JDCS
디지털콘텐츠학회논문지
Journal of Digital Contents Society
Vol. 18, No. 8, pp. 1501-1507, Dec. 2017

원격로봇교사의 키와 초등 수업 통제력의 영향 분석

배 일 한[1] · 한 정 혜[2*]
[1]카이스트 문술미래전략대학원
[2]청주교육대학교 컴퓨터교육과

Analysis on Teacher's Height and Authority in Robot-assisted Learning

Il-han Bae[1] · Jeong-hye Han[2*]
[1]Korea Advanced Institute of Science and Technology
[2]Cheongju National University of Education

[Abstract]

Telepresence in robot assisted learning has preferred low-height, shorter than life-size robotic platforms for reasons such as operational stability, user convenience and psychological comfort in human robot interaction. If, however, the reason for using a telepresence robot is to display the authority of a social superior to a social inferior, one can hypothesize that a robotic platform which reflects real-life height advantage would be better suited for the stated purpose than conventional low-height platforms. In order to test the hypothesis, we examined whether the height of the robot had an effect on an instructor connected to a telepresence robot in robot-assisted learning with regard to controlling a large number of elementary school students. The pre-and post experiment demonstrates that the use of a life-size telepresence robot, compared to a child-size telepresence robot, failed to make a meaningful difference in the instructors' authority being accepted by the students. However, behavioral measures shows that a taller robot has more merits in controlling students.

[요 약]

로봇보조학습의 원격로봇교사의 키는 작동의 안정성, 사용자의 편리성과 심시적 안정감의 이유로 실제 교사의 키보다 작은 경우가 선호된다. 그러나 원격로봇교사는 수업에서 때때로 학생을 통제해야할 필요성을 고려한다면, 로봇의 플랫폼은 실제 교사의 키 정도가 좋을 것으로 가정하였다. 이를 위하여 초등학교 체육수업에서 원격연결 로봇교사의 키와 수업통제력의 영향을 실험해 보았다. 사전과 사후 실험비교를 통하여 아동크기의 원격교사 로봇과 실제 교사 크기의 원격교사 로봇간의 유의미한 차이는 얻지 못하였으나, 행동분석관찰에서는 큰 키의 로봇이 학생을 통제하는 데에는 장점이 있음을 보였다.

색인어 : 권위, 키, 로봇보조학습, 원격로봇, 행동분석관찰
Key word : Authority, Height, Telepresence robot, Robot-Assisted Learning

http://dx.doi.org/10.9728/dcs.2017.18.8.1501

Received 05 September 2017; **Revised** 22 October 2017
Accepted 05 December 2017

***Corresponding Author; Jeong-hye Han**

Tel: +82-043-299-0853
E-mail: hanjh@cje.ac.kr

Ⅰ. Introduction

Robotic learning (r-Learning) is divided into learning by educational service robots for language learning or physical exercise [1,10] and by hands-on robots for enhancing creativity and problem solving [2]. An educational service robot as a teaching and learning assistant is divided into three categories: the teleoperated (or telepresence) type, autonomous type, and transforming type [1]. In this paper we focus on the telepresence.

Regardless of region and era, humanity has always understood the advantage of height when it comes to exercising authority on others. According to research done on human communication regarding human height, tall individuals tend to have an advantage compared to shorter individuals in areas such as position, leadership and dominance. Of particular note is the strong positive correlation between height and authority status in males [3,4]. The height of a male leader has a positive correlation with that leader's level of charisma perceived by his followers [5]. In addition, those who have received higher education tend to be taller, on average, than those who have lower levels of education [6]. An employee's height has a definite correlation with his/her pay and success levels at work [7]. In individual relations, interpersonal dominance could be observed in instances such as two people meeting in a narrow street; the shorter person would tend to yield first [8].

We do know that bipedal humanoid robots and social robots capable of communicating with humans have been designed for the most part to be shorter in height than their users, in order to minimize the psychological discomfort and intimidation they may bring. When Honda was designing Asimo, the robot that brought more attention than any other to humanoid robots, it took great care to have Asimo's design be non-threatening and friendly [9]. As a result, Asimo was designed to be 120~130cm tall —a height which allowed adult humans to speak at eye-level with Asimo while the human was sitting down.

Since Asimo's unveiling, most robotics corporations and researchers have accepted the implicit principle that an anthropomorphic robot should have a height shorter than the average adult human. For instance, IROBI(90*cm*), HRP-4(151*cm*), Pepper (120*cm*) developed in Japan, HUBO (130*cm*) from South Korea, and the PR2 from Willow Garage (130-164*cm*) are all shorter than the average adult height [8,9,11].

This research seeks to put forward the possibility that the current practice of setting the height of anthropomorphic robots to be lower than that of the average local user may not be a best choice for communication environments utilizing telepresence robots. In cases where the telepresence robot's function is to affirm the robot operator's authority in a vertical, top-down fashion, it may be beneficial to have the robot in question be taller than the users. In this paper, we explore how the height of telepresence robots affects robot-mediated communication in a vertical superior-subordinate power dynamic. To do so, we will be conducting experiments in robot-assisted learning between elementary school students and teachers.

Ⅱ. Why life-size telepresence robot matters

For the local user, a telepresence robot that is shorter in height is more approachable, and is safer and easier to operate [12]. However, operators cannot fully utilize the advantages afforded in interpersonal relationships by such robots.

If the height-authority relationship proven in human communication [3,4,5,6,7,8] applies to robot-mediated communication, a telepresence robot platform shorter than adult height is useful for stimulating communication and enhancing the friendship between the robot-assisted teacher and the students. However, in situations such as a teacher needing to discipline a misbehaving student or to control a large number of students' actions, a platform that is at a similar height to the average of young students may prove to be a disadvantage.

In a superior-subordinate power relation where the superior commands and controls the subordinate, it would seem to follow that the use of a telepresence robot that reflects the actual height of the operator—as opposed to a robot that is shorter than the user's actual height—may be more effective, but there is no definite proof of this. This is because there has been little commercial use of telepresence robot platforms which are over 180*cm* in height and can be an adequate substitute for a life-size adults above the average.

With the preceding research, perception of the problem, we assumed a situation involving an instructor and students from an actual elementary school in order to identify the effects that the discrepancy of height between telepresence robots and the robot operators would have on the subordinate party in a hierarchical power dynamic—in this case, elementary school students.

We will be using a modified Questionnaire on Teacher Interaction (QTI), used in pedagogy, to observe students' perceived levels of instructor authority in five sub-elements: leadership, friendliness, understanding, students' responsibility & freedom, and strictness [14,15]. We will also accompany a task measure with the video analysis in order to measure the extent to

which students complied with the instructor's commands in the robot-assisted learning.

The following three research questions were put forward.

- Q1: Which factors (teacher's height, robot height, and interaction effect) cause influence on student obedience?
- Q2: How does the instructor's authority change measured by the five sub-elements of QTI via a robot?
- Q3: What do we find student's perception or behavioral patterns?

Ⅲ. Method

3-1 Telepresence robot for education.

For the experiment, we created an educational telepresence robot that could depict the height of a robust male instructor. The telepresence robot was technically a personified tablet PC stand whose height can be adjusted between 145 and 195*cm*. Tablet PC attached on top of the rod can pan up to 300 degrees and tilt up to 45° while being equipped with a table PC. In order to increase the anthropomorphic effect, the robot was clothed. After placing the telepresence robot on location, the instructor could connect from a remote location via a Skype video call and issue commands to the students.

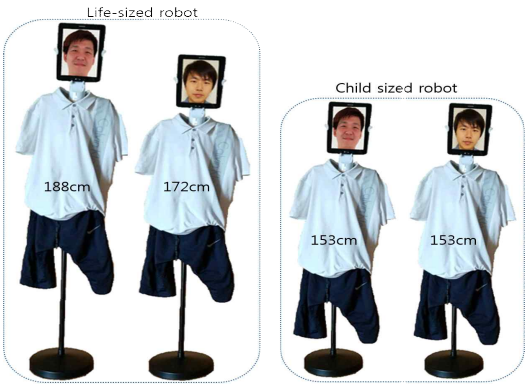

Fig. 1. Four types of robot-assisted teacher mediated by children-size robots or their life-size robots.

3-2 Experimental Design

In order to test out the aforementioned hypotheses, we recruited an elementary school and designed an experiment that two male teachers connect to telepresence robots with two different height: child-size vs. life-size. The experiment subjects were two classes of sixth-graders. The total forty nine students of two classes were divided into four groups having similar demographic profiles.

Two male instructors were chosen to operate telepresence robots with different heights. One male instructor has 188*cm* height rendering him tall by Korean standards. The other male instructor has 172*cm* rendering him normal height. As for the telepresence robots, the shorter, child size version is set at 153*cm*, the average height of Korean sixth-graders. The taller robot, life –size version is set at two male instructor's original heights. As a result, each male teacher instructed two student groups via serially connecting to a child-size and their life-size robot platforms.

The experiment was set that each subject group serially enters the gymnasium to encounter one of four types of robot-assisted teachers: child or life-size robots which is remotely operated by two male teachers. Each type of a robot-assisted teacher commanded the students to line up and practice badminton in a physical education class for 40 minutes.

Table 1. Four student groups allocated by two male instructors and two different heights of robots.

teacher \ robot	child-size	life-sized	total
172cm	11	13	24
188cm	12	13	25
Total	23	26	49

3-3 Measures

We used two methods of measurement for the experiment: a questionnaire for the students administered before and after the robot experiment and a behavioral measurement of the students' response during the robot experiment in a gymnasium.

1) Pre- and post-experiment questionnaire

Two questionnaires were administered to the forty nine students, one before and one after the experiment. The pre-experiment questionnaire was administered in order to obtain the instructor's real-life tendencies from the students' perspective. The post-experiment questionnaire was administered to obtain the students' evaluation on their experience with the robot-assisted teacher. The questionnaires were a modified Korean version of the 48-item version of the QTI, whose original version [14] based upon the theory of student-teacher interactivity put forward[15].

For the purposes of this experiment, five sub-elements of the QTI were chosen: two regarding instructor authority (leadership, strictness) and three regarding instructor unauthorized attitude (students' responsibility & freedom, friendliness, understanding). Three questions were formed for each sub-element, creating fifteen questions in total. Each question used the Likert scale, with 1 representing 'absolutely not' and 5 representing 'absolutely.' A higher score indicates that the respondents are experiencing the

interaction in question more strongly. Through two questionnaires, we evaluated how the existing offline teacher-student interaction changes in a robot-mediated communication environment by looking at the five sub-element scores. The results were analyzed by two-way ANOVA.

2) Behavioral Measures

Behavioral Measures in the gym class, we made a qualitative evaluation of the students' task fulfillment of badminton practice and attitudes to the robot-assisted teacher. The students were to carry out the five assignments given to them by the robot-assisted teacher in sequence. First, as class started, the students were to line up in front of the robot-assisted teacher. Second, the students were to bring badminton racquets and shuttle cocks, placed in the corner of the gym, to the front of the robot-assisted teacher. Third, the students would pair off and play badminton for six minutes. Fourth, the students would play badminton alone in place for three minutes. Finally, the students would return the racquets and shuttlecocks to their original location. Regarding the instructor's commands to the students, the verbal expressions used, the number of times repeating the command and vocal tone were kept identical. Whole process of the two robot-assisted classes was recorded via digital camcorder. Through the analysis of video footage, the participation rate of students in each assignment given by the teacher was measured to perform a comparative evaluation between two experimental groups. Additionally, student's attitude to the robot-assisted teacher during assignments was also observed.

Ⅳ. Results

4-1 ANOVA Analysis

We conducted two-way ANOVA about the teachers' height and the robot's height which might affect the authority of robot-assisted teachers for Q1.

Table 2. Two-way ANOVA for five sub-elements of robot-assisted teacher's authority in response to heights

2way-factors / Authority	teacher height F (p-value)	robot height F (p-value)	teacher*robot F (p-value)
leadership	.825 (.368)	.944 (.337)	.089 (.765)
understand	.986 (.326)	1.330 (.255)	1.161 (.287)
strictness	**9.368 (.004)**	0.528 (.471)	.008 (.930)
freedom& responsible	.291 (.592)	1.569 (.217)	.150 (.698)
friendliness	**6.415 (.015)**	.010 (.922)	.047 (.829)

The robot's height does not make a statistically meaningful difference in five sub-elements of the authority of robot-assisted teachers. Also, any sub-element of the authority were not affected by interaction effect (teacher*robot) between teachers' height and robot's heights. Thus, students obey the commands which reflects the actual height (or personality) of the instructor without considering the mediation of robots and robot's height.

Table 3. The mean of post-test by Wilcoxon signed-rank test

Height	172cm teacher		188cm teacher	
Factor	child-size Mean	life-size Mean	child-size Mean	life-size Mean
leadership	**3.909 (0.026)**	3.778 (0.865)	▽3.905 (0.786)	▽3.571 (0.786)
understand	▽3.455 (0.165)	3.917 (0.383)	3.762 (0.999)	▽3.191 (0.357)
strictness	▽2.576 (0.916)	**▽2.417 (0.041)**	▽2.952 (0.500)	▽3.191 (0.680)
freedom & responsible	▽3.212 (0.783)	3.389 (0.250)	▽3.381 (0.345)	**▽2.857 (0.041)**
friendliness	3.909 (0.476)	3.861 (0.503)	▽3.619 (0.990)	▽3.143 (0.971)

▽ means the mean of post-test decreases from ones of pre-test

For Q2, we explored the results by Wilcoxon signed-rank test as shown in Table 3. From the result of Q1, we can consider the strictness and friendliness. Four cases for two instructors' strictness were decreased from pre-mean to post-mean (2.667→2.576, 2.778→2.417,3.191→2.952, 3.048→3.191). That means the strictness of teacher's authority decreases via robots. We may estimate the cause from the fixed-mediated robot. Also, as you see in the row of friendliness the 172*cm*-teacher are felt more friendly than the 182*cm*-teacher. The mediation of robots can strengthen the teacher with higher affinity higher, and the other with lower affinity lower. We can see the same pattern for leadership factor.

4-2 Behavior Analysis

The behavioral measures in robot-assisted learning show that students obey the commands of the taller robot little more strictly than the commands of the shorter robot. The video footage analysis revealed that when using a shorter telepresence robot, the students were likely to react without wariness.

Figure 2 shows that male students that first encountered a child-size, 153cm tall robot-assisted teacher robot-assisted teacher whose real human height is 188cm gathered around the robot stand without wariness and even touched it (top). Students voluntarily lined up from the closest line from the robot stand (middle). Three female students lost attention while the latter part of badminton practices(down). As the eye-leveled tall robot-assisted instructor commanded the first assignment "Line up, please", thirteen students voluntarily gather and positioned

from the shortest line, about 1.8*m* distant from the robot stand. Then, students generally followed the obeyed the commands of shorter robot-mediated instructor. But in the latter part of badminton practice, three female students in the rear line started to lose attention on the assignment of "Play badminton alone in place". Three girls just kept talking each other before the robot-assisted instructor warned them to practice again.

Fig. 2. Student's attitude to the child-size robot-assisted teacher.

The other case of students meeting child-size 153cm tall robot-assisted teacher whose real human height is 172cm also demonstrated similar phenomenon: lack of wariness, touching a robot-assisted teacher, lining up closely, two male students baldly lost attention while the latter part of badminton practices.

Fig. 3. Students' attitude to the life-size robot-assisted teacher

The above video analysis of instruction via two child-size robots shows that a shorter telepresence robot might fail to fully deliver the real instructor's authority on students.

In contrast, both life-size: 188*cm*, 172*cm* tall robot platforms seem to deliver stronger authority to students. When entering into a gym, a student groups who met 188cm tall robot-assisted instructor evidently showed some wariness, and they did not get closely to the taller robot stand. Students naturally lined up from the second shortest line, 2.6*m* away from the robot stand as shown in Figure 3. Students also well obeyed the commands of two taller robot-assisted instructors during the process of practices, and no one under the instruction of a 188*cm* life-size robot-assisted instructors openly lost attentions on the assignments till badminton practice ended.

The other case of a student groups who first met 172*cm* tall robot-assisted instructor demonstrated relatively less wariness as slightly touching a robot-assisted instructor compared to the case of meeting 188*cm* robot-assisted instructor. Though, all students well followed the commands of the life-size 172*cm* tall robot-assisted instructor till badminton practice ended.

Ⅴ. Discussion

The results of the experiment, in behavior measurement and two questionnaires partially support the claim that a life-size robot platform has a positive correlation with conveying instructor authority in an education environment. Even though students assessed a child-size robot-assisted instructor higher which is recognized friendlier than a taller robot-assisted instructor, the life-size robot height delivered stronger authority that students obeyed the command of a robot-mediated instructor more strictly.

Students did not get closer to the 188*cm* tall robot-mediated instructor. It reconfirm the relation between telepresence robot height and human-robot distance of [16]. This result raises the possibility that using a life-size telepresence robot, as opposed to using the standard shorter robot, can increase the effectiveness of communication in situations reflecting a hierarchical power dynamic. The taller robot has advantages in authority and dominance when dealing with elementary students, but a shorter robot has advantages in non-authority and familiarity. Knowing the pros and cons of raising the height of robot platforms by one feet will be of significant aid in future robot design for developers and researchers. If the purpose of a robot-mediated communication is establishing the operator's position and enhancing the operator's authority to locals, as opposed to providing polite service, raising the height of the robot platform to

a life-size level should be a consideration. We hope that this research contributes to increasing the variety of heights seen in telepresence robots.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea funded by the Ministry of Education, Science and Technology (NRF-2015R1D1 A1A09060450).

Reference

[1] J.H. Han, *17. Robot-Aided Learning and r-Learning Services*, Human-Robot Interaction, Daisuke Chugo (Ed.), ISBN:978-953-307-051-3, INTECH, Austria, Feb., 2010.

[2] S. H. Lee, J. H. Han, Analysis on Creativity and Solving-Problem Ability with Hackathon-based Elementary SW Education

[3] T. Gawley, T. Perks, J. Curtis, "Height, gender, and authority status at work: analyses for a national sample of canadian workers," *Sex Roles,* Vol 60, pp. 208–222, 2009.

[4] R.M. Stogdill, "Personal factors associated with leadership: a survey of the literature," *Journal of Psychology,* Vol.25, pp. 35–71, 1948.

[5] M. R. Hamstra, "'Big' men: Male leaders' height positively relates to followers' perception of charisma," *Personality and Individual Differences,* Vol 56, pp. 190–192, 2013.

[6] AEJM. Cavelaars, AE. Kunst, JJM. Geurts, R. Criales, L. Grotved, et al. "Persistent variations in average height between countries and between socio-economic groups: an overview of 10 European countries, " *Annal of Human Biology,* Vol. 27, pp. 407–421, 2000.

[7] TA. Judge, DM. Cable, "The effect of physical height on workplace success and income: Preliminary test of a theoretical model," *Journal of Applied Psychology,* 89: pp. 428–441, 2004.

[8] G. Stulp, AP, Buunk, S. Verhuls, TV. Pollet, "Human Height Is Positively Related to Interpersonal Dominance in Dyadic Interactions," *PLoS ONE* 10(2): e0117860 doi:10.1371/journal, 2015.

[9] K. Kaneko, F. Kanehiro, M. Morisawa, K. Akachi, G. Miyamori, A. Hayashi, N. Kanehira, "Humanoid robot HRP-4 − Humanoid robotics platform with lightweight and slim body," *Proc. IEEE/RSJ Int.Conference on Intelligent Robots and Systems*, pp. 4400-4407, 2011.

[10] Jeonghye Han, "Analysis on Children Robot Interaction with Dramatic Playes for Better Augmented Reality", *Journal of Digital Contents Society* 17(6): pp. 531-536, 2016. https://doi.org/10.9728/dcs.2016.17.6.531

[11] Retrieved Sep 21, 2016, from http://www.willowgarage.com/pages/pr2/specs

[12] I. Rae, L. Takayama, & B. Mutlu, "The influence of height in robot-mediated communication," in *Proceedings of Human-Robot Interaction: HRI 2013,* Tokyo, Japan, pp. 1-8, 2013.

[13] S. Stefan "The new robotics—towards human-centered machines," *HFSP Journal,* 1:2, pp. 115-126, 2007.

[14] D. Fisher, B. Fraser, & J. Cresswell. "Using the "Questionnaire on Teacher Interaction" in the Professional Development of Teachers," *Australian Journal of Teacher Education,* 20(1). 1995.

[15] T. Wubbels, M. Brekelmans, and H.P. Hooymayers, "Interpersonal teacher behavior in the classroom," In *Educational environments: antecedents, consequences and evaluation,* eds. Fraser B J and Walberg H J pp. 141-160. Oxford, UK: Pergamon Press. 1991.

[16] T. van Oosterhout, A. Visser, "A visual method for proxemics measurements," in *Proceedings of the Workshop on Metrics for Human-Robot Interaction,* pp. 61–68, 2008.

Il-han Bae

1996: Bachelor of Business Administration at Korea University
2010: Master in Journalism at Korea University
2015: PhD in Futures Studies at University of Hawaii at Manoa

1997~2010 : Electronic Times reporter
2010~2015 : Hawaii Research Center for Futures Studies
2015 ~Present : Research Professor of Graduate School of Future Strategy at KAIST
※ HRI, futures studies, robot, drone

Jeong-hye Han

1992: Bachelor, Chungbuk National University
1994: Master, Chungbuk National University
1998: Ph.D., Dept. of Computer Science, Chungbuk National University
1999: Post Doctor, Dept. of Industrial Information, Yonsei University

2016~2019 : co-Chair of Steering Committee, International Conference of IEEE/ACM Human Robot Interaction
2015~2017 : Non-executive Director, KIRIA(Korea Institute for Robot Industry Advancement)
2011~2012 : Visiting Scholar, H-STAR(Human-Science, Technology for Advanced Research) Instititue, Stanford University
2001~Present: Professor, Dept. of Computer Education, Cheongju National Unviersity of Education
1999~2001 : Professor at Divison of Computer and Statistics, National Institute of Professional Administration
※ Human Robot Interaction, Children Robot Interaction, Robot Education