no significant difference in the factors of ANX, ATT, FC, ITU, PAD, PENJ, PS, PU, SI, SP, TTrust, PEOU, US, ME and PITU by gender. Although it is not at a significant level, out of the 15 factors, female teachers had greater responses than male teachers from 12 factors.

<Table 3> U-Test of Mann-Whitney by gender and by years of exerience

Gender	ANX	ATT	FC	ITU	PAD	PENJ	PS	PU	SI	SP	TTrust	PEOU	US	ME	PITU
Male Mean	3.00	3.37	2.50	3.08	4.13	3.38	3.24	3.57	3.10	3.33	3.13	3.33	3.42	3.62	3.53
SD	1.35	1.32	1.34	1.14	.79	1.24	1.24	1.28	1.28	1.34	1.25	.91	1.15	1.22	1.39
Female mean	3.37	3.12	2.75	3.30	4.06	3.86	3.38	3.70	3.34	3.34	3.18	3.46	3.56	3.62	3.75
SD	1.08	1.09	.95	.90	.64	.75	.90	.81	.96	.96	.64	.69	.88	.93	1.00
Mean	3.28	3.18	2.69	3.25	4.08	3.75	3.34	3.67	3.28	3.34	3.16	3.43	3.53	3.62	3.70
U	316.5	326.0	308.0	339.0	354.5	309.0	354.0	372.0	319.0	365.5	372.0	319.0	351.0	395.5	362.0
p-value	.361	.443	.292	.573	.746	.302	.742	.962	.376	.881	.962	.377	.704	.807	.836
Year	ANX	ATT	FC	ITU	PAD	PENJ	PS	PU	SI	SP	TTrust	PEOU	US	ME	PITU
<15 mean	3.14	3.13	2.47	3.13	3.94	3.60	3.12	3.56	3.15	3.13	3.17	3.47	3.43	3.51	3.51
SD	1.00	1.18	1.02	1.04	.68	1.02	1.03	.98	1.02	1.11	.86	.76	.91	.98	1.10
>15	3.54	3.27	3.06	3.45	4.31	4.00	3.73	3.86	3.50	3.69	3.16	3.34	3.69	3.80	4.02
Mean SD	1.35	1.09	1.02	.77	.60	.59	.76	.81	1.04	.84	.73	.72	.98	1.01	1.02
Mean	3.28	3.18	2.69	3.25	4.08	3.75	3.34	3.67	3.28	3.34	3.16	3.43	3.53	3.62	3.70
U	386.0	452.5	333.0	414.0	340.0	376.5	297.0	412.5	363.0	335.5	480.0	439.0	410.0	398.5	353.5
p-value	.148	.589	.029*	.286	.036*	.115	.008**	.277	.075	.032*	.868	.465	.257	.199	.054

* $p<0.05$, ** $p<0.01$

Although not a significant difference, twelve out of fifteen factors was slightly higher for female than for male teachers. In other words, there was no significant difference between Mann-Whitney's two U-tested groups. Thus, hypothesis 1 was rejected based on the above results.

4.2 Comparisons of the Means and Standard Deviation of the Factors by Years of Experience

Based on 15 years of experience in <Table 3> shows the mean, standard deviation and U-test of Mann-Whitney of the two groups. It can be seen that elementary school teachers with 15 years of experience and above had positive responses from all factors of ANX, ATT, FC, ITU, PAD, PENJ, PS, PU, SI, SP, TTrust, PEOU, US, ME and PITU from the test results of each factor. Among the factors, FC, PAD, PS and SP had significant differences in the responses. Although responses on PITU was more positive from teachers with 15 years of experience and above, the significance level was 0.054, which is slightly greater than 0.05.

Based on the above results, hypothesis 2 that each factor of the comprehensive acceptance model of ANX, ATT, FC, ITU, PAD, PENJ, PS, PU, SI, SP, TTrust, PEOU, US, ME and PITU will vary by years of experience was partially accepted.

4.3. Correlation between the Acceptance Intention and Factors

The average of ITU and PITU in <Table 3> shows that the perceived use intention increased after operating and controlling the robot from 3.25 to 3.7, indicating less technical resistance to it. Therefore, it may be sufficient to analyze only the ITU, the acceptance intention before robot experience.

To investigate whether the acceptance intentions of on-site elementary school teachers is affected by PU, PENJ, TTrust, ATT or SI as shown on <Table 4>, the study identified the correlations among the factors by nonparametric Spearman's correlation. It was shown that PU, PENJ, TTrust, ATT and SI all affect

the acceptance intention of the telepresence robots. The correlations 0.613 for ATT, 0.597 for SI, 0.586 for PU, 0.519 for PENJ, and 0.329 for Ttrust were obtained and they all are positive.

<Table 4> Nonparametric Kendall's Tau-test

explanary variable	reponse variable	Intercept	Beta	Tau	p-value
PU	ITU	0.4887	0.7519	0.586	2.4671e-10***
PENJ		0.0125	0.8313	0.519	1.4466e-08***
Ttrust		1.6401	0.5075	0.329	0.00047803***
ATT		1.1072	0.6675	0.613	2.7685e-11***
SI		1.0000	0.6667	0.597	2.2768e-10***

*** $p<0.001$

Therefore based on the above results, hypothesis 3 was accepted.

4.4 Implications

According to the United Nations Conventions on the Rights of the Child, although disabled children and children in vulnerable environments have the right to be educated and children should be educated regardless of gender discrimination, there are still children who are vulnerable in education. According to the Korean Educational Statistics Service (KESS), the number of students with disabilities in special needs classes or special needs schools increased by 1.56 times in 2018 compared to 2005. For a customized education curriculum that considers the characteristics of the disabilities, there should be considerations to apply the education service robots and telepresence robot-assisted learning. Furthermore, according to NICE statistics, the number of multicultural students increased by three times for the past seven years until 2018. To reduce the study interruption rates and improve the educational level of multicultural students, telepresence robot-assisted learning should be considered to support the Korean education of the students from multicultural families. In addition, if it is possible to provide opportunities for regular education for students who are in isolated situations due to disease with using telepresence robots, it will be possible to minimize the secondary problems that can rise from disease and hospitalization, such as the educational, social and behavioral problems.

Furthermore, if small-size elementary schools of rural areas or other regions can use telepresence robots for regular education for shared education, it will be possible to meet more the needs and satisfaction levels of the students and the teachers, and it will be possible to prevent the collapse of rural areas by saving small schools. In addition, replacing remote video learning by implementing robots in the classrooms for international virtual education, not only it will secure interest and satisfaction, but it will also improve learning performances, and will assist in the education to provide a sense of identity and belonging for the students as a member of the global community.

Telepresence robot-assisted learning enables remote students to interact and community experiences through the robots, while teachers or students in classroom situations can use remote robots to live as if they were in the same classroom. In addition, the post-perceived intention of the teacher is positive, and the applicability of telepresence robot-assisted learning may be expected to be high and easy rather than we expect.

5. Conclusion

In order to derive the factors influencing the acceptance intention of elementary school teachers by telepresence robot-assisted learning, a questionnaire was conducted after the robot was operated and experienced. The results show that there are no gender differences in the competences and attitudes of elementary school teachers for telepresence robot-assisted learning. The elementary school teachers who have more than 15 years of experience responded more

positively to FC, PAD, PS, and SP factors rather than short experienced teachers. The factors, PU, ATT, PENJ, SI, and Ttrust were all significant to the acceptance intention of elementary school teachers after the experience of telepresence robot-assisted learning. Since the Double robot used in this experiment is very simple to use, the perceived easy of use was not taken into consideration, and it can be seen that this is a very important factor for the diffusion and dissemination of robot-assisted learning. Therefore, in regard to the UTAUT model for estimating the intention of accepting robot-assisted learning in the future, the teacher's career, perceived usefulness, attitude, perceived playfulness, and trust of technology, attitude and social influence may be considered. The attitudes and social impacts on telepresence robot-assisted learning can be improved through training sharing the values and utilization of educational service robots in the field of education.

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