1. **Background**

In 2010, approximately 3 051 217 of Columbia’s 45 509 584 habitants reported living with a disability, 34 238 of whom were children between 0 and 4 years with ambulation disabilities (Consejería Presidencial para la Primera Infancia, 2013). Additionally, many of the families of these disabled children have low economic resources (Narváez Tulcán, 2002). When a family member has a disability, the whole family is effected. Also, the child´s condition may cause barriers in social development with other children, resulting in hindered development their social capacities. This may affect the child’s personality long-term, making him insecure and introverted (Zambrano Torres & Pautt Figueroa, 2014). this causes a major concern to the family; therefore, they seek ways to mitigate this situation.

This project starts when a family with a two years old child with spina bifida came to the Rehabilitation Engineering Laboratory seeking help. They were searching for a device that provides their child the ability to move safely, comfortably and independently, and as well as facilitates interaction with other children of the same age.

Problem Statement/Research Question

Commercially-available wheelchairs for children are extremely expensive and the average Colombian families do not have the financial resources to pay for it. Also, the Colombian Mandatory Health Plan (POS) does not offer a wheelchair option that is customizable to the necessities of each patient. For this reason, families seek alternative methods to meet these unique needs. However, sometimes the alternative options are not the best solution for the optimal physical and social development of the child. In this specific case study, the solution that the family chose was to let the boy crawl using only his hands when socializing with other children and for the rest of the time he was carry held by his mom or other relatives.

The lack of alternative options to a commercial wheelchair provides a unique opportunity to help these families. Is it possible to develop a low cost device that allows the movement, independence and development of social skills for children between 1 and 5 years old who have mobility impairments or spinal cord injury?

1. Methods/Approach/Solutions Considered

The design process used in this project is based on an assistive technology device process previously developed by the Rehabilitation Engineering Laboratory:

1. Needs identification: In this step it was identified that the boy was not capable of walking; his family mentioned that he needed comfort, security and a new, improved way to socialize with other kids of the same age.

2. Skills identification: This step includes physical, psychological, cognitive skills and also, medical diagnoses. The child has spina bifida, which causes severe weakness of the legs that prevents walking. He has normal cognitive development for his age, which allowed him to perform all the requested tasks, including manual propulsion of a wheelchair.

3. Taking measures: This step includes obtaining appropriate anthropometric measures. To obtain necessary measurements (height, leg length, Midshoulder height and sitting) of the child, a flexometer, goniometer, and inclinometer were used.

4. Characterization of the environment: Determined present and future environments where the assistive technology device is going to be used. The device was going to be used in different environments. The two main places that were identified are his family home and his school, which both contain primarily flat surfaces.

5. Evaluation of the interface: At this stage the prototype device is designed, constructed and evaluated. To meet the needs for movement and independence, a wheelchair that fit the anthropometric measures of the child was designed. To meet the financial constraint, low-cost materials were desirable. Moreover, lightweight materials were desirable for easy transportability of the device A prototype was constructed using a small plastic chair, children's bicycle wheel, casters and fiberglass. After the wheelchair prototype was made, the child was brought into the lab for the first evaluation to determine what be further improved and what features were missing.

Figure 1: First prototype and evaluation

6. Make the final product: After considering the suggestions from the patient's family, the final product can be made. A company call Fiverglass helped to make the final wheelchair.

Figure 2: First approach to the final product

7. Training: Teach the patient how to use the assistive technology device. When the final device was obtained, the child was called for a final evaluation to teach him how to use the wheelchair.

8. Follow up: The patients' family was contacted to determine if the product was being used correctly and how the performance was. A few months after the final delivery, the family evaluated the performance of the wheelchair by completing a survey. A patient visit was also made to assess the performance of the wheelchair.

Figure 3: Follow up after four months.

2. Description of Final Approach and Design

The final approach was determined after obtaining and considering the suggestions made by the family. To build the primary part of the wheelchair, two molds were formed from fiberglass. The molds can be reused in the future to make additional wheelchairs. One mold is for the actual chair and the second is for the platform where the wheels attach and the patient can rest their feet. The wheels were taken from the first prototype. To give security to the child a breastplate was placed to hold the child in the seat while he is using the wheelchair. For the final cosmetic details, the chair was painted with colors that the family requested.

Figure 4: Prototype process.

3. Outcome

During the prototype evaluation and the final delivery, the patient demonstrated competence operating the wheelchair. From the first time that he sat on it, the propulsion was instinctive, which means that when the child sat in the chair he automatically started to coordinate his upper extremity movements to cause the wheelchair to move.

Gomez et al. developed a survey to evaluate assistive technology devices to measure the level of importance and satisfaction of size, weight, durability, esthetic, comfort, safety, usability and effectiveness. The child’s mother and professor answered the survey and the results were satisfactory, where all the characteristics were considered really important and satisfactorily met. Also, they emphasized that the wheelchair helped the child develop his social skills because now, he can play and share with his friends. The survey also contained questions for a health professional to confirm this device did not cause any new medical complications. The results of the survey demonstrate that the wheelchair has allowed a complete inclusion into his environment and improved social development for the patient (Gómez Vélez & Restrepo Arango, 2016).

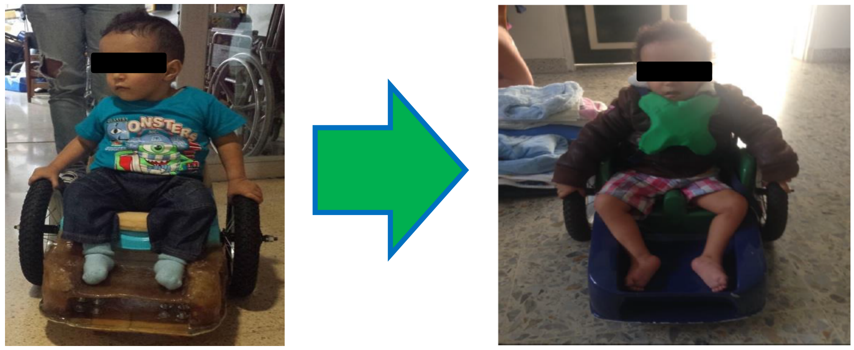

Figure 5: First time on the chair and follow up.

4. Cost

All the costs are reported in Colombian Pesos (COP) and all anticipated expenditures are included. There are two quotations, one for the device prototype and the second for the final product. The first quote is more expensive because it includes all the materials and time required for the prototype design and development. The design process requires additional labor cost and technical services, resulting in a larger cost for the prototype (2 316.95 USD). However, included in the prototype quote is the cost for the molds, which are used to create the final product. Thus, for the final product manufacturing time is optimized and therefore cost is reduced. The final price (322.52 USD) of the device is approximately three times cheaper than the commercial one (900 to 1100 USD).

PROTOTYPE QUOTATION

PROJECT NAME MOOVIC

EXPECTED EXPENDITURES			COP
1	LABOR COST	$	3,835,000.00
2	MATERIALS	$	387,500.00
3	TECHNICAL SERVICES	$	1,630,000.00
4	LICENSING	$	-
5	LOCAL TRASPORTATION	$	20,000.00
6	TRAVELS	$	-
7	EQUIPMENT AND MACHINES	$	280,000
	SUBTOTAL		$ 6,152,500.00
	ADMINISTRATION AND UNFORESEEN		$ -
	TOTAL WITH ADMINISTRATION AND UNFORESEEN		$ 6,152,500.00

PROJECT VALUE WITH ADMINISTRATION, UNFORESEEN AND UTILITY (COP)	
$	6,645,000.00
Current exchange rate 4/11/2017	$1USD= $2,868.00 COP
PROJECT VALUE WITH ADMINISTRATION, UNFORESEEN AND UTILITY (USD)	
$	2,316.95

Table 1: Prototype quotation

FINAL PRODUCT QUOTATION

PROJECT NAME MOOVIC

	EXPECTED EXPENDITURES		COP
1	LABOR COST	$	186,000.00
2	MATERIALS	$	143,000.00
3	TECHNICAL SERVICES	$	400,000.00
4	LICENSING	$	-
5	LOCAL TRASPORTATION	$	20,000.00
6	TRAVELS	$	-
7	EQUIPMENT AND MACHINES	$	20,000
	SUBTOTAL	$	769,000.00
	ADMINISTRATION AND UNFORESEEN	$	99,970.00
	TOTAL WITH ADMINISTRATION AND UNFORESEEN	$	868,970.00

PROJECT VALUE WITH ADMINISTRATION, UNFORESEEN AND UTILITY (COP)	
$	925,000.00
Current exchange rate 4/11/2017	$1USD= $2,868.00 COP
PROJECT VALUE WITH ADMINISTRATION, UNFORESEEN AND UTILITY (USD)	
$	322.52

Table 2: Final product quotation.

5. Significance

This project allowed the patient to have greater independence due to the ability to move around without the help of an adult or crawl using only his hands. Also, the social skills were improved as the survey showed because now, he can play and share with other children. This wheelchair helps him to gain muscle strength in his arms, which allows him to get used to the propulsion movement (4).

In the future, this device can help other children with similar diagnoses. This wheelchair is cheaper than current commercially available options. In addition, construction of future wheelchairs could be easier because the molds are already made; this will allow faster and cheaper production of the device than the initial prototype.

Figure 6: Patient using the final product.

6. Acknowledgements and References

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