An investigation of the needs on educational robots

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Abstract—**Robot has been receiving increasing attention and robot in education is considered a promising aid for teaching and learning in many ways. This study attempts to investigate the need of the educational robot among six different user groups (pre-school user, primary school user, high school user, college user, adult user and elderly user). A triangulation technique was applied for cross validation, including systematic literature review, experts' interview and instructors' survey. It is expected that through this research the need of educational robot for six user groups can be clearly identified and to propose future directions for the development of educational robots.**

Keywords*- educational robot, need of educational robot, *triangulation technique

I. INTRODUCTION

Robot has been receiving increasing attention and becoming the focal point in recent years[1]. Due to its great potentials for application, robotic technology is regarded poised to become dominate in the future, and to bring massive change and impact on all aspects of human's daily life[2], [3]. Of the many applications, educational robot is one of the most important and promising applications[4].

Many of robot's attributes, including repeatability, flexibility, digitalization, humanoid appearance, body movement and interaction, are related to instructional goals, and are fit for educational purpose[5]. Robot as an integral component of society, has great potential of being utilized as an educational technology[6], [7]. Robot provide learners with hands-on experiences, fun activities in the class and attractive learning environments[6]. In this way, robots are found to be engaging, motivating for leaner[8]. The use of educational robot is concluded in many researches to be useful in enhancing learner's learning motivation and learning performance [9]–[11].

Educational robot is also a useful learning technology to support developing the 21st century learning skills. The use of educational robot can enhance learners' problem solving ability and to bring changes to students' learning attitudes. Instead of being a teaching object, passively receiving the lectures from instructor, students are motivated to be active learners, thus cut short the time required for learning. Moreover, the use of educational robot in a class creates a team work learning environment for students to practice communication and collaboration [12]–[15].

The majority of educational robot research has focused on using robots in STEM education[16], [17]. In these works, robots serve as a learning kit for students to be familiar with programming and mechanics, combined with hands-on theory and constructivism, and most of these activities are designed only for extra curriculum or after-school programs. This tendency indicates that the use of educational robots in other subjects is still unknown to the researchers and to teachers. Not having clear ideas about the role of robots in learning and how to use them leads teachers' to have a critical attitude toward them. [17] The other challenge is the lack of design of appropriate teaching materials and curriculum[6], [16], [17]. Robots are just tools, and it is the design of the curriculum and pedagogy that will impact learning performance [6].

The era of the robot is approaching. There is a need to make an effort to understand more about the implementation of educational robots, the design of appropriate teaching materials and curriculum, and other related issues. This study proposes to obtain in-depth understanding through an investigation on the needs of educational robots for six age groups. With the comprehensive understanding of educational robots, many innovative applications in education can be rooted in a solid foundation. This study attempts to answer the following research questions:

1. What important needs can an educational robot meet?
2. What are the specific needs for education using robots in each age group?

II. METHOD

A. Data collection and analytical framework

A triangulation technique is applied to validate the data, by cross verification between a literature review of empirical studies, expert interviews and instructor surveys. We classified the result collected from three data sources alone two dimensions: user group and timeframe and presented in an expert meeting for final validation.

The analytical framework requires partitioning both the user groups and the achievability timeframe. The user groups must be analyzed individually because the needs for educational robots can vary between groups. We divided users into six age groups: pre-school students, primary school students, high school students, college students (including graduate students), adults (working adults) and elderly (age

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over 65). The data is also partitioned according to achievability timeframe because robotics is a rapidly developing field, with many of the most promising areas of application being still in their infancy. Due to the issue of technology maturity, the achievability timeframes are divided between short-term, mid-term and long-term, based on which potential applications are projected to be implementable in 1-2 years, 3-4 years or over 5 years, respectively.

In the first step, we identified artificial intelligence, speech recognition and motion as three core technologies in this field. We then asked the experts to identify difficult levels as being achievable in the short-term, mid-term or long term. At the end, 5 levels were identified for each core technology and were then scored with a 1, 2, 3, 4 or 5 accordingly.

In the third step, we evaluated each application in order to obtain scores for that application in each of the three core technology areas. In many cases, a given application would pose several difficulty levels within a single technology area. In these cases, the score of that application for that technology area would be chosen as the highest value of any of the difficulties it posed for that technology. (The rationale is that science advances simultaneously along all fronts, so short-term difficulties will naturally be likely to have been solved by the time that the mid-term difficulties are solved.) In the fourth step, we add the scores from each of the three core technology areas, to obtain the overall difficulty score of each application. We label the given applications as short-term, mid-term, and long-term, based on scores ranges of 1-5, 6-10, and 11-15 respectively.

B. *Systematic literature review*

We adapted the data from that compiled in Liu, et al. [18]. Keywords such as "education and robot", "teacher and robot", "child and robot", "students and robot" and "classroom and robot" were used as protocols for recruiting papers from the social science citation index. The result were refined and limited to educational researches published from 2010 to 2016. They were then classified by subject, role of the robot and user group.

C. *Expert interviews*

12 experts who are specialized in both education and technology were invited, including 6 professors in digital learning and 3 ECOs of technology companies and 4 instructors that have more than 10 years teaching experience in primary and high school from Taiwan. A soft ladder method was applied in conducting in-depth interview to obtain insights from the experts on the needs of educational robot for six age groups.

D. *Instructor surveys*

We conducted the instructor survey by using a snowball sampling method. We designed a six rounds survey to make sure a convergence and sample size in our survey. For each round, the online questionnaire system would only take 10 responses. The participants were required to fill in a personal information form, watch a video of a family robot from youtube channel and then answer three open questions concerning the demands of educational robot in their working places. At the end, we received a total number of 307 responses. After that, we listed all the demands that had been raised at each round, and counted how many new demands were proposed at each round. We then applied a scree plot on the number of the new demands at each round, and identified that the collection of demands had reached a convergence at round 4.

III. PRELIMINARY RESULT

The research yields a result of 63 unique demands from the three data sources. The demands are then categorized into 14 general categories, including robots for language education, robot for educational robotics, robot teaching assistant, robots for social and special education, robot learning counselor, robot teaching agent, robot secretary, smart classroom manager, robot learning companion, care robot, robot tutor, robots for physic education, general education and STEM education. For each of the three source, the size of each category is then calculated as the number of demands that were placed into that category, allowing for repeats. From these sizes, percentages can be calculated, such that the total percentage across all 14 categories is 100% (for each of the three sources). Next, the percentages obtained for each of the three sources are averaged together to obtain an overall percentage, as plotted in Figure 1. This figure indicates that the largest demand is for Language Education and for Educational Robotics (*i.e.*, kits for robotics education).

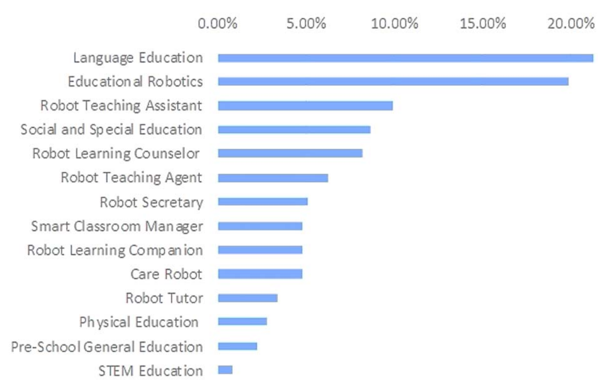

Figure 1. The ranking of the needs for educational robots

The results show that many educators want assistance in the mundane or administrative aspects of their work. In other words, the scope of what defines an educational robot should be broad enough to cover not only direct teaching, but also uses that more indirectly contribute to learning (e.g., counseling, or day care, or classroom management). Technologies such as the internet are producing paradigm shifting education, in which learning is no long happening only in the classrooms or limited to certain traditional subjects. Educational robots may bridge the gap by supporting both formal and informal learning.

We next examine how the demands for the different application categories vary across age groups. In this rough calculation we apply a binary test to each of the three sources: if that demand was identified for that age group from within the data for that source, then a value of 1 was set (the value was 0). Then, by adding up the values from all three sources, a number in the range of 0 to 3 can be obtained, indicating the prevalence of that demand for that age group across all three sources. The result is plotted in Figure 2. In this figure, three items obtained a full score of 3: Educational Robotics for college students, Language Education for pre-school children, and Social and Special Education robots for pre-school children. In this new figure, Educational Robotics obtains the highest ranking across all age groups, followed by Language Education. Although these were also the top two items in Figure 1, their order is now switched. Moreover, the results shows that age groups have different demands. The pre-school group has highest demand in two categories: using robots for language education and for social and special education; the primary school group's highest demand is for Educational Robotics and Language Education; the high school and the college groups' largest demands are for educational robotics; the adult groups' highest demand is for a Robot Learning Counselor; and the elderly group's highest demand is Physical Education.

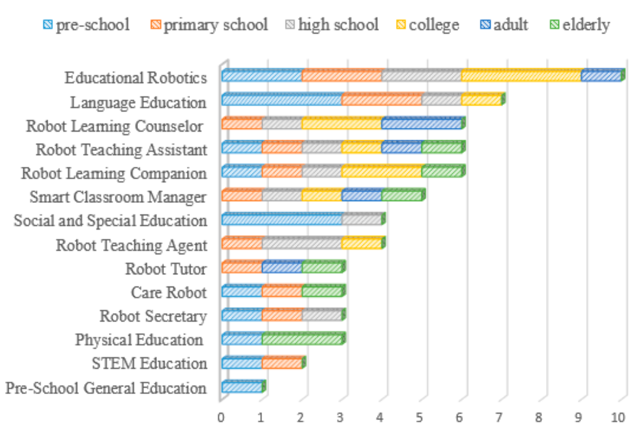

Figure 2. Age groups and demands

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REFERENCES

[1] H. Tamada, A. Ogino, and H. Ueda, "Robot Helps Teachers for Education of the C Language Beginners," in *Human-Computer Interaction. Novel Interaction Methods and Techniques*, Springer, Berlin, Heidelberg, 2009, pp. 377–384 [Online]. Available: http://link.springer.com/chapter/10.1007/978-3-642-02577-8_41. [Accessed: 24-Jan-2017]

[2] R. Calo, "The case for a federal robotics commission | Brookings Institution," *Brookings*. 15-Sep-2014 [Online]. Available: https://www.brookings.edu/research/the-case-for-a-federal-robotics-commission/. [Accessed: 24-Jan-2017]

[3] "Robotics 2020 Strategic Research Agenda for Robotics in Europe." [Online]. Available: https://www.kowi.de/Portaldata/2/Resources/horizon2020/coop/Robotics-2020-SRA-Draft.pdf. [Accessed: 24-Jan-2017]

[4] B. Mutlu, J. Forlizzi, and J. Hodgins, "A Storytelling Robot: Modeling and Evaluation of Human-like Gaze Behavior," 2006, pp. 518–523 [Online]. Available: http://ieeexplore.ieee.org/document/4115652/. [Accessed: 24-Jan-2017]

[5] C.-W. Chang, "Exploring the Possibility of Using Humanoid Robots as Instructional Tools for Teaching a Second Language in Primary School," *Educ. Technol. Soc.*, vol. 13, no. 2, pp. 13–24, 2010.

[6] D. Alimisis, "Educational robotics: Open questions and new challenges," *Themes Sci. Technol. Educ.*, vol. 6, no. 1, pp. 63–71, Jun. 2013.

[7] A. Felicia and S. Sharif, "A Review on Educational Robotics as Assistive Tools For Learning Mathematics and Science," *Int. J. Comput. Sci. Trends Technol.*, vol. 2, no. 2, pp. 62–84, Apr. 2014.

[8] G.-D. Chen, Nurkhamid, and C.-Y. Wang, "A Survey on Storytelling with Robots," in *Edutainment Technologies. Educational Games and Virtual Reality/Augmented Reality Applications*, Springer, Berlin, Heidelberg, 2011, pp. 450–456 [Online]. Available: http://link.springer.com/chapter/10.1007/978-3-642-23456-9_81. [Accessed: 30-Jan-2017]

[9] P.-Y. Chung, C.-J. Chang, Y.-D. Liang, B.-Y. Shih, M.-Z. Lin, T.-H. Chen, and Y.-H. Chen, "Design, Development and Learning Assessment by Applying NXT Robotics Multi-Media Learning Materials: A Preliminary Study to Explore Students' Learning Motivation," *World Acad. Sci. Eng. Technol.*, vol. Vol. 65, May 2010 [Online]. Available: http://203.71.232.26/handle/987654321/1193. [Accessed: 30-Jan-2017]

[10] R. Mitnik, M. Nussbaum, and M. Recabarren, "Developing Cognition with Collaborative Robotic Activities on JSTOR," *J. Educ. Technol. Soc.*, vol. 12, no. 4, pp. 317–330, Oct. 2009.

[11] F. Klassner and S. D. Anderson, "LEGO MindStorms: not just for K-12 anymore," *IEEE Robot. Autom. Mag.*, vol. 10, no. 2, pp. 12–18, Jun. 2003.

[12] R. D. Beer, H. J. Chiel, and R. F. Drushel, "Using autonomous robotics to teach science and engineering," *Commun. ACM*, vol. 42, no. 6, pp. 85–92, Jun. 1999.

[13] E. Mauch, "Using Technological Innovation to Improve the Problem-Solving Skills of Middle School Students: Educators' Experiences with the LEGO Mindstorms Robotic Invention System," *Clear. House J. Educ. Strateg. Issues Ideas*, vol. 74, no. 4, pp. 211–213, Mar. 2001.

[14] I. R. Nourbakhsh, K. Crowley, A. Bhave, E. Hamner, T. Hsiu, A. Perez-Bergquist, S. Richards, and K. Wilkinson, "The Robotic Autonomy Mobile Robotics Course: Robot Design, Curriculum Design and Educational Assessment," *Auton. Robots*, vol. 18, no. 1, pp. 103–127, Jan. 2005.

[15] B. S. Barker and J. Ansorge, "Robotics as Means to Increase Achievement Scores in an Informal Learning Environment," *J. Res. Technol. Educ.*, vol. 39, no. 3, pp. 229–243, Mar. 2007.

[16] F. B. V. Benitti, "Exploring the educational potential of robotics in schools: A systematic review," *Comput. Educ.*, vol. 58, no. 3, pp. 978–988, Apr. 2012.

[17] O. Mubin, C. J. Stevens, S. Shahid, A. A. Mahmud, and J.-J. Dong, "A REVIEW OF THE APPLICABILITY OF ROBOTS IN EDUCATION," *Technol. Educ. Learn.*, vol. 1, no. 1, 2013 [Online]. Available: http://www.actapress.com/PaperInfo.aspx?paperId=43268. [Accessed: 24-Jan-2017]

[18] D.-J. Liu, R.-H. Huang, N.-S. Chen, and L. Fan, *The Current Situation and Trend of Global Development of Educational Robots*. Beijing: Posts & Telecommunications Press, 2016.