Research Assessment Exercise 2020
Impact Case Study

University: The Chinese University of Hong Kong
Unit of Assessment (UoA): 41
Title of case study: Enhancing Social and Behavioral Skills through an Evidence-Based and Innovative Intervention for Autism: Robot for Autism Behavioral Intervention Program (RABI)

(1) Summary of the impact (indicative maximum 100 words)

Through deploying social robots, the RABI curriculum reduces autism severity and increases social and behavioral functioning of 3-18-year-olds with autism. RABI was developed from the application of theories pertaining to the special learning needs of individuals with autism. Eighteen local and Macau non-government organizations and (mainstream/special) schools have adopted RABI to benefit their students. Their feedback includes "significant improvements in students' verbal and non-verbal communication" and "generalization of acquired skills to students' daily lives". The government has also identified RABI as an innovative and successful intervention for autism. RABI is currently expanding via business and will be applied internationally.

(2) Underpinning research (indicative maximum 500 words)

The Intense World Theory and Social Motivation Theory of Autism suggest that individuals with Autism Spectrum Disorder (ASD) have excessive reactivity due to a particular form of brain hypertrophy and have deficits in communications with humans. Both theories contributed to the development of highly structured learning environments using social robots to enhance the social and behavioral functioning of these individuals. Social robots operate within predictable and lawful systems, manifesting an encouraging learning environment amongst learners with ASD, while reducing the need for instructors to repeat themselves excessively. The findings generated from the pretest-posttest designs supported the effectiveness of RABI, thereby providing an alternative to conventional intervention where human teachers or therapists play the sole or significant role.

Our prior research on gestural learning amongst school-aged children with ASD was based on our previous findings, which suggested delays in nonverbal communication skills amongst 6-12-year-old Chinese-speaking children with autism, when compared to their typically developing counterparts [3.1,3.2]. A theory-based intervention was then developed. In an experimental study (funded by CUHK) [3.3] adopting a pretest-posttest design, 6-12-year-old Chinese-speaking children with autism were taught to recognize, imitate, and produce 20 different gestures by watching robot animations. Findings showed that children were able to recognize and imitate more gestures upon receiving this condensed version of the RABI program. The children also generalized the learned gestures appropriately to novel settings with human researchers after intervention.

CUHK then granted additional funding examining the efficacy of social robots in the learning experience of school-aged learners with ASD using RCT. In a newly developed theory-based intervention program, the social robots were tasked to teach research participants to appropriately express their emotions and needs verbally. The positive results of direct human-to-human interactions suggests that RABI can improve the learning and behavioral outcomes of children with ASD [3.5].

A follow-up pretest-posttest experiment funded by the government (EDB-QEF) found that RABI closed the gap on gestural production skills between preschool-aged Chinese-speaking children with ASD and their typically developing peers after two-week intensive training [3.4]. Its findings

solidified the positive learning outcomes of RABI in young children with ASD. More importantly, this study generated a new assessment tool in evaluating gestural learning outcomes in both typically- and atypically-developing children.

Subsequent studies funded by the government (EDB-QEF and RGC) developed a sound research design comparing the effectiveness of human-based interventions to robot-based interventions. Findings highlighted that children with ASD learn equally well in the robot- and human-based interventions, suggesting that robot-based intervention can serve as an effective intervention alternative to human-based intervention [3.6]. Compared with human-based, robot-based interventions can be implemented on a much larger scale even under limited resources.

All the studies above underpinned the further expansion of RABI. With funding from government (SIE), recently more comprehensive robot-based play-drama protocols and pretest-posttest experiments were designed and have yielded significant improvement for crucial aspects of social competence, including joint attention, play behaviors, and narration, in preschool children with ASD (So et al., Research in Developmental Disabilities, 2019; Journal of Autism and Developmental Disorders, 2019).

(3) References to the research (indicative maximum of 6 references)

[3.1] So, W.C., Lui, M., Wong, T.K., & Sit, L.T. (2015). The use of hand gestures to communicate about nonpresent objects in mind among children with autism spectrum disorder. *Journal of Speech, Language, and Hearing Research*, 58, 373-382. DOI:10.1044/2015_JSLHR-L-14-0213

[3.2] So, W.C., Wong, M.K.Y., Yip, V., & Lui, M. (2015). The development of co-speech gesture and its semantic integration with speech in 6- to 12-year-old children with Autism Spectrum Disorders. *Autism: International Journal of Research and Practice*, 19(8), 956-968. DOI: 10.1177/1362361314556783

[3.3] So, W.C., Wong, M.K.Y., Cabibihan, J-J., Lam, K.Y., Chan, Y.Y, & Qian, H.H (2016). Using robot animation to promote gestural skills in children with autism spectrum disorders. *Journal of Computer Assisted Learning*, 32, 632–646. DOI: 10.1111/jcal.12159

[3.4] So, W.C., Wong, M.K.Y, Lam, W.Y., Cheng, C.H., Yang, J.H., Huang, Y., Ng, P., Wong, W.L., Ho, C.L., Yeung, K.L., Lee, C.C. (2018). Robot-Based Intervention May Reduce Delay in the Production of Intransitive Gestures in Chinese-Speaking Preschoolers with Autism Spectrum Disorder. *Molecular Autism*, 9:34. DOI: 10.1186/s13229-018-0217-5

[3.5] So, W.C., Wong, M.K.Y., Lam, K.Y., Lam, W.Y., Chui, T.F., Lee, T.L., Ng, H.M., Chan, C.H., & Fok, C.W. (2018). Using a social robot to teach gestural recognition and production in children with autism spectrum disorders. *Disabilities and Rehabilitation: Assistive Technology*, 13(6), 527-539. DOI: 10.1080/17483107.2017.1344886

[3.6] So, W.C., Wong, K.Y., Lam, W.Y., Cheng, C.H., Ku, S.Y., Lam, K.Y., Huang, Y., Wong, W.L. (2019). Who is a better teacher for children with autism? Comparison of learning outcomes between robot-based and human-based interventions in gestural production and recognition. *Research in Developmental Disabilities*, 86, 62-75. DOI: 10.1016/j.ridd.2019.01.002

(4) Details of the impact (indicative maximum 750 words)

Approximately 2000 preschool children are diagnosed with ASD every year. Since 2015, RABI has provided training in a plethora of social and behavioral skills, ranging from self-care and

conversation, and vocational skills for 915 3-18-year-olds with ASD in HK and Macau and created impact in the following aspects:

Impact on enhancing social and behavioral skills in local ASD

The RABI curriculum has been adapted by 18 non-government organizations and schools in Hong Kong and Macau. Preschoolers who have received the nine-month intervention have had their autism severity reduced by 45% and cognitive abilities increased by 18%. Consistent with the published research findings [3.3-3.6], testimonials from stakeholders reiterate the positive impact of RABI [5.1]. The Assistant General Secretary (Education) of the Hong Chi Association, a representative organization that operates 13 special schools in Hong Kong, ***"witnessed improvements in students' verbal and nonverbal skills"***. Another representative of a non-government organization, Sheng Kung Hui Welfare Council stated, ***"RABI enhanced students' learning motivation."*** Teacher reports included, ***"Students were able to generalize their acquired skills, and incorporate them into their daily lives"***. Parents were ***"impressed with the positive changes in social behaviors"***.

Impact on local education policy and initiatives

The Secretary for Innovation & Technology Bureau (ITB) of Hong Kong S.A.R. Government identified RABI as a successful program that adopts innovative technology for the benefit of the society [5.2]. Funded by ITB, RABI is providing an intervention for an additional 900 preschool children with ASD, which is 48.2% of the newly diagnosed ASD preschool children in 2018.

RABI has also informed special needs education policy and decision-making by defining the beneficial use of social robots in the field of special education. Specifically, the team has assisted schools and organizations to incorporate information and communication technology (ICT) initiatives to their operational practices. 25 training workshops were delivered for over 350 teachers, parents, caregivers, and staff. This provided them with detailed evidence-based manuals and guidelines [5.3], thereby enhancing their professional development and competency in administrating robot-based intervention in schools and at homes.

Furthermore, RABI has educated the public on the special learning needs of individuals with autism via mainstream media. Since 2015, 64 news articles (e.g., South China Morning Post, Mingpao, Hong Kong Economic Journal) and TV programs (e.g., TVB, news.gov.hk, Hong Kong Council of Social Services) have featured RABI [5.4], reaching approximately 25,000 viewers. Additionally, the RABI team has delivered keynote speeches at the major events and exhibitions, attracting approximately 550 audiences [5.5]. After attending Learning and Teaching Exhibition 2018, The Salvation Army SKY Family and Child Development Centre were ***"amazed by RABI's effectiveness in helping ASD children in learning language and social behavior"*** [5.6]. Steered by the Office of the Government Chief Information Officer, Hong Kong ICT Awards 2018 presented a merit award to RABI, acknowledging its innovative use of social robots in educating children with autism [5.7]. The idea of using social robots to educate individuals with ASD has also elicited interests amongst professionals abroad. NHK (the sole public broadcaster of Japan) and NHK-World Japan featured RABI in their documentary, "Life with Robots", which aired from March to September 2019. Approximately 30,000 people watched it to date.

Impact on establishing international social ventures

The positive outcomes of RABI initiated a three-year collaboration between the Faculty of Education at CUHK and NEC-Hong Kong Limited [5.8], a local business corporation affiliated with NEC Corporation in Japan. NEC-HK manufactures the social robots, HUMANE, the essence of the RABI program. The CUHK-NEC collaboration not only generated approximately HKD [redacted] in sales (approximately 40 units of HUMANE), but it also enhanced the technical specification of HUMANE through hardware enhancement, artificial intelligence technology, big

data analytics, and more. NEC-HK also provides immediate assistance for add-on demand features in RABI programs provided in Hong Kong and around the world [5.9]. Thereafter, advanced technology, including facial and voice recognition, spontaneous interaction with robots through smart watch and machine learning, and motion detection has been specifically developed for HUMANE, thus further improving the functions of these robots. This has enhanced the effectiveness of RABI and improved the quality of life of children with ASD.

Through NEC-HK's network with [redacted], RABI has established social ventures in Australia and Japan, where its services will be made available at five special schools in these regions, such as [redacted] School [5.10]. In total, 1500 pupils with ASD from schools and organizations abroad will benefit from RABI. The participating schools will adopt the established RABI guidelines and curriculum from 2019.

(5) Sources to corroborate the impact (indicative maximum of 10 references)

[5.1] Selected letters from the following non-government organizations and schools (both mainstream and special) registered to use RABI since 2015:
Special schools:
Hong Chi Morninghill School, Tsui Lam; Hong Chi Morninghill School, Tuen Mun; Hong Chi Lions Morninghill School; Rotary Club of Hong Kong Island West Hong Chi Morninghope School; Po Leung Kuk Yu Lee Mo Fan Memorial School; Evangelize China Fellowship Holy Word School.
Mainstream schools:
Fortress Hill Methodist Secondary School; Taoist Ching Chung Primary School (Wu King Estate).
Non-government organizations:
Heep Hong Society; SAHK; Hong Kong Christian Service; Sheng Kung Hui Welfare Council; The Salvation Army; The Neighborhood Advice-Action Council.

[5.2] Acknowledge from Innovation and Technology Bureau of Hong Kong S.A.R. Government (July 7, 2019).

[5.3] An example of a manual for parents and teachers in 2016.

[5.4] Media coverage of RABI since 2015.

[5.5] Invitation letter for Hong Chi Schools Professional Development Day, and Thank you letters from the Learning and Teaching Expo and the Gerontech and Innovation Expo cum Summit 2018.

[5.6] Appreciation letter from Salvation Army SKY Family and Child Development Centre.

[5.7] HK ICT Awards 2018 Booklet p. 15: Smart People (Smart Inclusion) Certificate of Merit.

[5.8] Memorandum of understanding signed by the Dean of Faculty of Education and the Managing Director of NEC-Hong Kong Limited on May 28, 2018.

[5.9] Letter of collaboration with NEC-Hong Kong Limited.

[5.10] Letter of collaboration with Professor [redacted]