Submitted: 05/05/10 **Project Number:** AHH - 0903

Optimizing the WPI Assistive Technology Resource Center: Marketing and Documentation

An Interactive Qualifying Project

submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for

the Degree of Bachelor of Science

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Abstract

The Assistive Technology Resource Center (ATRC) at Worcester Polytechnic Institute (WPI) was created in 1999 with the mission to serve as a regional provider of assistive devices and services. The Center is unique in its ability to provide a technical aspect to the development of customized assistive technology to its clients. An IQP group, Lyons and Trimby (2008), reevaluated the operations of the ATRC nine years after its establishment. The team determined that one area to focus on would be the organization of past projects completed within the ATRC into a centralized database. A second IQP group, Hristov, Mawhiney, and Wilson (2009), created a database encompassing several projects but the need still existed for a more comprehensive document. This project concentrated on the development of two different documents that could be distributed to students and potential clients. The first of these documents, a marketing document, included summaries of carefully selected projects that represent an appropriate range of devices developed within the ATRC. The second document, the comprehensive document of past projects, offered detailed descriptions of most of the completed projects since the ATRC's establishment. A direction that a future IQP group could take would be to implement these documents by mailing them to potential clients and by uploading them to the ATRC webpage.

Acknowledgements

The team acknowledges several individuals for their assistance in the completion of this project. Their extensive knowledge in their respective areas of expertise helped the team to successfully accomplish the goals of the project. The team would like to express their sincere gratitude to Professor Hoffman for his advice and guidance. His patience and encouragement kept the team headed in the right direction. The team would also like to thank Andrea Fandetti for providing her unique perspective on the writing. Finally, the team would like to thank Professor Bureau and the students interviewed for adding their input to the documents.

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Chapter 1. Introduction

Assistive Technology (AT) is technology that promotes greater independence for people with disabilities through the use of rehabilitative devices. According to the Assistive Technology Act of 2004, assistive technology is defined as "…any service that directly assists an individual with a disability in the selection, acquisition, or use of an assistive technology device" (Assistive Technology Act of 2004). The purpose of assistive devices is to enhance the independence of individuals with disabilities by allowing them to perform tasks that they were previously unable to perform, or by improving their ability to perform certain tasks.

Commercial assistive devices are available for use by individuals with disabilities, but these devices often require modifications to suit the specific needs of the individual. In the case where a commercial device simply does not suit all of the user's needs, either the modification of an existing device or the design of a custom device may be required. While there are several regional centers in Massachusetts that work with assistive technology and can aid a person with disabilities in purchasing a commercial product, they often do not have the means to modify the commercial product or create customized solutions. The design and development of the customized product would then need to be carried out at a different assistive technology center with the appropriate manufacturing capabilities. A more efficient method for providing assistive technology would be to have a regional center with the ability to create a solution to a client's request and develop the custom solution through the use of interdisciplinary teams. A comprehensive regional center would facilitate the development of optimal solutions with greater efficiency due to internal collaboration of professionals.

In 1999, the Assistive Technology Resource Center (ATRC) was created at WPI when the Fairlawn Foundation of Worcester awarded the Rehabilitation Laboratory at the university a grant for the development of a specialized Assistive Technology Center. The Center's mission was determined to be "to foster the use of assistive technology through collaboration with professionals associated with local and regional clinical, educational, governmental and social service organizations that serve persons with disabilities" ("About Us").

The operation of the ATRC was reevaluated in 2007 by an IQP group, "Implementation of Best Practices in the Operation of the WPI Assistive Technology Resource Center" (Lyons, and Trimby), so that improvements could be made where necessary. The students analyzed certain aspects of the Center that were outdated and provided methods for further development. One improvement they suggested was that a comprehensive database of projects completed at the ATRC and the list of contacts of the ATRC should be created and maintained. Another IQP group, "Optimizing the WPI Assistive Technology Resource Center: Operation and Management" (Hristov, Mawhiney, and Wilson), in 2009 implemented these recommendations and also suggested remedies for other problem areas. This latter group developed the database of over sixty projects, including the dates of completion, the names of the projects, the names of students, advisors, clients and others involved, the abstracts, and the category of assistive technology. Both of these project groups focused on optimizing the ATRC in order to ensure the continued efficiency of the Center.

Similarly, the goal of this project was to advance the ATRC through better marketing and communication of its mission and efforts to the rest of the community. In order to do so, the team would create a marketing document that would give a brief overview of relevant projects completed at the ATRC since its inception. The document would help future clients to get a better sense of what the Center does and how they can interact with the Center. Additionally, there was a need for the construction of a more comprehensive database that would inform students and potential clients about all of the previous projects completed at the ATRC. This database would be more detailed than the one created by Hristov, Mawhiney, and Wilson in that it would inform the reader of the problem statement, methodology, and results, in addition to the information provided by the previous database. These documents would help the ATRC to continue fulfill its mission and goals by providing information on the development of new assistive technology to the community.

Chapter 2. Background

2.1. ATRC Background

2.1.1. Establishment

In 1998, there was a need for a center that could provide the necessary engineering skills for the technical aspects of rehabilitation and the development of assistive technology within Central Massachusetts and surrounding areas. Existing organizations such as extended care facilities, disability services organizations, physical therapy centers, special education departments of primary and secondary schools, rehabilitation centers and hospitals, and other assistive technology and rehabilitation organizations focused more on providing support for persons with disabilities rather than the technical aspect of creating assistive devices. Rehabilitation engineering activities at WPI had to be conducted in association with more distant facilities such as the Massachusetts Hospital School in Canton, MA, which had on-staff technical expertise.

Consequently, Professors Allen H. Hoffman and Holly K. Ault proposed the idea of creating an Assistive Technology Resource Center at WPI that would provide a centralized source of technical information regarding current assistive technologies as well as the technical expertise of engineering students (Hoffman, Ault, & Catricala, 2001). The ATRC was thus founded in 1999 with the aid of a Fairlawn Foundation grant.

The Rehabilitation Engineering Laboratory is a 700 square foot area located on the first floor of Higgins Laboratories (HL 129) at WPI. The building houses the Mechanical Engineering Department, one of the largest and oldest departments at WPI, and more recently some additional areas that focus on Biomedical Engineering. The laboratory contains various tools and materials for engineering students to design, manufacture, and evaluate assistive devices.

The ATRC functions according to a set of professional rules titled "Standards of Practice" established by RESNA (Rehabilitation Engineering and Assistive Technology Society of North America). This document is a code of conduct with regard to assistive technology and was developed to help professionals working with assistive technology to serve their clients properly and ethically (RESNA Professional Standards Board, 2004). Some guidelines include: individuals shall engage in only services within their scope of competence, individuals shall truthfully and accurately represent their credentials, individuals shall cooperate with members of other professions. See Appendix A for the complete RESNA Standards of Practice.

2.1.2. Mission and Goals

The mission statement of the ATRC as stated on the WPI website is:

"The mission of the ATRC is to foster the use of Assistive Technology through collaboration with professionals associated with local and regional clinical, educational, governmental and social service organizations that serve persons with disabilities. The ATRC disseminates technical information regarding the availability and use of assistive devices. When an appropriate commercial device is not available, the ATRC will collaborate with cooperating organizations in developing modifications to existing devices or the design of a custom device. The ATRC focuses on mechanical and electro-mechanical devices."

Mission Statement, 1999 (ATRC, 2004)

This mission statement remains a foundation for the continued development of the ATRC. The Center aims to provide information about previously developed assistive technologies and to create and develop customized devices that can be either mechanical or electro-mechanical in nature.

The two main objectives of the ATRC with regard to assistive technology are:

1. To provide a centralized information resource for rehabilitation professionals within the region.

2. To provide a technically based resource for either the modification, or the design and development of customized assistive devices.

(Hoffman, Ault, & Catricala, 2001)

2.2. Previous Studies

In order to ensure the continued efficiency of an organization's operations, a periodical assessment of the organization's functions and operations must be conducted. A comparison between the given organization's practices and those of other similar successful organizations can be conducted and reviewed for the development of future recommendations for the organization. In the case of the ATRC, much of the information about the Center's operations is not in a concrete written form, but rather can be attained through an analysis of its operations and communications with individuals who have been involved or are currently involved with the ATRC. In order to develop future plans for the Center that will not be outdated as the Center evolves; recommendations must be created with the organization's future in mind. In 2007, the co-directors of the ATRC, Professor Hoffman and Professor Ault, decided that an evaluation of the Center's past practices and accomplishments would be useful in order to provide guidance for the future development of the ATRC.

2.2.1. Lyons and Trimby Study (2008)

As a part of their Interactive Qualifying Project, in 2008, Christopher Lyons and Paul Trimby conducted this evaluation so that the results of the study could be used as guidelines for future practices within the ATRC. By researching the past operations of the Center and conducting surveys and interviews with professionals with a background in assistive technology, the students described their findings and recommendations in a final report (Lyons and Trimby, 2008).

They determined that in order to be successful, an organization must expand itself, remain organized as it expands, and continue to work at a high level of professionalism. From these conclusions, they generated several approaches that could be used to optimize the future operations of the ATRC.

They suggested that the visual appearance of the laboratory space should be improved by re-arranging the tools, performing a weekly walk-through, clearing the counter space, and designating space in the lab for completed projects. The report also recommended that comprehensive databases of the projects completed by the ATRC and the list of professional contacts of the ATRC should be created and maintained as the Center grows. Additionally, the students recommended that the ATRC website be updated with current information about news, activities, and projects so that information about the ATRC's continued growth and successes can be available to potential clients.

Lyons and Trimby (2008) also generated ideas for improving the way that the ATRC markets itself to both clients and affiliates. It was suggested that the list of organizations in the area with similar missions be generated, as prospective affiliates of the ATRC. The students made recommendations for the management of the ATRC by stating that the current administration fulfills the managerial, academic, and public relations positions at the ATRC. The Center faculty also shares some of the operational activities with the Center manager who often is a graduate student. If more students were recruited to work at the Center, the workload could be distributed more effectively. The issue of funding at the ATRC was also raised and it was suggested that a database be compiled that would include grants already procured and any potential grants that could be pursued in the future. For this purpose, it was recommended that a comparison between the ATRC and other similar organizations could help in gaining insight into how other centers procure and maintain external funding. This paper formed the basis for a second study of the ATRC that focused on the implementation of the recommended practices.

2.2.2. Hristov, Mawhiney &Wilson Study (2009)

As a continuation of the Lyons and Trimby IQP (2008), Stoyan Hristov, Kelsey Mawhiney, and Zachary Wilson, completed an IQP that involved the implementation of the recommendations made in the previous study. The students analyzed the results of the Lyons and Trimby paper to determine which aspects of improving the operations of the ATRC could be realistically executed within the timeline of the project. The areas of focus were determined to be the reorganization of laboratory space, the creation of a projects database, and the improvement of the management and marketing at the Center in relation to its expansion.

This IQP group determined that the ability of the ATRC to continue to grow in its efforts to provide services and assistive technology to clients depended upon efficient operations. In order to optimize the efficiency of the projects completed in the laboratory, the laboratory space was first reorganized by placing materials in specified drawers, labeling the drawers, and moving expensive equipment to a designated place in the laboratory. A suggested floor plan was also devised with the intent of reorganizing movable tables within the laboratory area to maximize workspace without compromising safety.

Next, the group focused on developing a database of the major projects completed within the ATRC since it was established in 1999. Information about past projects was obtained from hard copies of qualifying project reports and the library database of qualifying projects. The database grew to include over sixty projects and included the date that the project was completed, the name of the project, the names of students, advisors, and clients involved in the project, a project abstract, the targeted activity type, and the type of assistive technology used.

The website was also updated by reorganizing the information presented about current and past projects at the ATRC into one comprehensive database organized by the project's year of completion. The "Newsletters" page was also updated with newsletters previously distributed and the "Journal Publications" page was updated with recent publications.

Each component of this IQP was completed as a means to optimize the efficiency of the ATRC's operations. Proper management would allow the Center to run smoothly and to expand as necessary, while proper marketing would allow the mission on the Center to reach potential clients. Future recommendations made in the IQP report emphasized the need to maintain the organization of laboratory space and the need to maintain the projects database for both the managerial and marketing aspects of the ATRC's operations.

2.3. Current Databases of Projects

2.3.1. George C. Gordon Online Library Database

Currently, the WPI library website contains a page titled "MQP and IQP reports" from which students can access the database containing these reports. Students can search for a project report based on the division in which it was completed, the name of any of the authors of the report, or the name of the project advisor. Additionally, it is possible to browse through a list of projects by year, from 1999 through 2010, or by the location of the project center. Since all IQP and MQP reports completed at WPI between the years of 1999 and 2010 are available through this database, it is an efficient method for interested parties to access project reports.

Upon clicking on the link to a certain project, the user of the database is directed to a page containing information about project submission date, authors of the report, the URN (the number identifying the report), the division that the project falls under, the project center, the project sponsor(s), the title of the project, the names of project advisors, and the abstract from the project report. Below this information, there is a link to the PDF file of the entire report. People using the library database to find a specific project report can find important information about the project on the first link that they access, and then the detailed project report if they require more specific details about the project.

2.3.2 Hristov, Mawhiney, Wilson (2008) Microsoft Access Database

The IQP group, "Optimizing the WPI ATRC Operation and Management" (Hristov, Mawhiney, Wilson) created a database of all major projects completed through the ATRC since its establishment in 1998. The design team used Microsoft Access as the program to manage the database because it can be easily obtained by the Center administrators or by any student who needs information. Additionally, it can be updated by future groups and it is user-friendly. Microsoft Access provides tools to sort and search the database and is available to all WPI students.

The team used the Library database and Professor Hoffman's collection to compile all of the information that they needed. The database was organized into the following fields: Date (mm/yyyy), Project Name, Status, Student(s), Advisor(s), Sponsor(s), Abstract, Awards, Online, Web Page Name, Primary Disability, Activity, Assistive Technology, Context, and Client Age. The IQP group also created a guide on how to use the database so that future groups could edit and maintain it as needed.

Though these two databases provide efficient ways for students to access information about a project and the abstract for the project report, there is the need for a comprehensive document that includes summaries of relevant projects that can be accessed by WPI students and potential clients of the ATRC. These databases contain information about a variety of design projects completed within the ATRC such as MQP’s, IQP’s, and Graduate Theses, but are not comprehensive enough to include course design projects completed by students in undergraduate engineering design courses.

The development of a more comprehensive and inclusive document will allow interested individuals to access more detailed summaries of the project report than they could gain from only reading the project abstract. By reading a summary of a given project, students and clients can gain a comprehensive understanding of the project without reading the entire project report.

Chapter 3. Problem Statement

After ten years of operation, the ATRC directors, Professors Hoffman and Ault, realized the need to better market and communicate the mission and efforts of the ATRC to the community. The goal of the present project was to create two documents: (1) a marketing document that would detail projects relevant to the progression of the ATRC's growth and (2) a comprehensive document that would detail all relevant projects. Implementation of these documents would facilitate interactions with clients, students, and service providers. These documents would also help the ATRC to continue to fulfill its mission of providing assistive technology to the community.

Chapter 4. Methodology

4.1. Previous Studies

The work of the Hristov, Mawhiney, and Wilson IQP group resulted in several deliverables intended to optimize the operations of the ATRC, one of which was a comprehensive database of projects completed at the ATRC. The database was created as a response to the need for a centralized list of projects that can be updated as new projects are completed. The database, which is in the form of a Microsoft Access document, allows the user to search for a specific project by name and obtain details about the project such as client information, type of assistive technology used, and a project abstract. It allows an individual with a specific project in mind to gain access to information about the project without needing to obtain the project report.

4.2. Marketing Document

In addition to the Microsoft Access database, there also exists a need for a document that can provide information about the ATRC to parties outside of the Center who may not have a specific project of interest. Rather than presenting information about a comprehensive list of ATRC projects, this document would provide a brief summary of a broad range of projects completed within the ATRC. In the interest of maintaining a manageable length for the reader, the document would contain information about fewer successful, relevant projects that could be read and understood by various individuals outside of the ATRC. The document would serve as a marketing tool to display the assistive technology developed at the ATRC through student projects to other service providers, as well as to clients.

The team began the task of developing the Marketing Document by initially reading through the database compiled by the Hristov, Mawhiney, and Wilson IQP team. To determine the most relevant projects for the marketing document, the team first examined the previous database and listed all of the projects in chronological order. Only projects that were delivered and used by clients and agencies outside of WPI were considered for inclusion. After discussing with Professor Hoffman, the team determined the final list of projects that were necessary to have in the document. One project type that should be included in the document are ones completed off campus such as the MQP in Melbourne, Australia. Also, projects currently in use such as the design of an aerosol spray can adaptor for a carpenter who underwent partial finger amputations should be included. The projects that were included in the final outline were: Design of a Glide Control Mechanism for a Manual Wheelchair (Bonniejean Boettcher, Timothy MacLean, Kenneth Sundberg, 2002), Design of an Elevating Legrest for a Wheelchair (Eric Couture, 2006), Design of a One-Arm Driven Manual Wheelchair (Dominic DiGiovanni, Valerie Marrion, Hamlet Nina, 2009), Independent Transfer System For a Person with Limited Strength (David Curran, 2007), Adaptable TV Remote (2003), Improving Disabled Tram Access in Melbourne, Victoria (Alexander Christakis, Katie Flynn, Jennifer Himottu, 2008), Adapting Hands-On Science Programs for Students with Disabilities (Nicholas Simone, Erin Vozzula, Lynn Worobey, 2007), Adaptive Spray Can Holder (Pedriant Pena, Cordero Marrero, Claire Piard, Alexandra Gunderson, 2006), Portable Single Switch Activated Bowling Game (Jeff Prunera, Jacob H. Saffron, Jonathan Alfred Welch, 2009) , and Manual Wheelchair Handbook Study for the Massachusetts Department of Developmental Services (Daniel Asselin, Nikolas Ledoux, David Willens, 2008).

Once the team determined the list of projects that should go in the document, the projects were organized into five categories: daily living, education, vocational, sports, and research studies. Daily living would incorporate all the projects that resulted in the improvement of an individual’s day-to-day living. These devices could have increased a person’s mobility or his ability to perform common household tasks. Projects in this category include Design of a Glide Control Mechanism for a Manual Wheelchair, Design of an Elevating Legrest for a Wheelchair, Design of a One-Arm Driven Manual Wheelchair, Independent Transfer System for a Person with Limited Strength, Adaptable TV Remote, and Improving Disabled Tram Access in Melbourne, Victoria.

Some projects of the ATRC were centered on education. The goal of these projects is to create and develop adaptive resources that cater to students who have learning disabilities, developmental disabilities, and physical limitations in a classroom setting. Adapting Hands-On Science Programs for Students with Disabilities was a project that worked to improve the educational experience of students with disabilities.

Similarly, projects that serve individuals with disabilities in the workplace have been completed at the ATRC. One such project was the Adaptive Spray Can Holder, which bridged the gap between the person’s physical abilities and his daily job requirements.

Additionally, some projects were categorized as sports since existing sports equipment was modified to suit the needs of individuals with physical limitations. The Portable Single Switch Activated Bowling Game was placed in the sports category.

Finally, the team wanted to show that ATRC has current ongoing research studies in the lab. The Manual Wheelchair Handbook Study for the Massachusetts Department of Developmental Services (DDS) resulted from the need to develop a handbook for group homes operated by DDS.

As the team was developing the drafts for the marketing document, it was brought to the students' attention that they were not always using People First Language. People with disabilities are people, first. They should not be stereotypically categorized as "the handicapped" or "the disabled." Instead, "individuals with disabilities" or "Bob has a developmental disability" would be more appropriate. This method of putting the person first is a more respectful and accurate way of communicating ideas. A disability is simply a medical diagnosis and it would be rude to devalue an individual by using extreme words because of his or her illness. The words used to describe a person have a powerful impact on his self-image. Therefore, warm words should be used when talking about individuals with disabilities. The team went through the document several times to make certain that no unacceptable language was used. A full list of People First Language terms can be found in Appendix B.

Finally, searches were conducted online to determine whether any similar documents are available from other assistive technology centers. From other marketing tools, the type of information that would need to be presented in the document, as well as the type of language used to communicate the information could potentially be determined. Similar documents were not found, but a review of the websites of service providers such as Seven Hills Foundation (http://www.sevenhills.org/) offered valuable guidance as to the objectives of assistive technology and rehabilitative services. The team decided that an incorporation of these objectives of empowerment and independence into the goal of the development of assistive technology would provide a warm aspect to the Marketing Document.

4.3. Document of Past Projects

A comprehensive document containing summaries of all projects completed within the ATRC since its inception would be valuable for several groups of people. The target audience of this document would include WPI students, potential clients, ATRC management, and marketing professionals at WPI. Students interested in completing a project at the ATRC would find this document useful in obtaining information about the types of design solutions that have been produced through the ATRC. Potential clients of the ATRC would refer to this document to determine whether the types of devices that are developed within the ATRC could meet their assistive technology needs. This document could be benefit ATRC management in providing easy and up-to-date access to summaries of all past projects. Finally, marketing professionals at WPI who do not have the necessary technical background to glean the information that they need from project reports would be able to instead refer to the succinct paragraphs presented in the document. Gaining this information in a more understandable way will allow these professionals to better market the ATRC's services to the general community.

One of the functions of the completed document is to serve as a resource for students who want to gain information about the projects completed within the ATRC in order to help them to make decisions about potentially working on a project at the ATRC. In order to begin the creation of a document that would include summaries of many of the projects completed at the ATRC, the team first interviewed two students to obtain their opinions as to the content of the document. The team determined that the input from the students interviewed would be valuable in establishing the content of each project summary. Both students were asked about which type of information about past projects they would find useful if they were to consider working on a qualifying project within the ATRC. Additionally, they were asked about their preference in terms of the overall format of the document and the ease of looking for and finding a specific project of interest.

The team found that including sufficient information about the problem statement and solution was important to both students interviewed. Additionally, it was determined that other important information to include about each project is detail about the methodology since any students interested in similar projects would be interested in learning about the process of the project, and not solely the initial client statement and result. The students both suggested a chronological format that would allow the user of the document to search for a specific project based on the year of completion.

In order to gain a better understanding of the readers' reactions to the document, the team interviewed Professor Robert Bureau of Assumption College for his feedback concerning the language used in the document. Professor Bureau works as Master of Education in the field of rehabilitation counseling, and therefore would be able to provide a unique perspective on the document. The team met sent several paragraphs to Professor Bureau and met with him to receive feedback and critique. Professor Bureau identified certain phrases and terminology used in the document that were not appropriate according to Person First standards. A complete explanation of Person First Language and list of appropriate terminology can be found in Appendix B.

The team then developed an outline of a general format for each paragraph that would be written for a given project. First, the problem statement given to the group would be introduced, along with any general background about the client or user. A description of the design process would follow. This description would include any significant information about the generation of preliminary research conducted by the project group, the development of design alternatives, and the evaluation of the design alternatives in the generation of a final design. Then, information about the final device created and any testing or evaluation of a prototype would be presented.

This outline was created in order to allow for a uniform structure that could be applied to most of the projects summarized in the document.

Since the Microsoft Access Database developed by the Hristov, Mawhiney, and Wilson IQP group did not supply information about course design projects, the team determined that the inclusion of these projects in the Document of Past Projects would be imperative. Some of the devices developed through these introductory courses have been very successful in that they have served as solutions to real world problems. Course design projects result in the first generation prototype of a given device.

The Engineering Projects in Community Service (EPICS) Program at WPI allows groups of undergraduate students to solve engineering and technology based problems that benefit the local community. Often, students in multi-disciplinary teams will further develop course design projects into second and third generation devices that can then be given to the client. In this way, a link exists between the first generation prototype designed by course design groups and the further development into a final product by EPICS groups. This link allows for the entire design process, from the receiving of the problem statement to the generation of a custom solution, to be completed by WPI undergraduates. Many of the devices resulting from course design projects and EPICS groups are currently used by the clients who initially approached the ATRC with their assistive technology requests. These design projects continue to be of great value to the ATRC in helping the Center to fulfill its mission of providing assistive technology to the community.

Keeping in mind the various categories of projects that would be included in the document, the team decided that the overall document should be organized by project type, starting with MQPs and then going into IQPs, Graduate Master of Science Theses and Course Design Projects. This would aid the target audience in finding the project that they are most interested in. Within each category, the projects would be arranged chronologically. Each category would also have a paragraph explaining the type of project so that individuals who are not familiar with the WPI qualifying projects would have a better understanding of the extent of the project requirements when reading the document.

The team decided that each project should be titled in one format with the type of project (MQP, IQP, etc.) listed first, then the title, followed by the students involved in the project. The date of completion would be included in the next line as month, year. An example of the format is as such:

> **IQP: <u>Evaluating a Wheelchair Maintenance Resource</u>** – Joseph A. Sarcione, Christopher L. Kopec, and Adam J. Trimby
>
> *May, 2004*
>
> Keywords: Wheelchair Maintenance

Once the overall format was decided, the team determined the relevant projects that would be included in the document. The team first worked on writing up all projects advised by Professor Hoffman that were online in the library database of MQPs that were completed no earlier than 1991. As the team proceeded through the write-ups, notes were kept of all relevant pictures that could be included in the final document. These pictures would be interspersed between the paragraphs to provide a supplementary view of certain devices. The team then worked on MQPs that were only available in hard copy format in Professor Hoffman's office. Once all of the MQPs were completed, the team moved on to IQPs that were found in the library database. Some of Professor Ault's IQPs were found to be relevant to the ATRC because they were associated with prosthetic devices for individuals with disabilities. The team included several projects that were conducted off campus to show the wide range of projects that the ATRC has to offer. Next, the team worked on the Graduate M.S. Theses completed within the ATRC. One MQP and a few Graduate Theses contain proprietary information and are not available to the public. Professor Hoffman supplied the paragraphs regarding these projects. Finally, the team worked on Course Design Projects. Only a few of these were chosen according to which ones were successfully implemented and being used outside of WPI.

Chapter 5: Project Results

5.1 Marketing Document

The Marketing Document was developed and came to include five pages of project summaries of all the projects listed in Section 4.2. The first page of the document is an aesthetically pleasing title page including a picture of the Rehabilitation Engineering Laboratory in Higgins Laboratory. The projects are organized into categories of daily living, education, sports and recreation, vocation, and research studies. Each category is introduced by a paragraph explaining the related type of assistive technology developed at the ATRC. Each project summary begins with the problem statement, followed by the project goals, and ends with a description of the final device. The document concludes with a line targeted to clients with information on how to contact the WPI ATRC by phone, mail, or email. Each project mentioned in the document that has been published is referenced and relevant project sponsors are acknowledged in a brief paragraph. All relevant pictures depicting project results are interspersed throughout the document.

5.1 Document of Past Projects

The Document of Past Projects is a document chronicling over 61 projects completed within the WPI ATRC since 1999. The document is organized by project type: MQP, IQP, Graduate M.S. Thesis, and Course Design Project. Each section opens with a concise explanation of the project and how it fits in the WPI curriculum. Within each section, the projects are ordered by month and year of completion. Under this information, there is a list of keywords that are relevant to the given project.

Each paragraph begins with the goal of the project, which leads to a description of the problem statement. Any background information necessary for the understanding of the project and solution is then presented. A thorough description of the methodology used by the project group then follows. The paragraph concludes with a detailed description of the final product and any further recommendations suggested by group. Any pictures that were available for use by the IQP team can be found below the summary of their respective project.

At the end of the document, there is an index containing all keywords used throughout the document. The project numbers that correspond to a keyword are listed below that keyword. This system allows a user to search for a project of interest by identifying a keyword and then referring to related projects.

Chapter 6. Discussion

The overall goal of the IQP was to optimize the operations of the ATRC through marketing and documentation. The team focused on developing two documents, one for the purpose of giving potential clients a sense of the types of products developed at the ATRC, and the other for the purpose of providing students, clients, and ATRC management with a comprehensive overview of the projects completed throughout the history of the ATRC. Since the first document serves as a marketing tool, it provides a very brief five page overview of selected projects. The second document is intended to provide summaries of all MQP's, IQP's, Graduate Theses, and Course Design Projects completed through the ATRC since 1999, and is therefore a more comprehensive document including summaries of sixty-one projects.

The marketing document was completed first by initially identifying the most relevant projects that would demonstrate the ATRC's continued success over the years. Once these projects were identified, project reports were obtained and summaries of these projects were compiled together. A title page and pictures of the projects were added to supplement the writing and the ATRC's contact information was supplied at the end of the document. When distributed to potential clients and local affiliates, the document will serve as a concise representation of the ATRC's activities and achievements.

The document of past projects was completed in categories; summaries were first written of MQP's, then IQP's, Graduate theses, and finally, Course Design Projects. Each summary included information about the initial client statement, the goal of the project, the methodology used in developing the result, the description of the final deliverable, and any future recommendations made. In addition to the summary, the names of student(s) who were involved in the project, and the month and year of completion were provided. The document was organized based on project type (MQP, IQP, Graduate Thesis, or Course Design Project), with descriptions of each of these project types preceding the list of project summaries. This document can be used by WPI students interested in completing any of these types of projects at the ATRC, by potential clients who are interested in gaining a detailed understanding of one or more ATRC project, or by ATRC management looking for details about a specific project.

This IQP was focused on writing these two documents but not on their actual implementation for the purpose for which they were created. A direction for a future IQP group at the ATRC could be to implement these documents by either distributing them to affiliates or by making them available in a location online that is accessible to the general public. Ideally, the marketing document would be distributed to potential clients and affiliates through mail in order to generate interest in the ATRC. The comprehensive document of past projects, on the other hand, could be more useful to users if available in a location online that can be accessed by generating a web search. Additionally, the comprehensive document of past projects will need to be updated regularly as new projects are completed so that it stays current and up-to-date for immediate use at any time.

Chapter 7. Future Recommendations

7.1. Implementation of Marketing Document

The team first recommends that the marketing document be implemented through distribution to the intended users. These users include potential clients, local affiliates, and professionals in the field of rehabilitative services. It is recommended that the document be distributed through mail as a hard copy in order to reach a wide audience, as well as to best ensure that the document will be read by the receiver. The list of local potential local affiliates that the marketing document could be mailed to was compiled by the IQP group of Hristov, Mawhiney, and Wilson (2009) and can be found in Appendix C.

A future IQP group working on implementing this marketing tool could first send the document to select affiliates and solicit feedback based on their impressions of the document.

Survey: Effectiveness of Marketing Document

Please circle the most appropriate response for each question, 1 being "strongly disagree" and 5 being "strongly agree."

This document provides adequate information about the ATRC's mission:

1 2 3 4 5

This document provides adequate information about the types of projects completed at WPI:

1 2 3 4 5

This document provides a good variety of projects:

1 2 3 4 5

Each project summary provides enough detail for a good understanding of the project:

1 2 3 4 5

This document is concise enough to be read quickly:

1 2 3 4 5

The organization of projects into categories (daily living, sports, etc.) was helpful:

1 2 3 4 5

Any other feedback would be greatly appreciated!

By taking the feedback into consideration, the group could incorporate suggestions for improvement into the existing document. The improved marketing document could then be sent out to the entire audience based on the aforementioned list of potential local affiliates.

7.2. Implementation of Document of Past Projects

For implementation of the document of past projects, the team first recommends that it be added to the ATRC website in the form of a PDF file. Since it is a large document of over forty pages, it would not be practical to send either a hard or soft copy to interested parties. Instead, people who are interested in reading a summary of a project could find the information through a link on the ATRC website leading to the document.

Additionally, the team recommends that this document be regularly updated as new projects are completed at the ATRC. One way to ensure that the document stays up-to-date would be to ask each project group to write a concise summary of their project. This summary should include the initial goal of the project, the problem statement received, the methodology, final results, and any relevant future recommendations. Doing so would provide anyone accessing the document at any time with the most current information about projects completed at the ATRC.

Another link on the ATRC website could direct the user to a questionnaire requesting feedback concerning the document of past projects. The questions could take a similar form to those in the proposed survey in Section 7.1.

The team also suggests the addition of a link to the project report immediately following its respective project summary. This would allow any individual seeking more detailed information to easily access the project report from within the document itself.

7.3. Updating the ATRC Website

Currently, the ATRC website does not provide adequate up-to-date information that students and clients can access. It was last modified in 2004, and therefore needs to be updated with current information in order to be more useful.

Firstly, all newsletters released since the fall of 2004 need to be added to the "Newsletters" section on the website so that interested members of the community can remain up-to-date on the ATRC's activities. Additionally, the "Past Projects" page of the website is currently organized into categories of "Mobility", "School/Workplace", "Daily Living", and "Recreation." Some design projects as well as research studies do not fit cleanly into one category and may encompass either none or more than one category. A more convenient method of organization of projects could be to categorize the projects based on project type (MQP, IQP, Graduate Thesis, or Course Design Project). This would allow students interested in one type of project to obtain information about that type of project without any confusion as to the work that a given project type entails.

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Appendix A. RESNA Standards Of Practice For Assistive Technology Practitioners And Suppliers

These Standards of Practice set forth fundamental concepts and rules considered essential to promote the highest ethical standards among individuals who evaluate, assess the need for, recommend, or provide assistive technology. In the discharge of their professional obligations assistive technology practitioners and suppliers shall observe the following principles and rules:

1. Individuals shall keep paramount the welfare of those served professionally.

2. Individuals shall engage in only those services that are within the scope of their competence, considering the level of education, experience and training, and shall recognize the limitations imposed by the extent of their personal skills and knowledge in any professional area.

3. In making determinations as to what areas of practice are within their competency, assistive technology practitioners and suppliers shall observe all applicable licensure laws, consider the qualifications for certification or other credentials offered by recognized authorities in the primary professions which comprise the field of assistive technology, and abide by all relevant standards of practice and ethical principals, including RESNA's Code of Ethics.

4. Individuals shall truthfully, fully and accurately represent their credentials, competency, education, training and experience in both the field of assistive technology and the primary profession in which they are members. To the extent practical, individuals shall disclose their primary profession in all forms of communication, including advertising, that refers to their credential in assistive technology.

5. Individuals shall, at a minimum, inform consumers or their advocates of any employment affiliations, financial or professional interests that may be perceived to bias recommendations, and in some cases, decline to provide services or supplies where the conflict of interest is such that it may fairly be concluded that such affiliation or interest is likely to impair professional judgments.

6. Individuals shall use every resource reasonably available to ensure that the identified needs of consumers are met, including referral to other practitioners or sources which may provide the needed service or supply within the scope of their competence.

7. Individuals shall cooperate with members of other professions, where appropriate, in delivering services to consumers, and shall actively participate in the team process when the consumer's needs require such an approach.

8. Individuals shall offer an appropriate range of assistive technology services which include assessment, evaluation, recommendations, training, adjustments at delivery, and follow-up and modifications after delivery.

9. Individuals shall verify consumer's needs by using direct assessment or evaluation procedures with the consumer.

10. Individuals shall assure that the consumer fully participates, and is fully informed about all reasonable options available, regardless of finances, in the development of recommendations for intervention strategies.

11. Individuals shall consider future and emerging needs when developing intervention strategies and fully inform the consumer of those needs.

12. Individuals shall avoid providing and implementing technology which expose the consumer to unreasonable risk, and shall advise the consumer as fully as possible of all known risks. Where adjustments, instruction for use, or necessary modifications are likely to be required to avoid or minimize such risks, individuals shall make sure that such information or service is provided.

13. Individuals shall fully inform consumers or their advocates about all relevant aspects, including the financial implications, of all final recommendations for the provision of technology, and shall not guarantee the results of any service or technology. Individuals may, however, make reasonable statements about prognosis.

14. Individuals shall maintain adequate records of the technology evaluation, assessment, recommendations, services, or products provided and preserve confidentiality of those records, unless required by law, or unless the protection of the welfare of the person or the community requires otherwise.

15. Individuals shall endeavor, through ongoing professional development, including continuing education, to remain current on all aspects of assistive technology relevant to their practice including accessibility, funding, legal or public issues, recommended practices and emerging technologies.

16. Individuals shall endeavor to institute procedures, on an on-going basis, to evaluate, promote and enhance the quality of service delivered to all consumers.

17. Individuals shall be truthful and accurate in all public statements concerning assistive technology, assistive technology practitioners and suppliers, services, and products dispensed.

18. Individuals shall not invidiously discriminate in the provision of services or supplies on the basis of disability, race, national origin, religion, creed, gender, age, or sexual orientation.

19. Individuals shall not charge for services not rendered, nor misrepresent in any fashion services delivered or products dispensed for reimbursement or any other purpose.

20. Individuals shall not engage in fraud, dishonesty or misrepresentation of any kind, or any form of conduct that adversely reflects on the field of assistive technology, or the individual's fitness to serve consumers professionally.

21. Individuals whose professional services are adversely affected by substance abuse or other health-related conditions shall seek professional advice, and where appropriate, withdraw from the affected area of practice.

22. Individuals shall respect the rights, knowledge, and skills of colleagues and others, accurately representing views, information, ideas, and other tangible and intangible assets including copyright, patent, trademark, design contributions, and findings.

Appendix B. People First Language Document

To ensure INCLUSION, FREEDOM, AND RESPECT for all, it's time to embrace

PEOPLE FIRST LANGUAGE

by Kathie Snow, www.disabilityisnatural.com

Did you know that people with disabilities constitute our nation's largest minority group (one in five Americans has a disability)? It is also the most inclusive and most diverse group: all ages, genders, religions, ethnicities, sexual orientations, and socioeconomic levels are represented.

Contrary to conventional wisdom, individuals with disabilities are not:

- People who *suffer* from the *tragedy* of *birth defects.*
- *Paraplegic heroes* who *struggle* to become *normal* again.
- *Victims* who *fight* to *overcome* their *challenges.*

Nor are they the *retarded, autistic, blind, deaf, learning disabled,* etc.—*ad nauseam!*

They are *people:* moms and dads; sons and daughters; employees and employers; friends and neighbors; students and teachers; scientists, reporters, doctors, actors, presidents, and more. People with disabilities are people, *first.*

> ***The difference between the right word and the almost right word is the difference between lightning and the lightning bug.***
> Mark Twain

They do not constitute the stereotypical perception: a homogenous sub-species called "the handicapped" or "the disabled." They are unique individuals.

The only thing they may have in common with one another is being on the receiving end of societal misunderstanding, prejudice, and discrimination. Furthermore, this largest minority group is the only one which *any person can join at any time:* at birth or later—through an accident, illness, or the aging process. When it happens to *you,* will you have more in common with others who have disability diagnoses or with family, friends, and co-workers? How will you want to be described and how will you want to be treated?

WHAT *IS* A DISABILITY?

Is there a universally-accepted definition of disability? No! First and foremost, a disability descriptor is simply a *medical diagnosis,* which may become a *sociopolitical passport* to services or legal status. Beyond that, the definition is up for grabs, depending on which service system is accessed. The "disability criteria" for early intervention is different from early childhood, which is different from vocational-rehabilitation, which is different from special education, which is different from worker's compensation, and so on. Thus, "disability" is a *social construct,* created to identify those who may be entitled to services or legal protections due to *characteristics* related to a medical condition.

—THE POWER OF LANGUAGE AND LABELS—

Words are powerful. Old, inaccurate descriptors and the inappropriate use of medical diagnoses perpetuate negative stereotypes and reinforce a significant and an incredibly powerful attitudinal barrier. And this invisible, but potent, force—not the diagnosis itself—is the *greatest obstacle* facing individuals who have conditions we call disabilities.

When we see the diagnosis as the most important characteristic of a person, we devalue her as an individual. Do *you* want to be known for your psoriasis, gynecological history, the warts on your behind, or any other condition?

Unfortunately, disability diagnoses are often used to define a person's value and potential, and low expectations and a dismal future may be the predicted norm. A person's diagnosis is often used to decide how/where the person will be educated, what type of job he will/won't have, where/how he'll live, and more, including what services he is thought to need.

With the best of intentions, we work on people's bodies and brains, while paying scant attention to their hearts and minds. And far too often, the "help" provided can actually cause harm—*and can ruin people's lives.* For "special" services frequently result in the social isolation and physical segregation of children and adults: in special ed classrooms, congregate living quarters, day programs, sheltered work environments, segregated recreational activities, and more. Are other people isolated, segregated, and devalued because of *their* medical conditions?

—Inaccurate Descriptors—

"Handicapped" is an archaic term (no longer used in federal legislation) that evokes negative images of pity, fear, and more. The origin of the word is from an Old English bartering game, in which the loser was left with his "hand in his cap" and was said to be at a disadvantage. Based on this meaning, it was applied to people with certain conditions. A *legendary* origin of the word refers to a person with a disability begging with his "cap in his hand." This antiquated, derogatory term perpetuates the negative image that people with disabilities are a homogenous group of pitiful, needy people! Others who share a certain characteristic are not all alike, and individuals who happen to have disabilities are not alike. In fact, people with disabilities are more *like* people *without* disabilities than different!

"Handicapped" is often used to describe modified parking spaces, hotel rooms, restrooms, etc. But these usually provide *access* for people with physical or mobility needs—and they may provide *no benefit* for people with visual, hearing, or other conditions. This is one example of the misuse of the H-word as a *generic descriptor.* (The accurate term for modified parking spaces, hotel rooms, etc. is "accessible.")

> ***If thought corrupts language, language can also corrupt thought.***
> George Orwell

"Disabled" is also not appropriate. Traffic reporters often say, "disabled vehicle." They once said, "stalled car." Sports reporters say an athlete is on "the disabled list." They once said, "injured reserve." Other uses of this word today mean "broken/non-functioning." *People with disabilities are not broken!*

If a new toaster doesn't work, we say it's "defective" or "damaged" and return it. Shall we return babies with "birth defects" or adults with "brain damage"? The accurate and respectful descriptors are "congenital disability" or "brain injury."

Many parents say, "My child has special needs." This term generates *pity,* as demonstrated by the usual response: "Oh, I'm *so sorry,*" accompanied by a sad look or a sympathetic pat on the arm. *(Gag!)* A person's needs aren't "special" to him—they're ordinary! Many adults have said they detested this descriptor as children. Let's learn from them, and *stop using this pity-laden term!*

"Suffers from," "afflicted with," "victim of," "low/high functioning," and similar descriptors are inaccurate, inappropriate, and archaic. A person simply "has" a disability/medical condition.

—Disability is *Not* the "Problem"—

We seem to spend more time talking about the "problems" of a person with a disability than anything else. People *without* disabilities, however, don't constantly talk about *their* problems. This would result in an inaccurate perception, and would also be counterproductive to creating a positive image. A person who wears glasses, for example, doesn't say, "I have a *problem* seeing." She says, "I wear [or need] glasses."

What is routinely called a "problem" actually reflects a *need.* Thus, Susan doesn't "have a problem walking," she "needs/uses a wheelchair." Ryan doesn't "have behavior problems," he "needs behavior supports." Do *you* want to be known by your "problems" or by the many positive characteristics which make you the unique individual you are? When will people *without* disabilities begin speaking about people *with* disabilities in the respectful way they speak about themselves?

Then there's the use of "wrong" as in, "We knew there was *something wrong* when..." What must it feel like when a child hears his parents repeat this over and over and over again? How would *you* feel if those who are supposed to love and support you constantly talked about what's "wrong" with you? Isn't it time to stop using the many words that cause harm?

The Real Problems are Attitudinal and Environmental Barriers!

The real problem is *never* a person's disability, but the attitudes of others! And a change in attitudes and beliefs can change everything.

If educators believed in the potential of *all* children, and if they recognized boys and girls with disabilities need a quality education so they can become successful in the adult world of work, millions of children would no longer be *segregated and undereducated* in special ed classrooms. If employers believed adults with disabilities have (or could learn) valuable job skills, we wouldn't have an estimated *(and shameful)* 75 percent unemployment rate of people with disabilities. If merchants saw people with disabilities as customers with money to spend, we wouldn't have so many inaccessible stores, theaters, restrooms, and more. If the service system identified people with disabilities as "customers," instead of "clients/consumers/recipients," perhaps it would begin to meet a person's *real* needs (like inclusion, friendships, etc.) instead of trying to remediate his "problems."

If individuals with disabilities and family members saw *themselves* as first-class citizens who can and should be fully included in all areas of society, we might focus on what's really important: living a *Real Life in the Real World*, enjoying ordinary opportunities and experiences and dreaming big dreams (like people without disabilities), instead of living a *Special Life in Disability World*, where low expectations, segregation, poverty, and hopelessness are the norm.

—A New Paradigm—

"Disability is a natural part of the human experience..."
U.S. Developmental Disabilities/Bill of Rights Act

Like gender, ethnicity, and other traits, a disability is simply one of many natural characteristics of being human. Are *you* defined by your gender, ethnicity, religion, age, sexual orientation, or other trait? No! So how can we define others by a characteristic which is called a "disability"?

Yes, *disability is natural*, and it can be *redefined* as "a body part that works differently." A person with spina bifida has legs that work differently, a person with Down syndrome learns differently, and so forth. And the body parts of people *without* disabilities are also different—it's the *way* these differences affect a person which creates the eligibility for services, entitlements, or legal protections.

The greatest discovery of my generation is that human beings can alter their lives by altering their attitudes of mind.
William James

In addition, a disability is often a *consequence of the environment.* For example, most children with ADD and similar conditions are not diagnosed until they enter public school. Why is this? Could it be that as young children, their learning styles were supported by parents, preschool teachers, etc.? But once in public school, if the child's learning style doesn't mesh with an educator's teaching style, the child is said to have a "disability." Why do we blame the child, label him, and segregate him in a special ed classroom? Shouldn't we modify the regular curriculum (per special ed law) and/or provide supports to meet his needs so he can learn in ways that are best for him?

When a person is in a welcoming, accessible environment, with the appropriate supports, accommodations, and tools, does he still have a disability? No! *Disability is not a constant state.* The *diagnosis* may be constant, but whether it's a disability is more a *consequence of the environment* than what a person's body or mind can/cannot do. We don't need to change people with disabilities through therapies or interventions. We need to change the *environment,* by providing assistive technology devices, supports, and accommodations to ensure a person's success!

Using People First Language is Crucial!

People First Language puts the person before the disability, and describes what a person *has,* not who a person *is.*

Are you "myopic" or do you wear glasses?
Are you "cancerous" or do you have cancer?
Is a person "handicapped/disabled"
or does she have a disability?

If people with disabilities are to be included in all aspects of society, and if they're to be respected and valued as our fellow citizens, we must stop using language that devalues and sets them apart.

The use of disability descriptors is appropriate *only* in the service system (at those ubiquitous "I" team meetings) and in medical or legal settings. Medical diagnoses have no place—and they should be irrelevant—within families, among friends, and in the community.

Many erroneously share a diagnosis in order to convey information, as when a parent says, "My child has Down syndrome," hoping others will realize her child needs certain accommodations or supports. But the outcome of this action can be less than desirable! A diagnosis can scare people, generate pity, and/or set up exclusion ("We can't handle people *like that...*"). In these circumstances, *and when it's appropriate,* we can simply describe the person's *needs* in a respectful, dignified manner, and *omit the diagnosis.*

Besides, *the diagnosis is nobody's business!* Have individuals with disabilities given us permission to share their personal information with others? If not, how dare we violate their trust! Do *you* routinely tell every Tom, Dick, and Harry about the boil on your spouse's behind? (I hope not!) And we often talk about people with disabilities *in front of them, as if they're not there.* We must stop this demeaning practice!

My son, Benjamin, is 22 years old. His interests, strengths, and dreams are more important than his diagnosis! He loves politics, classic rock, and movies, and has earned two karate belts, performed in plays, and won a national award for his *Thumbs Down to Pity* film. Benj is attending college, where he's a member of Phi Theta Kappa national honor society, and he wants to become a writer. He has blonde hair, blue eyes, and cerebral palsy. His diagnosis is just one of many characteristics of his whole persona. *He is not his disability, and his potential cannot be predicted by his diagnosis.*

When I meet new people, I don't whine that I'll never be a prima ballerina. I focus on my strengths, not on limitations. Don't you do the same? So when speaking about my son, I don't say, "Benj can't write with a pencil." I say, "Benj writes on a computer." I don't say, "He can't walk." I say, "He uses a power chair." It's a simple, *but vitally important,* matter of perspective. If I want others to know what a great young man he is—more importantly, *if I want him to know what a great young man he is*—I must use positive and accurate descriptors that portray him as a valuable, respected, and wonderful person.

The words used to describe a person have a powerful impact on the person's self-image. For generations, the hearts and minds of people with disabilities have been crushed by negative, stereotypical words which created harmful, mythical perceptions and caused other detrimental consequences. We must stop believing and perpetuating the myths—*the lies*—of labels. Children and adults who have conditions called "disabilities" are unique individuals with unlimited potential, like everyone else!

The Civil Rights and Women's Movements prompted changes in language and attitudes. The Disability Rights Movement is following in those important footsteps. People First Language was created by individuals who said, "We are *not* our disabilities." It's not "political correctness," but good manners and respect.

We can create a new paradigm of disability. In the process, we'll change ourselves and our world—as well as the lives of millions of children and adults. It's time to care about the *feelings* of the *people we're talking about* and to carefully consider what *perceptions* we create about people with disabilities with our words.

Isn't it time to make this change? If not now, when? If not you, who?
Using People First Language is the right thing to do, so let's do it!

Examples of People First Language

Say:	Instead of:
People with disabilities.	The handicapped or disabled.
Paul has a cognitive disability (diagnosis).	He's mentally retarded.
Kate has autism (or a diagnosis of...)	She's autistic.
Ryan has Down syndrome (or a diagnosis of...)	He's Down's; a Down's person; mongoloid.
Sara has a learning disability (diagnosis).	She's learning disabled.
Bob has a physical disability (diagnosis).	He's a quadriplegic/is crippled.
Mary is of short stature/Mary's a little person.	She's a dwarf/midget.
Tom has a mental health condition	He's emotionally disturbed/mentally ill.
Nora uses a wheelchair/mobility chair	She's confined to/is wheelchair bound.
Steve receives special ed services	He's in special ed; is a sped student/inclusion student.
Tonya has a developmental delay	She's developmentally delayed.
Children without disabilities	Normal/healthy/typical kids.
Communicates with her eyes/device/etc.	Is non-verbal.
Customer.	Client, consumer, recipient, etc.
Congenital disability	Birth defect.
Brain injury	Brain damaged.
Accessible parking, hotel room, etc.	Handicapped parking, hotel room, etc.
She needs . . . or she uses	She has a problem with. . . /She has special needs.

Keep thinking—there are many other descriptors we need to change!

Appendix C. Marketing Document

THE ASSISTIVE TECHNOLOGY

RESOURCE CENTER

The ATRC at WPI

Email: atrc@wpi.edu
Phone: 1-508-831-6056
Address: Room 129 of Higgins Labs
WPI, 100 Institute Road
Worcester, MA 01609

The Assistive Technology Resource Center

At Worcester Polytechnic Institute

The Assistive Technology Resource Center (ATRC) of Worcester Polytechnic Institute was founded in 1999. The center serves individuals with disabilities by providing them with an access to assistive devices through collaboration with other rehabilitation organizations with respect to modification of an existing device, or design of a custom device. Currently, it is overseen by Mechanical Engineering Professors Allen H. Hoffman, and Holly K. Ault, and Andrea Fandetti, the present Lab Manager. Assistive technology is intended to enhance individuals' qualities of life by giving them greater independence in performing otherwise difficult tasks due to their disability. Past ATRC activities have generated assistive devices designed to improve people's lives in the areas of daily living, education, vocation, and sports.

Within the ATRC, assistive technology devices are designed by both undergraduate and graduate students as a part of the WPI curriculum. Undergraduate students are required to complete two major projects, where students typically work in groups of three over three academic terms. The junior level project merges society and technology to develop results that have a societal impact. The senior design project gives students the opportunity to apply their four years of study within their major discipline to the solution of a real world problem. Additionally, in several engineering design classes, students are given six weeks to design and develop a prototype for solving an assistive technology problem. Graduate students can also develop new devices or conduct research on existing devices as part of their thesis or directed research.

Assistive devices are intended to increase the independence of people with disabilities by enhancing their existing capabilities through the use of technology. Several projects within the ATRC have resulted in devices that improve an individual's day to day life. Daily living aids can facilitate a person's mobility and his or her ability to perform common household tasks such as grooming and eating. The ATRC has worked on projects including wheelchair components, prosthetics, and devices that help with common tasks such as eating independently, dressing, and operating common appliances. Some typical projects in this area are described in the following paragraphs.

The Monson Developmental Center[1] approached the ATRC with the request for a device to eliminate a hazardous condition for a wheelchair user with cognitive disabilities and autism. The patient enjoyed propelling himself backwards at high speeds, thereby creating an unsafe condition. Three WPI students developed an adjustable glide control mechanism that depended on adjustable friction belts wrapped around the hubs of the wheels (Figure 1). This mechanism prevented the wheelchair from reaching high speeds but still allowed the patient to maneuver independently (Boettcher, McLean, Sundberg, Klockars, Hoffman, 2006)[I].

Figure 1. Glide control mechanism on wheelchair

People who use wheelchairs need to elevate their legs periodically in order to prevent loss of circulation in their lower extremities, which can cause pressure sores and swelling of the legs. With currently available legrests, wheelchair users are often unable to elevate their legsrests independently. Even when a caregiver helps them, the limited extension of the legrest may not entirely alleviate the problem. A graduate student created a new design for an elevating legrest that could be independently operated by the user (Hoffman, Couture, 2006)[II]. This new legrest follows the arc of the person's leg and is extended through a range of degrees of extension as it elevates the leg. The design also includes an adjustable pivot point that allows for use by different sized people (Figure 2). This device met with a favorable response from a potential user, but further improvements are necessary before it can be made available in the commercial market.

Figure 2. Elevating legrest on wheelchair

Individuals with disabilities such as those caused by stroke often find it difficult to operate a manual wheelchair since a standard wheelchair requires the use of both hands. While one arm drive wheelchairs are commercially available, they are often difficult to operate. A student group developed a new one arm drive wheelchair which minimizes the dexterity and strength required to operate the wheelchair and provides a comfortable position for the user's hand. This design is potentially useful for patients with mobility limitations as a result of clinical conditions such as cerebrovascular disease (stroke), osteoarthritis, and multiple sclerosis (Hoffman, Cassidy, LeMarbre, Madsen, Ault, 2007)[III].

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[1] *http://www.graham-meus.com/Pages/Monson.html*

Several individuals with disabilities are transported between their homes and daily workplaces in large vans, but many find it difficult to enter the van because of the distance between the ground and the base of the van. The step stools on the market do not provide enough stability to the user because of the small tread area on the base of the stool. In order to solve this problem, a course design project at WPI was completed through the ATRC to improve accessibility of multi-passenger vans. Student groups developed prototypes that were sturdy, easy to store, and safe to handle. One prototype that was developed was a collapsible step stool with extended rods for users to grip for stability (Figure 3). This product ensures the safety of an individual with disabilities entering a large van because of the stability it provides through a comfortable base to step onto and handles to grasp onto when entering the van.

Figure 3. Accessible step stool

Individuals with visual impairments, physical disabilities, and cognitive disabilities are often unable to operate standard TV remotes because of the complexity of the buttons. Since the adaptable remotes on the market are not applicable to every person with disabilities, the main goal of a course design project was to design a remote that can be used by individuals with varying disabilities. Groups of students from a design class developed several prototypes, with one group creating a simplified, color-coded remote with a total of five buttons of different shapes (Figure 4). Though the remote was designed for a specific client, it could potentially be used by individuals with other visual, physical, and cognitive disabilities.

Figure 4. Adapted TV remote

The tram system in Melbourne, Australia currently includes 150 accessible tram stops but the Public Transport Division of the Department of Infrastructure[2] is investigating creating more stops by 2012. In 2008, a group of WPI students worked to identify another 270 potential stops. The team considered the road structure and the environment around the tram stop to identify which tram stops to make accessible. They developed a rating system to prioritize certain tram stops in order to aid the Public Transport Division in concentrating their efforts.

Another area of focus in the broad category of assistive technology is special education. In the school setting, adaptive resources allow students with disabilities to learn at the same pace as

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[2] *www.doi.vic.gov.au/transport*

other students. Adaptive resources, when used in the classroom, aid students who have learning disabilities, and physical limitations. Other projects completed through the ATRC are aimed at facilitating classroom learning for those with disabilities. Examples of assistive technology in the classroom include visual aids, modified computer access methods, and adapted recreational activities.

Three WPI students worked with schools in Melbourne, Australia to adapt their existing hands on science programs for students with disabilities. The group worked to identify the disabilities that were not compatible with the programs in place and categorized them into auditory, visual, and mobility impairments. They created a matrix that the teacher can use in order to identify an accommodation for a student based on her disability and the type of science experiment. This matrix has been implemented in different educational institutions by the Melbourne Commonwealth Scientific and Industrial Research Organization Centre[3] and is now available for use by teachers in order to provide students with disabilities the opportunity to excel in science programs.

Assistive technology can also serve individuals with disabilities in the workplace. These devices bridge the gap between the person's physical abilities and daily job requirements. The support that vocational assistive technology provides allows individuals with physical or cognitive disabilities to complete their regular activities in the workplace. Some examples are devices that facilitate communication, labor-intensive activities, or use of specialized computer software.

A maintenance man and finish carpenter who works for a commercial property owner and general contractor had an accident that resulted in portions of two fingers on his right hand being amputated. This loss of function in his dominant hand limited his ability to perform the task of using aerosol spray cans at his job. As a course design project, three student groups worked on this problem and developed three different solutions. The user tested all of them and chose the design that only involved his thumb and pinky finger to hold the can and allowed him to use his middle finger to activate the spray (Figure 5). He currently uses this device at his job.

Figure 5. Adapted spray can holder

Assistive technology can also be applied to sports and recreational activities. Existing sports equipment can be modified to suit the needs of individuals with physical limitations. Examples of modified equipment include adaptations to video game controls, cuffs on racket grips, seating systems on boats, and modifications to skiing and biking gear.

[3] *http://www.csiro.au/*

Some residents with special needs at the Seven Hills Pediatric Center[4] wanted to bowl but were physically limited. Three students designed a device that consisted of a ball launching mechanism, a ball catching device, a ball returning system, and a method for easy pin setup. The portable device is activated by a single switch so it is easy to use while sitting in a wheelchair. This game is currently being used at Seven Hills today.

In addition to designing and developing devices, the ATRC is also involved in various research studies. Due to the lack of instructional manuals, staff members in direct care homes often have difficulty in performing simple repairs to wheelchairs and reporting more complicated problems to repair technicians. The Department of Developmental Services (DDS)[5] sponsored a project at WPI, which involved the development and implementation of a wheelchair maintenance manual. The main goal of the project was to improve communication between staff at the DDS group homes and wheelchair vendors. The manual was tested in four group homes in the Worcester County and staff found that both the repair of simple issues and the communication process for more complex repairs became more efficient.

Past projects of the ATRC have been successful in meeting the unique needs of clients and users and in improving the user's quality of life. The ATRC continues to offer students the opportunity to complete design projects in the Center, which in turn allows for the development of new devices and technology.

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The ATRC is located in Room 129 of Higgins Labs at WPI, 100 Institution Road, Worcester MA 01609 and may be contacted by email (atrc@wpi.edu), or by phone at 1-508-831-6056.

I. Eric M. Couture (2006), "The Design and Manufacture of an Elevating/Articulating Manual Wheelchair Legrest."

II. B. Boettcher, T. McLean, K. Sundberg, B. Klockars, and A.H. Hoffman (2006), "Design of a Glide Control Device for a Manual Wheelchair", in Proceedings of the 2006 Annual RESNA Conference, Atlanta, GA.

III. A. Hoffman, S. Cassidy, S. LeMarbre, T. Madsen, H. Ault (2007), "Development of an Ergonomic One Arm Drive Wheelchair", Proceedings of the 2008 Annual RESNA Conference, Washington, D.C.

[4] *http://www.sevenhills.org/*
[5] *mass.gov/dmr*

Appendix D. Document of Past Projects

DOCUMENT OF PAST PROJECTS

ASSISTIVE TECHNOLOGY RESOURCE CENTER

Worcester Polytechnic Institute

This document contains summaries of all projects completed within the ATRC since its inception in 1999. This document was created so that interested individuals can obtain a concise description of a particular project. The projects are organized by project type (MQP, IQP, Graduate M.S. Thesis, and Course Design Project) and within each category, they are listed in chronological order. Each summary is preceded by the title of the project, the names of students who were involved in the project, the date of submission, and identifying keywords. At the end of the document, an index containing all keywords provides the numbers of the projects that correspond to a given keyword.

Major Qualifying Projects

The Major Qualifying Project (MQP) is the project that students complete in their senior year at WPI. The MQP is designed to allow undergraduate students to apply their four years of study within their major discipline to the solution of a real world problem. The MQP both complements the courses completed at WPI and represents a type of project that students will go on to work on in their careers. The MQP is a group project of three to four interdisciplinary students, each contributing his or her specific area of expertise to the development of a solution to the problem statement. Some MQP's result in professional publications and in a few cases, patent applications. The potential for the final design to gain a publication or patent allows the students in the MQP group to gain an exposure to the business and marketing side of engineering design.

1. MQP: Design and Fabrication of a Child Mobility Device – John Desrosiers, Troy Nielsen, and James Trapp

April 1991

Keywords: Mobility, Children, Cerebral Palsy

The goal of this project was to design an electrically powered mobility device for a two year old child with cerebral palsy at the Massachusetts Hospital School (MHS). The device would need to accommodate different types of therapeutic seating devices since the child will use it for the rehabilitative treatment of his functional limitations. Frequent use of the mobility device should increase his muscular control functions and heighten his sense of ambulatory independence. The team first researched wheelchairs, powered mobility for children, power wheels toys, and cerebral palsy to form a set of task specifications and design considerations. An initial design was developed which included a frame design, a power system consisting of two motors, and an electrical control system. The final design consisted of an aluminum tube frame, two 6-volt DC motors, and microswitch directional controls. This design was loaded with approximately 40 pounds and tested on an artificial turf football field for a distance of 50 yards. After performing these tests and obtaining advice from the project advisors and the MHS personnel, some modifications were made to the initial design. The turning of the device was changed from two motors driving forward to one motor driving forward and the other driving in reverse. The device can accommodate different seating systems, can travel on both outdoor and indoor terrain, and can adjust according to the body size of the child for the next three to four years. The final product was presented to the child and his family and then some recommendations were made for future design improvement.

2. MQP: <u>The Art Class Assistor</u> – Brendan McLellan, and Lap Nguyen

May 1992

Keywords: Classroom, Cerebral Palsy, Muscular Dystrophy

The objective of this project was to develop a supportive device that would support the arms of students who have various forms of muscle weaknesses and enable them to perform normal artistic activities in art class. These students are not able to move their arms easily over the paper, so often have trouble drawing. The design team first researched cerebral palsy and muscular dystrophy, two common conditions that result in muscle weakness. The team then explored existing devices such as the Roll and Slide, drafting tables, and computer plotters. After design specifications were created, some preliminary designs were considered including the rotating spring locked device, the rotating and sliding device, the overhead supportive device, and the replaceable tray. The final design chosen consisted of a paper tray, side tracks (bottom track, top track, and spacer), Thomson pillow bearings and shafts, arm support, roller bearings, and stopper. It supports the student's arm and enables the student to move to any portion of the paper to accomplish the necessary drawing activities. Testing of this device was conducted on a student at the Massachusetts Hospital School with muscular dystrophy. The device was also left with the art teacher for several weeks so she could complete the analysis on how effective the device would be for other students. The results showed that the device enhanced the performance of drawing for both left and right-handed students who had various forms of muscle weakness. Even though the final product was developed for an art class setting, it could be modified to accommodate individuals who have difficulty in performing other activities. Several different people used the device over a period of several years.

3. MQP: <u>The Design and Development of a Reacher/Gripper Device</u> – David Flinton, William Sullivan

May 1992

Keywords: Arthrogryposis, Powered Arm, Children, Object Transport

The goal of this project was to develop a device that would allow a student with Arthrogryposis at the Massachusetts Hospital School to grip and transport objects from ground level to within her own reach, while seated in an electric wheelchair. The student is not able to grip objects that have fallen to the ground due to the muscle weakness and irregularities in her hands and arms. The design team set out to design a robotic arm that would allow her to reach for these objects on the ground while seated in an elevated position in her wheelchair. Reacher and gripper devices are commercially available, but this student was unable to maintain a firm grip on the device as she was raising the object from the ground. The design specifications for this project stated that the device must include a locking mechanism so that the user does not need to maintain any force on the device while it is being used. Other design specifications included that the device must be motorized and switch operated, must not interfere with the other functions of the wheelchair, and must be safe for the user. The final design involves three main components: a gripper, an arm, and a control box. The powered gripper consists of a rotating threaded rod that allows it to grasp an object placed between a set of two fingers. The arm allows for the transport of the gripper and object from ground level to within the student's reach by way of another motor. The control box is the component of the device operated by the user and has two toggle switches that are used to operate the device. Preliminary testing and testing by the user both indicated that the device met its functional requirements by allowing the user to easily grip objects on the ground and retrieve them from her position while seated in a wheelchair. This project was published in the Proceedings of RESNA Conference in 1993.

A.H. Hoffman, H.K. Ault, D.R. Flinton and W.B. Sullivan, "The Design and Development of a Reacher/Gripper Device for a Child with Arthrogryposis", *Proceedings of the RESNA'93 Conference*, Vol. 13, pp. 507-509, 1993.

4. MQP: <u>Design and Manufacture of a Rehabilitative Mobility Device for a Physically Challenged Child</u> – Jennifer Almy, Dean Giolas, Brian Goetz, Eric Graham, Gary Krebs

January 1993

Keywords: Arthrogryposis, Children, Mobility, Therapeutic Assistant

The goal of this MQP was to design and develop a therapeutic and recreational mobility device for a three year old child with a physical disability. The child has a case of Arthrogryposis Multiplex Congenita, a disorder that causes him to have a limited range of motion in his knees, dislocated hips, clubbed feet, and irregularly positioned thumbs. The child's therapists indicated that the device should allow the child to repeatedly flex his knees as a therapeutic exercise without pushing him beyond his abilities. The MQP team assessed which motions the child was capable of performing in order to determine which motions to incorporate into the mobility device. The team decided to build a scooter that would be adjustable to the child's growth. Any changes in his range of motion over at least three years should produce appropriate torques and velocities without too much friction. The final design involved a standard tricycle frame with additional tubing to increase the length of the wheel's base. Two adjustable foot plates that can be raised or lowered were used for different types of therapy involving one or both legs. The tricycle also incorporates an adjustable seat and handlebars that can be locked into a certain position to accommodate a larger range of motion. Testing of the tricycle by the child indicated that he was able to easily use the tricycle and enjoys riding it. The grips on the tricycle and the foot plates both present therapeutic benefits by both allowing him to open his grip and use his legs with the proper hip motion. The child's teachers, therapists, and parents, also stated that the child enjoys using the scooter and is able to successfully operate it. The device was successfully used until the client outgrew it.

5. MQP: Design, Construction, and Evaluation of a Universal Arm – Kerry M. Bagdonovich, Kathryn M. Coughlin, James N. Woyciesjes

April 1993

Keywords: Mechanical Arm, Cerebral Palsy

The goal of this MQP was to develop an assistive device that would hold and position objects both horizontally and vertically to aid a client at the Massachusetts Hospital School with cerebral palsy. The student has limited motor control on the right side of her body, which prevented her from being able to dry her hair, hold a mirror, use a camera to take pictures, and perform other tasks independently. The design team worked to develop a mechanical device that can be operated with a hand crank to allow the student to perform these tasks independently, while encouraging therapeutic exercise through the use of the crank. The MQP team worked with the student to evaluate her physical abilities, such as the extent of her motor control, in order to determine the range of smotion that the device must have and her ability to turn cranks and knobs that could be incorporated in the final design. The prototype developed involved a hand crank rotation that can be operated with one hand and translated into vertical motion of the device. The device contains an attachment interface for it to connect to the object being positioned on the device. The interface involves two degrees of freedom and consists of a knob and handle attachment to hold and mount the object in place. Testing of the device showed that the client was able to operate the universal arm with ease by turning the knobs to secure an object and operating the hand crank for vertical motion. The device presented benefits to the student because of her new ability to perform certain tasks independently that had not been possible before. Additionally, motor control of the student's right hand improved through her use of the hand crank while operating the device.

6. MQP: A Secondary Joystick Adapter For Force Reduction – Enrico Cafro, Michele Suszko, and Steven Yany

April 1994

Keywords: Cerebral Palsy, Wheelchair Joystick

The purpose of this project was to develop a customized design of a secondary joystick linkage retrofitted to interface with the current joystick on the wheelchair of an individual with cerebral palsy. The continuous and sudden movements of the individual exert excessive forces on the wheelchair joystick, resulting in frequent breakage. A secondary joystick was necessary to limit the forces applied to the original joystick. The design team first researched the effects of cerebral palsy, his current joystick, modes of failure, and other current joystick designs. Task specifications were then listed based on the advantages and disadvantages of existing designs and several models for prototypes were created. The design that accounted for the most task specifications was then manufactured. This design has a thicker, stronger shaft and a ball joint as the pivoting mechanism, reducing the amount of force applied to the original joystick. A simple platform allows the ball joint to easily rotate within. This mechanism gives the joystick the capability of being displaced a greater distance than the original one. Mechanical stops prevent excessive force from being transferred to the wheelchair joystick. Most of the parts of the device were then machined from sheets of aluminum and the others were purchased or donated. Once fully, assembled, a few minor modifications were made and sent to the student at the Massachusetts Hospital School for feedback. This joystick adapter was successful in reducing the force applied to the Invacare joystick.

7. MQP: <u>Design and Fabrication of a Backpack Access Device</u> – Susan MacPherson, Christopher Michalak, Michael Olivia, James O'Sullivan Jr.

April 1996

Keywords: Cerebral Palsy, Children, Object Transport

The goal of this MQP was to design a backpack access device to allow a student at Massachusetts Hospital School with cerebral palsy to independently access her backpack. The student had limited range of motion and fine motor control on her left side, so she required a device that would transport her backpack from the storage position at the rear of her wheelchair to a location that she can access, and then back to the storage position. The design team created a list of the device's functional requirements which stated that the device must not limit the student's range of motion, must not interfere with the function of the wheelchair, must be able to firmly secure the backpack, and must be able to support the weight of a 16 pound backpack. After evaluating four initial design alternatives, the team determined that the alternative that best addressed the functional requirements was a design that involved a robotic four bar mechanism connected by joints to allow rotational motion with a pivot at the back of the wheelchair frame. The device was powered by a motor that generated the appropriate amount of torque to allow the device to perform its task of transporting a 16 pound backpack from the rear of the wheelchair to the front of the wheelchair. In the final design, the straps of the student's backpack are placed over a coupler extension and a chain drive system consisting of the motor and a crank shaft allows translational motion of the slider joint to transport the backpack. Testing and evaluation of the device showed that the student was able to easily and independently operate the device by pressing the toggle switches on the control box mounted on the wheelchair armrest. After minor modifications based on the client's feedback, the device was found to meet most of the initial task specifications and functional requirements.

8. MQP: <u>Swing Away Joystick</u> – Erica Gadbois, Andrew Kohm, and Michele Provencher

May 1997

Keywords: Wheelchair Joystick, Cerebral Palsy

The objective of this project was to design a new swing away joystick that would enable individuals to independently move themselves up to and under desks or tabletops without interference from the joystick. A student with cerebral palsy from the Massachusetts Hospital School relied on an electric wheelchair as a means of getting from place to place. Unfortunately, he had problems approaching a desk since the joystick arm on the wheelchair protruded too far forward. The design team first researched existing joystick arms and necessary accommodations for individuals with cerebral palsy. Several preliminary designs were then created according to the task specifications. Three designs were manufactured: the Dual Arm Joystick, the Single Arm Joystick, and the Parallelogram Joystick. These prototypes were tested on a replica of the left side of the student's wheelchair and were also evaluated by the student at the Massachusetts Hospital School. The final design chosen was the Dual Arm Joystick. This design incorporated the joystick as an attachment to a metal rod, which was angled in a vertical plane so that it would not hit the armrest as it swung away. Two pivot joints allowed the joystick to swing outward from the chair. The team then considered two locking mechanisms for the joystick, a U-shaped lock and a "Z" lock. The "Z" lock was more durable and locked with much more accuracy. Thus, the final design of the Swing Away Joystick combined the Dual Arm Joystick and the "Z" locking mechanism. This device was not drastically different from the original device being used by the student so he was able to adapt to it with little difficulty.

9. MQP: <u>Powered Arm Orthosis</u> – Shawn Moynihan, Michael Pousland, and Rebecca Prince

May 1997

Keywords: Muscular Dystrophy, Powered Arm

The goal of this project was to design and manufacture a wheelchair mounted device that would effectively increase the overall mobility and range of motion of those with Muscular Dystrophy (MD). MD is a progressively debilitating neuromuscular disease, making the individual's muscles weaker over time and causing the lack of ability to move his extremities without difficulty. The design team first researched existing arm mobility devices and existing wheelchair attachment brackets to create several conceptual designs. After rating these designs, a final prototype was designed using anthropometric data, to determine sizes and weights of the arms of potential users. The orthosis has powered flexion/extension about the elbow, powered flexion/extension about the shoulder, and passive rotation about the shoulder of the left arm, allowing the individual to move his arms as he desires. Two toggle switches that are attached to the right armrest of the wheelchair control these movements. The mechanism's power is supplied by a 12V DC battery and motion is generated by two parallel shaft DC gear motors. After the mechanism was fully assembled and mounted to the wheelchair, each of the three group members tested the device in several stages. First, the device was tested without using the power transmission to evaluate the kinematics of the device. For the second tests, just the circuits and motors were tested. Finally, three chains were placed on the device to transmit power and the arm was activated. Analyses of these tests showed that certain adjustments needed to be made before the device was ready for actual use. The design team made some recommendations for future groups to continue development of the device.

10. MQP: <u>Powered Arm Orthosis II</u>– Dennis Hubbard Jr., Gregory Murphy, Victor Guy

April 1998

Keywords: Powered Arm, Muscular Dystrophy

The goal of this MQP was to improve on a design for a powered, wheelchair mounted mechanical arm orthosis that was developed as a prior MQP in 1997. Individuals with Duchenne's Muscular Dystrophy are unable to have complete mobility in their arms and legs, but do possess hand function, which can be used provided the hand can be properly positioned. A powered orthosis can help to increase in the independence of individuals with limited arm motion by allowing them to perform daily activities without assistance. Current assistive devices are focused on providing non-powered assistance, but powered devices are relatively rare and require a novel design concept. In order to develop the device, the design team considered the natural ability of the client's arms, response time, and the strength that the device would require in order to perform the appropriate tasks. The final orthosis would need to accurately mimic the natural movements of the client's shoulder and forearm to prevent any injury to the client. The design team also determined that the design must be adjustable in order to accommodate any changes in the user's condition. The final wheelchair mounted design involved two hydraulic cylinders to provide the powered motion for the shoulder and elbow, parallel rods to allow for necessary sliding of the elbow for abduction, and an elbow segment to allow for movement at the elbow. The user interface consisted of switches that were integrated into an electric control system and could be easily placed in the neutral position to eliminate any unwanted action of the device. The device included four degrees of freedom: two powered and two passive, and allowed for shoulder flexion, extension, humeral rotation and elbow flexion. The elbow contained powered flexion/extension as well as a passive joint. The shoulder joint allowed for hydraulically powered humeral flexion/extension. Humeral rotation was incorporated through a passive swivel joint. The group conducted tests of deflection under static loading conditions, the rate of rotation at the shoulder and elbow joints, and functional testing by users. Evaluations showed that the device met most of its objectives, allowed for a full range of motion, and provided appropriate stability and safety to the user.

11. MQP: <u>Powered Arm Orthosis III</u> – Christopher Felice, Sean Smith

January 1999

Keywords: Powered Arm, Muscular Dystrophy

The goal of this MQP was to design a body-mounted powered arm orthosis that would provide powered flexion and extension of the shoulder, abduction and adduction of the arm, flexion and extension of the elbow, and humeral rotation. Individuals with Duchenne Muscular Dystrophy have slowly diminishing muscle control and strength in their arms, but maintain both strength and mobility in their hands. They are unable to perform daily tasks such as grooming and eating, so there is the need for an orthotic device that individuals with decreased arm strength can use to perform these tasks. Current products allow the individual to perform certain specialized motions, but do not restore an individual's freedom of motion. The objectives of this project were to develop a device that would provide sufficient power to move the device itself, as well as the user's arm, and would produce forces and velocities comparable to those of a fully functional arm since high forces and speeds can pose safety risks. Prior MQPs resulted in prototypes that involved electric motors and hydraulics, both of which were wheelchair mounted. A device that would transfer power from an external mechanism, but utilize the passive motion of the joints for alignment would provide enhanced integration of the dev ice with the joints of the arm and shoulder. The MQP group considered a kinematic analysis of a human arm, the daily activities that an individual performs, and the required range of motion of the device in order to develop a prototype of the orthosis. The final design concept was determined by testing prototypes of the components. The outer radius of the upper elbow joint cuff accommodates passive humeral rotations of 180°. A pin connects the upper portion of the elbow joint to the lower portion of the elbow joint to allow for flexion and extension. Analysis of the device indicated that the powered arm orthosis provides four degrees of freedom and allows for the passive self-alignment of the joints, while still providing the appropriate motions at the shoulder and elbow joints.

12. MQP: <u>Design of Laptray Easel for Disabled</u> – Kristofor Hallee, Annika Nilson, Tamara Samuels

May 1999

Keywords: Cerebral Palsy, Wheelchair Laptray

The goal of this MQP was to design an integrated easel and tray system for a student at the Massachusetts Hospital School who uses a wheelchair and has cerebral palsy. The student has uncontrollable muscle activity in his arms, legs, and trunk, and therefore, he is secured in his wheelchair with straps. He uses a picture board on his laptray to communicate with others through eye movements and he uses an easel attached to the laptray in order to hold books, magazines, and papers that he needs to read. The system that the student was using involved an easel mounted on tracks on the side of the tray. Due to the linkage between the two components, the system obscured his view of others and was only stable in one position. The student was in need of a laptray and easel system with a two-degree of freedom linkage, allowing for the easel to be stored underneath the laptray when not in use. The MQP team developed a system involving two gears to allow for the rotation of the easel around the horizontal and vertical axes, as well as for the movement of the easel toward and away from the user. Another gear mechanism allowed for the easel to be locked into place after being positioned correctly. The design team evaluated the final design by testing for any potential failure of the device, especially focusing their efforts on ensuring the proper operation of the locking mechanism. They also tested the system to ensure that it would withstand appropriate loads, that it was easily adjustable, and that it would stow under the laptray. Results of the testing showed that the device was easy to adjust and manipulate and that it improved the range of vision for the user due to the storage capabilities of the easel under the laptray.

13. MQP: Two Degree of Freedom Automated Prosthetic Wrist – Theron Johnson, Siu Ng, Garrett Sutton, Eric Wilhelm

May 1999

Keywords: Joint Prosthetic, Hand Positioning

The goal of this MQP was to design and develop a prosthetic wrist with two degrees of freedom to enable the user of the prosthetic device to better position his arm for gripping, grasping, and turning items. Current powered prosthetic wrists have one degree of freedom, which allows the user to pronate and supinate the arm, or turn the palm outward and inward, respectively. Though these two motions allow individuals using the prosthetic wrist to turn doorknobs and dials, there are still several daily activities such as combing one's hair and operating keys that require another degree of freedom. Therefore, a powered prosthetic wrist capable of not only pronation and supination, but also flexion and extension of the wrist with the ability to position the hand to grasp and grip objects could be beneficial to individuals using an artificial wrist. The design team determined that the prosthetic wrist should be compatible with pre-existing prosthetic hands, allow for a realistic range of motion, be constructed to have realistic dimensions, and contain a mechanism to allow the user to know the position of the wrist and return it to the neutral position. The design team considered various types of gears and linkage systems to determine which would best meet the design specifications and be most efficient. The gear allowing for the two axes of motion at the wrist was selected. The final design consisted of gears and rotation bearings within an outer tube. The prosthetic wrist was designed with the intention of being incorporated into an existing arm using screws and fasteners. Testing of the final design found that the wrist did incorporate two degrees of freedom to allow for gripping and grasping purposes and was able to generate appropriate torque outputs with a range of weights.

14. MQP: The Aquatic Rehabilitation Aid – Nancy Bedrossian, Kristin Carreau, Benjamin Nawrath

May 1999

Keywords: Therapeutic Assistant, Stability

The goal of this MQP was to design and develop a device that can provide support and stability to students who participate in therapeutic gait training using the buoyant forces of water.

During aquatic rehabilitation, students often have difficulty in maintaining stability as they walk and sometimes use a land walker for stability, however land walkers are not intended for use in the pool and can be difficult to use. The MQP group worked with a group of seven students at the Massachusetts Hospital School to represent a range of the body sizes that the device must accommodate. A list of design specifications were determined and included: the weight of the device should be greater than the buoyant force on the device so that it rests on the floor of the pool, it must be made of non-corrosive materials to prevent oxidation, it should resist tipping when in use, and the components of the device (straps, handgrips, height level) should be adjustable to accommodate several body types. The design team developed a prototype of a ring walker, which involved a frame, armrests, a belt, and four wheels. The prototype was then evaluated in a series of tests that determined its volume, weight, center of mass, and the buoyant force acting on the device. Testing of the device by a rehabilitation engineer and a student at the Massachusetts Hospital School indicated that the device was generally stable, but the height adjustment pins were difficult to manipulate. The final device was created by incorporating the suggestions from the testing process and staff and students at the Massachusetts Hospital School were satisfied with the stability that the device provided when used in conjunction with aquatic rehabilitation.

15. MQP: <u>Development Of a Prototype Bumper System For Powered Wheelchairs</u>-

Rosanna Catricala, Stefan Kohn, Justin Ripley

May 1999

Keywords: Bumper System, Footrest

The goal of this MQP was to design an energy absorbing bumper system that can protect the feet of a wheelchair user when the user is participating in contact sports or any other activities that involve contact between the wheelchair and its surroundings. Wheelchair users are able to play sports in existing powered wheelchairs that can weigh up to 300 lbs and travel at speeds up to 7 mph. However, a collision between a wheelchair traveling at these speeds and any surrounding objects can potentially injure the user, damage the wheelchair, or damage the surroundings. The design team developed a prototype of a bumper system that could be reversibly attached to a wheelchair, which consisted of two components, a modified footrest hanger and an integrated footbox. The footrest hanger is shaped like a parallelogram and includes a footrest and an energy absorbing element. When the user’s feet are placed on the footrest, the parallelogram deforms and the energy absorbing element compresses. The footbox contains an impact barrier and allows for lateral and frontal movement of the footrest. Static tests and impact tests were conducted to ensure that the bumper system could withstand the appropriate forces and strains. The evaluation of the bumper system indicated that when the bumper system was used in conjunction with the wheelchair, collisions during contact sports reduce the impact on the user and minimize damage to the wheelchair.

A.H. Hoffman, H.K. Ault, R. Catricala, G.M. Rabideau, S. Kohn and J. Ripley, "Development of a Prototype Bumper System for Powered Wheelchairs", *Proceedings of the RESNA 2002 Conference,* pp.468-470, 2000

16. MQP: Powered Wheelchair Dynamic Stability Model – Trevor W. Martin

January 2000

Keywords: Stability, Wheelchair Mathematical Model

The goal of this project was to develop a mathematical model to the dynamic stability of powered wheelchairs. Dynamic stability is the study of the set of circumstances that causes tipping when a wheelchair strikes an obstacle. Since manual wheelchairs experience more tipping than powered wheelchairs, there are not many prior studies involving the dynamic stability of powered wheelchairs. Stability models can make the wheelchairs safer but manufacturers do not take them into account. These manufacturers and individuals who use wheelchairs could benefit with a better understanding of the circumstances under which their wheelchairs will experience tipping. Using a complete free-body diagram that showed all of the forces acting on the wheelchair, a mathematical model was developed separately for each of the following situations: accelerating uphill, accelerating downhill, turning, and turning on a sloped surface. Then, Newton's laws were used to generate force and moment equations. These equations were solved under reasonable assumptions. Integrating these separate models into one, a flow chart was then created to give the final model a structured framework. The result was mathematical models for the dynamic stability of the powered wheelchair in the form of a flowchart. Using this flowchart, very few measurements are required to determine the correct model for a given set of circumstances. Also, turning models for stability were found to be much more complex than the uphill and downhill models.

17. MQP: Design and Fabrication of a Retractable Wheelchair Foottray – Kenneth Belliveau, and Melissa Carreau

May 2000

Keywords: Dystonia, Wheelchair Accessory

The goal of this project was to design a work surface that is both retractable and detachable from the user's powered wheelchair and can be operated independently by the user. The client served by the device has a neurological disorder called Dystonia that has rendered her arms and hands essentially useless for functional activities and has confined her to a wheelchair. The client uses her feet to perform daily tasks including writing and typing on a computer keyboard. To accommodate such activities, the client needs a work surface at her foot level. The design team created a set of specifications, goals, and preferences to describe the functional requirements and physical limitations of the product to be designed. The next step in the design process was to develop a number of tentative foot tray designs. Using a design decision matrix, the team evaluated the tentative designs to decide which would most effectively satisfy the user's needs. Of eight preliminary design ideas, three concepts were chosen for further development.

Physical models of these designs were created to determine their operating characteristics in all foreseeable situations. The most feasible design was selected as the final foot tray design.

The tray top offers 348 square inches of workspace. Shutters increase the work surface area by 71 percent. The tray top is constructed out of Lexan, which is a shatter resistant polycarbonate. The slides, to which the tray unit is attached, will hold up to 100 lbs of force in the vertical direction. These components have proven large and strong enough to support a variety of activities. Finally, the team suggested few improvements for the device such as: reattaching the bumpers to the C-channel, removing the small handle on the left shutter, realigning the C-channels, etc.

18. MQP: Arm Orthosis Body Mount – Adam G. Beckett, and Kurt L. Haggstrom

December 2000

Keywords: Muscular Dystrophy, Prosthetic Mount

The goal of this project was to design a device to mount a powered arm orthosis onto the body of a person using a wheelchair. Mounting the device onto the body is necessary because the individual would be much less constrained than if the orthosis was mounted on the wheelchair. The target users are individuals with Muscular Dystrophy, a degenerative disease that affects the skeletal muscles of the body. These users lack sufficient muscle control in their arms. A mounting system for a powered arm orthosis would help with daily activities. The design team researched shoulder kinematics and met with an orthotist to determine the design specifications of the mounting system. Four prototypes were designed, built, and tested. These prototypes were made of scrap material and were fit to a body-form for testing purposes. Markers and two lasers were placed on each of the prototypes so the motion under loading conditions could be mapped and analyzed. The most important specification was stability. Stability is required of the body mount because it must align the orthosis properly with the user's shoulder joint in order to function correctly. After testing the four prototypes, the final body mount was designed using the results of the tests. The final prototype was chosen based on optimal results of stability tests and deflection analysis of the prototype with an applied load. Detailed CAD models of the harness were constructed so that another group could analyze the models and build the device. Materials were selected for each of the components and an assembly procedure was developed so that the harness could be manufactured.

19. MQP: Dynamic Seating System Design – Brynn Hart, Nathan Smith, Melanie Tetreault

January 2001

Keywords: Dynamic Seating, Stability

The goal of this MQP was to create a model of a dynamic seating system to be used to relieve discomfort that individuals often experience due to the rigid seating systems present in standard wheelchairs. Due to the rigidity of the seating system, individuals seated in wheelchairs may experience lumbar extensor spasticity, which is the involuntary extension of the lumbar muscles of the lower back. This causes discomfort and an inability to maintain an upright posture for the user of the wheelchair. A dynamic seating system can alleviate this problem by supporting the user and responding to any changes in the user's position while seated in the wheelchair, while still maintaining the functionality of the seat. The design team modeled a system that would mimic the motion of an individual having a spasm in the lumbar muscles while seated in the wheelchair. Another objective of the design was to ensure that the seating system would force the user to return to his/her initial seating position after the completion of the spasm. The group considered the interactions between the user seated in the wheelchair and the wheelchair itself in order to model the points of contact as points of either rotational or translational motion. From there, three designs were selected for analysis of static stability on different angles of inclination in both the forward and rearward directions. By evaluating the forces due to the damper of the system at the point of attachment on the seat back and the spasm forces experienced at the shoulder blades, the design team determined the stability of the dynamic seating system in the different allowable positions. This project provided a model to determine the effect that the load on the wheelchair has on the dynamic movement of the seating system. This report also provided experimental values and analysis that can be used in future analysis and development of dynamic seating systems.

20. MQP: Design Of Tuck-Away Manual Wheelchair Brakes – Todd Clark, Christopher Meyer, and Garret Mier

April 2001

Keywords: Wheelchair Brake, Mobility

The goal of this project was to design, test and deliver a final manufactured manual wheelchair brake that would not interfere with the propulsion path of the user or injure the hand of the user in any way. Existing brakes often interfere with the individual's propulsion stroke and require frequent adjustments. Some brakes also cause injuries to the hands that could potentially be avoided with a tuck-away brake system. The MQP team first studied the forces involved in wheelchair propulsion and the stroke patterns of an individual using the wheelchair to create a set of functional requirements for the final design. Then, twelve conceptual designs were generated that addressed the gears, the spokes, the grips, the toggle bar, the mount, and the locking mechanism of the brake system. A design matrix was applied to determine the final three brake designs and engineering drawings were produced to assist with manufacturing process. The brakes that were manufactured were the Modified Quadra, the Bicycle Brake, and the Sliding Toggle Brake. The Modified Quadra was made up of five parts including the tube, the shaft, the handle, the brass cap, and the knurl brake. The Bicycle brake was composed of the support tube, the brake arm, and the mounting bracket. The components of the Sliding Toggle brake were the base tubes, the telescoping link, the brass-bearing link, the mount, and the modified handle for a four-bar toggle brake. Each manufactured brake was tested and evaluated according to the design specifications and recommendations were made according to analysis of the results and consultation with students and caregivers at the Massachusetts Hospital School. The recommendations made for the Modified Quandra indicated that the angle of the brake should be minimized in order to decrease the amount of friction to allow smoother motion of the braking mechanism. Recommendations for the bicycle brake involved the use of a larger brake caliper to allow for better gripping of the brake, as well as easier adjustment by the user. Recommendations made for the Sliding Toggle brake involved modification of the handle to allow for more stowage underneath the seat

21. MQP: <u>Design of a Glide Control Mechanism for a Manual Wheelchair</u> – Bonniejean Boettcher, Timothy MacLean, and Kenneth Sundberg

May 2002

Keywords: Stability, Mobility

The goal of this project was to design and develop a glide control mechanism for a middle aged client with autism at the Monson Developmental Center. The client enjoyed propelling himself backward in his wheelchair which could often pose a safety hazard if he ran into objects or into other people. The development of an attachable glide control mechanism would prevent the wheelchair from excessive gliding while still maintaining its freedom of motion. The design team first created a list of preliminary design concepts that would all reduce the amount of glide when attached to the wheelchair. These concepts included bicycle brake calipers, a friction clutch, a friction belt, a "Wheel of Fortune" friction device, a dragging brake, an electromagnetic device, a piston device, and a rotating brake. Lists of advantages and disadvantages were created for each device, and then each design was rated based on a priority matrix. After further analysis of cost and feasibility, the friction belt was chosen for development into a prototype. This design would include two belts which press against two hubs that are attached to the wheels of the wheelchair. The tension that this setup creates results in a greater frictional force between the belt and the hub, decreasing the ability of the wheels to rotate freely. The device was developed and tested for maneuverability, glide limitation, safety, wheel balance, and accessibility to the client. The device was then tested by the client and it was found that the glide control mechanism appropriately limited the speed that the wheelchair was able to reach, without inhibiting the mobility of the wheelchair.

22. MQP: <u>Adaptive Saddle for Massachusetts Hospital School</u> – Lisette Manrique, and Michael Landi

April 2003

Keywords: Therapeutic Assistance

The goal of this project was to design an adaptive saddle, which will promote independence for the rider and assist in therapeutic exercises, while maintaining safety for the rider, sidewalker, and horse. The staff of the horseback riding programs at Massachusetts Hospital School (MHS) was seeking an improved method for maintaining the positioning of students with disabilities in the saddle. Modifications to a saddle were designed and constructed to assist Physical Therapists and students of the Hippotherapy and therapeutic riding programs at MHS. The design's intent was to provide a saddle with removable/adjustable supports on both the back and front of the saddle. Safety, weight and durability were the most important aspects, which were taken into consideration throughout the design process. Seven preliminary designs were developed, which included both rigid and foam supports. A ranked functions chart was used to determine which design best fit the task specifications. A combination of a rigid, adjustable surcingle & back thoracic support was chosen as a final design. The device was tested both at WPI and at MHS and was proven to withhold all applied loads and moments. However, the horse was sensitive to the noises and to the different structure of the modified structure, creating an unsafe environment for the rider. The team recommended that the thoracic support not be used in future hippotherapy, that the surcingle device be used as forward leaning support, and that the staff conduct extensive training with the horses.

23. MQP: <u>Design of an Elevating legrest for a Wheelchair</u> – Johanna Barlow, and Daniel Reed

April 2003

Keywords: Wheelchair Legrest, Spina Bifida, Cerebral Palsy, Muscular Dystrophy

The goal of this project was to design an elevating legrest for a wheelchair that will improve circulation in the user's legs by allowing the knees to be straight when the legrest is in the elevated position, and the hips and upper legs to be stationary. Individuals with Spinal Bifida, Cerebral Palsy, and Muscular Dystrophy need the assistance of mobility devices such as a wheelchair to enable their independence. These wheelchairs need to provide proper support for comfort and need to allow the individual to reposition one's self in the chair. Changing one's position on the wheelchair is necessary for facilitating circulation in the limbs and decreasing the under-leg soreness. The design team began by creating functional requirements for the device and analyzing the fundamental governing equations. Three preliminary designs were then generated for each aspect of the device: motion of the legrest, user interface, locking mechanism, and attachment mechanism. Analyses of these design concepts through prioritization of functional requirements and creation of design matrices produced a final design. The device fits on the chair and matches the arc of legs within a 13-17 inch range. Adjustments to the pivot location can be made vertically and horizontally at 1/8" intervals, which will accommodate the use of various sized cushions and different femur lengths between users. The pivot adjustment can work for knee locations differing by as much 3 inches, both vertically and horizontally. The team concluded by suggesting few improvements for the device such as: introducing a new material to reduce the friction between the upper and the lower section of the legrest, developing a new locking mechanism that increases the degree of leg flexion, etc.

24. MQP: <u>Design of a Linkage Based Articulating Wheelchair Legrest</u> – Rebecca Duhaime, and Amy Gray

May 2004

Keywords: Wheelchair Legrest

The goal of this project is to design an articulating elevating legrest, which will not interfere with the wheelchair function. Current designs for articulating wheelchair legrests do not provide the extension and elevation needed to reduce hip flexion and increase blood circulation. Existing products and patents for available articulating legrests are also not as durable as the non-articulating variety. A 2002-2003 MQP attempted a similar project with a manual wheelchair user as a client. The end product did not interface with the wheelchair and had other manufacturing problems, and now serves as a prototype for analysis. Evaluation of the prototype concluded that there was binding in the slider caused by a lack of planar motion and an insufficient bearing surface.To solve these problems, an articulating wheelchair legrest that consists of a planar six bar linkage coupled with a linear slider was designed and built. The linkage system accommodates the elevation motion while the linear slider system accommodates the extension motion. When compared to an articulating design developed by the student group in 2002-2003, this design decreases the overall size and weight and increases durability. The team concluded by suggesting few improvements for the device such as: machining the linear bearing system with greater precision and allowing it to self align more readily to reduce binding, incorporating a plastic shield to protect hands from moving the linkage, and placing an activation handle at the lower end of the housing for mechanical advantage.

25. MQP: <u>Design of a One-Arm Driven Manual Wheelchair</u>– Jennifer Cofske, Barrett Franklin, and Darcy Vought

April 2005

Keywords: Mobility, Wheelchair Brake

The goal of this MQP was to design a wheelchair that can be operated using a single arm. Individuals with conditions such as stroke, osteoarthritis, and multiple sclerosis often have mobility limitations that present the need for a one-arm driven wheelchair. Commercially available devices that address this need can be difficult to use because of the dexterity or the hand positioning required for operation. Therefore, there is the need for a design for a one-arm driven manual wheelchair that minimizes the required dexterity for operation while improving comfort. The design team generated a list of required functions: the device must allow the wheelchair to be propelled using one arm, the device must allow the wheelchair to be steered using one arm, and the device must allow the wheelchair to brake using one arm. A list of means for meeting these functional requirements was developed, and then design alternatives using combinations of these means were generated. After an evaluation of the design alternatives, the double uni-directional cam clutch system using a toggle-stick was chosen for the final design. A rotor brake system was chosen for the braking mechanism. Each of the three components (propulsion, steering, and braking) were manufactured and were tested individually, and as a complete system. The design of the one-arm driven manual wheelchair was successful in decreasing the force required for propulsion, while maintaining appropriate forces for braking. While the three components used worked effectively when used independently of each other, the overall performance would require improvement prior to use by a client.

26. MQP: <u>Design of a One-Arm Driven Manual Wheelchair</u>– Sean Cassidy, Shaun LeMarbre, and Tiffany Madsen

Keywords: Mobility, Wheelchair Brake

March 2006

The goal of this MQP was to design a wheelchair that can be steered with one arm and has braking and propulsion mechanisms. About 25% of wheelchair users have medical conditions that can limit their mobility, and therefore need wheelchairs that are capable of single-appendage operation. The design team generated means for the required functions of the device. Possible means for steering the wheelchair included throttle-based steering, foot-steering, lever-based turning, bicycle cables under tension, and finger steering. Some possible braking mechanisms included cantilever bicycle brakes and disc brakes. Finally, some mechanisms explored for the propulsion system included a weighted hand crank, a cam-clutch with jointed rocker, a clutch-cable, and geared forward/reverse propulsion. The alternatives were evaluated and the cables in tension was chosen for the steering mechanism, rim brakes were chosen for the braking mechanism, and a dual rachet and pawl system was chosen for the propulsion mechanism. Each component of the design was manufactured and the components were assembled to form the final device. Testing was conducted in categories of propulsion, steering, braking, and overall performance. For the categories of propulsion, steering, and braking, the forces required for each action were measured and analyzed. In the overall performance category, an obstacle course was constructed and the operators of the course would observe the user's ability to complete the course with minimal instruction. Results of testing indicated that the wheelchair is capable of simultaneous braking and steering and minimized the amount of force required for propulsion.

27. MQP: <u>Design and Development of a Transhumeral Prosthetic Mounting System</u> - Michael Bertini, Zachary Dominguez, Joshua Morin, Elizabeth Palumbo

April 2006

Keywords: Prosthetic Mount, Stability

The goal of this project was to design, test, and develop a shoulder mount device that would accommodate an existing prosthesis used by an individual with a trans-humeral amputation. Due to the complexity of the glenohumeral joint at the shoulder, prosthesis attachment for individuals with trans-humeral amputations is not ideal in terms of load bearing capacity and range of motion. In order to develop a stable mounting system, the MQP group considered four commonly encountered loading positions that require the device to sustain high loads and still allow for a large range of motion. The design team developed a mounting system involving a harness, which serves to distribute the load over the user's torso, an exoskeletal shoulder joint, which allows for greater range of motion, and an interface that connects the mounting system with the prosthesis. Tests of the final device showed that it is able to withstand the appropriate axial and torsional loading and it permits a wide range of motion, thereby satisfying its functional requirements.

28. MQP: <u>Design of Trans-humeral Prosthetic Mounting System for Use in High Load Activities</u> – Bethany Corliss, Dave Giebenhain, Richard Gilley

May 2007

Keywords: Prosthetic Mount, Amputation

The goal of this project was to allow individuals with trans-humeral amputations to perform high load activities with their prostheses. Existing upper arm prostheses utilize a harnessing system to mount the device onto the residual limb of the individual with the amputation. This structure limits the range of motion for users, making them unable to carry out high load bearing activities. The design team first researched the human anatomy and other parallel systems, and also current technology regarding exoskeletons and harnesses. Several preliminary models were then developed all of which included a prosthesis attachment, a torso attachment and a mechanism connecting the two. The details of each design were evaluated by ranking them according to design specifications. The final design chosen includes a full back vest with a steel arch over the shoulder for mounting, a humeral bar, inner and outer rings, and prosthesis attachment bars. The arrangement of these components allow for three degrees of freedom of the shoulder joint. Optimal materials were chosen for the parts such as duck cloth with ionomer foam for the vest and the humeral attachment, steel for the shoulder arches, and nylon for the securing straps.

29. MQP: <u>Independent Transfer System for a Person with Limited Strength</u> – David Curran

May 2007

Keywords: Muscular Dystrophy, Mobility

The goal of this project was to develop a system to help a person with Muscular Dystrophy and limited strength with the act of transferring himself or herself from a bed to either of two wheelchairs and back. The client should be able to operate the device with no assistance and the device should be able to operate with no more power than can be provided by a standard residential electrical outlet. The design team first conducted research on current methods for making assisted transfers. Ideas were then generated for modifications to those methods. Machine elements that were able to perform certain duties of an aide were also researched. The team then tested the conceptual designs with mathematical and computer generated models. A final system was then generated that consists of a patient transfer lift and lifting hanger, a remote control for the lift, a women's life jacket, and a SALA Seat Sling. The client operates the device by first using the remote control to lift her from a lying position. Once she is in a sitting position, the life vest can be lowered to secure her arms into place. The user can then slide the sling under her knees and instruct the system to transport her to the wheelchair using the remote control. After the transfer, she can remove the components of the system from her body and then direct the system away from the wheelchair.

30. MQP: <u>Analysis of a Lower Limb Prosthesis</u> – Victoria Richardson, Erin Vozzola

April 2008

Keywords: Prosthetic Leg, Amputation

The objective of this project was to determine the optimal parameters for a low technology monolimb, which is a lower leg prosthesis. The monolimb was created by the Center of International Rehabilitation (CIR) in Chicago for individuals in underdeveloped countries with below the knee amputations. It is created by heating a sheet of thermoplastic material and by forming it over a mold, which results in a rib on the posterior side. The prosthesis has a circular shank that replaces the tibia and allows for attachment of a standard prosthetic foot. The shank was analyzed using the finite element analysis computer program, COSMOSWorks. The team compared the circular shank with the rib and without the rib to see which would have the ability to withstand a greater load. Different combinations of diameters and rib lengths were tested and the results were further compared to those with elliptical shanks. The dimensions were maximized by using the largest distance between the knee and the ankle that still allowed a fully functional knee. Using standards and guidelines set forth by the International Organization for Standardization for sizes of lower limb prostheses, the team analyzed the models on COSMOSWorks. The results showed that an increase in diameter or an increase in rib length would decrease stress and displacement values in the shank. Also, elliptical shanks seemed to have lower stress and displacement values. However, a material analysis showed that the elliptical shanks had more mass than the cylindrical shanks, making the elliptical shanks more expensive and heavier. Thus, the team recommended the cylindrical model to the CIR.

31. MQP: <u>Testing and Analysis of Low Cost Prosthetic Feet</u>- Morgan Carpenter, Carolyn Hunter, Dean Rheaume

April 2008

Keywords: Prosthetic Foot, Amputation

The Center for International Rehabilitation (CIR) requested the ATRC to compare its monolimb, which is a simple prosthetic leg, coupled with the Solid Ankle Cushioned Heel (SACH) prosthetic foot to the monolimb coupled with the new Shape and Roll (SR) prosthetic foot. The monolimb developed by the CIR uses a standard bolt to attach to the prosthetic foot. One existing prosthetic foot widely used by many individuals with amputations in low-income countries, the SACH foot, was created by the International Committee of Red Cross (ICRC). The SR foot was designed by Northwestern University but can be manufactured for use in developing countries. The team tested each foot in different stages of a gait using finite element analysis (FEA) and physical testing to compare effect of two prosthetic feet. The FEA determined the stresses and strains within the monolimb and the foot caused by the forces present during gait. The physical testing was used to determine the strains caused by different loads on the foot. Results of both tests showed that the SACH foot performs better than the SR foot when coupled with the monolimb. The team found that the SACH foot is able to compress more in all orientations than the SR foot, giving it more flexibility.

Figure 1. The Monolimb with a Prosthetic Foot

32. MQP: <u>One-Arm Drive Manual Wheelchair</u> - Dominic DiGiovanni, Valerie Marrion, Hamlet Nina

April 2009

Keywords: Mobility, Wheelchair Accessory

The goal of this project was to design a wheelchair component that would allow for the wheelchair to be operated with the use of only one arm. Individuals affected by stroke, Parkinson's disease, and arthritis are unable to operate traditional wheelchairs, which require the use of two hands. While some one- arm driven wheelchairs are commercially available, they do not easily accommodate a patient's changing condition. For instance, if a patient using one arm wheelchair regains the use of an arm through therapy, some one arm wheelchairs cannot be adjusted to incorporate both hands. There is the need for a removable accessory that can be attached to a range of existing standard wheelchairs to allow for one-arm control. The team considered the physical and mental capabilities of the user as factors in the design. The design team also evaluated two commercially available one arm drive wheelchairs in order to determine which aspects of current designs require improvements and modifications. The group designed an accessory that involves a shifter that allows the user to direct the motion of the wheelchair. The shifter engages one of two clutches to move the wheelchair either forward or backwards using a lever operated propulsion system. The user steers the wheelchair by rotating the handle of the shifter and brakes by squeezing the brake handle. The final device can easily be mounted on either side of a standard wheelchair without making any structural adjustments to the wheelchair. Testing of the one arm drive wheelchair indicated greater ease of use and comfort for the user.

33. MQP: Design and Manufacturing of a Portable Single-Switch Activated Bowling Game

- Jeff Prunera, Jacob Saffron, Jonathan Welch

April 2009

Keywords: Single Switch Mechanism

The goal of this MQP was to design a modified, automated bowling game that allows residents with special needs who reside at the Seven Hills Pediatric Center in Groton, Massachusetts to bowl independently. Seven Hills requested that the ATRC develop a bowling game that residents can play with minimal staff involvement. Residents enjoy bowling, but the game previously used at the center required extensive set-up and assistance by staff members for resetting each frame throughout the game. The design team proposed a design that involves an automated launching mechanism to launch a ball into ten pins that allows the user to choose the path of the ball as it approaches the pins. The final design is single switch activated; the user presses a button with his or her head or hand in order to launch the ball. A multi-lane ramp allows the user to choose one out of five lanes to launch the ball down in order to direct it towards the pins. The design also includes an optional ball retrieval mechanism that can be used in order to return the ball back to a box near the beginning of the ramp for another launch. This bowling game is currently in use at the Seven Hills Pediatric Center.

Interactive Qualifying Projects

The goals of the IQP are to promote learning through group work, allow students to design their own educational program, and ensure that students have competence in relating society and technology. The project is usually designed to address a societal problem using technology. Students usually complete this project in their junior year and typically collaborate with three or four other students. Teamwork and responsibility are major emphases of the IQP. Many projects have been completed off campus to improve the community life of people internationally and outside of campus. Since technical education is limited in its ability to provide students with an interdisciplinary experience, the IQP tries to do so by combining students from various majors and backgrounds.

34. IQP: <u>Development of an Educational Resource for Preventative Wheelchair Maintenance</u> – Ethan Holmes, Andrew Young

March 2001

Keywords: Wheelchair Maintenance

The goal of this IQP was to compile an instructional manual wheelchair maintenance resource and to develop a distribution plan for the resource to reach individuals who use wheelchairs. The Massachusetts Department of Developmental Services (DDS) approached the ATRC with the request for a resource that wheelchair users can refer to in order to obtain information about routine manual wheelchair maintenance. Many users do not perform maintenance procedures, which can lead to unsafe conditions and reduce the lifespan of their wheelchair. The IQP group conducted research about wheelchair maintenance, means by which to distribute a resource, the healthcare system in Massachusetts, and the target population. They also visited rehabilitation centers and wheelchair providers to assess current practices and standards. The group then interviewed several individuals including four wheelchair users, parents of wheelchair users, staff at a DDS group home, the President of Wheelchair Unlimited, and the DDS Training Coordinator. It was determined that existing maintenance procedures are lacking because of the unavailability of easily accessible information. The group found that most people would prefer an internet resource because the ease of access, and that those who do not have internet access would prefer an instructional video. The group compiled two resources: a website and an instructional video that included three categories of preventative maintenance: weekly, monthly, and annual procedures. The website included the descriptions of the procedures, pictures and a bulletin board for users and professionals to post questions and answers. The effectiveness of the two resources was determined by interviews of two professionals from the DDS Monson Developmental Center and it was found that they were generally successful both in terms of detail and layout.

35. IQP: <u>Transporting Personal Oxygen Bottles in Vehicles – Is it Safe?</u> – Jesse Chisholm, Sarah Duford, and Kathryn McGovern

March 2004

Keywords: Safety

The goal of this project was to assess the risks involved in the transportation of personal oxygen bottles and to determine ways to reduce these risks. Oxygen tanks are prescribed to individuals whose lungs cannot solely supply enough oxygen. These individuals may have conditions such as Emphysema, Sarcoidosis, Idiopathic Pulmonary Fibrosis and other heart and lung diseases. Transportation of oxidizing gases poses many safety risks since they can explode and cause fires. There are standards set by the U.S. Department of Transportation, the Compressed Gas Association, and others on the containment, storage, and handling of the compressed oxygen gas and liquid oxygen but there are no regulations regarding how these personal oxygen bottles must be secured during transportation in vehicles. To aid in determining the risks involved with transporting oxygen, a questionnaire was developed and distributed to potential clients, current standards were investigated, and accident statistics were analyzed. Analysis of the responses was used in conjunction with the established risks to assess the severity and likelihood of hazard occurrence. The major hazards were determined to be an oxygen-enriched environment, combustion, and the transformation of the bottle into a projectile in the case of an accident. Suggested regulations to minimize these risks were to secure the bottle vertically around the center of mass of the bottle with a restraint, ventilate the vehicle properly, and prohibit smoking in the vehicle. Implementation of these safety standards would reduce the risk of injury to an individual during the transportation of a personal portable oxygen bottle.

36. IQP: <u>Evaluating a Wheelchair Maintenance Resource</u> – Joseph A. Sarcione, Christopher L. Kopec, and Adam J. Trimby

May 2004

Keywords: Wheelchair Maintenance

The goal of this project was to create a wheelchair maintenance resource that would include a website, a checklist, and a manual. The intended audience of this resource would be adult wheelchair owners and the caregivers of those with cognitive impairments. These individuals do not necessarily have mechanical experience with tools and maintenance so the resource should provide all such information. The design team's concept contained three items: the manual, the checklist, and the website. The manual is a compilation of all of the detailed information regarding wheelchair maintenance. It is divided into sections, each of which details a subsystem of the wheelchair. The user can identify the conditions associated with the malfunctioning of a wheelchair. The manual also helps the person who uses the wheelchair to determine if the wheelchair is not functioning correctly in order to avoid further damage. Next, the checklist includes a series of steps to guide individuals through the process of checking critical aspects of the wheelchair. It can also serve as a maintenance history report if the user records all the information chronologically. The checklist is broken down identically to the manual with sections to aid in the thought process. Finally, the website contains the manual and checklist. It was designed to provide information about wheelchair maintenance in a simplistic fashion that is accessible to both the user and the distributor. The website also gives contant information for wheelchair services and wheelchair providers. The design team evaluated the effectiveness of the resource through surveys and found it to be useful for many individuals.

37. IQP: Campus Safety For Persons With Disabilities- Sara Gouveia, Eric Wilusz

February 2007

Keywords: Safety

The goal of this IQP was to conduct a campus safety study at WPI in order to organize procedures for individuals with disabilities during emergency situations. National emergencies such as terrorist attacks and Hurricane Katrina have brought attention to deficiencies in emergency preparedness plans, which did not fully address the needs of individuals with disabilities. At the local level, the plans at schools and universities such as WPI were reevaluated to take into consideration the assistance that individuals with disabilities require during emergency situations. The IQP group researched the recommendations made by government organizations and disability advocacy organizations for procedures during emergency situations and found them to correlate with several of the existing policies at WPI, but also found that improvements can be made in certain areas. The group determined that campus safety could be improved during campus-wide emergency situations such as hurricanes, power outages, and snowstorms by providing a means for individuals with disabilities to evacuate the area or reach a shelter. Additionally, the team found that procedures during power outages should be revised to better suit individuals with disabilities by setting aside accessible buildings for them to stay in during the emergency. The group proposed color-coded maps to detail proper safety procedures in the case of each type of emergency and to increase the awareness of the resources currently provided by the Disability Services Office at WPI. These maps would be placed in academic buildings and residence halls to ensure that each individual in need of assistance during emergency plans can access the relevant information in several areas throughout the WPI campus.

38. IQP: Environmental Control for Persons with Disabilities– Kevin Harrington, Timothy Loughlin, and Bryan Mancuso

March 2007

Keywords: Environmental Control

The goal of this IQP was to develop introductory information for people who are unfamiliar with environmental control technology. Environmental control technology allows users of the technology to control electronics remotely using a given data transmission medium, thereby giving the user increased independence. The IQP group had three overall goals: to gain an understanding of current environmental control technology, to use a simple environmental control device to develop laboratory modules that can be used in the Rehabilitation Engineering course at WPI, and to develop a tutorial to introduce health care professionals to the use of environmental control technology for use by individuals with disabilities. For their tutorials, the IQP group used X-10 technology, which is a type of environmental control technology that transmits its signal through a building's electrical wiring. Each system includes an input device (which accepts input from the user), a processor (which sends the signal to the electronic device), and the output (which is the device). The device is switch controlled to allow operation by the user. The IQP group developed laboratory modules explaining how the device works as a learning tool for students and tested the modules with student volunteers. The introductory manual designed for health professionals was also tested by physical therapists and occupational therapists. Testing of both deliverables received favorable responses and recommendations about content that could be added into the two items were made.

39. IQP: <u>Adapting Hands-On Science Programs for Students with Disabilities</u> – Nicholas Simone, Erin Vozzola, and Lynn Worobey

April 2007

Keywords: Classroom, Science Programs

The goal of this project was to develop a framework for adapting hands-on science programs that are accessible to students with disabilities. The Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia recognized that their science programs did not accommodate all individuals and so sought to make adjustments. The students identified the disabilities that were not compatible with the programs in place and categorized them into auditory, visual, and mobility impairments. Interviews were conducted both in the United States and Australia with science teachers, specialist teachers, interpreters, teachers of the deaf, special education coordinators, school administration, and officers of the Victorian Department of Education. From these interviews, the students obtained valuable information regarding methods of best practices, student support and aid, science specific adaptations, and the varying range of student abilities. They created a matrix that the teacher can use in order to identify an accommodation for a student based on his or her disability and the type of science experiment. This matrix has been implemented in different educational institutions by the Melbourne Commonwealth Scientific and Industrial Research Organization Centre and is now available for use by teachers in order to provide students with disabilities the opportunity to excel in science programs.

40. IQP: <u>Implementation of Best Practices in the Operation of the WPI Assistive Technology Resource Center</u> – Christopher Lyons and Paul Trimby

March 2008

Keywords: ATRC

The goal of this project was to provide an assessment of the ATRC and discover the best practices of other successful rehabilitation centers. The objective also included providing recommendations and a five-year plan to ensure the efficiency and efficacy of operations. A review of the practices was necessary because some methods and services provided by the ATRC may have become outdated, therefore no longer meeting the original mission statement. The initial goal of the ATRC was "to create a model for an Assistive Technology resource center at WPI, means of coordinating and supporting project activity in the disability fields between the project centers throughout the world and WPI campus" (Martin & Thamilavel, 1999). Lyons and Trimby critically analyzed the operations of the ATRC as well the operations of similar assistive technology centers. Surveys and interviews were conducted to determine what improvements to the ATRC individuals in the community saw as necessary. The final five-year plan included an executive summary explaining the objectives of the ATRC, a description of the ATRC, a description of services offered by the ATRC, a marketing plan, an operational plan, information about current management and organization, and a financial plan.

41. IQP: <u>Improving Disabled Access to the Tram System in Melbourne, Victoria</u>– Alexander Christakis, Katie Flynn, and Jennifer Himottu

April 2008

Keywords: Public Transportation

The goal of this IQP was to assist the Melbourne Department of Infrastructure's Public Transport Division in creating more accessible tram stops. Currently, 150 accessible tram stops exist and the goal of the Public Transport Division is to have a total of 420 accessible stops by 2012. The existing accessible tram stops were generally chosen in the less challenging areas, which are not highly popular destinations. However, there is the need for accessible stops in more popular areas that will still hold to environmental and governmental regulations. The IQP team devised a rating system that would prioritize the list of tram stops to be updated based on several objective factors. The group took into account the size of the tram stop, the surrounding traffic flow, distances from local disability centers, and the types of buildings in the area surrounding the tram stop. After compiling a preliminary list of stops to upgrade, the IQP team examined 27 of the stops with the intention of observing the inbound and outbound areas, as well as sidewalk waiting areas. Each stop was rated based on these criteria, and point value systems were used to prioritize the suggestions made. Both the physical and the spatial features of the potential stop were included in a final table, each ranked on a scale of 1-5. This project culminated in a portfolio with 54 tram stops on 3 different tram routes rated by priority based on factors of safety, ease of construction, and popularity. This project will allow the Public

Transport Division to move closer toward its goal of having a total of 420 tram stops and allowing more members of the community to access public transportation.

42. IQP: <u>Manual Wheelchair Handbook Study for the Massachusetts Department of Developmental Services-</u> Daniel Asselin, Nikolas Ledoux, David Willens

May 2008

Keywords: Wheelchair Maintenance

The goal of this IQP, which was sponsored by the Department of Developmental Services (DDS), was to conduct a manual wheelchair maintenance study in order to improve communication between staff of direct care homes and wheelchair vendors. The existing policies in place at the DDS do not involve any standardized procedures for reporting a problem with a wheelchair. Additionally, there is no schedule in place for routine wheelchair inspections and preventative maintenance. The IQP group determined that providing direct care staff with reference materials to help them identify the parts of a wheelchair will allow them to perform simple repairs themselves and report more complicated repairs with greater accuracy. The project group revised a previous wheelchair maintenance manual (Trimby, Sarcione, and Kopec, 2004) with the purpose of improving communication by making it easier to read and understand by direct care employees. They also separated the document into two parts, one detailing repair procedures, and the other describing maintenance procedures for a wheelchair inspector. The revised maintenance procedures were implemented in four group homes in the Worcester County and it was found that both the repair of simple issues and the communication process for more complex repairs became more efficient. The staff members' understanding of wheelchair terminology seemed to improve with use of the manual, and therefore, their ability to report complex wheelchair problems and maintain the wheelchairs also improved.

43. IQP: <u>Optimizing the WPI Assistive Technology Resource Center: Operation and Management</u>- Stoyan Hristov, Kelsey Mawhiney, Zachary Wilson

May 2009

Keywords: ATRC

The goal of this IQP was to re-evaluate the operation of the ATRC in response to any issues that could potentially be causing the ATRC to operate at less than its full potential. The ATRC specializes in the design and modification of assistive technology devices to suit a specific individual's need. The ATRC was founded in 1999, and ten years later, an IQP group re-evaluated the operation of the center and proposed some recommendations. The purpose of this IQP was to implement some of the recommendations proposed in the previous report (Lyons and Trimby, 2008) and to re-organize the center to allow for optimal function. The IQP group changed the layout of the laboratory space by organizing materials into drawers and cabinets, as well as labeling each storage area clearly. The reorganization allowed for more organized, safer work stations that project groups can use. The IQP group also created a comprehensive database of all projects completed at the ATRC, which included the names of the students involved in the project, the title of the project, the date of submission, the advisors of the project, and the abstract. Finally, the project group also worked to update the ATRC website to provide up to date information about projects, newsletters, and publications. The reorganization of the lab, the creation of the database of past projects, and the renovation of the website all contributed to greater efficiency to the operation and management of the ATRC.

44. IQP: <u>History and Future of Rehabilitation Robotics</u> – Christopher Frumento, Ethan Messier, and Victor Montero

March 2010

Keywords: Therapeutic Assistant, Rehabilitation Robotics

The objective of this project was to discuss and analyze recent developments in the field of rehabilitation robotics. In particular, the students evaluated the application and potential future of robotic devices. Engineers have been performing research in order to combine robotics with the rehabilitation field in the past. Analysis of the most recent robotic devices being developed or already in use within this field showed that some of the designs were invented to enhance the performance of the human body while others were created for medical treatment. These devices improve the daily life of individuals who have been affected by a degenerative disease or traumatic injury. Specifically, the students analyzed exoskletons, bionic limbs and bionic arms. The BLEEX and LOPES, the lower extremity exoskeletons, were analyzed, as well as the full body exoskeleton, the HAL5. The bionic hands were the I-limb, Shadow Hand and Smart Hand and the bionic arms were the Luke Arm, Proto-1, and Proto-2. Results showed that the success of these devices was related to good accessibility, lower cost, simplicity, and lower maintenance. Other criteria investigated were the adaptability, safety, and environmental concerns. Some devices also incorporated more of the human aspect of sensory feedback, allowing the individual using the product to actually feel what they are interacting with. The students concluded that the technology contained in the I-limb would be the most likely to be enhanced and further developed.

Graduate Master of Science Theses

45. Graduate M.S. Thesis: <u>Development of a Mathematical Model to Investigate the Static and Dynamic Stability of a Wheelchair System</u>- Christopher Bruno

April 1997

Keywords: Wheelchair Mathematical Model, Stability

The goal of this graduate thesis was to develop a mathematical model of a standard wheelchair with a humanoid model while the human is firmly secured in the wheelchair. In the United States, there are, on average, 50 wheelchair related deaths and 36,500 wheelchair related emergency room visits every year. About 3 out of every 4 of these incidents can be attributed to wheelchair instability, or more explicitly, the wheelchair's ability to remain upright when moving up or down a slope or undergoing a collision with its surroundings. There have been investigations to examine the static and dynamic stability of wheelchairs in the past, but there is the need for a published theoretical analysis of wheelchairs under a range of experimental conditions. In order to analyze the stability of a wheelchair, Bruno stimulated a variety of tests by placing the wheelchair on a stable platform for static testing and by rolling the wheelchair down the ramp, for dynamic testing. The static stability was determined by measuring the maximum angle that the system of the wheelchair and human could be tilted without tipping over. Dynamic stability was evaluated by changing in the angle of the ramp that the wheelchair was pushed on and by noting any issues with the wheelchair. The results of the analysis showed a correlation with the experimental values and the mathematical model proved to be accurate in the case of static stability. The dynamic stability results showed some accuracy, but did not correlate as effectively with experimental data because of the instability and movement throughout the wheelchair system during dynamic testing conditions.

C. Bruno, "<u>Development of a Mathematical Model to Investigate the Static and Dynamic Stability of a Wheelchair System</u>", M.S. Thesis, Worcester Polytechnic Institute, Worcester, MA, 1997.

C. Bruno and A.H. Hoffman, "<u>Modeling the Dynamic Stability of an Occupied Wheelchair</u>", Proceedings of the RESNA'98 Conference, pp. 164-166, 1998.

46. Graduate M.S. Thesis: <u>Design Modification, Fabrication, Construction and Performance Evaluation of a Prototype Body Mounted Upper Extremity Orthosis</u> – Hiroshi Toriumi

May 2000

Keywords: Muscular Dystrophy, Mechanical Arm

The goal of this MQP was to design an upper extremity orthosis with four degrees of freedom that would allow for shoulder flexion, shoulder abduction, humeral rotation, and elbow flexion. In some musculoskeletal diseases such as Duchenne Muscular Dystrophy (DMD), skeletal muscle groups progressively degenerate, with the most proximal groups degenerating first, and the most distal groups degenerating last. Teenagers with DMD often retain fine motor control in their hands, but do not have enough arm strength to allow them to use their hands. Current robotic assistive devices and arm supports often have a limited range of motion and can be difficult to control. Therefore, there is the need for an upper extremity orthosis that can optimize the user's range of motion and allow for maximal use of their existing muscle functions. A previous design project at WPI (Felice and Smith, 1999) created the concept idea of a body-mounted arm orthosis, which could be mounted directly onto the body of the individual instead of the wheelchair. In the new design, pin joints at the shoulder ring and at the elbow joint allow for shoulder abduction and elbow flexion, respectively. The prototypes allows a user to perform daily tasks such as grooming, feeding, and reaching for, picking up, and manipulating objects by activating switches on the device. Testing of this passive prototype indicated that if powered, the orthosis would allow the user to perform eight basic daily living tasks by activating a sequence of switches. Though the device was designed specifically for users with DMD, it also has the potential to be useful for individuals with other forms of muscular dystrophy, spinal cord injuries, and stroke. This project was published in the Proceedings of the 2002 Annual RESNA Conference.

A.H. Hoffman, H.K. Ault, H. Toriumi, S.A. Smith, C. Felice, "The Design and Kinematic Evaluation of a Passive Wearable Upper Extremity Orthosis", *Proceedings of the 2002 Annual RESNA Conference*, in press, 2002.

47. Graduate M.S. Thesis: Development of Simplified Gait Analysis System – Rosanna Catricala

May 2001

Keywords: Joint Prosthetic, Gait

The objective of this project was to develop a simplified gait analysis system to study the effect of restricted ankle motion on individuals with lower limb prostheses during stair ambulation. Stair ascent and descent is difficult for persons with below the knee amputations since they need to use a prosthesis, which can restrict flexion in the ankle region. Five individuals who did not have any physical disabilities were chosen as the subjects for this experiment. An ankle-foot prosthesis (AFO) was used to restrict flexion in the ankle. There were four different conditions that the subjects had to participate in: normal stair ascent, normal stair descent, stair ascent with an AFO, and a stair descent without an AFO. The simplified gait analysis system used three types of custom designed goniometers (6 total), to determine angle of rotation of the hip knee and ankle joints. Voltages from potentiometers incorporated into the gonimeters were recorded. Results of testing showed that stair ascent with the AFO increased hip flexion, range of motion, and maximum angular velocity. During stair descent, an increase in flexion in the left hip and a decrease in the flexion of the right knee were observed.

R. Catricala, "Development of a Simplified Gait analysis System to Determine the Effect of Restricted Ankle Motion During Stair Ambulation", M.S. Thesis, Worcester Polytechnic Institute, Worcester, MA, 2001.

A.H. Hoffman, H.K. Ault, R. Catricala, "The Development of a Regional Assistive Technology Resource Center", Proceedings of the 2001 Annual RESNA Conference, pp.172-174.

48. Graduate M.S. Thesis: The Impact of Using An Obstacle Sensing System In The Power Wheelchair Training of Children With Disabilities - Lisette Manrique

April 2005

Keywords: Wheelchair Training, Children, Mobility

The purpose of this investigation was to study the effectiveness of using an obstacle sensing, ranging device that provides auditory cues during powered wheelchair training. Children at the Massachusetts Hospital School often find it difficult to independently maneuver their wheelchair because they lack the cognitive ability to drive safely and consistently. First, Manrique conducted tests to determine whether the auditory feedback provided by the ranging device was beneficial. Case studies were conducted by evaluating each of the subjects without a ranging/sensing device and then with the device. Manrique also studied the improvement of the child's everyday mobility by assessing them over a long period of time. Finally, she tested whether there was any internalization of the auditory cues presented to the child by analyzing the subject's mobility skills after the removal of the device. The results of this study demonstrate that the use of a ranging device can be used effectively to train children with disabilities. An improvement of mobility skills was noticed after the removal of the device, indicating that there was some internalization of the auditory cues presented by the device.

L. Manrique, G. Rabideau, G. Reinhold, A. Hoffman (2007), "Using and Obstacle Sensing System in Power Wheelchair Training of Children", in Proceedings of the 2007 Annual RESNA Conference, Phoenix AZ.

49. Graduate M.S. Thesis: The Design and Manufacture of an Elevating/Articulating Manual Wheelchair Legrest – Eric Couture

April 2006

Keywords: Wheelchair Legrest

The goal of this project was to design an elevating legrest for a wheelchair that could be independently operated by the user and would not interfere with the other functions of the wheelchair. People who use wheelchairs need to elevate their legs periodically in order to prevent loss of circulation in their lower extremities, which could cause pressure sores and swelling of the legs. Even when a caregiver helps them, the limited extension of the legrest may not entirely alleviate the problem. The modified legrest follows the arc of the person's leg and extends the legrest as it is elevated. The design also includes an adjustable pivot point that allows for different degrees of extension depending upon the user's size. A student at the Massachusetts Hospital School tested the device for a week and reported that the user-operated elevation was a big advantage over other types of elevating legrests.

E. Couture, " The Design and Manufacture of an Elevating/Articulating Manual Wheelchair Legrest ", M.S. Thesis, Worcester Polytechnic Institute, Worcester, MA, 2006.

A.H. Hoffman, Eric D. Couture (2008), "Design and Development of an Elevating Articulating Manual Wheelchair Legrest" in Proceedings of 2008 International Mechanical Engineering Congress and Exposition, Boston, MA.

Figure 2. Elevating Legrest on Wheelchair

50. Graduate M.S. Thesis: Design of a Power-Assist Hemiplegic Wheelchair – Keith Liadis
May 2006

Keywords: Hemiplegia, Mobility

The goal of this project was to produce an add-on system of components for a manual wheelchair that would allow a user to effectively propel their manual wheelchair with one arm. Current one-handed manual wheelchairs are difficult to propel because one arm can only provide half the power that is ascertained in a two-handed manual wheelchair. A power-assisted hemiplegic (one-sided paralysis) wheelchair was developed that can effectively be propelled with one arm while remaining maneuverable, lightweight, and foldable. An existing manual wheelchair was minimally modified and fitted with power-assisted components that could alternatively be attached to a wide range of manual wheelchairs. The design implements a motor and gear train to power the wheel on the user's affected side, encoders on both rear wheels to track wheel position, and a heel interface on the footrest to control steering. A controls program was developed that analyzes wheel position and steering to respond to the motion of the hand-driven wheel. Extensive testing was performed to ensure design integrity. Testing results showed that the prototype successfully met and exceeded predetermined design specifications based on industry standard testing procedures. The team concluded by suggesting few improvements for the device such as redesigning the gear box to optimize size and weight, and performing full standardized testing on the final product.

51. Graduate M.S. Thesis: <u>Electromechanical System Integration for a Powered Upper Extremity Orthosis</u>- Michael Scarsella

April 2007

Keywords: Powered Arm

Wearable robotics for assistance and rehabilitation are not yet considered commercially mainstream products, and as a result have not yet seen advanced controls systems and interfaces. Consequently, the available technology is mostly adapted from systems used in parallel technologies, rather than custom applications intended for human use. This study concerns itself with the design and development of a custom control system for a 2-degree of freedom powered upper extremity orthosis capable of driving elbow flexion/extension 135º and humeral rotation 95º . The orthosis has been evaluated for use as both a long-term assistive technology device for persons with disabilities, and as a short-term rehabilitative tool for persons recovering injury. The target demographics for such a device vary in age, cognitive ability and physical function, thus requiring several input parameters requiring consideration. This study includes a full evaluation of the potential users of the device, as well as parameter considerations that are required during the design phase.

The final control system is capable of driving each DOF independently or simultaneously, for a more realistic and natural coupled-motion, with proportional control by pulse-width modulation. The dual-axis joystick interface wirelessly transmits to the 1.21 pound control pack which houses a custom microcontroller-driven PCB and 1800 milliamp-hour lithium-ion rechargeable battery capable of delivering 4 hours of running time. Upon integration with the 2 DOF orthosis device, a user may complete full range of motion with up to 5 pounds in their hand in less than 7 seconds, providing full functionality to complete acts of daily living, thus improving quality of life.

52. Graduate M.S. Thesis: <u>Optimization for Commercialization of a Two Degree of Freedom Powered Arm Orthosis</u>- Steven Toddes, Jr.

April 2007

Keywords: Powered Arm

In the United States, more than 18 million people suffer from upper extremity injury. This population is in need of a device both to aid in the completion of activities of daily living (eating and grooming), as well as to provide daily muscular therapy. To assist persons suffering from disabling upper extremity neuromuscular diseases, this thesis concerned the redesign of a powered arm brace from a proof-of-concept design to a more functional, marketable product. The principles of Design for Manufacturability and Assembly (DFMA) were employed as part of the design methodology to create a product that could be scaled into production. Additionally, numerical analyses including Finite Element Analysis (FEA) were completed to prove the both the safety and structural integrity of the orthosis in computer simulations. The design was then successfully tested with marked improvement over the previous design, including a 58% reduction in weight, decreased manufacturing costs, and a significant improvement in functionality and comfort.

<u>Course Design Projects</u>

Course design projects are seven week projects completed in courses by underclassmen that result in the design and construction of a first generation prototype of an assistive device. Students learn to develop a device based on an initial problem statement that is often submitted by an agency or organization that provides services to persons with disabilities. Students develop design alternatives that meet the design objectives and then evaluate the alternatives to propose a final design. A prototype of the final design is then developed and depending on the nature of the device, it may also be tested. Course design projects allow students to complete a short term project while experiencing the design process. While some prototypes are of sufficient quality to be directly used by the sponsoring organization, most require further refinement. The EPICS (Engineering Projects in Community Service) program within the Rehabilitation Laboratory of WPI often refines the course prototypes so that they can be delivered to the sponsoring organization. A few typical devices developed through course projects are described in the following paragraphs.

53. Course Design Project: <u>Development of a Single Switch Operated Dice Roller</u>

Keywords: Single Switch Mechanism

The goal of this course design project was to develop a prototype for a single switch operated dice roller. Some individuals with physical or mental disabilities have difficulty rolling dice because of the motor control required for the task. A single switch operated device would allow these individuals to press a button on the device that would trigger the rolling of the dice. Prototypes were developed by two different groups. The first prototype involves a motor, which tips a transparent container that holds the dice. The second prototype involves a white platter, which vibrates in the vertical direction when the switch is pressed. The first prototype was chosen to be developed and was constructed by an EPICS team.

54. Course Design Project: <u>Design of Adaptive TV Remotes</u>

Keywords: Simplification of Existing Devices

The goal of this project was to design a TV remote that could be operated by persons with varying combinations of physical and cognitive disabilities. Standard remotes have too many buttons that are packed tightly together so some individuals are unable to use the device. Additionally, commercial products available for persons with disabilities do not satisfy many individuals because they do not address their disability specifically. Students in several courses have developed prototype solutions for this problem. Most solutions involve developing an outer casing for the remote that incorporates larger buttons having distinctly different shapes that would be applicable to clients with more debilitating difficulties. Currently, there is ongoing work to further develop a reconfigurable casing that could be easily adapted to specific individual needs.

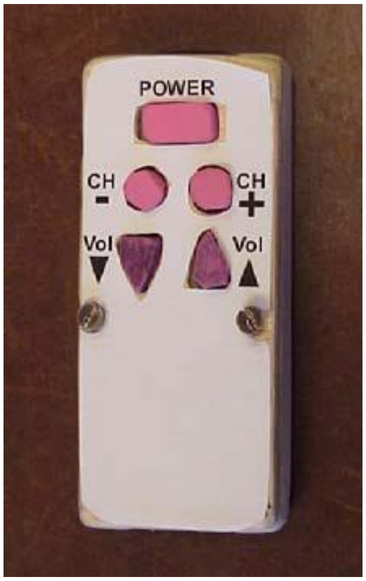

Figure 3: Adapted TV remote

55. Course Design Project: <u>Development of a Posterior Walker for the Visually Impaired</u>

Keywords: Mobility

The goal of this project was to design a walker for individuals with visual impairments. These individuals need to rely on sensory aids, assistive technology, or other people everyday to perform basic tasks. A walker that allowed use of a white cane was necessary for them to move from place to place. Traditional walker designs have obstructing crossbeams that prevent the user from “sweeping” the area with a cane. The students determined the most optimal height and width for the frame based on recent United States population anthropometric data. The user interface increases control and agility due to the swiveling ability of the armrests, in which the distal portion of the rest rotates it medially. The centering of the lateral balance of the user results in a single interface, allowing agile mobility and traditional hand positioning for caning. Therapists and able-bodied users evaluated the walker in a controlled environment and assessed the agility gained from the arm positioning, as well as the normalization of the hand positioning for caning feedback. Propulsion of the walker was easily controlled and was found to be less tedious than with standard walkers. The final product generated was a low cost, easy to operate walker that can be used in and out of an institution without many modifications. The final device was developed through the EPICS program.

M. J. Scarsella, G. A. Fredette, B. D. DuBois, E. R. DeStefano, A. A. Katz, C. Hunter, K. E. Bombassaro, A. H. Hoffman (2007), “Development of a Posterior Walker for the Visually Impaired”, in <u>Proceedings of the 33rd Northeast Bioengineering Conference</u>, pp. 261-262, Stony Brook NY.

56. Course Design Project: <u>Design of a Drawer Under a Wheelchair Lap Tray</u>

Keywords: Wheelchair Laptray

The goal of this project was to design a storage drawer for a lap tray. Lap trays are often used in conjunction with wheelchairs to allow users to read, write, and paint from their wheelchairs. Lap trays are often secured to the wheelchair by way of a clamp, strap, or fixed swivel system. The current limitation that exists with wheelchair lap trays is that they do not include a storage area for the user to place small items such as cell phones, writing utensils, and any other objects that they would need easy access to. The goal of this course design project was to build a lightweight sliding drawer that would attach under a wheelchair lap tray and be capable of opening and closing easily and holding small items. Two different solutions were developed for this purpose. The first involved a polycarbonate drawer that uses a magnet to secure the opening and closing mechanism. The sliding of the drawer is accomplished by drawer runners with rollers. This design was successful in that it was inexpensive, lightweight, durable, and safe for the user. A second group proposed a design involving a pull out drawer that has a frame, which attaches to the tray with Velcro. The drawer is placed between the legs of the client and the tray, and a magnetic latch secures the drawer in position. The sliding mechanism is on the drawer and frame, and involves a built in stopper. This design was found to be easy to use and accessible to the client. The design was inexpensive, safe, and met the functional requirements in terms of the weights and forces it would withstand. One of the prototypes is currently in use at the Massachusetts Hospital School.

57. Course Design Project: <u>Seven Hill Mini Golf Device: The Spring Loaded Piston</u>

Keywords: Single Switch Mechanism

The goal of this project was to design a portable miniature golf device that can be carried on the golf course. Staff members at the Seven Hills Foundation realized that some of their residents were unable to participate in golf because their disabilities prevented them from properly learning the sport. Existing golf devices were too large and inconvenient to transport. Creating a device that is single switch activated, can be prepared and set up by a personal care assistant, and is light enough to transport would allow the resident to feel some control over his environment. Specifically, the individual would be able activate the device and project the ball with an accompanying sound. Each team member came up with a design alternative and the final design was selected by combining the best components of each design. The final design was a highly portable, battery run device that can launch a standard gold ball up to 41 feet across turf surface. This spring piston design had a hollow PVC tube with a spring mounted at one end. A small piston was attached to the spring with two or three notches holes on top. A button activates an electric motor that raises the pin temporarily, allowing the spring to re-expand and propel the piston towards the ball. The materials of the product were determined based on price, density, and machinability. Testing and evaluation of the device showed that it was the most compact and transportable while being the simplest mechanically.

58. Course Design Project: <u>Design of a Spray Can Holder</u>

Keywords: Amputation

The goal of this course design project was to design a spray can for a man who is missing two joints on his right index finger and one joint on his right middle finger. The man works as a finish carpenter and uses an aerosol spray can with his right hand for at least twenty minutes per day. The missing digits in his right hand make it difficult for him to aim and spray the can simultaneously using his thumb. Therefore, the man was in need of a spray can device that would allow him to hold and spray an aerosol can using only his right hand, leaving his left hand to hold other objects. The design team developed design specifications for the device including that it should require less than 15 Newtons of force from the user, should not cause pain or discomfort to the user, should cost less than $30, and should be durable enough for everyday use. Four design alternatives were developed: the first involves the use of the thumb to press down on a bottom lever, the second involves the use of the index finger to push a nozzle, the third involves the placement of the hand beneath a hollow tube and the use of the thumb to spray the can, and the fourth involves the use of the thumb and little finger to hold the device. The fourth design was selected for development since it met the greatest number of design specifications and ranked highest in a comparison matrix. The final design consisted of a holder for the thumb, a holder for the pinky finger, and a bottom cover to keep the can in place. The device was tested by the man and improvements were made to the device based on his suggestions. Foam was added to the can holder and finger holes for comfort, and an elastic band was placed around the device for support. The device was successful in that it met its design objectives and received a favorable response from the user.

Figure 4: Adapted spray can holder

59. Course Design Project: <u>Sensory Stimulation Table to Address Institutional Depression</u>

Keywords: Therapeutic Assistant

The goal of this Introduction to Engineering course project was to create a multisensory activity table for a resident at the Glavin Regional Center. A 46-year-old man with profound mental disabilities is developmentally and behaviorally similar to a child of two years. He only has few physical limitations so he enjoys exploring, coloring and other playful activities. However, wandering and exploring unsupervised is extremely unsafe for him and for the other residents. Therefore, a sensory-stimulation device with attached components that he can activate/explore without breaking or detaching and losing the pieces is necessary. The design team considered creating such a device that included a fan, a radio, a color show, heavy strung breads, or musical toys for components. The final device stimulated a broad range of senses of the individual, provided ease of activation, and was durable.

60. Course Design Project: <u>Single Switch Activated Frisbee Thrower</u>

Keywords: Single Switch Mechanism

The goal of this project was to develop a Frisbee thrower that could be activated with a single switch for persons in wheelchairs with disabilities. Individuals at the Seven Hills Center who have limitations on arm strength, range of motion, and/or muscle control find it difficult to throw a Frisbee without assistance. The design team created a device that was a modified form of Frisbee golf. It can be used by a wide range of persons with disabilities because it is single switch operated.

61. Research Experience for Teachers (RET) Project: <u>Fishing Assistant</u>

Keywords: Single Switch Mechanism, Classroom

The goal of this RET project for two middle school teachers was to develop a single switch operated reaching device that can be used to pick up and release objects such as game pieces and cards on horizontal and inclined surfaces. Currently, electromechanical devices used to pick items up and place them in a different spot are often not available commercially and those that are available often require modifications. Two middle school teachers followed the standard engineering design process in designing two components for the device: a reaching mechanism and a two-sided game board. The reaching device consists of an extendable pole that has a hinged arm at the end. A switch on the reaching device activates an electromagnet that is then able to lift a game piece or card with a paper clip attached. The switch can be placed at any position along the pole to accommodate a specific user's needs. The teachers also developed a board game to be used in conjunction with the fishing assistant. One side of the board game contains a simple fishing style game and the other side can be used for tic-tac-toe or for color matching games. The fishing assistant and board game are now used at Seven Hills Pediatric Center where residents are able to play the fishing board game by grasping the handle of the fishing assistant and activating the switch with either their heads or hands. Additionally, the fishing assistant has been used to teach the residents Morse code through auditory stimulus. The switch can be used to activate a buzzer, which makes either a dot or dash sound.

Appendix E: Potential Local Affiliates

Adapted Activities Library A program of Department of Mental Retardation 200 Trapelo Road Waltham, MA (781) 894-3600 **Program Type(s):** Equipment	Adaptive Design A program of ESIS 3 Randolph Street Canton, MA (781) 830-8714 **Program Type(s):** Equipment
Adaptive Design Services/Clinical Resource Team 195 Industrial Drive Northampton, MA (413) 585-1153 Program Type(s): Equipment	Architect Greenfield, MA (413) 774-2248 **Program Type(s):** Equipment
Assistive School System Educational Technology Services, Inc A program of ASSETS, INC. 256 Union Street New Bedford, MA (508) 992-3128 **Program Type(s):** Community Technology Center, Consulting/Training, Diagnosis/Evaluation, Independent Living	Assistive Technology Resource Center A program of Wrentham Developmental Center - DMR Emerald Street Wrentham, MA (508) 384-3116 **Program Type(s):** Equipment, Information and Referral
Augmentative Communication Program A program of The Fernald Center 200 Trapelo Road Waltham, MA (781) 894-3600 **Program Type(s):** Equipment	Ayers Handicap Conversion Center, Inc. 440B East Squantum Street Quincy, MA (617) 328-0102 **Program Type(s):** Equipment
Crystal Springs School A program of Institute for Developmental Disabilities, Inc 38 Narrows Road Assonet, MA (508) 644-3101 **Program Type(s):** Education 3-22	Department of Biomedical Engineering A program of Brigham and Women's Hospital 75 Francis Street Boston, MA (617) 732-8889 **Program Type(s):** Equipment
Department of Physical/Occupational Therapy A program of Children's Hospital FA123 300 Longwood Avenue Boston, MA (617) 355-7212 **Program Type(s):** Equipment	Design-Able, Inc. 323 Manley Street West Bridgewater, MA (508) 436-7414 [x104] **Program Type(s):** Equipment

Disability Services A program of Greenfield Community College One College Drive Greenfield, MA (413) 775-1812 **Program Type(s):** Post-Secondary Education	**Donald L' Homme / Home Accessible Modification** A program of Marani Construction Corp. 4 Shaker Ave Wareham, MA (508) 272-1786 **Program Type(s):** Equipment, Home Modification
Equipment Program A program of Better Hearing Solutions 24 Park Avenue Worcester, MA (508) 753-8155 **Program Type(s):** Equipment	**Equipment Program** A program of Assabet Valley Collaborative 215 Fitchburg Street Marlborough, MA (508) 485-9430 **Program Type(s):** Equipment
Equipment Programs A program of KarTech, Associated Hyannis, MA (508) 771-3585 **Program Type(s):** Consulting/Training, Equipment, Social/Leisure, Support Groups-Networks, Vocational	**Family Center** A program of Clarke School for the Deaf Round Hill Road Northampton, MA (413) 584-3450 **Program Type(s):** Education 3-22
Foley Medical Supply 28 White's Path South Yarmouth, MA (508) 394-1375 **Program Type(s):** Equipment	**Hawthorn Medical Associates** 535 Faunce Corner Road North Dartmouth, MA (508) 996-3991 **Program Type(s):** Equipment
Hearing Center A program of Mercy Medical Center 231 Carew ST Springfield, MA (413) 748-6840 **Program Type(s):** Aging, Communication, Consulting/Training, Diagnosis/Evaluation, Equipment	**Home Accessible Modification / Ramps and Lifts** A program of Manchester Home Improvement 209 Rogers Avenue West Springfield, MA (413) 733-4689 **Program Type(s):** Aging, Home Modification, Independent Living, Institutions
Home Accessible Modifications A program of Bill Croston Building Construction 55 Suomi Rd Hyannis, Ma 02601 Osterville, MA (800) 924-1073 **Program Type(s):** Equipment, Home Modification	**Housing Devices, Inc.** 407 R. Mystic Ave. Medford, MA (781) 395-5200 **Program Type(s):** Equipment
Inpatient/Outpatient Rehab Services A program of HealthSouth Rehabilitation Center 14 Chestnut Place Ludlow, MA (413) 589-7581 **Program Type(s):** Equipment, Inpatient Medical, Outpatient Medical/Allied Health	**Joseph P. Mattei & Associates, AIA** A program of The Shelburne Architects 25 Guy Manners Road Shelburne, MA (413) 625-2584 **Program Type(s):** Equipment

Kelley Assistive Technology Resource Center A program of Hogan Regional Center DMR Northeast Region 450 Maple Street Hathorne, MA (978) 774-5000 **Program Type(s):** Equipment	**Liberating Technologies, Inc.** 325 Hopping Brook Rd Holliston, MA (508) 893-6363 **Program Type(s):** Equipment
Lincoln Auto School 10 Cross Street Whitinsville, MA (508) 473-9344 **Program Type(s):** Equipment	**Low Vision Rehabilitation Service** A program of New England Medical Center 750 Washington Street Boston, MA **Program Type(s):** Equipment
Medequip, Inc. 134 Bliss Street West Springfield, MA (413) 737-5466 **Program Type(s):** Equipment	**Motion Automotive Specialty** Route 20 Brimfield, MA (413) 245-9949 **Program Type(s):** Equipment
Natick Area Office A program of Massachusetts Rehabilitation Commission 251 West Central Street Natick, MA (508) 651-7531 **Program Type(s):** Vocational	**New England Wheels, Inc.** 33 Manning Rd Billerica, MA (800) 886-9247 **Program Type(s):** Equipment, Transportation
Nicholas Warren Ergonomic Services 50 Forbes Avenue Northampton, MA (413) 585-5909 **Program Type(s):** Equipment	**Occupational Rehabilitation Group, Inc.** Cambridge, MA (617) 661-5667 **Program Type(s):** Consulting/Training, Equipment, Vocational
Operation Independence, LLC. 325 School Street Watertown, MA (617) 923-4545 **Program Type(s):** Equipment, Home Modification	**Quality Van Sales** 349 Old Colony Rd, Rte 123 Norton, MA (800) 408-8550 **Program Type(s):** Equipment
SafetyCare A program of Natale Company 9 Third Road Woburn, MA (781) 933-7205 **Program Type(s):** Equipment	**SHARE Foundation, Inc.** A program of University of Massachusetts / Dartmouth 285 Old Westport Road North Dartmouth, MA (508) 999-8482 **Program Type(s):** Equipment

Shore Educational Collaborative A program of Shore Educational Collaborative - Owen School 100 Revere Beach Parkway Chelsea, MA (617) 887-2930 **Program Type(s):** Education 3-22	**Solutions for Accessibility** 119 Poplar St Watertown, MA (877) 923-8877 **Program Type(s):** Consulting/Training, Equipment, Housing
Special Clothes / Special Children Harwich, MA (508) 430-2410 **Program Type(s):** Equipment	**Therapeutic Equipment Center** A program of The Fernald Center 200 Trapelo Road Waltham, MA (781) 894-3600 **Program Type(s):** Consulting/Training, Day/Work Activity, Equipment, Institutions, Transportation, Vocational
Vocational Rehabilitation A program of Massachusetts Commission for the Blind - Region II 390 Main Street Worcester, MA (508) 754-1148 **Program Type(s):** Communication, Day Care, Diagnosis/Evaluation, Early Intervention, financial Assistance/Planning, Information/Referral, Inpatient Medical, Legal/Advocacy, Mental Health, Respite, Support Groups-Networks, Transitional/Supported Employment, Transportation, Vocational	**Weldon Center for Rehabilitation** A program of Mercy Hospital 233 Carew St Springfield, MA (413) 748-6800 **Program Type(s):** Equipment, Inpatient Medical, Outpatient Medical/Allied Health
William Starck Architects, Inc. 114 Durfee Street Fall River, MA (508) 679-5733 **Program Type(s):** Consulting/Training	-