Effects of Four-Axis Joystick Device Interactive Technology on Children With Special Needs

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Abstract
In recent studies, employing self-made assistive technology as a resource in special education stands out as a crucial intervention for children with special needs. This study suggests creating an interactive tool intended to serve as an educational interface for children with diverse disabilities. The participants in this study were three children with cerebral palsy, multiple disabilities, and learning disabilities. This study uses a four-axis joystick device with multimedia and programming software to develop an interactive feedback interface to promote movement training and learning motivation of students with special needs. Utilizing this device, which involves a joystick, a self-modeled laser-cut wooden box, and connection to the Printed Circuit Board Assembly for its operation, enables a computer, tablet, or mobile phone connection. Ultimately, using this customized interactive technology involves utilizing multimedia platforms or program software to cater to the specific needs of children with special requirements. This aids in facilitating physical or learning training for children with special needs. Through the case study paradigm, we can understand the training effectiveness of children with different needs, including the effectiveness of the upper limb fine motor training process and learning outcomes. It collects professional advice and feedback from special education teachers and parents, concluding with a discussion of the study's findings.

Keywords: Assistive Technology, Interactive Technology, Children With Special Needs

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Introduction

In the 21st century, we've witnessed a cascade of technological advancements. The user base for assistive technology has been steadily growing, underscoring the heightened significance of selecting and deploying appropriate assistive technology tools and services. It's imperative to consider each user's unique circumstances, encompassing individual traits, preferences, perceptions, and attitudes, to ensure that unsatisfactory outcomes don't lead to the abandonment of assistive technology (Sung et al., 2018). In recent years, Maker has emerged. People who love technology and are keen on practice enjoy sharing technology and exchanging ideas, and have incorporated it into their lives, communities, courses, etc. Of course, assistive technology equipment is no exception.

The capacity to harness do-it-yourself (DIY) techniques and tools for crafting personalized digital assistive technologies (DIY-ATs) has been acknowledged for quite some time (Parry-Hill et al.,2017, Hook et al., 2014). In addition to being able to design and produce according to the individual needs of users, DIY-AT can also reduce manufacturing costs, replicate experience and provide painless learning, helping people with special needs who are in urgent need of assistive devices and have financial burdens to use assistive devices easily and Avoid lengthy time in obtaining assistive devices and reduce the burden of huge amounts of money.

Currently, numerous individuals have utilized the DIY or maker movement to engage in research on assistive technology, yielding positive outcomes. 表單的頂端 an affordable, open-source DIY prototyping platform to fabricate personalized alternative augmentative communication (AAC) devices tailored for nonverbal children and youth in Western Kenya (Hamidi et al., 2022); Additionally, Hamidi (2019) leverages a comparable platform for collaboratively designing interactive audio interfaces to bolster speech-language therapy and music therapy in the United States; Mettler et al. contend that enabling the active participation of the elderly in the planning, design, and utilization of DIY AT can yield satisfactory effectiveness (2023); 3D printing push switches and toy modifications have also achieved good results in mathematical operations and cooperative learning for children with special needs(Sung et al., 2018); Utilizing 3D printing technology, this study creates a multimedia interactive feedback interface designed to train children with learning or physical disabilities in coin insertion, thereby enhancing their learning motivation. The human-machine interface is developed using Microsoft Visual C# (Chen et al., 2018).

Method

A case study methodology was employed to investigate the effectiveness of specially designed teaching activities, which integrate assistive technology with toys and games for both learning and physical training interventions. This approach involved the utilization of a laser-cutting wooden box and a Four-Axis Joystick, in conjunction with a PCBA board, to facilitate the physical training and learning of special needs students in elementary schools. Subsequently, professional suggestions and feedback from the participating special education teachers were collected, summarized, and integrated.

Study Subjects

This study focused on three elementary school students with distinct special needs, including Cerebral Palsy (CP), Learning Disability (LD), and Autism Spectrum Disorder (ASD). The first student diagnosed with CP exhibited high muscle tension, poor hand stability, and limited fine motor skills in their fingers. The second student, with a learning disability, had transitioned from regular classes to the special education classroom for multiple subjects. The final student, who was diagnosed with Autism Spectrum Disorder (ASD), experienced learning challenges and had been identified by the special education teacher as requiring improvement in interaction skills. Consequently, this student was selected to participate in the study aimed at enhancing their ability to engage with others.

Study Instruments

1. Wooden Box Produced With Laser Cutting

Our team is called Excellent Assistive Technology (AxcellenT for short) (see Fig. 1). We manufacture, modify, and adjust assistive technology devices according to the different special needs of children with disabilities, including 3D printing technology and laser cutting technology equipment (see Fig. 2). In this study, participants had to operate devices to activate modified toys and an online platform to perform tasks. In order to help more children with special needs, AxcellenT makes the production process and results of assistive technology devices available to the public for free (see Figure 3).

Fig. 1 Axcellent Website

Fig. 2 Wooden Box Produced with Laser Cutting

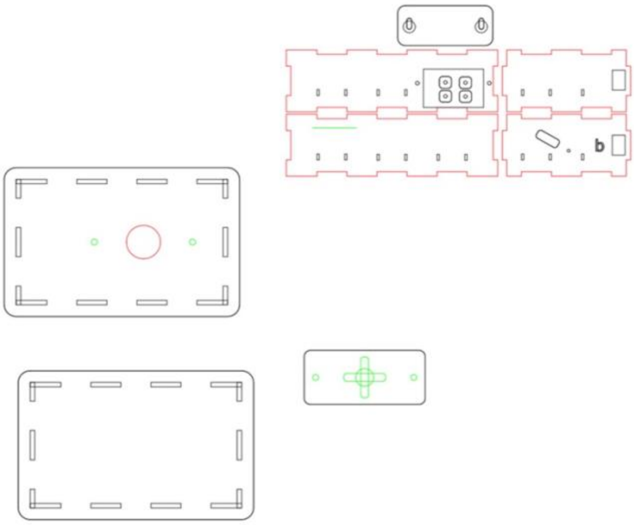

Fig. 3 Public Four-Axis Joystick Device Design

2. Printed Circuit Board Assembly (PCBA) Called "Scratch Board"

The technical key to the integrated design of “toy mechanism” and “program interaction” is to use a Printed Circuit Board Assembly named "Scratch Board" which was developed by Maker Liao, Hong-De (see Figure 4). This board offers several functionalities:

2.1 It utilizes a single chip capable of programming the 41 most commonly used characters in Scratch.
2.2 It can interface with back-end PCs, laptops (NB), tablets, smartphones, and other smart devices via USB connection.
2.3 It supports plug-and-play functionality, allowing for direct control of smart devices without the need for initial driver installation, unlike conventional control panels.
2.4 The Scratch program can be seamlessly utilized for adjustment and trigger control.

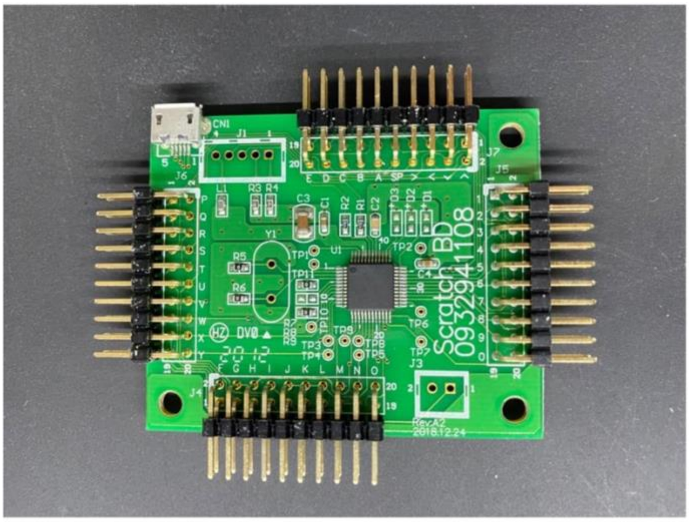

Fig. 4 Scratch Board

3. Four-Axis Joystick

The purpose of choosing a four-axis joystick is to train students in the up, down, left, and right directions and to have a sense of presence on a game console (see Figure 5). In addition, an innovative online platform called Wordwall is also used to gamify the course content, add visual prompts, and reduce the burden on students.

4. Variation Type - Dance Dance Revolution (DDR)

Additionally, various special switches can be employed as substitutes for the four-axis joystick, tailored to the specific requirements of individual students. Furthermore, we have developed a variant wherein the four directional keys are separated (see Figure 6), similar to those found in games like Dance Dance Revolution or the classic game of Snake. Thereby fostering increased opportunities for student interaction and collaboration.

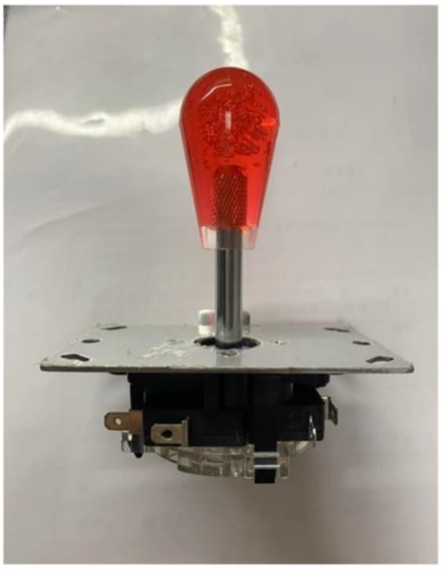

Fig. 5 Four-Axis Joystick

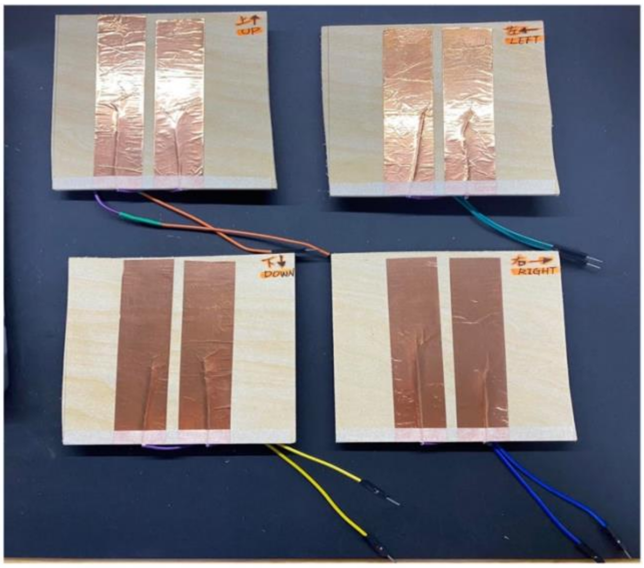

Fig. 6 Variation type of direction

Research Process

Case1. Students With Cerebral Palsy

The initial case involves a student with cerebral palsy, characterized by heightened muscle tension and limited fine motor skills in the hands. Considering the student's anticipated reliance on an electric wheelchair in the future, a four-axis joystick is implemented to enhance directional perception and cultivate operational proficiency. The training regimen comprises several stages:

1. Introduction to Four-Axis Joystick: The student undergoes initial training to familiarize themselves with the operation of the four-axis joystick.
2. Remote Control Car Manipulation: Progressing to the next stage, the student learns to manipulate a remote control car to navigate towards specified target objects.
3. Computer Game Engagement: Subsequently, the student engages in computer game activities, further refining their control and coordination skills.
4. These training stages are recurrent, allowing for repeated practice and skill enhancement (see Figure 7).

Fig. 7 Students with cerebral palsy training process

Case 2. Students With Learning Disability

The second scenario involves a student grappling with learning disabilities, primarily characterized by challenges in comprehension, particularly in Mandarin and mathematics, resulting in persistently subpar academic performance.

To address these issues effectively, we employ a strategic approach: Utilizing the four-axis joystick in tandem with Wordwall, we gamify the learning process. By incorporating game elements, we gradually tailor the difficulty level of course content to suit th e student's learning pace (see Figure 8).

Fig. 8 Students with learning disability learning application process

Fig. 9 Students with ASD learning collaborative engagement process

Case 3. Students With Autism Spectrum Disorder

The third student, diagnosed with autism spectrum disorder (ASD), was identified by the special education teacher as requiring enhancements in interaction abilities. As such, they were selected to participate in this study aimed at fostering improved interpersonal skills.

In our intervention, we introduced a novel approach: We devised a variant that separates the four directional keys independently, drawing inspiration from popular games like Dance Dance Revolution (DDR) and the classic Snake. In this setup, four students were assigned to each direction, with students with ASD actively participating by controlling one of these directions (see Figure 9).

Conclusions and Suggestions

Application of DIY assistive technology devices and interactive technology integrated with games in special education has gradually become a tendency. Drawing from the study process, observations, and feedback provided by the special education teachers of the participants, the authors have formulated the following conclusions and recommendations:

1. DIY assistive technology devices offer the advantage of customizable design, allowing for tailored adjustments to precisely match the unique needs of individual students. By harnessing this flexibility, educators can create solutions that cater specifically to the diverse requirements of each learner, ultimately enhancing their overall educational experience and effectiveness.
2. The integration of interactive technology in student learning environments enhances engagement, personalization, collaboration, feedback, motivation, and accessibility, ultimately contributing to more effective and enriching educational experiences. This dynamic adjustment not only bolsters the student's engagement but also alleviates the sense of academic burden, fostering a more motivated learning environment.
3. When collaboration is emphasized to promote the cooperation of children with special needs, such collaborative learning can enhance the chance and capacity of students with special needs to engage with others.
4. This type of DIY assistive technology devices and interactive technology are not constrained by environmental limitations, providing parents with the flexibility to easily assist their children in using them at home. This not only expands the learning environment but also enhances opportunities for parental involvement in their child's education, fostering a supportive and enriched learning experience outside of traditional classroom settings.

References

Chen, S. H., Lin, C.Y., & Mao, Q. C. (2018). Effects of 3d Printing Interactive Technology on Special Education for Children with Different Disabilities. *Proc. The Asian Conference on Education 2018*(333-340). Osaka: The International Academic Forum.

Hamidi, F., & Marcu, G. (2019). DIY Assistive Technology Prototyping Platforms: An International Perspective. *IEEE Pervasive Computing,* 18(4), 12–16. doi:10.1109/MPRV.2019.2947749

Hamidi, F., Owuor, P. M., Hynie, M., & Baljko, M. (2022). "Knowledge Comes Through Participation": Understanding Disability through the Lens of DIY Assistive Technology in Western Kenya. *Proceedings of the ACM on Human-Computer Interaction, 6*(CSCW1), 1–25. doi: 10.1145/3512919

Hook, J., Verbaan, S., Durrant, A., Olivier, P., & Wright, P. (2014). A study of the challenges related to DIY assistive technology in the context of children with disabilities. *Proc. Conf. Designing Interactive Syst* (pp.597-606). New York: Association for Computing Machinery.

Mettler, T., Daurer, S., Bächle, M. A., & Judt, A. (2023). Do-it-yourself as a means for making assistive technology accessible to elderly people: Evidence from the ICARE project. *Information Systems Journal, 33*(1), 56–75. doi:10.1111/isj.12352

Parry-Hill, J., Shih, P. C., Mankoff, J., & Ashbrook, D. (2017). Understanding volunteer AT fabricators: Opportunities and challenges in DIY-AT for others in e-NABLE, *Proc. CHI Conf. Human Factors Comput. Syst* (pp.6184-6194). New York: Association for Computing Machinery.

Sung, R. R., Lin, S.W., & Lin, C. Y., (2018). Collaborative Assistive Technology in Mathematics Learning for Students with Special Needs. *Proc. The Asian Conference on Education 2018*(889-898). Osaka: The International Academic Forum.

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