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# Portable Seating Attachment for Autistic Individuals

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## **PORTABLE SEATING ATTACHMENT FOR AUTISTIC INDIVIDUALS**

### **Introduction**

The Portable Seating Attachment for Autistic Individuals Team (“the team” for short), comprised of Mechanical Engineering students Loreal Camp, Chika Eke, Robin Rackerby, Mischa Tucker, and Engineering Management student Marissa Birmingham, set out to develop a device to assist individuals with autism who struggle with sensory processing disorders. The project consisted of background research, engineering calculations, fabrication, testing, and market analysis for a prototype designed by the team.

### **Background**

Autism is a neurological disorder that impairs an individual’s ability to communicate and interact with others. It is often referred to as a spectrum disorder because there is a wide variation in symptoms among children. For example, one team member worked with a child with autism who was completely nonverbal, but instead used sign language to communicate, and an adult autistic person who had no trouble speaking. Autism is reported to occur in all racial, ethnic, and socioeconomic groups and in 2010, Centers for Disease Control and Prevention (CDC) estimated that 1 in 68 children in the United States identify with this disorder.

Many people with autism also suffer from other disorders and symptoms. The disorder that the team’s device focuses on is sensory processing disorder. Sensory processing disorder (SPD) is a condition that has been found to affect three-quarters of children with Autism and prevents certain parts of the brain from receiving the information needed to interpret sensory information

correctly. One of the senses that SPD affects is the vestibular sense, which uses semicircular canals in the inner ear to control balance and postural alignment. The damage that SPD causes to the vestibular system, which is important for postural alignment and balance, is especially detrimental to individuals who need to sit in a classroom or office for long periods of time. Those affected have trouble telling how their bodies are moving in relationship to space and gravity and exhibit behaviors such as repetitive fidgeting, slouching, and sliding off their chair. Positive forms of vestibular input that help these individuals to remain in place include linear swings, trampolines, and rocking chairs.

The team approached the director for the Autism Society of Oregon to discuss what product would best serve the needs of the autism community and those who have this condition. Currently, alternative seats such as ball chairs, gel cushions, and motorized gliding chairs are used to address the need for vestibular input. The issue is that these seats are either too large to carry around when an individual moves to a new environment or are limited to one function such as bouncing. The team members decided to address this issue by designing a portable and multifunctional seating attachment. Since vestibular damage is found in multiple disorders (e.g. Autism, attention deficit disorder, traumatic brain injury), the design of this seating attachment could have a widespread effect on classroom and workplace performance.

### **Criteria**

In order to address the issues presented by this challenge, the team established criteria for excellence to analyze the final prototype. The seating attachment must be portable (easily carried with two hands), must weigh less than 15 pounds, must fit onto a standard size chair, and must not make the user more than six inches taller than their regular seated height. The device must also be multifunctional (have the ability to bounce, swivel, and rock). This device will fill the gap in the

market formed by current alternative seats that are either too bulky to carry around or limited in functionality. The constraints for the project included time, money, technical skills, and safety. The project was completed prior to April 14th and within the budget of \$700. The prototype was constructed in the University of Portland Machine Shop.

### **Early Prototypes**

The group completed preliminary design on two prototypes. The first prototype, nicknamed the “360 rocking prototype,” specifically addressed the rocking and swiveling functionalities specified in the design criteria table. Modeled after a bosu exercise ball, the 360 rocking prototype was constructed by purchasing a 16” diameter birchwood balance board and covering it with a massaging core balance cushion. Two tennis balls were cut in half, drilled, and nailed to a bottom sheet of wood to form a socket for the half-ball on the balance board. The back support of this prototype was constructed with a Petmate Sport Ball Launcher. This formed a curved rod which was attached to a rectangular section from a sheet of plastic. These materials were chosen because the durability of the plastic seemed to provide adequate lumbar support for brief testing on team members. In terms of our criteria for excellence, this prototype fit on 3 different types of chairs, could be carried with two hands, and was multifunctional (could rock, swivel, and bounce). However, preliminary testing of the prototype indicated that the bottom half-ball of the balance board added undesirable height to the seat attachment and caused abrupt rocking that was uncomfortable for the user.



Figure 1: 360 Rocking Prototype

The second initial prototype, nicknamed the “Rock ‘n Bounce prototype,” incorporated bouncing, rocking, and swiveling functionalities into the seat. To construct this prototype, materials were obtained from the machine shop on the University of Portland campus. These materials consisted of a 14x14 inch plywood square cut from scrap wood, springs with similar stiffness, and foam core cut to fit the plywood. The springs were secured under the plywood board and the foam core was placed on top, for cushioning. The team decided to move forward with this design after testing both prototypes on team members and obtaining an opinion from the faculty advisor. The springs in the rocking and bouncing prototype allowed for a more comfortable rocking motion than the motion demonstrated in the 360 rocking prototype. They also provided the bouncing motion requested by an occupational therapist. The design incorporated a “wobble” by using a central larger spring with smaller springs arranged around it to create a seat that could freely lean in all directions, while maintaining the ability to bounce in all of those associated positions. The first iteration used four small springs at the corners of the prototype, while the second used 6 springs to increase the rocking capabilities of the device.

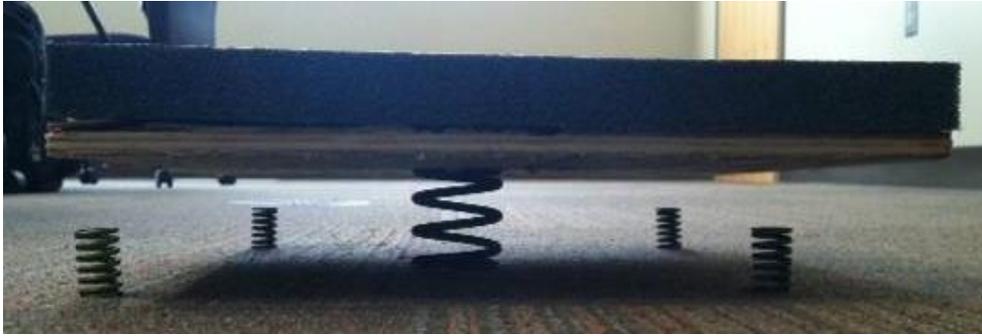


Figure 2: First Iteration of Selected Prototype



Figure 3: Second Iteration of Selected Prototype

### **Final Design Decisions**

The final design was centered on the rocking and bouncing capabilities of a center spring. The development of this design incorporated four major decisions: materials, springs, fasteners, and frequency selection. Quintessential to the second iteration of the prototype, shown above in Figure 3, were the springs that were used to facilitate the rocking, bouncing, and twisting motions. Initially, the team used a large center spring and multiple smaller springs arranged radially around the large spring. This design was chosen in order to assist with load distribution and to create a more even bounce. However, it was decided that the use of multiple springs was not feasible for mass production, as it was too expensive and the tight tolerances of the springs made the design too difficult to manufacture. Ultimately, the team decided to use a single center spring. This design

facilitated rocking, bouncing, and twisting while enabling the product to be inexpensive and easily manufacturable.

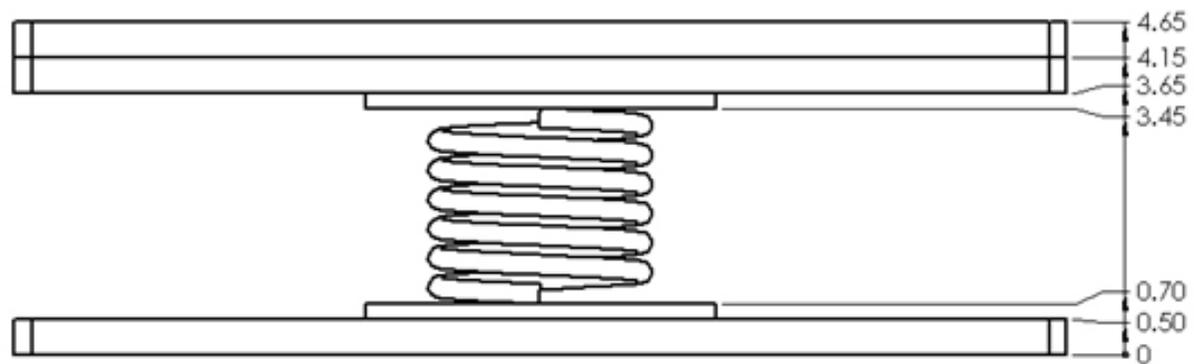


Figure 4: Final Design

\*Dimensions in inches

The materials selected included plywood for the top and bottom platforms and neoprene for the protective cover of the device. Plywood was chosen for its durability and lightness. Other materials considered for platform use include plastic and metal. Plastic was considered to warp too easily under the loading. Metal would make the device too heavy to be as portable as we would like. Plywood was the optimal choice.

When choosing the material to encase the seat in, multiple factors were considered such as the durability, cost, and weight of the fabric. The seat cover was designed to protect the user from pinching their fingers between the platforms or in springs; this meant the material needed a proper thickness. The seat cover would also be to make the device less conspicuous, as the cover would hide the internal components. The material of the cover also needed to be very flexible and durable in order to accommodate the bouncing and rocking motions of the device. It was preferred that the material have a high friction coefficient to ensure that the device stays on the chair and the user does not slide off the device. A variety of materials were considered, but black neoprene was ultimately selected for its flexibility, toughness, thickness, and grip. Neoprene had the added

benefit of being water proof, which would protect the inner components of the device during transport and from spills.

The center spring was selected based on the assumption that a user of average weight in North America (177.9 pounds) would supply the static load. The team evaluated the specifications of the spring. The spring is essential to the multifunctional capabilities of this seating attachment. Some of the criteria used for the spring design were the height, the total available displacement of the spring, the material, the cost and the vendor availability. Using the spring constant equation for a spring in compression, the dimensions of the optimal spring was determined. These results were then inputted into Advanced Spring Design, a software that checked the validity of the design and provided analysis. Once the spring design was completed, the team investigated possible vendors that had a similar spring in stock, which would help decrease cost. The Spring Store had a spring that closely reflected the optimal spring. All of the design criteria were met with this design.

One of the biggest challenges the team faced was determining the best possible method to attach the springs. Initially, the team used a washer, nut, and screw assembly to clamp the closed and ground ends of the spring to the wood. However, this method required using two dead coils, which decreased the number of active coils used for bouncing and increased the height of the device. Additionally, when the user bounced or rocked, the screws would hit one another and the washer ground against the spring, creating stress concentrations.

As a potential solution, the team analyzed the feasibility of welding the spring to a steel plate as a method of fastening the spring to the device. Through research, the team determined that the strength of the weld would be approximately equal to the strength of the parent material, which was the spring. A finite element analysis of the base of the spring, welded joint, and plate assembly

under a static load in bending was conducted. The team found that the maximum stress in the joint was considerably less than the maximum allowed stress of the spring, resulting in a factor of safety of 200. It was determined that a welded joint would be able to withstand the forces produced by the user under fatigue loading as a result of the high safety factor. Welding was chosen as the method to secure the end coils of the center spring to steel plates on the top and bottom platforms of the device.

The team evaluated the rocking capability of the seat attachment by comparing the frequency of the device to an optimal frequency, which would provide the greatest amount of vestibular therapy to the user. A literature search led to the discovery that rocking chairs are recommended by occupational therapists as an effective form of the vestibular therapy in individuals with Autism. Data was obtained from previous studies in order to identify that the preferred frequency of a standard rocking chair is 0.5 rocks/second. Consequently, the team made the design decision to select 0.5 as the optimal frequency. Video capture data analysis and Logger Pro software were used to complete feasibility testing on the rocking capability of the current prototype.

In conjunction with material choices, other factors were considered in order to increase the safety of the design. To minimize the possibility of pinching fingers while rocking, the team considered placing rubber stoppers at the corners of the base to prevent the possibility of hard stops and to guarantee that there would be a safety gap if fingers got caught. The team also obtained ethical clearance from the International Review Board (IRB) to test the prototype on individuals with autism. While testing was not able to occur during this iteration of the project, the feedback collected would help the team enhance the safety and user experience of the device.

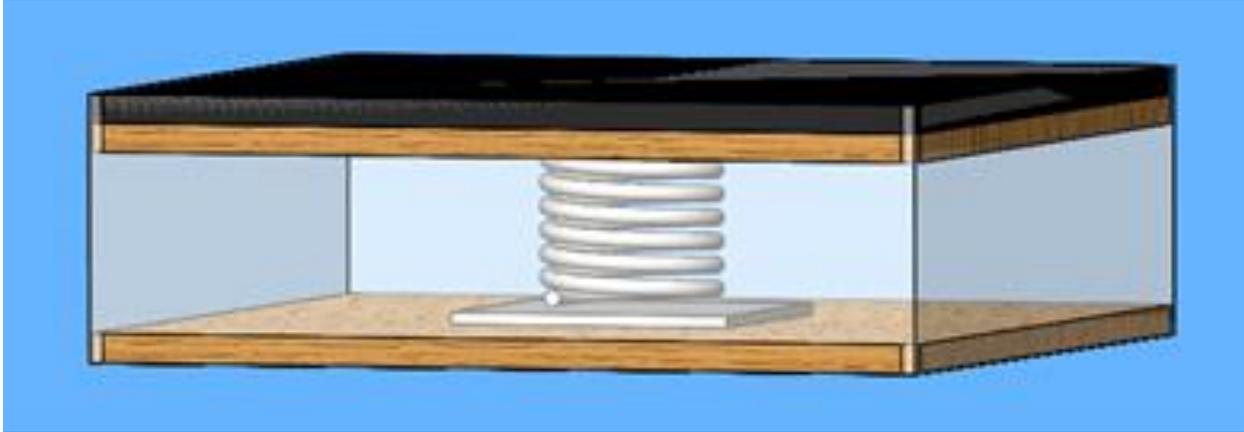


Figure 4: Final Design

The device met the team's criteria of being portable and lightweight. In order to increase the portability of the device, the team considered sewing handles to the sides of the device, however this was not done to the current prototype due to time restrictions. Additionally, the criteria for versatility was changed from being able to fit three chairs to fitting a standard wheelchair. This was done to ensure that the device adhered to an industry standard. The device met the team's criteria of being subtle - under a static load the device was slightly under six inches. However, this criteria may need further development, as 5-6 inches may be too high for users with shorter legs, especially in chairs that do not have adjustable heights. The device meets the multifunctional criteria and has the ability to bounce, rock, and swivel.

The team tested the device themselves on multiple occasions, and the device appears to meet the safety criteria, however more testing should be done to verify this. IRB testing has been approved, but autistic individuals have not tested the device yet. While their feedback will assist in the improvement of the safety and functionality of the device, the team does not expect the seat attachment to pose any safety hazards when used as directed. Proper use is defined as rocking, bouncing, and swiveling while user maintains contact with the device. The prototype is designed to support an adult with an average weight, which is approximately 180 pounds. Under this

loading, the expected stresses in the device are significantly less than the material limits. As a result, the team expects the device to last for at least five years.

## **Conclusions**

In conclusion, the final design is portable, weighs less than 15 pounds, meets the standard we selected for size, is multifunctional, and does not make the user more than six inches taller than their seated height. Therefore, it meets all of the criteria for excellence. Recommendations for future work include exploring design improvements that would lower the height of the device to increase ease of use for children and on non-adjustable chairs. Another design consideration would be to make it possible to switch out the springs so that the device can be used as an individual gains weight throughout adolescence and adulthood. Completing additional research on the demographic in terms of height, weight and environment would aid in future spring design. From a marketing and economics standpoint, the team would like to further explore vendor costs to get a better idea of price.

It is important to look at the business environment before entering a new product onto the market. Although the demographic of this product is very difficult to pinpoint, the ideal consumer participates in multiple activities where an aid for active sitting would be beneficial, so the portability aspect of the device becomes important. Based on the SWOT analysis (found in the following Market Analysis) and in comparison to top competitors currently in existence, the device fills a gap in the market by taking desirable traits and combining them into an ideal product.

## **MARKET ANALYSIS**

### **Background**

The purpose of the device is to allow the user to participate in active listening and increase the user's focus. This device was designed to compete with products such as Rifton Activity Chair and Therapro Disc-O-Sit. The benefits of our device include its portability, slim profile, and ability to use with a variety of chairs. This device also fills a gap in the market by taking two desirable traits (multifunctionality and portability) and combining them.

One factor in determining the potential success of our device is through a look at the market that we are attempting to penetrate. Knowing the business environment helps our team make better decisions. There are many factors at play when it comes to producing, promoting, and selling our product. The following market analysis will present our device's strengths, weaknesses, opportunities, and threats in a SWOT analysis.

### **Business Environment**

#### **Social**

The social environment plays a big role in the development of our product. To differentiate our product from those existing in the market, we emphasize its portability. We are operating with the knowledge that those with autism who we expect will use our product prefer a discreet, low profile device. We are operating on the assumption that portability is important to a significant portion of people in the market segment. Any shift in social consensus about discreetness or need for ease of portability would have a great effect on our product. If there is no need of a portable product, we would be out of business.

#### **Demographic**

Our demographic target is people with Autism Spectrum Disorder who have Sensory Processing Disorders (SPD), or who could benefit from a device that assists with active listening. This is hard to pinpoint, as there are many subtypes of SPD (as seen in Figure 1). There are different ways to treat each subtype. Some with SPD crave additional stimuli such as rocking or bouncing, whereas for others, this would make them feel worse.

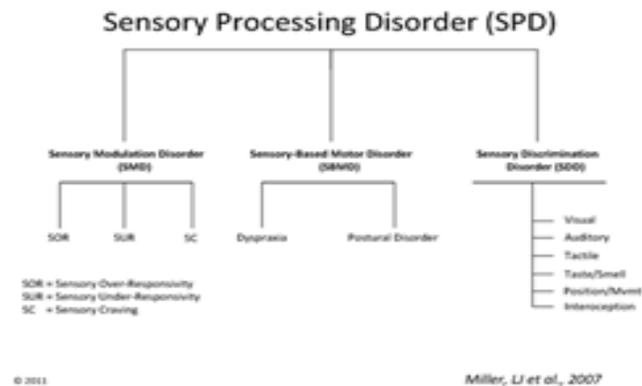


Figure 1

Because both autism and SPD can occur in anyone, there is no age group or income level group that we are targeting specifically. Insurance doesn't usually cover the cost of therapy or assistive devices, so it puts a strain on families who need to support an autistic member. Here are some statistics taken from the Center for Disease Control website:

- It is estimated to cost at least \$17,000 more per year to care for a child with ASD compared to a child without ASD. Costs include health care, education, ASD-related therapy, family-coordinated services, and caregiver time. For a child with more severe ASD, costs per year increase to over \$21,000. Taken together, it is estimated that total societal costs of caring for children with ASD were over \$9 billion in 2011.
- Children and adolescents with ASD had average medical expenditures that exceeded those without ASD by \$4,110–\$6,200 per year. On average, medical expenditures for children and adolescents with ASD were 4.1–6.2 times greater than for those without ASD.

Differences in median expenditures ranged from \$2,240 to \$3,360 per year with median expenditures 8.4–9.5 times greater.

- In 2005, the average annual medical costs for Medicaid-enrolled children with ASD were \$10,709 per child, which was about six times higher than costs for children without ASD (\$1,812).
- In addition to medical costs, intensive behavioral interventions for children with ASD cost \$40,000 to \$60,000 per child per year.

Because autism is clearly expensive, providing a reasonable price alternative is crucial to being recognized as competitive on the market. While it is very challenging to pinpoint exactly how many people are even likely to use a product like ours, we can say that our ideal consumer participates in multiple activities that active listening would be beneficial. This would mean that our device's portability becomes important for that consumer in order to travel with the device from activity to activity.

### **Market Analysis**

S.W.O.T analysis is a method of strategic planning that is implemented in analyzing the strengths, the weakness, the opportunities and the threats that are involved in operating a particular business organization. The key role of this analysis is for us to become better aware of our business in a strategic sense.

**Strengths:** Our strengths lie first and foremost in our device's portability. This convenience is what differentiates us from other chairs on the market and makes the product unique. Second, our device is multifunctional – not only can the user bounce, but also rock and swivel as well. Third, our price fills a gap in the market. We could charge a reasonable and competitive price of around \$300 for our product while still turning a profit.

Weaknesses: Our biggest weakness is that we don't have a brand name established like our competitors already do. Having brand recognition and awareness within the market is crucial to the success of a new product. Other weaknesses include our budget limit and limited time frame for research and development.

Opportunities: Our portability is our greatest product differentiator. While there are seat cushions that aid in active listening such as Disc-O-Sit, our product is the most multifunctional. We can provide several functions (bounce, rock, and swivel) just like a full chair such as Rifton's Activity Chair can provide. Our price is also an opportunity. Where the Disc-O-Sit is just \$45, a full-blown Activity Chair starts at over \$1000. Our seat attachment, priced at \$300, fills a gap in the marketplace.

Threats: Our biggest threats are our competitors. Since they have brand recognition and awareness already, should they decide to launch a product line similar to ours we would be driven out of business quickly. In order to survive, our device needs to be recognized as a competitive alternative on the market.

### **Microenvironment**

The microenvironment focuses on the factors that affect our ability to serve our customers. First, our suppliers: any delay in supply delivery will hinder production. Quality supplies are crucial in order to make a quality product. For our prototype, we used wood, foam, steel plates, and springs. Negotiating with suppliers for better deals and delivery time is key. In terms of marketing intermediaries, we would initially target autism therapists and autism societies. Entering this segment would get our product recognized among the existing active sitting chairs on the market. After we have some marketability, we would build our brand name and target consumers

as well as therapists. It may make sense to work with a reseller to diversify our distribution channels.

Competition is another crucial factor in evaluating the business environment. Assessing competition is based on factors such as price, quality and innovation. Our product's greatest competition comes from Rifton Equipment and Therapro. All of the big name competitors have a brand awareness advantage as our product is a new entrant to the market.

### **Biggest Competitors**

The top competitors for our product would be Rifton Equipment and Therapro. They each manufacture and distribute a variety of home care products for people with disabilities. Products that rival ours include the Rifton Activity Chair, which would serve the same functional purpose as our seating attachment, except as a whole chair, and the Therapro Disc-O-Sit, which serves as an aid for active listening that is highly portable, but does not have all of the same functionality that our device is capable of.

Rifton Equipment differentiates themselves by capturing a large market segment. They can fulfil needs for all kinds of disabilities, not just autism. Rifton targets both individual consumers and rehabilitation (physical therapy) practices and clinics. They provide products tailored to consumer's needs that are hand crafted with exceptional quality. To create customer value, they offer additional support materials and optional accessories that customize each device that they sell for the needs of their client. Rifton's Activity Chair, the product closest to ours, is highly adjustable. One benefit that it offers as a full chair is the confining arms that aid those who need that feeling for comfort. The downside to such a versatile option is that the product is very expensive, starting at over \$1000 for the cheapest model, not including any special features or

accessories. For even limited mobility, adding wheels and the option to sit lower or higher (to match a table height) changes the price to over \$3000.

Therapro differentiates themselves by finding a specific market niche: they target therapists within school systems. They offer therapy tools specific to an education environment. Therapro's products range from physical needs in the classroom (alternate seating, alternate writing surfaces, alternate clothing) to learning tools for those with different developmental needs (help with handwriting, listening, speech, etc.). Therapro's product that is comparable to ours, the Disc-O-Sit, is priced very affordably at just \$45. While an occupant of the small, highly portable pad can wiggle on a seat, the Disc-O-Sit does not provide a high range of functionality.

Successful companies like Rifton and Therapro make the decision early on to be entirely focused on the needs of the customer. Building safe, quality products is extremely crucial to this market, in order to develop a strong customer base and awareness of their brand. They developed good brand names early on and have built solid reputations from that.

### **Conclusion**

In essence, our product has both of the most desirable traits that our competitor's products have and combines them at a reasonable mid-range price. Although the Disc-O-Sit is smaller and lighter, our device is still competitively portable and has multiple functions. Compared to Rifton's \$1000 Activity Chair, at \$300, it is reasonably priced for a similar user experience. Price-wise and functionality-wise, our product fills a gap in the market.

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