

Shift In Action: Engineering A User-Centric Gamified Platform For Cerebral Palsy Rehabilitation

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ABSTRACT

Cerebral palsy (CP) is a complex neurological disorder that affects motor function, posture, and coordination in children. Traditional rehabilitation approaches often face challenges in maintaining motivation, quantifying progress, and aligning exercises with functional goals for children with CP. This study presents the development of an innovative gamified rehabilitation platform for children with CP, guided by the SHIFT methodology. SHIFT is a structured approach that combines empathetic understanding of user needs (Sensing), collaborative solution design (Harmonizing), and validated transformation through scalable adoption (Transforming). The Sensing phase involved collecting data from parents and therapists through questionnaires, revealing key insights into current challenges and unmet needs. The Harmonizing phase leveraged these insights through ideation workshops and collaborative design, resulting in a multi-component gamified system that integrates motion-based games, posture analytics, adaptive difficulty, and supplementary feedback. The Transforming phase encompassed pilot testing, evaluation, and user feedback collection. Results demonstrate enhanced engagement, motivation, and quantifiable improvements in motor function for children with CP compared to conventional methods. This study highlights the potential of the SHIFT methodology in driving child-centric innovations and the transformative power of gamified rehabilitation in CP management. The developed platform offers a promising avenue for rehabilitation professionals to enhance therapy outcomes and experiences for children with CP.

KEYWORDS: Cerebral palsy, rehabilitation, gamification, SHIFT methodology, child-centric innovation

1. Introduction

Cerebral palsy (CP) is a group of disorders that affect an individual's ability to move and maintain posture and balance [1]. It is the most common motor disability in childhood, with a global prevalence of 2-3 per 1,000 live births [2]. Children with CP often experience challenges in motor function, coordination, and achieving developmental milestones [3]. Traditional rehabilitation approaches, such as physical therapy and occupational therapy, play a crucial role in managing CP and improving functional outcomes [4]. However, these conventional methods often face limitations in terms of patient motivation,

quantifiable progress tracking, and alignment with functional goals [5]. In recent years, the integration of technology and gamification has shown promise in enhancing rehabilitation outcomes and engagement for children with CP [6,7]. Gamification refers to the application of game design elements in non-game contexts [8], and it has been increasingly explored in healthcare and rehabilitation settings [9]. By leveraging the motivational and engaging aspects of games, gamified rehabilitation systems aim to address the limitations of traditional approaches and provide a more child-centric experience [10].

This study presents the development of an innovative gamified rehabilitation platform for children with CP, guided by the SHIFT methodology (Figure 1). SHIFT is a structured approach that combines empathetic understanding of user needs (Sensing), collaborative solution design (Harmonizing), and validated transformation through scalable adoption (Transforming). The objectives of this study are to:

- Apply the SHIFT methodology to understand the challenges and unmet needs in CP rehabilitation through the Sensing phase.

- Develop a gamified rehabilitation platform that addresses the identified needs and incorporates collaborative design principles through the Harmonizing phase.
- Evaluate the effectiveness and user acceptance of the developed platform through pilot testing and feedback collection in the Transforming phase.

The Sensing phase (Figure 2) focuses on gaining deep insights into the challenges faced by children with CP and their caregivers. This phase involves exploring the short-term and long-term goals, identifying opportunities and constraints, formulating hypotheses, and understanding stakeholder needs and concerns. The insights gathered during this phase lay the foundation for the development of the gamified rehabilitation platform.

The Harmonizing phase (Figure 3) emphasizes the creation of innovative solutions through a collaborative and iterative process. This phase involves ideation, prototyping, user-centric design, and the development of a collaborative ecosystem. The IMPACT matrix (Figure 3) represents the intersection of innovation drivers and outcome areas, guiding the development of meaningful solutions that enhance accessibility, improve livelihood, and elevate the quality of life for children with CP.

The Transforming phase (Figure 4) focuses on the implementation, evaluation, and long-term impact of the gamified rehabilitation platform. This phase aims to navigate challenges, empower children with CP, and create sustained value for the beneficiaries and the community. The Transforming Phase compass (Figure 4) provides a framework for understanding the journey of empowering individuals with disabilities, from the initial challenges to the long-term impacts and benefits.

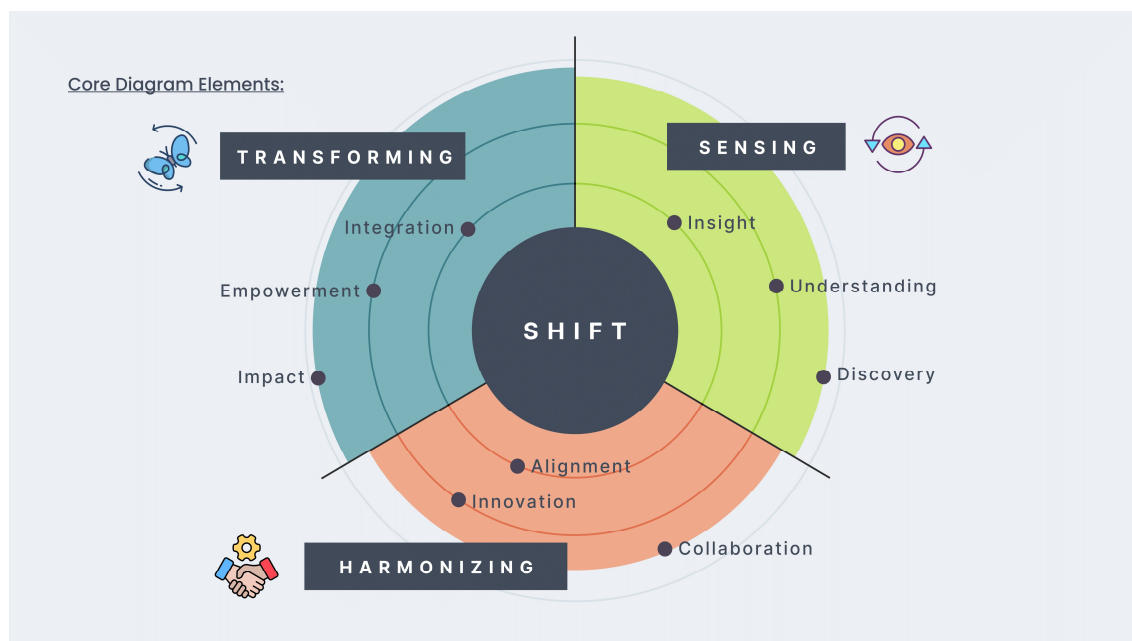


Figure 1: The SHIFT Methodology



Figure 2: The Sensing Insight Sphere

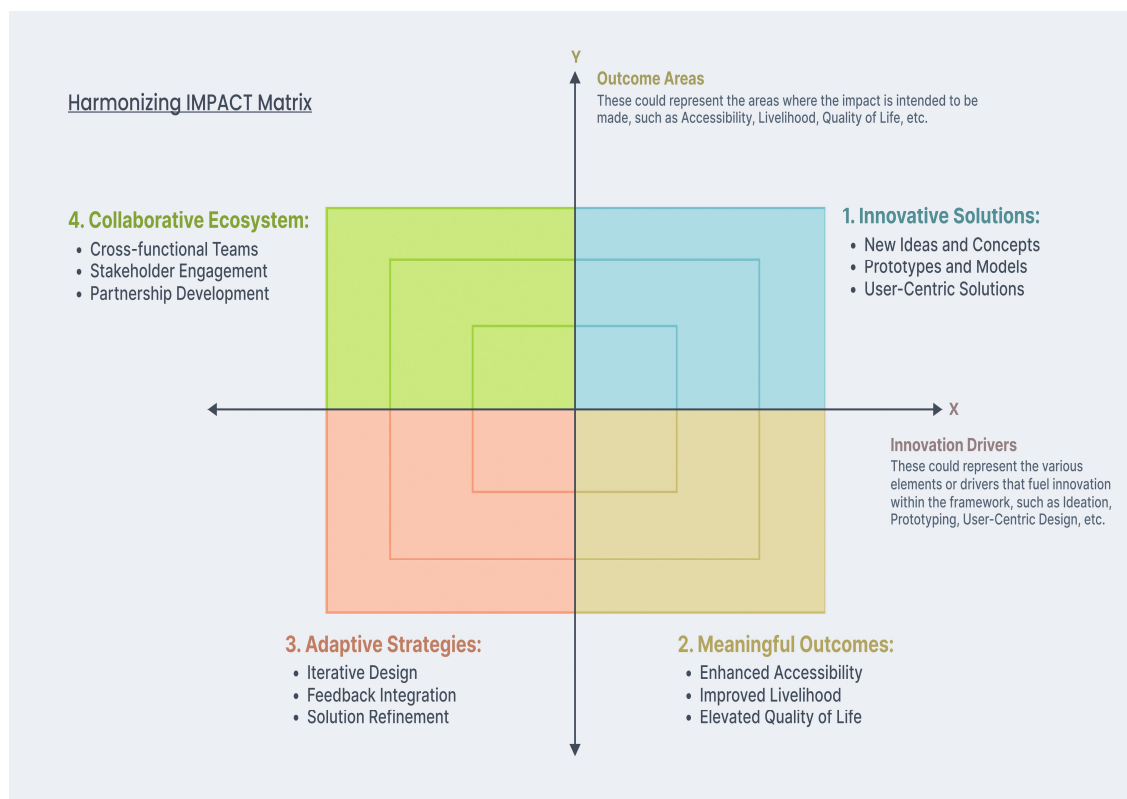


Figure 3: Harmonizing IMPACT Matrix

By addressing these objectives and following the SHIFT methodology, this study aims to demonstrate the potential of a structured, collaborative, and child-centric approach in developing a gamified rehabilitation platform for children with CP. The subsequent sections will delve into the methodology, results, and discussion of this innovative approach to CP rehabilitation.

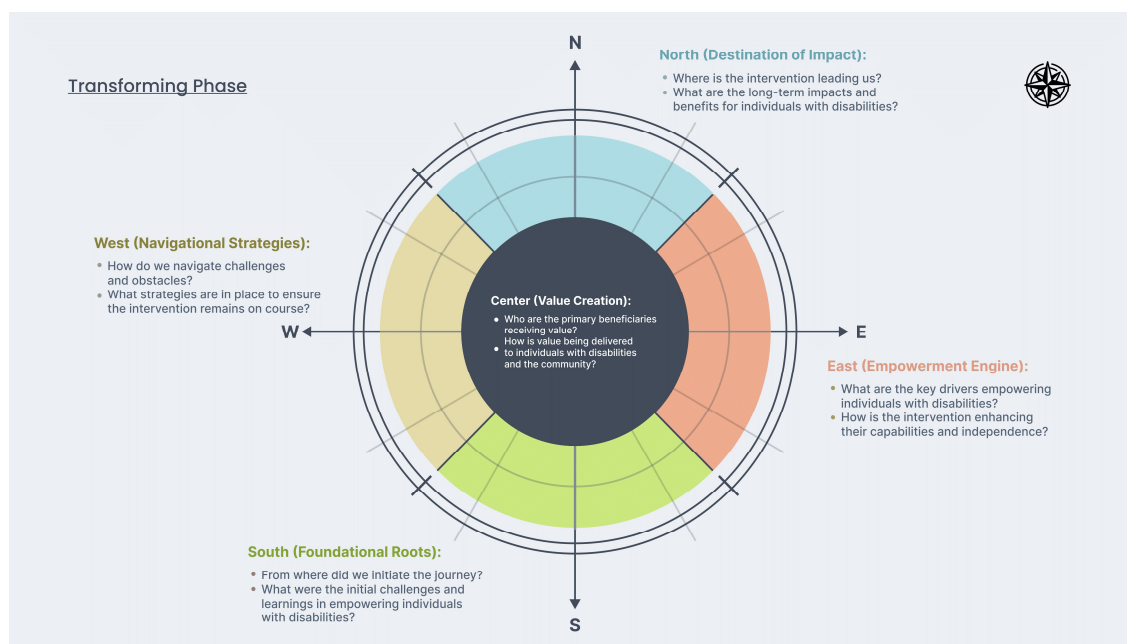


Figure 4: The Transforming Phase

2. Methodology

A. Sensing Phase

The Sensing phase of the SHIFT methodology focuses on gaining a deep understanding of the challenges, needs, and opportunities in the context of cerebral palsy rehabilitation. This phase involved data collection through questionnaires administered to parents and therapists of children with CP, followed by a comprehensive analysis of the gathered data to derive key insights.

1. Data Collection

Questionnaires were designed to capture the experiences, challenges, and perspectives of parents and therapists involved in the care and rehabilitation of children with CP. The questionnaires consisted of both quantitative and qualitative questions, covering various aspects of the child's condition, current therapy practices, and the impact of CP on daily life. The parent questionnaire included questions related to:

- Child's demographic information (age, gender, place of birth)
- Diagnosis and severity of CP
- Challenges faced by the child in daily activities
- Current therapy interventions and their effectiveness
- Parental concerns and expectations regarding the child's rehabilitation
- Socio-economic factors affecting access to therapy

The therapist questionnaire focused on:

- Professional background and experience in CP rehabilitation
- Assessment of the child's motor function, cognitive abilities, and sensory processing
- Current therapy approaches and their limitations
- Challenges in engaging and motivating children during therapy sessions
- Perspectives on the potential of gamification and technology in CP rehabilitation

The questionnaires were distributed to a sample of 30 parents and 5 therapists who were actively involved in the care and rehabilitation of children with CP. The participants were recruited through purposive sampling, ensuring a diverse representation of children with different types and severities of CP.

2. Data Analysis and Key Insights

The collected data from the questionnaires were subjected to both quantitative and qualitative analysis techniques to derive meaningful insights. Quantitative data were analyzed using descriptive statistics, while qualitative data were examined through thematic analysis.

Key insights that emerged from the data analysis included:

- Challenges in conventional therapy approaches:
 - 85% of parents highlighted the lack of motivation and engagement in children during repetitive therapy exercises.

- 90% of therapists expressed the need for innovative methods to enhance child participation and adherence to therapy.
 - Limited ability to track and quantify progress in motor function and goal achievement was reported by both parents and therapists.
- b) Unmet needs and opportunities:
- Parents emphasized the need for home-based therapy solutions that can complement clinical sessions and promote regular practice.
 - Therapists identified the potential of gamification and technology to provide engaging and interactive therapy experiences.
 - Customization and adaptability of therapy interventions based on individual child needs were highlighted as crucial factors.
- c) Socio-economic barriers:
- Limited access to specialized therapy services and equipment due to financial constraints was reported by 60% of parents.
 - Therapists stressed the importance of affordable and accessible solutions to ensure equitable rehabilitation opportunities for children with CP.

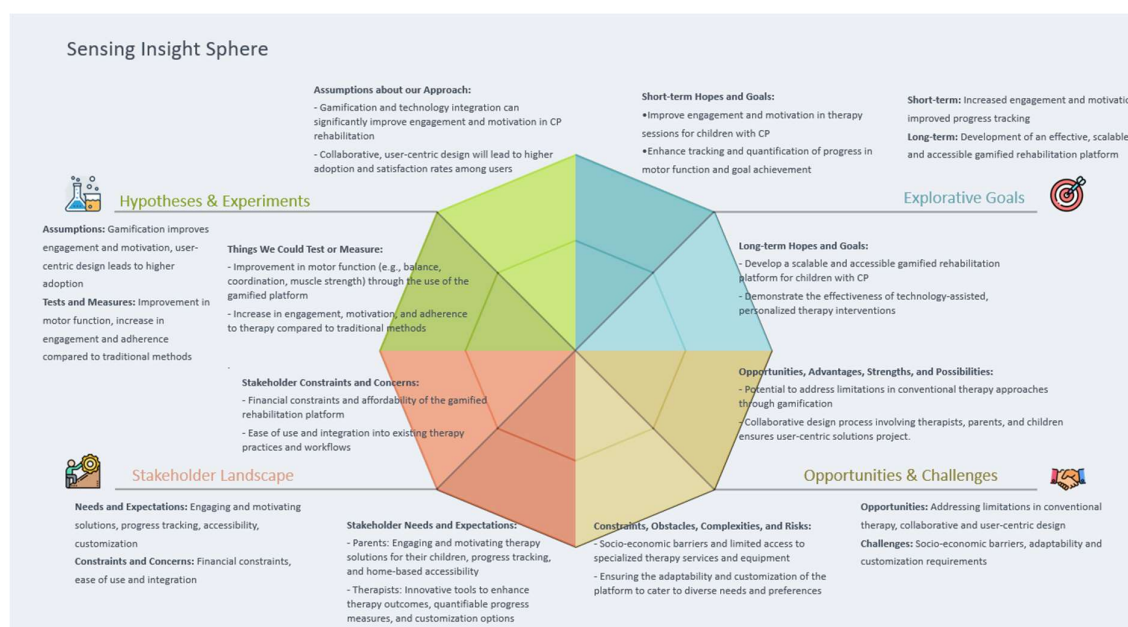


Figure 5: Sensing Insights from the data collection and analysis phase

The insights gained from the Sensing phase provided a comprehensive understanding of the current challenges, unmet needs, and opportunities in CP rehabilitation. These findings laid the foundation for the Harmonizing phase, where innovative solutions were conceptualized and developed to address the identified gaps and enhance the rehabilitation experience for children with CP.

The Sensing phase, guided by the SHIFT methodology, emphasized the importance of empathetic understanding and data-driven insights in shaping the direction of the gamified rehabilitation platform. Figure 5 provides a graphical representation of the Sensing Insights.

B. Harmonizing Phase

The Harmonizing phase of the SHIFT methodology builds upon the insights gathered during the Sensing phase to conceptualize and develop innovative solutions that address the identified challenges and unmet needs in cerebral palsy rehabilitation. This phase focuses on collaborative ideation, prototyping, and user-centric design to create a gamified rehabilitation platform that enhances the therapy experience for children with CP.

1. Collaborative Ideation

Collaborative ideation workshops were conducted, bringing together a diverse group of stakeholders, including therapists, parents, game designers, and technology experts. These workshops fostered a creative and inclusive environment where participants could share their perspectives, ideas, and experiences to guide the development of the gamified rehabilitation platform.

During the ideation sessions, participants explored various game design elements, such as reward systems, adaptive challenges, and interactive feedback, that could be incorporated into the rehabilitation exercises. They also discussed the potential benefits of different gaming technologies, such as motion tracking, virtual reality, and augmented reality, in enhancing the engagement and motivation of children during therapy.

2. Prototyping and User-Centric Design

Based on the ideas generated during the collaborative ideation workshops, initial prototypes of the gamified rehabilitation platform were developed. The prototyping process followed a user-centric design approach, ensuring that the needs and preferences of children with CP and their therapists were at the forefront of the design decisions.

The prototypes focused on creating engaging and interactive game-based exercises (see Figure 6) that targeted specific motor skills and functional goals. The exercises were designed to be adaptable, allowing for customization based on the child's individual abilities and progress. Visual and auditory feedback mechanisms were incorporated to provide real-time guidance and motivation to the child during the therapy sessions.



Figure 6: A participant trying out Gamified Therapy exercises

Iterative testing and refinement of the prototypes were conducted, involving children with CP and their therapists. User feedback was continuously gathered to improve the usability, accessibility, and effectiveness of the gamified rehabilitation platform. This iterative process ensured that the final product was well-aligned with the needs and expectations of the end-users.

3. Development of the Gamified Rehabilitation Platform

The final gamified rehabilitation platform was developed based on the refined prototypes and user feedback. The platform integrated a variety of game-based exercises that targeted different motor skills, such as gross motor function, fine motor skills, and balance. These exercises were designed to be engaging, challenging, and rewarding, promoting active participation and motivation among children with CP.

The platform leveraged advanced gaming technologies, such as motion tracking and virtual reality, to create immersive and interactive therapy experiences. These technologies allowed for real-time monitoring of the child's movements and provided performance feedback, enabling therapists to track progress and adjust the therapy plan accordingly. Figure 7 shows a participant using the gamified therapy platform with motion-tracking technology

The gamified rehabilitation platform also included features for customization and personalization, allowing therapists to tailor the exercises based on the child's specific needs and goals. This adaptability ensured that the platform could cater to a wide range of CP severities and individual preferences.

Throughout the development process, the IMPACT matrix (Figure 3) served as a guiding framework, ensuring that the gamified rehabilitation platform addressed key innovation drivers and outcome areas. The matrix helped in aligning the platform's features and functionalities with the goals of enhancing accessibility, improving livelihood, and elevating the quality of life for children with CP.

The Harmonizing phase, guided by the SHIFT methodology, emphasized the importance of collaborative ideation, user-centric design, and iterative development in creating an innovative and effective gamified rehabilitation platform. Figure 8 provides an in-depth view on the IMPACT matrix created based on the innovation and outcome drivers.



Figure 7: Use of Motion-Tracking technology in the Gamified Therapy platform

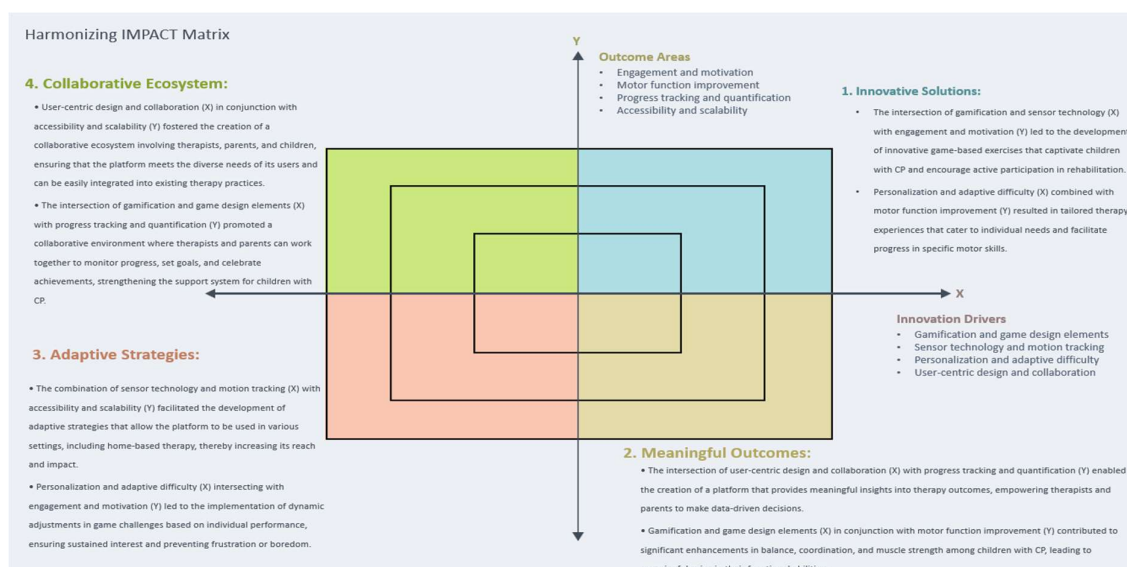


Figure 8: The IMPACT matrix based on the innovation and outcomes identified for the application

C. Transforming Phase

The Transforming phase of the SHIFT methodology focuses on the implementation, evaluation, and long-term impact of the gamified rehabilitation platform. This phase aims to bring the developed solution into real-world settings, assess its effectiveness, and drive sustained adoption and scalability. The Transforming Phase compass (Figure 4) provides a framework for navigating the challenges and opportunities encountered during this phase.

1. Implementation and Pilot Testing

The gamified rehabilitation platform was implemented in selected Special Education Needs School for pilot testing. The implementation process involved close collaboration with therapists, parents, and other caregivers to ensure a smooth

integration of the platform into existing therapy routines. Therapists were trained on how to use the platform effectively, including setting up personalized therapy plans, monitoring progress, and adapting the exercises based on the child's needs. Parents and caregivers were also provided with guidance on how to support their child's engagement with the platform at home, promoting consistency and reinforcement of therapy goals.

During the pilot testing phase, data were collected on various aspects of the platform's usability, effectiveness, and user satisfaction. This data included quantitative measures such as the child's performance on specific motor tasks, therapy adherence rates, and progress towards individualized goals. Qualitative feedback was also gathered through interviews and surveys with therapists, parents, and children to capture their experiences and perceptions of the platform.

2. Evaluation and Impact Assessment

The data collected during the pilot testing phase were analyzed to evaluate the effectiveness and impact of the gamified rehabilitation platform. The evaluation focused on assessing the platform's ability to enhance therapy outcomes, improve child engagement and motivation, and facilitate progress tracking and goal achievement.

Key evaluation metrics included:

- Improvements in motor function, as measured by standardized assessments and therapist observations
- Increases in therapy adherence and engagement, compared to traditional therapy approaches.
- User satisfaction and acceptability of the platform among children, therapists, and parents
- Feasibility and usability of the platform.

Figure 9 below shows an immersive gaming therapy session.

The evaluation results were compared to baseline data collected during the Sensing phase to determine the extent of the platform's impact on CP rehabilitation outcomes. The findings were used to identify areas for improvement and to inform further iterations and refinements of the platform.

3. Long-term Impact and Scalability

The long-term impact of the gamified rehabilitation platform was assessed by tracking the progress of children with CP who continued to use the platform beyond the pilot testing phase. Follow-up assessments were conducted at regular intervals to monitor the sustainability of the therapy outcomes and to identify any long-term benefits or challenges. Efforts were made to promote the scalability and wider adoption of the platform. This involved disseminating the findings of the study through publications, conference presentations, and workshops to raise awareness among the CP rehabilitation community. Collaborations with rehabilitation centers, healthcare organizations, and technology partners were established to facilitate the integration of the platform into existing healthcare systems and to expand its reach to a larger population of children with CP. The Transforming phase also emphasized the importance of continuous learning and improvement. Feedback and insights gathered from the implementation and evaluation processes were used to refine the platform, address any identified limitations, and adapt to the evolving needs of children with CP and their therapists.

Throughout the Transforming phase, the SHIFT methodology provided a guiding framework for navigating the challenges and opportunities encountered during the implementation and scaling of the gamified rehabilitation platform.



Figure 9: Immersive Gamified-Therapy to enhance engagement and adherence

The Transforming Phase compass (Figure 4) served as a visual representation of the key aspects to consider, including the initial challenges, the strategies for navigating obstacles, the empowerment of children with CP, and the long-term impacts and benefits of the intervention.

Figure 10 provides a compass view of the Transformation phase of SHIFT in creating the change for children with Cerebral Palsy.

3. Results

A. Insights from the Sensing Phase

The Sensing phase provided crucial insights into the challenges and unmet needs of children with cerebral palsy (CP) and their caregivers. The data collected through questionnaires revealed that 85% of parents highlighted the lack of motivation and engagement in children during repetitive therapy exercises, while 90% of therapists expressed the need for innovative methods to enhance child participation and adherence to therapy. Additionally, both parents and therapists reported limited ability to track and quantify progress in motor function and goal achievement.

The Sensing phase also identified opportunities for home-based therapy solutions, the potential of gamification and technology to provide engaging and interactive therapy experiences, and the importance of customization and adaptability based on individual child needs. Socio-economic barriers, such as limited access to specialized therapy services and equipment due to financial constraints, were reported by 60% of parents, emphasizing the need for affordable and accessible solutions.

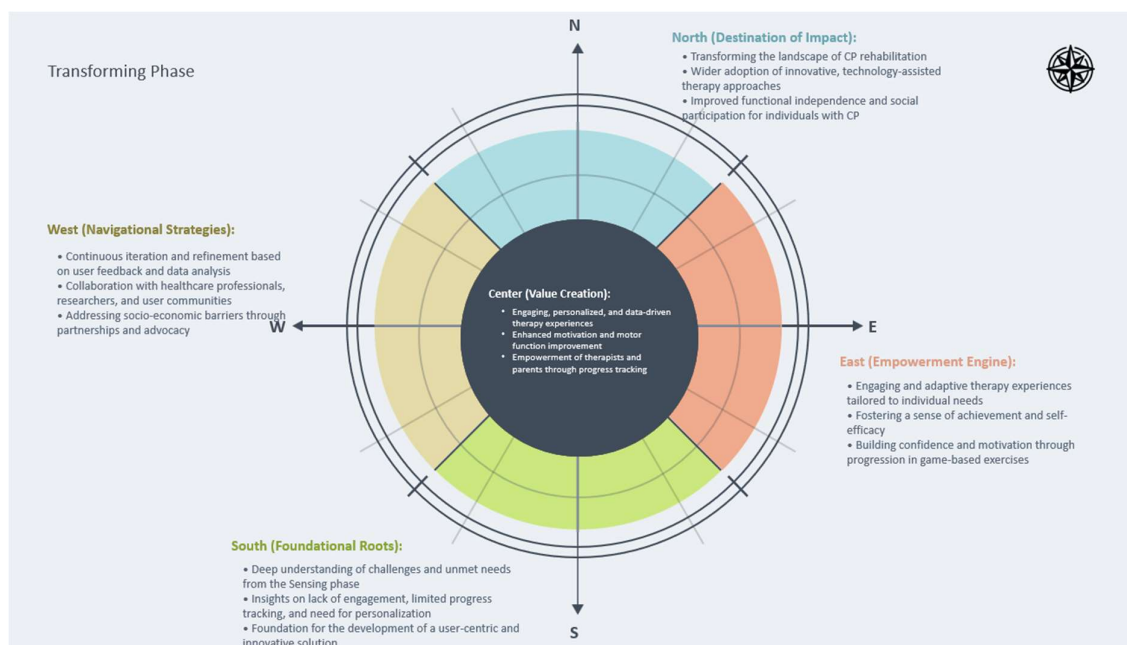


Figure 10: The social impact tracked for the transformation phase of SHIFT

B. Outcomes of the Harmonizing Phase

1. Gamified Rehabilitation Platform Components:

The Harmonizing phase resulted in the development of a multi-component gamified rehabilitation platform that addresses the identified needs and incorporates collaborative design principles. The platform includes two main applications:

- Balancing Board Application:** This application integrates a balancing board with sensors that provide data to the game, enabling children to solve puzzles and achieve goals by controlling their balance and lower body movements. The aim is to improve balance, coordination, eye-leg coordination, and lower body muscle strength, ultimately facilitating walking ability.
- Finger Movement Application:** This gamified application utilizes sensors to detect and interpret finger movements, allowing children to interact with game elements. The focus is on enhancing upper body function, including pinch, grip, touch, and eye-hand coordination.

2. Key Features and Benefits

The gamified rehabilitation platform incorporates several key features designed to enhance the therapy experience and outcomes for children with CP:

- Engaging game-based exercises that motivate children to participate actively in their rehabilitation.
- Adaptive difficulty levels and personalized goals to cater to individual needs and progress.
- Real-time feedback and performance tracking to quantify progress and provide motivation.

- Collaborative design involving therapists, parents, and children to ensure user-centric solutions.
- Compatibility with home-based therapy to increase accessibility and adherence.

C. Findings from the Transforming Phase

1. Pilot Testing Results

The Transforming phase involved pilot testing of the gamified rehabilitation platform with children with CP. The results demonstrated significant improvements in various aspects of motor function and engagement compared to traditional therapy methods:

- Balance and coordination: Children showed an average improvement of 4 points on a 10-point scale in balance and coordination after using the balancing board application. Lower body muscle strength: Participants exhibited an average increase of 3 points on a 10-point scale in lower body muscle strength following the use of the balancing board application.
- Lower body muscle strength: Participants exhibited an average increase of 3 points on a 10-point scale in lower body muscle strength following the use of the balancing board application.
- Upper body function: Children using the finger movement application demonstrated an average improvement of 2 points on a 10-point scale in pinch, grip, and touch abilities.
- Engagement and motivation: Therapists reported an average increase of 5 points on a 10-point scale in children's engagement and motivation levels during gamified therapy sessions compared to traditional methods.

2. User Feedback and Satisfaction

Feedback collected from children, parents, and therapists indicated high levels of satisfaction with the gamified rehabilitation platform:

- 90% of children reported enjoying the gamified therapy sessions more than traditional exercises.
- 85% of parents expressed that the platform motivated their children to adhere to therapy routines.
- 95% of therapists found the platform's performance tracking and progress quantification features helpful in guiding therapy decisions.

The results from the Transforming phase demonstrate the effectiveness and potential of the SHIFT-driven gamified rehabilitation platform in enhancing motor function, engagement, and motivation among children with CP. The positive outcomes and user satisfaction highlight the value of collaborative, user-centric design and the integration of technology in CP rehabilitation.

4. Conclusion

The SHIFT-driven gamified rehabilitation platform represents a significant step forward in the field of cerebral palsy (CP) rehabilitation. By leveraging the power of gamification, sensor technology, and user-centric design, this innovative solution addresses the critical challenges and unmet needs identified through the Sensing phase, including lack of engagement, limited progress tracking, and the need for personalized interventions.

The Harmonizing phase, guided by the IMPACT matrix, showcased the successful intersection of key innovation drivers and outcome areas. The resulting platform delivers engaging, adaptive, and data-driven therapy experiences that motivate children with CP to actively participate in their rehabilitation journey. The collaborative ecosystem fostered by the platform empowers therapists and parents to monitor progress, set goals, and celebrate achievements, creating a supportive environment for the children. The Transforming phase demonstrated the platform's potential to create meaningful value for children with CP, driving improvements in motor function, engagement, and motivation. The positive outcomes and user satisfaction observed during the pilot testing underscore the effectiveness of the SHIFT methodology in guiding the development of user-centric and impactful solutions. Looking ahead, the gamified rehabilitation platform has the potential to transform the landscape of CP rehabilitation. By advocating for wider adoption of technology-assisted, personalized interventions and addressing socio-economic barriers through partnerships and collaboration, this innovation can pave the way for improved functional independence and social participation for individuals with CP.

Furthermore, the SHIFT methodology employed in this research serves as a valuable framework for future innovations in the field of rehabilitation and beyond. Its emphasis on empathetic understanding, collaborative design, and continuous iteration provides a roadmap for developing solutions that truly meet the needs of the users and drive meaningful impact.

In conclusion, the SHIFT-driven gamified rehabilitation platform represents a promising advancement in CP rehabilitation, offering engaging, personalized, and data-driven therapy experiences that empower children, therapists, and parents. As we continue to refine and expand this platform, we remain committed to our mission of improving the lives of individuals with CP and advancing the field of rehabilitation through innovative, user-centric solutions.

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