CHAPTER 6
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Customized Adjustable Chair for a Handicapped Teen

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Client Coordinator: Marcia Lamkin, Marshall Elemenfa y School
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INTRODUCTION

The subject is a teen-aged male who was born with Cerebral palsy and who has since developed a severe case of scoliosis and a dislocated hip. He has extreme difficulty in his interactions in his classroom. He has limited control over his hands and arms, with a tendency to go into extension when he becomes tense. He is not able to communicate verbally but can express pleasure or displeasure gutturally. Owing to his condition he is limited to either his wheelchair or to a Bodymold beanbag chair (a beanbag that is conformed to his body and then is evacuated to make it rigid). The wheelchair allows him to sit up and to be transported, while the Bodymold allows him support while lying on the floor in his classroom. His participation in classroom activities is limited because he has difficulty lifting his head. The Bodymold limits his peripheral vision. He mostly just stares at the ceiling, although his eye movement indicates that he is interested in his surroundings.

The Bodymold chair does not keep his head from rotating, which causes Asymmetric Tonic Reflex (ATNR). This reflex causes his body to relax on one side and contract on the other, aggravating the scoliosis problem. Additionally, the Bodymold does not constrain his arms, and the resulting athoid movements cause damage to the joints, common in Cerebral Palsy victims.

Other difficulties arise with the Bodymold when the bean bag chair is evacuated to form around the subject, it becomes rigid, causing pressure point discomfort within a short time; the Bodymold loses its vacuum and has to be periodically reformed around his body; the Bodymold does not provide sufficient positional control over his head and shoulders, such that arching and subsequent extension cause his shoulders to painfully dislocate.

This team undertook the design and fabrication of a portable support chair that would allow the subject to be elevated so that he could more readily interact with his classroom, would provide the necessary restraints to limit his arm and head movements, would conform comfortably to his body to relieve pressure point discomfort over extended time periods, and would allow independent elevation of his legs to reduce the pain associated with hip dislocation and increase the therapeutic potential.

Additionally, the chair was required to be sturdy, lightweight, and portable; it needed to be usable by the therapists and desirable by the client.

SUMMARY OF IMPACT

The newly constructed chair, shown in Figure 6.1, is very pleasing to the client. His favorite color is orange, so the chair is painted orange. It is portable and lightweight, and can be rolled to allow him more classroom interaction.

Fig. 6.1. Photograph Of Client Enjoying His New Chair.

The upper portion of the chair can be elevated so that he can see what is occurring around him, and the head and arm constraints enable his extensions to be more readily controlled. The main support portion of his chair, a fiberglass shell, is lined with foam for pressure point relief.

His difficulties with ATNR are greatly reduced. Positive effects are already seen in hand-eye coordination owing to the arm restraints. Adjustable leg supports now allow the therapist, as well as the teacher, to move his legs without fear of positioning his dislocated hip in an uncomfortable position, and it is believed that the increased ability for leg motion will build muscle tone and mobility. The teen now enjoys having someone push him around the room so that he can observe the activity. The therapist is very pleased with the new chair, and believes it will enhance his classroom interaction as well as his opportunity to develop more active control over his environment. But the greatest blessing to the designers was to see for the first time, a smile as he tried out his new chair.

TECHNICAL DESCRIPTION

The major criteria in this design were:

- The client's head and torso needed to be elevated to a number of different positions to aid therapy and increase his field of vision.
- His legs must be able to be separately elevated and positioned owing to his dislocated hip.
- His upper arms must be constrained to prevent shoulder dislocations, and to aid in therapy by positioning his lower arms so that both hands can act together.
- The chair should be mobile so that the client can be moved around the classroom.
- The client's torso must be supported to allow extended periods in the chair with maximum comfort.
- The chair must be easy to clean.
- The client's head must be positioned straight forward to restrict ATNR.

The chair we designed and built consists of a fiberglass torso shell and plastic arm restraints and leg supports, all attached to a steel frame. The first decision in the design process was to develop a torso support. Many concepts were proposed and investigated, and after several iterations, we decided that a fiberglass shell would provide the best support and give us a stable platform for appendages. The next major hurdle we faced was obtaining a contour of the teen's body without causing him to endure any extra pain so that we could make his supporting chair. To do this, we cast a positive mold in his Bodymold chair using a wet plaster of paris with an open weave cotton mesh material for binding. The Bodymold with the teen's impression is shown in Figure 6.2.

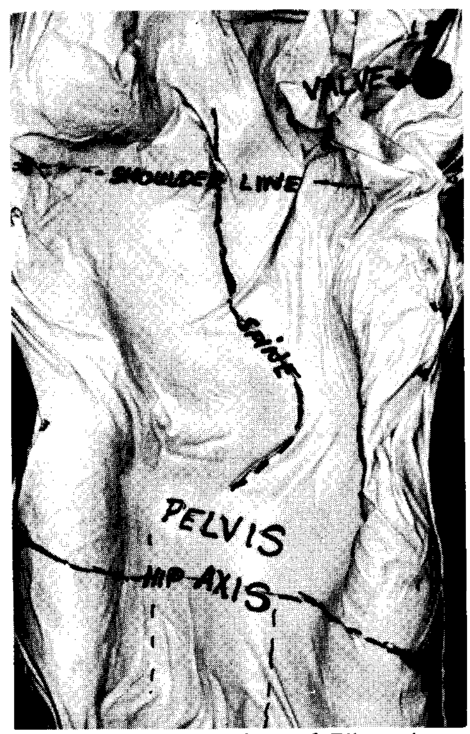

Fig. 6.2. Impression of Client in Bodymold.

After about three hours of drying time, we removed the positive plaster mold and sanded the surface to remove protuberances caused by creases in the Bodymold. To allow space for padding in the fiberglass shell small foam rubber squares were glued all over the plastic mold. The open weave cotton and additional plaster was then applied on top of the pads to provide a hard surface, which was again sanded after drying to smooth out the rough spots (see the cross-sectional sketch Figure 6.3).

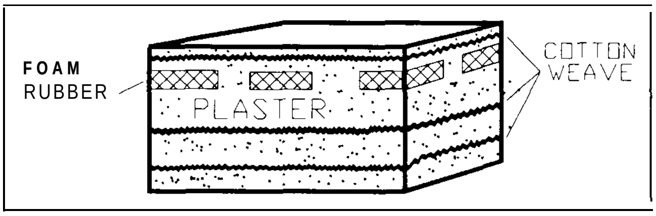

Fig. 6.3. Cross-section of Multilayered Plaster Mold.

To prepare the positive plaster mold for the fiberglass, it was coated with a thick layer of shellac to provide a non-porous surface. Mold release wax was rubbed over the mold and buffed in. Polyvinyl alcohol was next applied to protect the mold from attack by the polyester resin.

The fiberglass lay-up consisted of two layers of mat between two outside layers of cloth. After two days of curing, the shell was removed from the plaster mold and trimmed to fit the teen. The shell is shown in Figure 6.4.

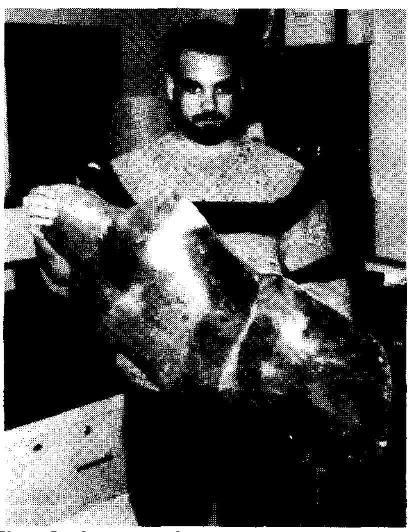

Fig. 6.4. Pat Shelly holding the trimmed Fiberglass Shell.

A frame was designed to support the fiberglass shell and to provide a mechanism to elevate the client. The frame was designed to be lightweight, easily fabricated, rugged, inexpensive, and yet strong. A side view of the assembled chair is shown in the photograph, Figure 6.5. One inch square hollow rectangular 1018 steel tubing was used for the frame. Stress analysis of the frame showed a maximum stress of about 8000 psi in cantilevered portions of the leg supports, which provides a factor-of-safety of about 5.

The frame was attached to the shell using two steel brackets riveted to the shell and drilled to receive chevron bars used to prop up the shell, Figure 6.5. The axis of rotation was maintained across the teen's hip line. This was accomplished using a 2-inch diameter steel pipe welded to a flat plate that was riveted to the shell to maintain the hip alignment, Figure 6.6. The shell then rotates about a 3/4 inch diameter steel pipe which is part of the frame, Figure 6.7.

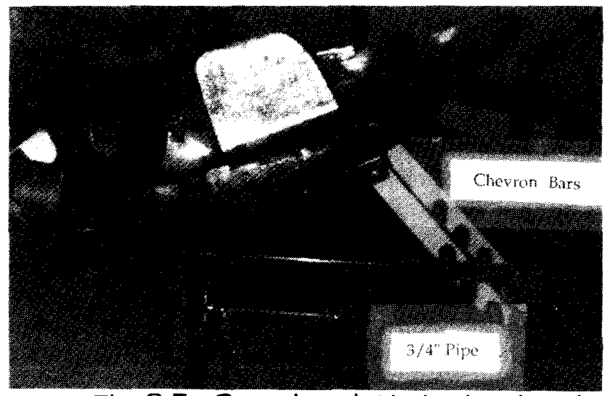

Fig. 6.5. Completed Chair showing the Chevron Bar Elevating System, Arm Restraint and Leg Supports.

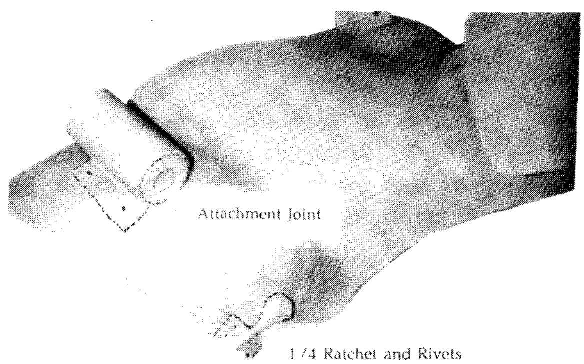

Fig. 6.6. Back of Shell showing the Attachment of the 1/4" Ratchet and the Rotation Joint.

A search for an appropriate material for arm restraints was also challenging. After several iterations we found a small rectangular 2-gallon plastic trash can that appeared to provide the appropriate shape. Several different arm restraints were built before we were able to finally achieve the best design. We sectioned the trash can and then reinforced it with fiberglass mat and cloth. The arm restrains, seen in Figure 6.5, were **then** epoxied and riveted to the fiberglass shell. These restraints have proven effective in limiting his athoid motion.

The design of appropriate leg supports was also material driven. Our search led us to choose plastic pipe that had a somewhat larger inside diameter than the client's legs. We sectioned the pipe, then covered it with foam and Scotchcast Plus^{R}, which is expensive but easier to work with than fiberglass. We attached a 1/4" ratchet handle for the knee joint, and 1/8" x 3/4" steel plates, about 14 inches in length, to connect the thigh support to the shell and to the lower leg support. Adjustment and locking was satisfactorily obtained by using 1/4" drive ratchets permanently attached to the shell and leg joints at the hip and knee locations, Figure 6.8.

A vinyl covered foam pad was used to cover all fiberglass parts for cushioning. The pads are attached to the shell (and other components) using Velcro strips so that the pads may be removed and cleaned as necessary. Hard rubber casters on the bottom of the steel frame provide the classroom mobility desired by the teacher. The chair and frame met all of the criteria given by the teacher and the therapist, and appeared to bring much joy to the client. We believe this project is a great success, and we have especially benefited in helping this teenager. Total cost of materials for this project was $428.

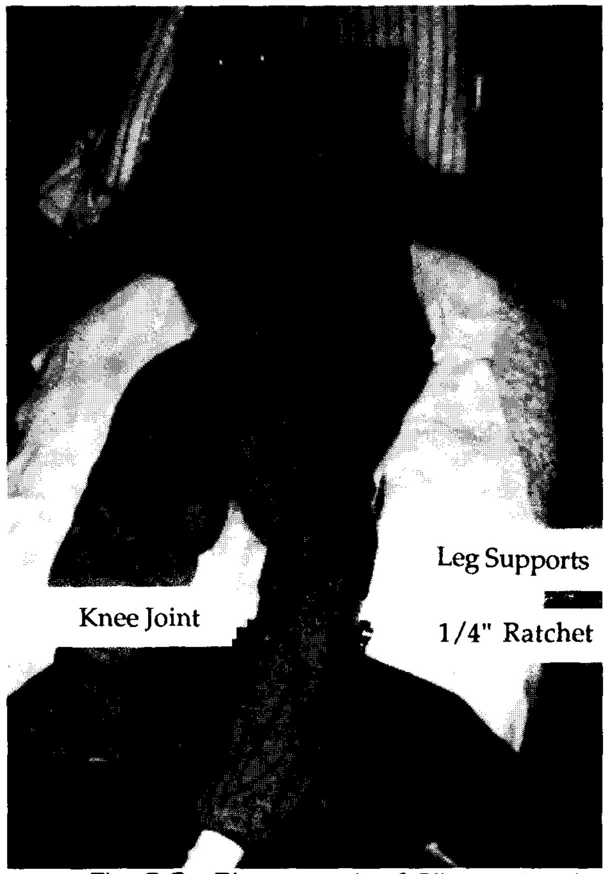

Fig. 6.8. Photograph of Client, showing Positioning of the Leg Supports.

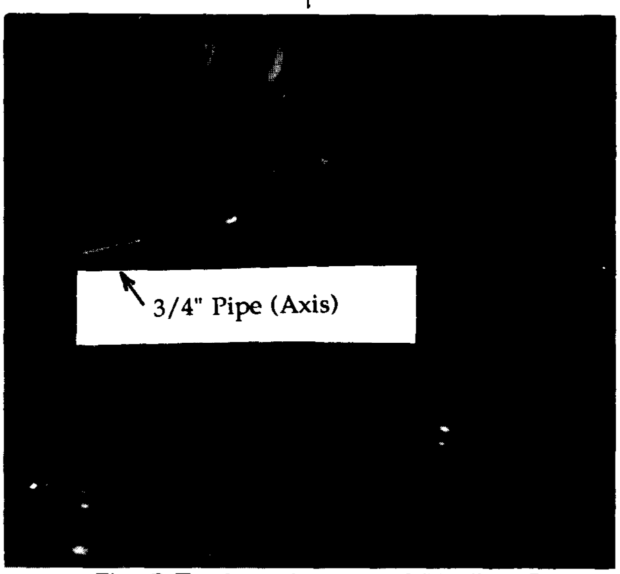

Fig. 6.7. Attachment of Shell to Frame.

A Learning Program for a Wheelchair Confined Teenager

Desingers: Steve Bull, Asim Chowdh y, Thang Nguyen
Client Coordinator: Joan Hendricks, Learning Disabled Classroom, Marshal School
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INTRODUCTION

This is a continuation of a project started in the Fall 1991 semester. The subject is a young teenage girl with motor control, hearing, vision, and mental difficulties resulting from the blockage of a shunt to her brain approximately two years ago. She has problems in distinguishing among colors. Her motor control is mainly restricted to limited head and arm movements. Her best control is in her left arm and hand. However, when she is nervous she has a tendency to pull her arm toward herself while keeping her hand pronated.

We wish to justify the continuation of last semester's project on two major grounds:

1. Learning programs need to change as the subject's ability increases, which is the desired effect of the program. This is quite a bit different from designing and constructing a mechanical apparatus that may fit a chronic condition, though, of course, there will also be cases in which recovery (or deterioration) necessitates alterations in mechanical devices aiding the subject.

2. We didn't get the program right the first time. Indeed, we doubt if one ever gets such a program perfect. We judged there to be sufficient room for improvement to warrant another version. The result was a much better-suited program about which the patient was very enthusiastic. Why is it hard to produce a good program on the first attempt? The reasons include the number of individuals who are "clients" for the program and hence have conflicting inputs into the program. This included the university professor, the classroom teacher, the therapist, the parents, and the child herself. The very process of making an educational program for a handicapped child involves guesswork and trial-and-error. The creation of software is famous for the necessitating iterations and revisions, and this is particularly true of our type of program.

The goal of the Fall 1990 team was to create a software package to teach the patient to guide an object around on a screen as a way of demonstrating the ability to guide a motorized wheelchair around. However, any increase in ability to manipulate a computer was judged to be of importance. The therapists also welcomed any attempt to train her to overcome her unwanted hand movements when she was trying to control the computer. For economical reasons, we placed the program in a very inexpensive computer platform (a Commodore 128, programmed in BASIC). She made use of a joystick to move one screen object to make contact with another screen object.

By the beginning of the Spring semester we were able to see that the Fall program was not particularly useful in generating enthusiasm or effort on the part of the subject. She had gotten possession of an electronic wheelchair, which she was learning to manipulate outside the bounds of our project. The spring team decided to switch the approach in a number of respects:

1. The project was moved to C programming on an IBM-PC style machine. It was felt that this allowed better quality programming that was much more capable of maintenance and expansion.

2. Manipulation was changed from the joystick to a mouse. Although this was harder for the subject to manipulate, the team thought that this skill would be much more useful in handling other programs.

3. Much concentration was focused on setting up a menu system that the subject herself could use. This entailed much rethinking and rewriting: aspects such as character color, size and shape were very important because of her impacted and perceptual ability.

A few games were also produced (time limitations precluded more), the idea here was that having fun is a strong motivator for learning. Interestingly enough, one of the games was also a pursuit game very similar to the Fall team's game.

SUMMARY OF IMPACT

There was general enthusiasm at what had been produced, the subject worked hard and enthusiastically during a demonstration, and the Client Coordinator seemed quite happy. The team not only built a program that was immediately useful, but also one that will serve as a suitable base for extensions of the program for both this subject and others. The teenager will be moving to another classroom in the Fall, and we anticipate having a team (which will include two of this semester's students) continue to work with both her and with other handicapped children in a special project. As a special note, members of the team worked very well with the subject and taught her mouse control (which she had not been able to learn from the normal therapists) as a side benefit of their interaction.

TECHNICAL DESCRIPTION

The program is written in Turbo C for an IBM PC compatible computer, a Microsoft compatible mouse, and a color monitor supported by at least an EGA video card with 256 K of video memory. A hard drive is not required but is recommended. Turbo C was used because of the problem of achieving block-enough fonts; the team started with Microsoft Quick C, which was better for the graphics, but had more font limitations. (The team recommends consideration of a commercial font package.)

The menu was the main focus of the programming. Selection is mouse-controlled, and the number of possibilities at a given menu level is controlled but may be altered by a programmer. Additional menus can also be fairly easily installed. Games or other programs can be attached to the menus with ease.

Cost of Project- The costs given below were initiated in the Fall 1990 work for this project. They were necessary to initiating the project, and indeed the subject and her family have the equipment at home where they can use the first version (Fall 1990) of the project. We have repeated the costs to indicate how the continuation of the project can actually smooth out the expenses connected with the work. As argued in the Introduction, this kind of project should be continued because the subject's abilities are expanding. We intend to continue to work with her, and we expect that there will be further expenses in the Fall when we add to the functionality of her programs and consider better how to move some of them into her home.

ITEM	COST
Max Joystick (modified after purchase)	$11.61
Commodore 128 with references, disk drive, printer, etc. (note - the disk drive was switched to another project and budgeted off at $125)	$200.00
Advertisement (to get the Commodore set)	$5.60
1571 Disk Drive (for use with Commodore 128)	$193.91
TOTAL	$411.12

A Learning Program For a Severely Involved Five-Year Old

Designers: *Tim Faulkner, Ahmed Omer, and Thomas Starling*
Client Coordinator: Beth Vint, Institutefor Human Development, NAU
Supervising Professor: Melvin Neville
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INTRODUCTION

This is a continuation of a project started in the Fall 1990 semester. The subject is a physically heavily involved five-year old in the Institute for Human Development Pre-School Program at Northern Arizona University who has extreme difficulty in interacting with the world. He has a little control over his hands, but this control is impaired through a tendency to go into an extension when he is tense. During an extension his muscles tense, his arms stiffen and straighten, and his head drifts and locks to the right side. Even when not in an extension, his eye-hand coordination is extremely poor, and he has no individual digit control. He has additional problems: lack of speech; a tendency to drool, which affects what devices would be safe for him; and hearing impairment. He hears mainly lower tones, and will go into an extension if startled. However, his communication through facial expressions is very effective.

The justification for continuations of these types of programs is presented in our other Northern Arizona University report, "A Learning Program for a Wheelchair Confined Teenager."

The goal of the Fall 1990 team was mainly to allow the subject to control his environment to some extent. A special switch (accessed in the same way as a fire button on a joystick: a whole-hand pressure would work) could be used to sequence through a number of screen presentations of colored geometric states. The reward for pressing the switch was a tune (different for each shape) and movement to the next shape. The program was quite successful in producing an enthusiastic set of responses from the subject.

SUMMARY OF IMPACT

The Fall 1990 design had success in inducing interaction on the part of the subject. The Spring 1991 contributions were as follows:

1. Programs were developed in which the subject could match to either color or shape. Coming up with this idea sounds simple enough, but it actually took iterative interaction with the therapists before our team finally understood what would be useful.

2. We amplified the program that could run on the Commodore equipment from last Fall, and we developed a very similar program that runs in C on an IBM PC clone to take advantage of some equipment that the family acquired. In the Fall, the subject will be moving to another school, and we do not know what equipment will be available to him there. The software we have developed here for the subject cannot only go with him but should also be quite useful for other children that the special classroom will undoubtedly have (this is one of the major features of software that is different from mechanical aids).

The programs, both on the Commodore and on the IBM PC, were quite successful in stimulating interest on the part of the subject and were praised by the therapists. It is still too early to see how well the subject learns selection of shapes and color from the programs, but they appear to have been the next logical step for him.

TECHNICAL DESCRIPTION

The platform used for one of the programs is that from the Fall 1990 work: a Commodore 64 computer with a switch hooked up to the joystick port of the computer. The switch is accessed in the same way as a fire button on a joystick. The language used is BASIC, which made it more difficult to structure the program as compared with a structured language such as C or Pascal. The program includes a number of alternatives, including the Fall 1990 program (still popular!). In addition, the subject can be exposed to selection for either geometric shapes of colors: on the left side of the screen the pattern to be matched appears and on the right two choices, one of which matches the desired characteristics. The match is randomized in terms of whether it is the upper or the lower of the two figures. Selection is caused by pressing the switch at the time the cursor is by the correct match; if the cursor is by the incorrect match, the user must try again. Reward is the next matching problem plus a tune.

The other platform runs on an IBM-PC style machine and is written in C. It makes use of a mouse. Its' characteristics are similar to those of the Commodore program, but with sufficient differences that the subject should not tire of one program because of having used the other recently. In addition to matching out of two possibilities, there is a level in which the match can be from among three possibilities. Tunes are not part of the reward, though a sound is. As with the Commodore program, a cursor moves regularly back-and-forth among the possible matches, and selection occurs by pressing (in this case, mouse buttons) when the cursor is by the correct match.

Cost of Project- The costs below were initiated for the Fall 1990 work. With evolving projects of this nature, costs occur unevenly, depending upon the needs of the steps being taken. The original costs started up the project, and indeed the equipment is still being used. The new equipment was actually obtained by the family. We anticipate having students continue to work with this child as his abilities evolve, and it is unclear what this will mean in terms of future expenses.

ITEM	COST
Commodore 64, cable, references, power supply, adaptor	$125.00
1541 disk drive (was switched from another project)	$125.00
TOTAL	*$250.00*