Soft Systems Methodology in Standardizing the Method for Applying Dolphin-Assisted Therapies in Neurodivergent Patients: Case Study of Delfiniti Mexico

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Abstract: Dolphin-assisted therapy (DAT) currently lacks a standard for their application, making it difficult to collect the consistent data necessary for comparative studies and the development of new evidence-based therapeutic strategies. Due to their high social component, DAT requires a standardized method that identifies the elements that affect them, understands their complex situations, and proposes solutions to the challenges. This study aims to establish the first steps towards standardizing DAT, using the Soft Systems Methodology (SSM) as the central approach. SSM is suitable for addressing complex and ambiguous problems that involve multiple actors and perspectives. Through SSM, the study seeks to visualize problems, clarify conflict relationships that hinder standardization, and propose effective solutions. To establish an initial standard method, a time and motion study is performed to identify activities that disrupt the sequence of operations and the capture of EEG signals collected before, during, and after DAT. SSM allows for summarizing the current system situation, identifying and analyzing problems, clarifying challenges, and proposing pertinent solutions to achieve the standardization of this therapy. This methodology facilitates the identification of critical points and the development of intervention strategies that could improve the efficiency and effectiveness of the therapeutic process, establishing a more coherent framework for the implementation of DAT. Thus, the contribution of this work is based on systems thinking to strategic management, as it demonstrates the potential role of systems thinking, specifically SSM, in analyzing complex problems, improving strategy mapping, fostering strategic decision making, and planning for the future in the context of strategic management.

Keywords: soft systems methodology; dolphin-assisted therapy; time and motion study; standardization

1. Introduction

Currently, the number of people with disabilities is constantly increasing. According to the World Health Organization, approximately 15% of the global population has some form of disability, amounting to 190 million people requiring some type of assistance service [1]. In Mexico, 7,168,178 people have disabilities along with some neurological conditions, representing 5.69% of the total population. Of this group, 2% are children. Figure 1 shows that 40.1% of the child population in Mexico suffers from mental illnesses and cognitive capacity problems. However, currently, there are no precise data available for the number of children with any neurodivergent condition [2].
Neurodiversity considers neurological differences and disabilities to be natural human variations that can be a central part of a person’s identity. Glannon in [3] acknowledges that the combination of abilities and disabilities in an individual is due to the specific neuronal connectivity of each person. Unfortunately, little attention has been paid to this issue [4].

Neurodiversity refers to a group of neurodivergent individuals [4]. Although initially this term was used to describe conditions commonly seen as pathological and associated with deficits [5], today, neurodiversity is considered an educational approach that recognizes various neurological conditions as normal variations resulting from changes in the human genome. Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), Dyspraxia (Developmental Coordination Disorder) and dyslexia are neurodivergent conditions that are part of the neurodiversity spectrum [4,5].

There are various therapies for treating infants with neurological and/or physical impairments, such as autism, Down syndrome, attention deficit, obsessive–compulsive disorder, and cerebral palsy, which aim to strengthen the development of individuals, promote their social integration, and improve their quality of life.

Although conventional therapies such as occupational therapy, speech therapy, and physical therapy are supported by scientific rigor, their limitations, such as lack of accessibility and slow progress [6], can lead people to seek alternatives. In response to this situation, various alternative therapies have been developed that address the physical, emotional, and spiritual needs of patients. These therapies complement traditional approaches to promote holistic recovery [6,7]. Alternative therapies can be a valuable complement to conventional medicine when recommended by medical professionals [8].

One of the alternative approaches is dolphin-assisted therapy (DAT), which has shown improvements in pain and learning advances in children with disabilities, thus capturing the interest of the general public [9]. Thus, DAT can be classified as an alternative and complementary therapy that uses the interaction between humans and dolphins, usually pregnant or lactating bottlenose females, in an aquatic environment to promote health and well-being. This unconventional approach relies on the relationship with animals to add additional benefits, such as improving emotional state and reducing stress, rather than replacing traditional medical methods. Its primary role is to complement traditional therapies, enhancing the quality of life for children with disabilities. Although scientific evidence of its efficacy is still developing, dolphin therapy is used to enrich traditional medical treatment, providing an additional dimension to the recovery process [10].

Currently, DAT is a therapy that lacks fully established pathological standards [11]. Various authors, such as [12–14], have identified variations in the processes applied to the patients, therapists, and/or specialists involved, and the duration and frequency of the session, as well as the type of dolphin and their training to achieve therapeutic effects.

Therefore, having a standardized method is essential to maximize the therapeutic benefits of DAT. According to [15], standardization facilitates the evaluation of the efficacy
of the intervention. By using uniform measures and methods, professionals can more accurately compare the results of different treatments to identify which techniques are most effective for specific conditions. In particular, in the case of DAT, one way to assess the efficacy of this type of therapy is by varying brain waves in neurodivergent children, using electroencephalographic (EEG) signals recorded before, during, and after DAT sessions.

Another advantage of standardization in these therapies is the improvement in data collection for research. Standardized methods allow consistent data collection, which is essential for conducting comparative studies and developing evidence-based therapeutic strategies. This, in turn, contributes to the advancement of knowledge in the field and the continuous improvement of clinical practices [16].

Specifically, in DAT, the lack of standardization can lead to significant variations in results, as methods, session frequency and duration, as well as the training and type of dolphins used, often differ widely [12–14]. So far, DAT research has not addressed the potential effects on dolphins, both cognitively and physiologically, nor has it examined whether there is any difference in dolphin behavior when interacting with healthy patients [17–23].

Therefore, to standardize these types of therapies with a highly social component, it is necessary to identify the elements that influence the object of study (the systems), understand the interactions, processes, and complex situations they present, clarify challenges, and propose solutions that allow establishing a standard method.

The Soft Systems Methodology (SSM) emerges as a response to the unsuccessful application of the hard systems methodology in complex real-world situations [24–26]. SSM seeks to address situations where people involved in a problem perceive and interpret the world uniquely and make decisions based on standards and values that others may not share [26,27]. This approach prioritizes flexibility, adaptability, and continuous learning [26]. To achieve this, SSM employs systemic ideas to formulate the following fundamental mental acts: perceive, select, predict, compare, and decide actions [28].

SSM has been applied in various areas of the healthcare sector. Goto and Miura in [28] used SSM to study long-term healthcare, while [29] applied it to reduce waiting times in a chemotherapy unit. Železnik in [30] employed SSM to identify the needs and challenges in the nursing field. Augustsson in [31–33] highlighted the importance of evaluating the results obtained in the implementation and intervention of SSM to understand its utility and contribution to healthcare. However, so far, SSM has not been used to promote the standardization of DAT.

Based on the above, this manuscript addresses the first steps towards standardizing DAT, using SSM. This research was carried out through the application of time and motion studies, with the purpose of creating a standard method that allows greater reliability in the capture, recording, and measurement of EEG signals from patients undergoing DAT.

This document is divided as follows. Section 2 shows the basic concepts used in the research. Section 3 presents the SSM that underpins the importance of standardizing DAT. Section 4 outlines the results of applying SSM to DAT. Section 5 presents the analysis and discussion of the results obtained. Finally, the Conclusions and Future Work are presented in the last Section 6.

2. Theoretical Framework
2.1. Soft Systems Methodology

The Soft Systems Methodology (SSM) emerges as a response to the unsuccessful application of the hard systems methodology in complex real-world situations [24–26]. SSM seeks to address situations where people involved in a problem perceive and interpret the world uniquely and make decisions based on standards and values that others may not share [26,27]. This approach prioritizes flexibility, adaptability, and continuous learning [26]. To achieve this, SSM employs systemic ideas to formulate the following fundamental mental acts: perceive, select, predict, compare, and decide actions [28]. So far, SSM has not been used to promote the standardization of DAT.
SSM begins by presenting each individual’s perception in relation to the context, and then various perceptions are incorporated. Subsequently, several perceived problematic situations are selected, and a conceptual action model is created in response to the situation, which is then compared with the current situation to develop an ideal and viable action model [24,28].

SSM consists of seven stages: (1) unstructured problem situation, (2) expressed problem situation, (3) root definition of relevant systems, (4) conceptual models, further divided into the formal system concept and other system considerations, (5) comparison of relevant systems, (6) desirable and feasible changes, and (7) actions to improve the situation and transform reality. Steps 1, 2, 5, 6, and 7 are in the real world, while steps 3 and 4 focus on systems thinking (Figure 2).

2.2. Time and Motion Study

The time and motion study is a scientific study aimed at optimizing the use of human resources by seeking the most efficient method to perform a task. It involves the use of various methods to calculate the time required, under standard measurement conditions, for tasks involving human activity [34,35].

The motion study, pioneered by Frank B. Gilbreth and Lillian M. Gilbreth, encompasses a series of procedures involving the description, systematic analysis, and improvement of work methods [36]. The term “time and motion study” refers to the three stages to achieve standardization: the method establishment, time evaluation, and creation of material to apply these data [35–37].

The purpose of these studies is to understand the skills required for people to carry out the work and consequently provide appropriate training [35]. Although time and motion studies lost popularity in the late 20th century [38], they have regained usage and are currently a highly used tool for analysis and improvement not only in the industrial sector but also in the healthcare sector [39,40].
3. Methodology

This study aims to comprehensively address DAT by identifying all elements influencing it (the system), as well as its interactions and processes for standardization. By characterizing the study system as complex and pluralistic following Jackson’s Context-Problem Matrix [26], it confirms that the SSM is the most suitable for investigating the impact of DAT on the rehabilitation of patients with physical and/or neurological disabilities. The information was collected with the support of Delfiniti in Ixtapa, Mexico. In this research, the first six steps of SSM, according to Checkland in [24], are applied.

- **Stage 1. The problem situation, unstructured**: A general description of the situation is provided to identify the issues in the system; however, emphasis is not placed on the relationship of its elements. This initial approach seeks to create a framework surrounding the system.

- **Stage 2. The problem situation, expressed**: The system’s structure is described by identifying the relationships among the various components identified in Stage 1. This phase demonstrates that the system is not isolated but has interrelations with other systems that influence it. Internal and external relationships of the system are established, constructing a “rich picture” that recognizes relevant systems linked to the overall problem.

- **Stage 3. Root definition of relevant systems**: The root definition of the relevant systems obtained in the previous stage is presented. This root definition is based on the acronym CATWOE (C: Customers, A: Actors, T: Transformation, W: Worldview, O: Owners, and E: Environment) and the main axiom: “X by Y to achieve Z”.

- **Stage 4. Conceptual models**: A conceptual model of the problematic situation is proposed, along with models B1 and B2 indicating relevant system activities identified in the previous stage.

- **Stage 5. Comparison of 4 with 2**: Conceptual models are contrasted with the current situation, aiming to highlight discrepancies between what is proposed in the conceptual models and what actually occurs in the system currently.

- **Stage 6. Feasible, desirable changes**: Based on the identified discrepancies between the current situation and conceptual models, adjustments are suggested to address them; these changes must undergo evaluation and approval by the individuals involved in the human system to ensure they are feasible and desirable.

The methodology used in this research was approved by the Ethics Committee of the National Polytechnic Institute of Mexico, according to the Confidentiality Commitment Letter D/1477/2020. This document endorses the collection method of various samples and the treatment provided to bottlenose dolphins by the research team. The responsible use of patient data was guaranteed and informed, and consent was given for the use of data obtained in the experiments. Before taking samples and connecting devices, the procedure was explained to the patients; those who disagreed could immediately withdraw their participation. Participants who accepted the methodology and materials for sample collection signed a written informed consent form (from 14 to 17 November 2023). Participants were also informed about the tests they would undergo, although some did not fully understand them before entering the tank with the cetaceans.

4. Results

4.1. System Definition

Figure 3 shows the system under study in this research. Patient data serve as the input of the system, while a reliable sample of patient EEG signals constitutes the output. Furthermore, feedback is addressed by standardizing DAT as seen within the black box of the system that contains neurodivergent children (NC), the dolphin (D), the therapist (Th) and the trainer (Tr).
4.2. Stage 1. The Problem Situation: Unstructured

Figure 4 illustrates the main subsystems that interact externally with the system. In the second level (blue halo) are the agents interested in the development and study of TAD, such as physiotherapists, Delfiniti staff, family members, doctors, and researchers from the Higher School of Mechanical and Electrical Engineering (ESIME, Escuela Superior de Ingeniería Mecánica y Eléctrica) Campus Zacatenco and the Research Center for Computing (CIC, Centro de Investigación en Computación). In the third level, we find the organizations, both public and private, that support the elements of the first level (yellow halo), including the National Polytechnic Institute (IPN, Instituto Politécnico Nacional), the municipal government, Dolphin Discovery, the Teletón Children’s Rehabilitation Center (CRIT, Centro de Rehabilitación Infantil Teletón), the Municipal System for the Integral Development of Families (DIF, Sistema Municipal de Desarrollo Integral de las Familias), and other therapies.

4.3. Stage 2. The Problem Situation: Expressed

Figure 5 presents the iconography of the elements identified in Stage 1. Figure 6 depicts the relationships that exist within and outside the system. The blue arrows indicate non-conflicting relationships, where the elements interact correctly, while the red arrows highlight the conflicting relationships that cause significant changes for the transformation and interrelation of the system. Table 1 provides a description of these conflicting relationships.

Figure 7 presents the rich picture of the system under study, consisting of four relevant systems: standardization, measurement, financial support, and agreements. It also shows the necessary interrelationships between these systems and other elements. The green arrows illustrate how the different relevant systems should interact to ensure that the system under study achieves its objective.

The Standardization System should have a bidirectional relationship with the Measurement System because through the standardization of therapy, a reliable sample can be obtained, which will address the uncertainty among physicians about the contribution of DAT to the rehabilitation of neurodivergent patients. Similarly, the Measurement System has a bidirectional relationship with the Financial Support System, as funding for this type of research will provide the software and hardware necessary to measure the efficacy of DAT.
Figure 4. Unstructured problem situation (where D = dolphin, Tr = trainer, Th = therapist, and NC = neurodivergent children, IPN = National Polytechnic Institute (IPN, Instituto Politécnico Nacional), CRIT = Teletón Children’s Rehabilitation Center (CRIT, Centro de Rehabilitación Infantil Teletón), Municipal DIF = Municipal System for the Integral Development of Families (DIF, Sistema Municipal de Desarrollo Integral de las Familias, CIC and ESIME Zacatenco Researches = Researchers from the Research Center for Computing (CIC, Centro de Investigación en Computación) and Higher School of Mechanical and Electrical Engineering (ESIME, Escuela Superior de Ingeniería Mecánica y Eléctrica) Campus Zacatenco.

The Financial Support System and the Agreements System will have a bidirectional relationship to facilitate agreements between organizations to provide and study DAT, addressing the families’ need to access these therapies. Furthermore, the National Polytechnic Institute (IPN), through COFAA, will manage the necessary monetary resources for the study and dissemination of the results of this research.
<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
<th>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Icon" /></td>
<td>Neurodivergent children undergoing TAD</td>
<td><img src="image2.png" alt="Icon" /></td>
<td>Family</td>
</tr>
<tr>
<td><img src="image3.png" alt="Icon" /></td>
<td>Trainer</td>
<td><img src="image4.png" alt="Icon" /></td>
<td>Delphinus Ixtapa (Ixtapa is the place where the study of dolphin therapy is carried out)</td>
</tr>
<tr>
<td><img src="image5.png" alt="Icon" /></td>
<td>Therapist</td>
<td><img src="image6.png" alt="Icon" /></td>
<td>Teletón Children’s Rehabilitation Center (CRIT, Centro de Rehabilitación Infantil Teletón)</td>
</tr>
<tr>
<td><img src="image7.png" alt="Icon" /></td>
<td>Dolphin</td>
<td><img src="image8.png" alt="Icon" /></td>
<td>Dolphin Discovery</td>
</tr>
<tr>
<td><img src="image9.png" alt="Icon" /></td>
<td>Researchers from the Center for Computing Research (CIC, Centro de Investigación en Computación) and the Higher School of Mechanical and Electrical Engineering (ESIME, Escuela Superior de Ingeniería Mecánica y Electrónica) Campus Zacatecas</td>
<td><img src="image10.png" alt="Icon" /></td>
<td>System for the Comprehensive Development of the Family (DIF, Desarrollo Integral de las Familias)</td>
</tr>
<tr>
<td><img src="image11.png" alt="Icon" /></td>
<td>Doctors</td>
<td><img src="image12.png" alt="Icon" /></td>
<td>ZIHUA CIUDAD DE TODOS</td>
</tr>
<tr>
<td><img src="image13.png" alt="Icon" /></td>
<td>Physiotherapist</td>
<td><img src="image14.png" alt="Icon" /></td>
<td>Other therapies</td>
</tr>
<tr>
<td><img src="image15.png" alt="Icon" /></td>
<td>National Polytechnic Institute (IPN, Instituto Politécnico Nacional)</td>
<td><img src="image16.png" alt="Icon" /></td>
<td>Commission for the Operation and Promotion of Academic Activities (COFAMA, Comisión de Operación y Fomento de Actividades Académicas). Institution responsible for managing the effective, efficient, and transparent use of the resources of the National Polytechnic Institute</td>
</tr>
</tbody>
</table>

**Figure 5.** Iconography of the elements identified in Stage 1.
<table>
<thead>
<tr>
<th>Relationship</th>
<th>Description of the Conflicting Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trainer → Therapist</td>
<td>The absence of the trainer causes delays in starting the DAT, as he authorize the therapist and the patient to enter the tank.</td>
</tr>
<tr>
<td>Therapist → Trainer</td>
<td>The absence of the therapist causes delays in starting the DAT, as they are the one who indicates the positions in which the trainer should place the dolphin during the development of the DAT.</td>
</tr>
<tr>
<td>Dolphin → Trainer</td>
<td>The dolphin's behavior is not controllable, as for biological reasons, it sometimes does not perform the activities that the trainer instructs.</td>
</tr>
<tr>
<td>Therapist → CIC and ESIME Zacatenco Researches</td>
<td>The absence of the therapist causes delays in starting the capture and recording of EEG signals during the DAT.</td>
</tr>
<tr>
<td>CIC and ESIME Zacatenco Researches → Trainer</td>
<td>Rearranging and preparing the equipment necessary for capturing EEG signals causes delays and interruptions in the DAT.</td>
</tr>
<tr>
<td>Trainer → CIC and ESIME Zacatenco Researches</td>
<td>The absence of the trainer causes delays in starting the capture and recording of EEG signals during the DAT.</td>
</tr>
<tr>
<td>CIC and ESIME Zacatenco Researches → Trainer</td>
<td>Rearranging and preparing the equipment needed for capturing EEG signals causes delays and interruptions in the DAT.</td>
</tr>
<tr>
<td>Delfiniti Ixtapa → Therapist</td>
<td>Lack of authority for enforcing orders for the standardization of the DAT.</td>
</tr>
<tr>
<td>Delfiniti Ixtapa → Trainer</td>
<td>Lack of authority for enforcing orders for the standardization of the DAT.</td>
</tr>
<tr>
<td>Trainer → Delfiniti Ixtapa</td>
<td>Sometimes, the trainer does not follow the instructions of the head of the organization to achieve the standardization of the DAT.</td>
</tr>
<tr>
<td>Therapist → Delfiniti Ixtapa</td>
<td>Sometimes, the trainer does not follow the instructions of the head of the organization to achieve the standardization of the DAT.</td>
</tr>
<tr>
<td>Doctors → Therapist</td>
<td>Disbelief about the DAT.</td>
</tr>
<tr>
<td>Delfiniti Ixtapa → Municipal government</td>
<td>Lack of agreements to provide the DAT.</td>
</tr>
<tr>
<td>Delfiniti Discovery → Municipal government</td>
<td>Lack of agreements to provide the DAT.</td>
</tr>
<tr>
<td>DIF → Family</td>
<td>Lack of resources to provide the DAT.</td>
</tr>
<tr>
<td>Family → DIF</td>
<td>Lack of resources to provide the DAT.</td>
</tr>
<tr>
<td>DIF → Municipal government</td>
<td>Lack of resources to provide the DAT.</td>
</tr>
<tr>
<td>CIC and ESIME Zacatenco Researches → IPN</td>
<td>Lack of financial support for the study of the DAT.</td>
</tr>
<tr>
<td>Municipal government → IPN</td>
<td>Lack of agreements to provide the DAT.</td>
</tr>
<tr>
<td>IPN → Municipal government</td>
<td>Lack of agreements to provide the DAT.</td>
</tr>
<tr>
<td>Family → Municipal government</td>
<td>Lack of resources to access the DAT.</td>
</tr>
</tbody>
</table>
Figure 6. System relationships inside and outside.

Figure 7. Rich picture.
4.4. Stage 3. Definition of the Root of Relevant Systems

Next, we present the root definition of the relevant systems obtained in the previous stage. This root definition is based on the acronym CATWOE (C: Clients, A: Actors, T: Transformation, W: Worldview, O: Owners, and E: Environment) and the main axiom: “X by Y to achieve Z”. In this way, we have the following.

4.4.1. Root of the System Study Object

A system comprised of researchers and graduate and undergraduate students from IPN must capture electroencephalographic (EEG) signals with the goal of measuring the effectiveness of DATs in neurodivergent patients.

- **C**: Neurodivergent children.
- **A**: Researchers and graduate and undergraduate students from IPN.
- **T**: EEG signal capture → Spectral Power Analysis and Fractal Analysis to estimate the effectiveness of a DAT.
- **W**: Record EEG signals during DATs to measure their effectiveness in patients with neurodevelopmental disorders.
- **O**: IPN, through COFAA.
- **E**: Budget from COFAA and IPN, IPN infrastructure, Municipal Government of Ixtapa-Zihuatanejo, Delfiniti Ixtapa, DIF Zihuatanejo.

4.4.2. Root of the System Relevant: Standardization

A system comprised of a therapist, a trainer, researchers, and graduate and undergraduate students from IPN, which must standardize the method of capturing EEG signals from DATs administered to neurodivergent children, with the aim of homogenizing results and minimizing downtime.

- **C**: Neurodivergent children.
- **A**: Therapist, trainer, researchers, and graduate and undergraduate students from IPN.
- **T**: Non-standardized EEG signal capture method → Standardized EEG signal capture method.
- **W**: Standardize the EEG signal capture method to homogenize results and minimize downtime.
- **O**: IPN.
- **E**: Dolphin, Delfiniti Ixtapa, Researchers and graduate and undergraduate students from IPN.

4.4.3. Root of the System Relevant: Measurement

A system comprised of researchers and graduate and undergraduate students from IPN must develop the necessary software and hardware for the processing of EEG signals to perform spectral power analysis of EEG signals captured before, during, and after DATs administered to neurodivergent children.

- **C**: Neurodivergent children.
- **A**: Researchers and graduate and undergraduate students from IPN.
- **T**: EEG signals → Spectral Power Analysis and Fractal Analysis.
- **W**: Development of software and hardware for the processing and interpretation of EEG signals.
- **O**: IPN.
- **E**: Budget and infrastructure of IPN, Solidworks, Matlab, Python, Colab, Git, and Docker.

4.4.4. Root of the System Relevant: Financial Support

A system comprised of IPN, COFAA, researchers, and graduate and undergraduate students from IPN must carry out the required procedures to secure financial support to publish research on DATs in high-impact journals focused on neurodivergent children.
• C: Neurodivergent children.
• A: IPN, COFAA, Researchers and graduate and undergraduate students from IPN.
• T: Research findings → Application for financial support for publication of results.
• W: Perform the required procedures to secure financial support for the research publication.
• O: IPN—COFAA.
• E: Regulations and guidelines of IPN.

4.4.5. Root of the System: Relevant Agreements

A system comprised of Delfiniti Ixtapa, the Municipal Government of Ixtapa-Zihuatanejo, DIF Zihuatanejo, IPN, and Dolphin Discovery must achieve high scientific productivity in publications to establish national and international agreements with companies that conduct DATs, specifically for neurodivergent children.

• C: Neurodivergent children.
• A: Delfiniti Ixtapa, Municipal Government of Ixtapa-Zihuatanejo, DIF Zihuatanejo, IPN, Dolphin Discovery.
• T: Published scientific productivity → Agreements with various organizations.
• W: Establish national and international agreements with companies that conduct DATs.
• O: Municipal Government of Ixtapa-Zihuatanejo, IPN.
• E: Regulations and guidelines of IPN and the Municipal Government of Ixtapa-Zihuatanejo.

4.5. Stage 4: Conceptual Model

Figure 8 shows the proposed systemic model, which aims to reduce the conflict relationships identified in the previous stages. Within this conceptual model, models B1, B2, B3, and B4 are nested and interrelated. The fact that these nested models are numbered does not imply that they must be carried out in strict sequential order; however, the proposed overall model will not achieve maximum effectiveness if models B1–B4 are not completed.

For the purposes of this manuscript, models B1 and B2 are shown below in Figure 9 and Figure 10, respectively. Model B1 outlines the process for standardizing the DATs; This model will be executed until a standard time is established for the activities developed in the DATs. On the other hand, Model B2 explains the processes for the development and redesign of the electroencephalographic device; This model will be performed as many times as is necessary until the device is functional, comfortable, and appealing to patients.

Models B1 and B2 have a bidirectional relationship, as the diagnosis of the current DAT method leads to the redesign of the devices used; thus, the redesign of these models modifies the time study conducted, which provides a basis for a new diagnosis, creating a continual improvement cycle between these two models.

4.6. Stage 5. Comparison of 4 with 2

From November 14 to 17 2023, a time and motion study (Model B1) was conducted to determine the sequence of operations during DAT aimed at children with various physical and mental disorders, including those with neurodivergence. This study involved two children with Spastic Cerebral Palsy (SCP), two with ASD, and two with Trisomy 21 (Down syndrome, DS). Based on this study, various activities that occur during DAT were classified (Table 2).

It is important to mention that, before starting a DAT, the dolphin trainer must authorize the entry of the therapist and patient into the tank where the DAT takes place, to prevent accidents or incidents during the therapy session (Figure 11).
Figure 8. Relevant activities model.

Figure 9. Model B1 of relevant activities.
Figure 10. Model B2 of relevant activities.

Table 2. Description and categorization of activities during a DAT (where ○ = Operation and → = Transportation).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Type of Activity</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Placement of the TGAM1 sensor on the patient’s skull.</td>
<td>Operation</td>
<td>○</td>
</tr>
<tr>
<td>B</td>
<td>Capturing and recording EEG signals from the patient: Before starting the therapy.</td>
<td>Operation</td>
<td>○</td>
</tr>
<tr>
<td>C</td>
<td>Patient enters the tank.</td>
<td>Transportation</td>
<td>→</td>
</tr>
<tr>
<td>D</td>
<td>DAT begins: capturing and recording EEG signals from the patient (During therapy). Maintaining contact with the dolphin at all times.</td>
<td>Operation</td>
<td>○</td>
</tr>
<tr>
<td>E</td>
<td>Patient exits the tank.</td>
<td>Transportation</td>
<td>→</td>
</tr>
<tr>
<td>F</td>
<td>Capturing and recording EEG signals from the patient: After therapy.</td>
<td>Operation</td>
<td>○</td>
</tr>
<tr>
<td>G</td>
<td>Removal of the TGAM1 sensor from the patient’s skull.</td>
<td>Operation</td>
<td>○</td>
</tr>
<tr>
<td>W</td>
<td>Wait for the dolphin trainer to be inside the tank (with the dolphin).</td>
<td>Wait time</td>
<td>D</td>
</tr>
<tr>
<td>X</td>
<td>Wait for the therapist to be inside the tank (to receive the patient).</td>
<td>Wait time</td>
<td>D</td>
</tr>
<tr>
<td>Y</td>
<td>Repositioning the TGAM1 sensor on the patient During therapy (it falls off).</td>
<td>Wait time</td>
<td>D</td>
</tr>
<tr>
<td>Z</td>
<td>Dolphin moves away from the patient.</td>
<td>Wait time</td>
<td>D</td>
</tr>
</tbody>
</table>
Figure 11. DAT applied to a patient.

In Table 2, it is observed that during DAT monitoring, some activities that do not add value are recognized, such as waiting times derived from the trainer (W), therapist (X), dolphin (Z), or TGAM1 sensor repositioning (Y). Figure 12 presents the results obtained in this study. The time to place and remove the sensor (activities A and G) varies depending on the type of condition the infant undergoing the DAT has.

Figure 12. Total time per activity per patient.

Although the current design of the device, including the TGMA1 sensor, causes losses within the sequence of operations, it does not account for the largest amount of wasted time during the process. This time is actually derived from the delays caused by the trainer before starting the DAT, which represent 19%, 14%, 8%, 15%, 13%, and 14%, respectively, of the total available time per patient (Figure 13).

In Figure 14, the waiting periods between patients are detailed. On day 4 (16 November 2023), the longest waiting time between patients was recorded, which was due to the trainer, after completing a DAT, being absent in order to carry out activities unrelated to the study. This caused the therapist to locate the trainer and inform them that their presence was necessary to resume DAT activities. Therefore, it is imperative to reduce these waiting periods to establish a standardized method that allows the uninterrupted capture and recording of EEG signals from patients undergoing a DAT.
4.7. Stage 6. Feasible, Desirable Changes

In Table 3, the proposed method is described, which involves five operations and two patient transfers. This is to eliminate activities that do not add value to therapy, such as the waiting periods mentioned above. Therefore, the estimated times are proposed for each activity. To capture and record EEG signals from the patient before and after therapy, 60 s is required. Meanwhile, capturing and recording the EEG signals from the patient during therapy takes 300 s (5 min). During this latter activity, it was agreed that the dolphin will maintain continuous contact with the patient. The times for activities A, C, E, and G have yet to be determined, as the first step involves standardizing the method used to conduct therapy. Afterward, the standard times for each of these tasks will be calculated. It is found that the times for placing and removing the sensor vary depending on the patient’s condition, and that the current design of the TGAM1 device causes delays in the sequence of operations. To reduce variability in these actions, it is proposed to redesign the device used to capture and record EEG signals before, during, and after study therapy, in order to make it comfortable, functional, and appealing to the patient.

To provide a standardized notation and graphically and clearly represent the activities carried out in DAT, the Business Process Model and Notation (BPMN) tool is used. This tool facilitates communication with stakeholders and helps understand how processes work and the steps involved [41]. Authors such as [41–44] applied BPMN in various health sector processes, supporting its utility in identifying key points within DAT. Figure 15 shows the proposed process for carrying out a DAT, in a standardized way, applying BPMN.
Figure 15. Proposed process for carrying out a DAT in a standardized manner, using BPMN.
Table 3. Proposed method for DAT execution.

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description of Activities</th>
<th>Estimated Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Placement of the TGAM1 sensor in the patient’s skull.</td>
<td>Pending definition</td>
</tr>
<tr>
<td>B</td>
<td>Capturing and recording EEG signals from the patient: Before starting therapy.</td>
<td>60</td>
</tr>
<tr>
<td>C</td>
<td>Patient enters the tank.</td>
<td>Pending definition</td>
</tr>
<tr>
<td>D</td>
<td>DAT begins: capturing and recording EEG signals from the patient (During therapy). Maintain contact with the dolphin at all times.</td>
<td>300</td>
</tr>
<tr>
<td>E</td>
<td>Patient exits the tank.</td>
<td>Pending definition</td>
</tr>
<tr>
<td>F</td>
<td>Capturing and recording EEG signals from the patient: After therapy.</td>
<td>60</td>
</tr>
<tr>
<td>G</td>
<td>Removal of the TGAM1 sensor from the patient’s skull.</td>
<td>Pending definition</td>
</tr>
</tbody>
</table>

5. Discussion

In this study, the objective was to fully address the application of DAT in the rehabilitation of neurodivergent children, identifying all the elements that influence it, as well as their interactions and processes to establish the initial steps for standardization. As shown in the “rich picture” (Figure 7), DAT is an activity with a high social component; therefore, the SSM was used as a method to study the application of this type of alternative and complementary therapy. Stages 1 and 2 identified the elements that compose and interact within the system, as well as highlighting the existing problems among them.

Significant conflicting relationships related to the lack of training and communication between trainers and therapists were detected, causing delays in the start of DAT. These situations not only result in delays in the execution of DAT operations, but also interrupt the capture of EEG signals before, during, and after therapy. Rearrangement and preparation of the necessary equipment for capturing EEG signals cause delays and interruptions in DAT, specifically, adjusting the device containing the TGAM1 sensor, placed in the patient’s cerebral cortex to record their EEG signals before, during, and after DAT. Therefore, feasible changes proposed in this investigation include an ergonomic redesign of this device to make it more comfortable, functional, and appealing to patients. With this redesign, we hope to reduce downtime before, during, and after DAT, which would allow for the reliable sampling of patient EEG signals and consequently measure and evaluate the effectiveness of DAT in patient rehabilitation.

Furthermore, the lack of financial support and agreements for the study and implementation of DAT by the institutions involved has resulted in a lack of standards in this field, leading to disbelief and distrust among doctors and therapists about the use and efficiency of this type of therapy for the treatment of infants with neurological disorders since the development of these therapies complements traditional approaches to promote holistic recovery [10].

To address this situation, the conceptual model was constructed, in which relevant activities for the standardization and measurement of DAT are proposed with models B1 and B2, respectively, showing the initial steps for creating a standard method for DAT. SSM leverages the theoretical and methodological framework of systems thinking to improve specific problem situations. SSM has been used in the development of human resources and organizations in various areas [31]. With a cyclical learning process, SSM anticipates that the solutions will be sustainable [45].
On the one hand, in this manuscript, stages 1–6 of SSM were developed to identify complex situations and visualize challenges in standardizing DAT, with the aim of having a reliable sample of EEG signals before, during, and after DAT to enable the collection of consistent data, which is essential for conducting comparative studies and developing new therapeutic strategies based on scientific evidence.

On the other hand, process modeling using the BPMN technique has shown that both the trainer and the therapist are essential to achieve a standard time in DAT. The absence of either causes delays in the DAT process as shown in Figure 15, where these elements are crucial to maintaining the continuous flow of therapy.

6. Conclusions and Future Work

The Soft Systems Methodology (SSM), an advanced technique that combines both social and technical aspects, is established due to the complexity and strong social nature of dolphin-assisted therapies (DATs). SSM is used to characterize the pertinent factors that drive DAT, as well as to analyze the complex interactions and processes involved. This approach makes it possible to decompose inherent problems, articulate current factors, and offer pragmatic solutions. The primary objective of applying SSM is to establish a standardized method that enhances the efficacy of DAT by addressing difficulties and optimizing activities that add value to the therapeutic process. Standardization of this therapy not only ensures high-quality treatments and improves patient experience but also promotes multidisciplinary integration and effective collaboration between healthcare professionals. This comprehensive approach contributes significantly to improving the care and treatment of patients participating in DAT. Through SSM, the problems, conflicting relationships, and relevant systems are identified, which allows the creation of the conceptual model. Specifically, models B1 and B2 show relevant activities for the standardization and measurement of DAT.

This manuscript represents a general framework applied specifically to DAT. Our findings are significant because they can serve as a reference point for standardizing other alternative therapies that lack an established framework. This could improve the consistency and reproducibility of the treatment, facilitate the comparison of results and effectiveness evaluations, and strengthen the credibility and acceptance of therapy among healthcare professionals and patients. In future work, our goal is to develop the ergonomic redesign of the electroencephalographic device, which is expected to reduce the downtime caused by its readjustment, impacting the reduction in the downtime caused by the trainer and therapist. This will enable the capture of EEG signals without interruptions before, during, and after DAT. Although the method has been described using BPMN, the simulation of this process remains pending for future work, with the aim of conducting a more detailed time study. Finally, the objective is to establish a standardized protocol for the DAT methodology and derive a benchmark time frame that enables the acquisition of more reliable samples. This will facilitate the precise measurement and evaluation of the efficacy of DAT specifically for the infant cohort under investigation.

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Conflicts of Interest: The authors declare no conflicts of interest.

References

2. INEGI. Informe Sobre la Discapacidad del Instituto Nacional de Estadística y Geografía de México; INEGI: Mexico City, Mexico, 2020.


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