LEVERAGING THE AURO MODEL FOR THE INTEGRATION OF HUMANOID ROBOTIC ASSISTIVE TOOLS IN AUTISM SPECTRUM DISORDER INTERVENTION

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A thesis submitted
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DECLARATION

I declare that this thesis entitled Implementing Robot As Assistive Tools For Autism Learning By Using Auro Model is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted as a candidature for any other degree.

Signature :.....

Name : Norshahidatul Hasana binti Ishak

Date : 28 May 2025

APPROVAL

I hereby declare that I have read this thesis, and in my opinion, this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.

Signature :.....

Supervisor Name : Siti Nurul Mahfuzah binti Mohamad

Date : 3 June 2025

DEDICATION

I dedicate this work to the cherished individuals who have been my unwavering support pillars throughout my journey as a PhD student. To my beloved father, Ishak Che Hassan, and my dear mother, Zaniah Che Wan, whose boundless love and sacrifices have been the foundation of my aspirations. To my loving husband, Wan Alfatah Burhanuddin, whose steadfast encouragement and understanding have been my source of strength. And to my precious children, Zulaikha, Dzakwan, and Hafidz, whose presence fills my life with joy and purpose.

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ABSTRACT

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder characterised by deficits in communication, social interaction, and the presence of repetitive behaviours. Despite numerous scientific efforts, the precise aetiology of autism remains inconclusive. Alarming trends indicate a consistent rise in autism diagnoses worldwide, heightening the urgency for effective educational interventions tailored to this population. While education is fundamental for all children, current pedagogical tools often fall short in addressing the unique cognitive and behavioural challenges faced by children with autism. This study investigates the potential of integrating robotics, specifically the humanoid robot NAO, as an assistive educational tool to improve cognitive engagement and learning outcomes among children with ASD. Preliminary investigations revealed that attention deficits and the need for repetitive instruction were primary barriers encountered by educators. To address these issues, this study introduces the AuRo model, a robot-assisted teaching and learning framework designed to support and enhance the educational experience of children with autism. The study is guided by three primary objectives:(i) to identify the most effective model for using robotics technology to aid children with autism in developing their cognitive ability; (ii) to construct AuRo model for teaching and learning for children with autism; and (iii) to evaluate the effectiveness of AuRo model for teaching and learning for children with autism. A mixed-methods approach was employed, combining quantitative assessments of student performance with qualitative observations focusing on robot acceptance, involvement in the teaching process (ITP), and quality of interaction (QI). Results demonstrated that the NAO robot effectively captured students' attention, improved their focus, and enhanced their engagement in learning activities. Participants showed positive behavioural responses, indicating the robot's potential as a motivational and interactive teaching aid. It is recommended that future development include emotion recognition capabilities and curriculum-wide integration, particularly for the Mathematics Level 1 syllabus. Expanding the study to include a larger sample size is also suggested to substantiate the findings and reinforce the model's generalizability.

MEMANFAATKAN MODEL AURO UNTUK PENGINTEGRASIAN ALAT PEMBANTU ROBOTIK HUMANOID DALAM INTERVENSI GANGGUAN SPEKTRUM AUTISME

ABSTRAK

Autism Spectrum Disorder (ASD) atau Spektrum Autisme merupakan gangguan neuroperkembangan yang kompleks, dicirikan oleh defisit dalam komunikasi, interaksi sosial, serta tingkah laku berulang yang berterusan. Meskipun pelbagai usaha penyelidikan telah dijalankan, punca sebenar autisme masih belum dapat dikenal pasti secara konklusif. Statistik global menunjukkan peningkatan berterusan dalam bilangan kes autisme, sekali gus menekankan keperluan mendesak terhadap intervensi pendidikan yang lebih berkesan dan sesuai untuk golongan ini. Pendidikan merupakan hak asas setiap kanak-kanak, namun kaedah pengajaran sedia ada sering kali tidak mencukupi dalam menangani keperluan kognitif dan tingkah laku kanak-kanak autisme secara menyeluruh. Kajian ini meneliti potensi penggunaan robotik, khususnya robot humanoid NAO, sebagai alat bantu pendidikan untuk meningkatkan tumpuan dan hasil pembelajaran dalam kalangan kanak-kanak autisme. Kajian awal mendapati bahawa masalah utama yang dihadapi oleh guru adalah kekurangan tumpuan dan keperluan kepada pengulangan yang kerap. Sebagai solusi, kajian ini mencadangkan pembangunan model AuRo, iaitu satu kerangka pengajaran dan pembelajaran berasaskan robotik yang direka khusus untuk menyokong dan meningkatkan pengalaman pendidikan bagi kanak-kanak autisme. Tiga objektif utama telah digariskan: (i) mengenal pasti model paling berkesan dalam penggunaan teknologi robotik untuk pembangunan kognitif kanak-kanak autisme; (ii) membangunkan model AuRo yang sesuai untuk persekitaran pendidikan khas kanak-kanak autisme; dan (iii) menilai keberkesanan model AuRo terhadap kanak-kanak autisme. Kajian ini menggunakan pendekatan kaedah campuran, melibatkan penilaian kuantitatif terhadap prestasi pelajar serta pemerhatian kualitatif yang menumpukan kepada penerimaan terhadap robot, penglibatan dalam proses pengajaran (ITP), dan kualiti interaksi (QI). Dapatan menunjukkan bahawa penggunaan robot NAO berjaya menarik perhatian murid, meningkatkan fokus, serta memupuk penglibatan aktif dalam aktiviti pembelajaran. Respons positif daripada pelajar membuktikan potensi robot ini sebagai alat bantu pengajaran yang interaktif dan bermotivasi. Kajian mencadangkan supaya pembangunan masa hadapan merangkumi keupayaan pengesanan emosi serta peluasan kandungan kepada keseluruhan kurikulum Matematik Tahap 1 bagi pelajar pendidikan khas. Tambahan pula, penglibatan saiz sampel yang lebih besar adalah disarankan bagi mengukuhkan keberkesanan model dan memperluas kebolehgunaan hasil kajian.

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LIST OF ABBREVIATIONS

SBP	-	*Sekolah Berasrama Penuh*
MOOC	-	Massive Open Online Courses
MBK	-	*Murid Berkeperluan Khas*
BL	-	*Ketidakupayaan Penglihatan" (BL)*
DE	-	*Ketidakupayaan Pendengaran" (DE)*
SD	-	*Ketidakupayaan Pertuturan" (SD)*
PH	-	*Ketidakupayaan Fizikal" (PH)*
LD	-	*Masalah Pembelajaran" (LD)*
MD	-	*Ketidakupayaan Pelbagai" (MD)*
PPKI	-	*Program Pendidikan Khas Integrasi*
ASD	-	Autism Spectrum Disorder
MoE	-	Ministry of Education Malaysia
SIT	-	Sensory Integration Therapy
HFASD	-	High-Functioning Autism Spectrum Disorder
EIP	-	Early Intervention Program
IEPs	-	Individualised Education Plans
WHO	-	World Health Organisation
VAK	-	Visual, Auditory, and Kinesthetic
ICT	-	Information and Communication Technologies
WAT	-	Wearable Assistive Tools
HRI	-	Human-Robot Interaction
VR	-	Virtual Reality

VHLQ	-	Visual Hybrid for Learning Quran
CASD	-	Checklist for Autism Spectrum Disorder
FGD	-	Focus Group Discussion
AuRo	-	Autism Robot

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LIST OF PUBLICATIONS

Siti Nurul Mahfuzah Mohamad, Norshahidatul Hasana Ishak, Sazilah Salam, Zulisman Maksom, Adili, Norazah Mohd Nordin, Nor Hafizah Adnan (2026). Humanoid Robot-Assisted Learning for Level 1 Autistic Children: Developing Test Plans to Enhance Number Recognition Skills. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, Vol 56, 2026.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Education is important in personal development and advancement, whether on an individual or national level. A study by Johnes et al. (2017) mentioned that the impact of education at the national level may affect economic growth. There are various ways of delivering education to the community, either from the young or the old. Delivering and accepting knowledge may be accomplished over a long period.

In Malaysia, the government education institutions include preschool education, a program for children aged four to six in the national school system. Primary education is a curriculum designed for children between the ages of seven and twelve. It typically takes six years to complete, but can be finished in five to seven years. The system comprises both national schools and national-type schools. Following primary education, secondary education consists of both upper and lower secondary levels. Secondary education can be obtained at academic, technical, vocational, and national religious schools. Post-secondary education refers to the educational level that follows lower and upper secondary education but does not include higher education. Schools classified as government-assisted educational institutions fall under "*Sekolah Berasrama Penuh*" (SBP), which the Fully Residential School Unit of the Schools Division oversees. Other academic institutions established at the school level are special education schools, which are the responsibility of the Special Education Department. Finally, sports schools are responsible for the sports division (*Sistem Pendidikan*, 2019). A study by

Gardiner (2018), mentioned that early education studies as early as two years old will be associated with improvement in children's cognitive and socio-emotional development at three years old. This is the reason education should start as early as possible, as it will relate to the next age of the children.

Technology is one of the tools that can help improve education. Examples of technology adoption in Malaysia's education include Massive Open Online Courses (MOOCs), e-learning, and others. Robot technology can be described as a new innovation in Malaysia to be implemented in special needs education. Using robot technology in special needs education, particularly for children with Autism Spectrum Disorder (ASD), presents several challenges. These challenges can be categorised into various levels, including technical, physical, and application-specific issues.

Regarding the technical and physical issues, one of the primary challenges is the availability and maintenance of the necessary hardware and software. Teachers and specialists often face difficulties due to inadequate devices and technical support (Athbah, 2024). The robot's design and functionality must be adaptable and flexible to cater to the diverse needs of children with ASD. However, designing robots that can operate effectively in unconstrained, real-world settings instead of controlled lab environments remains a significant hurdle (Di Nuovo et al., 2018; Hirokawa et al., 2019).

As for the application-level challenges, the robots need to be highly customisable to meet the individual needs of each child with ASD. This includes adapting to the child's specific social, communicational, and emotional requirements, which can be complex and resource-intensive (Hirokawa et al., 2019). The final challenge is education and training, where educators and therapists need adequate preparation to use robotic technologies effectively. There is also

a need to address their concerns about the potential redundancy of human efforts due to the introduction of robots (Di Nuovo et al., 2018).

Addressing these challenges requires a multi-faceted approach involving technological innovation, extensive research, and comprehensive training programmes for educators. By overcoming these obstacles, the potential of robot-assisted therapy and education for children with ASD can be fully realised, leading to improved social, communicational, and emotional outcomes for these children.

1.2 Research Background

Special education offers children with diagnosed disabilities tailored training specifically geared to address their distinct learning requirements, enabling them to reach their highest possible achievement. Special education plays an important part in meeting the special needs of individuals with disabilities. Malaysia offers multiple forms of special education, commonly referred to as Special Educational Needs or "*Murid Berkeperluan Khas*" (MBK). These categories include:

i. Sight impairment or "*Ketidakupayaan Penglihatan*" (BL)

ii. Hearing impairment or "*Ketidakupayaan Pendengaran*" (DE)

iii. Speech disabilities or "*Ketidakupayaan Pertuturan*" (SD)

iv. Physical inabilities (disabilities) or "*Ketidakupayaan Fizikal*" (PH)

v. Learning disabilities or "*Masalah Pembelajaran*" (LD) and

vi. Multiple disabilities or "*Ketidakupayaan Pelbagai*" (MD)