

UNIVERSAL DESIGN OF A POWERED WHEELCHAIR FOR PEOPLE WITH COGNITIVE DISABILITIES

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INTRODUCTION

The design of new mobility products typically do not have a history of being linked to academic research [1]. In the case of the Driving to Learn project and the parallel development of a special powered wheelchair for training, a linkage between research findings and design was established early on.

The Driving to Learn project started as a classic grounded theory study in the beginning of 1993. The substantive field of interest was what could be achieved if people with profound cognitive disabilities got access to practice in joystick-operated powered wheelchairs [2] – [3]. An early discovery was that people with profound cognitive disabilities needed learning characteristics that were lacking on regular powered wheelchair models. Due to their most limited understanding of spoken language they were not able to follow verbal instructions. It also showed that their *learning* of joystick-use was not supported by intelligent technology such as line followers or obstacle avoidance systems. To learn tool use the participants with profound cognitive disabilities needed access to practice of free driving using a joystick with high functional predictability for long periods of time. They also needed encouragement and manual guidance to explore and experiment with the joystick to increase understanding of tool function. These research findings cultivated the ideas underlying the development and design of a unique powered wheelchair for people with cognitive disabilities [4].

Action was taken to find a manufacturer with resources and interest in developing a new product for this population. In June 1994 contact was established with Permobil AB in Sweden and the first steps towards designing a prototype were taken. Between 1994 and 2006 three prototypes of a training powered

wheelchair were developed and tested in the Driving to Learn project [5].

PROTOTYPE I

As the first participants in the Driving the Learn project were of pre-school age the first prototype was built with a powered wheelchair chassis for children. During two days in December 1996 the author used the prototype for trials with 10 children with profound cognitive disabilities and 2 typically developing infants. The trials took place at a pediatric clinic, a day nursery and a special school in the northern part of Sweden. Two of the constructors and one sales person from the manufacturer attended the trials. The clinical testing was valuable as it brought new insights concerning the need for further adaptations. In August 1997 two adjusted prototypes were delivered to a pediatric clinic and a special school for evaluation in the project.

Special characteristics

A joystick with Safegate electronics was mounted in a tray in alignment with the midline of the user's body. The joystick box was descended so that only the joystick with its knob was above the tray surface. The tray was transparent; had a semicircular recess for the trunk; was attached to the arm rests; and provided support of the user's forearms. The control box was mounted on the rear of the back rest. With the tray mounted on the armrests the distance to the trunk was easy to adjust forward or backward. The chassis had cushions for easy adjustment of seat depth for children of different ages. The foot rests were easily adjusted for different leg lengths.

The programming of the Safegate electronics offered driving with low power and low speed. It also offered similar responses

from joystick tow in every direction without any delay, to provide high predictability of joystick function.

PROTOTYPE II

The positive outcome of using the first prototype at the pediatric clinic and the special school nurtured the interest in designing a prototype that could be used also with adults. The Koala chassis was used for the second prototype but was equipped with a seating unit for adult sizes. In 1998 it was delivered to a primary health care unit that provided rehabilitative day care two days a week. People in different ages and with different etiologies tried the prototype over a period of one and a half year.

Innovative thoughts of use and provision

During testing of the two prototypes it became evident that the Driving to Learn™ method could offer growing consciousness of tool use to a wide range of people with cognitive disabilities. The findings inspired the idea to design a "one-for-all" training powered wheelchair that could suite many people of different sizes and in different age groups. The plan was that a clinic, a day center or a special school could be the owner of a "one-for-all" chair and thereby provide many people with practice using the Driving to Learn™ method.

PROTOTYPE III

The design of the third prototype – the "one-for-all" chair – took a little longer to accomplish. Thoughtfulness and creativity was required to realize the design of a flexible construction with a seating unit that quick and easy could be adjusted without using hand tools. It was expected that the one-for-all" chair would be handled by many people at a location – therapists, teachers, assistants and other staff – thus, tools for making the necessary changes in-between different users were abandoned. Every adjustment should be possible to do with different quick release mechanisms.

The third prototype of the special powered

wheelchair was built on the model Entra, a powered wheelchair designed for adults. The "one-for-all" chair was named Entra Tiro and exhibited to the public for the first time in 2002. However, the idea of using the Entra Tiro for intervention with many people was not easy to convey as the typical use of powered wheelchairs in rehabilitation was for individual provision.

The work with further development of the Entra Tiro came to a standstill after 2006. One reason was that the interest for using the Entra Tiro and the Driving to Learn™ method in the Health Care systems in Sweden was still in its emergent phase and few exemplars of the chair were sold. Another reason was that Permobil AB in Sweden had developed new powered wheelchair models replacing the Entra chassis that was used for the Tiro. Permobil AB also was introducing new joystick electronics replacing the Safegate.

PERMOBIL EUROPE AND UPGRADING OF THE TIRO CONCEPT

At the beginning of 2007 Permobil Europe displayed interest in introducing the Driving to Learn™ method in Europe. However, they were reluctant to buy powered wheelchairs with the Safegate electronics [6]. The Tiro concept and a joystick with Safegate electronics was a necessity for the method as it was designed to suite the learning needs of people with profound cognitive disability [4]. Due to this disagreement there was a delay of presenting the Tiro concept and the Driving to Learn™ method in Europe. A first step to overcome the problem was to investigate new electronics for the concept. Programming of a new version of joystick electronics were tested at Permobil AB in Sweden in May 2007. The test results were good and indicated that it was possible to achieve necessary learning characteristics also with the new version of joystick electronics.

Determined attempts to co-operate with Permobil Europe on upgrading the design of the Tiro concept begun in 2008. The primary concern was to decide on which powered wheelchair model to use for the upgrading and which electronics was best suited to meet the

learning needs of people with different degrees of cognitive disability. Due to organizational changes in the company the budget for the upgrading of the design was tight and limited the possible choices of model, electronics, equipment and parts for making the necessary adaptations.

Special characteristics

The most critical issue was to agree on new joystick electronics that could be programmed according to the learning needs of people with cognitive disability. The choice was a VR-2 which was mounted in the center of a transparent tray with a semi circular recess for the trunk.

The most important feature of the chassis was that it should provide the users with a therapeutic working position. The seating unit should also be possible to adjust quick and easy for many users with different sizes and of different ages. However, the quick and easy change was difficult to achieve and a compromise was made due to the tight budget. The agreed adaptations of a powered wheelchair model C300 were carried out by Permobil Europe in Holland.

The special programming of the VR-2 joystick electronics considering the users learning needs was completed by Nilsson in a clinical environment. Test driving with ten users with different degrees of cognitive disability was intertwined with refinement of programming until the necessary learning characteristics were established.

EVALUATION OF THE UPGRADED CONCEPT

Evaluation of the upgraded design was performed by Nilsson at a day care unit for people with learning disabilities in Norrbotten, Sweden. The staff at the unit had partaken in the research project during six years. Thereby they had knowledge of the Driving to Learn method and were acquainted with the Tiro concept and the learning needs of the population. It proved to be difficult to change seat depth and thus the chair was not fulfilling the "one-for-all" concept. Furthermore the clinical evaluation verified that a number of

amendments and improvements were necessary to achieve a complete upgrading of the Tiro concept with the original design and functions.

FINAL AMENDMENTS OF THE DESIGN

During the autumn of 2009 a Swedish order of a chair with the Tiro concept pushed Permobil AB to accomplish the complete upgrading of the design. The modification and amendments were carried out in co-operation between Nilsson and Cronstrom who worked in the Permobil department that once had designed the Tiro concept.

RESULT – C300TIRO – THE LEARNING TOOL

In 2010 the long lasting co-operation between Nilsson, Permobil AB in Sweden and Permobil Europe resulted in C300TIRO – the Learning Tool [7] a training powered wheelchair meeting the learning needs of people with profound cognitive disabilities and the Driving to Learn method.



Figure 1: C300TIRO adjusted to adult size

The joystick has five programs to suite user performance at different phases in the process of learning joystick-use. The chair has a seating unit that can provide a therapeutic or 'functional sitting position' with the joystick mounted in a tray in alignment with the midline of the user's body. The Learning Tool also has a seating unit which is quick and easily changed from child to adult size without using any hand tools.



Figure 2: C300TIRO adjusted to child size

This universal design makes it possible to use one exemplar of the TIRO for many people despite of age and size.

DISCUSSION

Linking of academic research, testing in clinical practice and co-operation with a manufacturer of powered mobility products resulted in the development and design of a training powered wheelchair for people with cognitive disabilities. The Driving to Learn project provided evidence that users with cognitive disability need specific powered wheelchair characteristics to reach optimal levels in their learning process [3] – [4]. Permobil AB and Permobil Europe had the interest and the resources to develop and design a product providing people with cognitive disabilities with the necessary characteristics for easier learning. In times with reduced resources in special education and health care systems it is important to offer a product that can be used in practice to offer powered mobility to many people with different etiologies of their cognitive disabilities, children as well as adults [5]. Results from using the Tiro concept in practice have proved that it is worthwhile to use the concept and the Driving to Learn method with people who typically don't get access to practice in a powered wheelchair [8] – [9]. Even though it may need exceedingly long time periods of practice in a training powered wheelchair many individuals with

severe or profound cognitive disabilities can proceed through the process of learning joystick-use and unexpectedly reach levels of goal-directed or skilled driving [5] – [8].

CONCLUSION

One example of C300TIRO – the learning tool, offers many people with different kind of disabilities access to opportunities of practicing and learning joystick-operated powered mobility. Thereby many more people to a comparatively low cost can get the opportunity to develop different skills and learn more about tool use.

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