Integration between Engineering, Design, and Assistive Technology

CDIO in sprints for conceptual prototyping

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Dados Internacionais de Catalogação na Publicação (CIP)
(BENITEZ Catalogação Ass. Editorial, MS, Brasil)

B264i
1.ed.

Barbosa, Maria Lilian Araújo
Integration between engineering, design, and assistive technology [livro eletrônico] : CDIO in sprints for conceptual prototyping / Maria Lilian Araújo Barbosa, Maria Lúcia Leite Ribeiro Okimoto ; tradutor Laureano Vallese Pelegrin. — 1.ed. – Curitiba, PR : ABPTA, 2026.
PDF

Título original: Integração entre engenharia, design e tecnologia assistiva : CDIO em sprints para prototipagem conceitual.
Bibliografia.
ISBN 978-65-975756-1-9
DOI 10.52050/9786597575619

1. Design. 2. Engenharia. 3. Prototipagem. 4. Tecnologia assistiva (TA). I. Okimoto, Maria Lúcia Leite Ribeiro. II. Pelegrin, Laureano Vallese. III. Título.

05-2026/29 CDD 620

Índice para catálogo sistemático:
1. Protótipos : Design : Engenharia : Tecnologia 620

Aline Graziele Benitez – Bibliotecária – CRB-1/3129

ABPTA - Associacao Brasileira de Pesquisadores em Tecnologia Assistiva
https://abpta.com.br — Curitiba/PR — Brasil

Presentation

This work presents a method adapted from the CDIO model (Conceive-Design-Implement-Operate), conducted through sprints and integrating Engineering and Design core principles within the field of Assistive Technology (AT).

The methodology presented in this book was initially applied in the context of an undergraduate research project for students enrolled in the Mechanical Engineering program.

The course was conceived, structured, and implemented within the scope of the Postdoctoral Fellowship of Professor Maria Lílian de Araújo Barbosa, carried out in the Graduate Program in Mechanical Engineering at the Federal University of Paraná (PGMec/UFPR).

The activities took place at the Ergonomics and Usability Laboratory (LabErg/UFPR), with the support of NAPI-TA (New Research and Innovation Arrangements in Assistive Technology) of the Fundação Araucária (Araucária Foundation).

The structure of the method is transversal and multidisciplinary, grounded in active learning approach, which may be used in different contexts, including educational, corporate, and innovation environments.

Acknowledgments

We express our gratitude to the Assistive Technology NAPI and to the Fundação Araucária for the postdoctoral fellowship that made the development of this work possible.

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How to Use This Book

This book was written to provide support to educators, facilitators, and professionals in conducting structured, evidence-based processes for the creation of conceptual prototypes in Assistive Technology across the physical, digital, and graphic dimensions.

The content is divided into four sessions structured as sprints. Every chapter guides the facilitator regarding the objectives, results, tools, and decisions of each stage of the process: understanding a real-world problem, designing based on evidence, building conceptual prototypes, simulating use, and critically reflecting on the proposed solutions.

The adaptation of the CDIO stages into sprints changes the teaching practice into a space of co-creation, collaboration, experimentation, and reflection, fostering active learning throughout the process.

The use of clear and accessible language enables its application even with groups with no prior experience in Assistive Technology.

The facilitator does not need to be a specialist in Assistive Technology. Their role is to organize session timing, guide the use of tools, ensure methodological alignment. The method includes the occasional participation of specialists depending on the type of prototype under development. However, it is recommended that the facilitator have academic training or professional experience in Engineering and/or Design.

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Introduction

The adaptation of the CDIO model structured into sprints enables the development of conceptual prototypes in Assistive Technology at the exploratory level.

The way the method is organized allows any facilitator, even without prior knowledge of Assistive Technology, to use CDIO for AT as a tool for design reasoning, collaborative creation, simulation of use, and simulation of the context of use, thereby promoting active learning among participants.

This book does not propose user evaluation, final product testing, or technical/clinical validation. Any study, simulation, or interaction involving people—especially the elderly or people with disabilities—must adhere to ethical protocols strictly, as required in the institutional or research context in which the method is applied.

In the following chapters, the reader will find the key concepts, conceptual tools, guidelines for the facilitator, and the detailed procedures for conducting the four CDIO sprint sessions.

The conceptual tools indicated are not prescriptive and are easily found online. We suggest the use of the Miro platform (https://miro.com/), which offers tools and resources accessible for free.

CHAPTER 1
Key Concepts

This chapter presents the fundamental concepts necessary to understand the context of the CDIO method applied to the creation of conceptual prototypes in Assistive Technology (AT).

The terms compiled and presented here serve as a starting point for facilitators to acquire basic yet relevant knowledge for the application of the proposed method.

The terms are organized from general to specific, beginning with broader concepts and progressing toward more detailed definitions.

Assistive Technology (AT)

Assistive Technology (AT) is a set of resources, products, services, and systems and defined by the WHO (2022) as a subset of health technologies. AT serves to expand the functionality, autonomy, independence, and inclusion of people with different types of functional difficulties (such as motor, cognitive, sensory ones), whether permanent or temporary.

For the purposes of this book, we have adapted and adopted three categories:

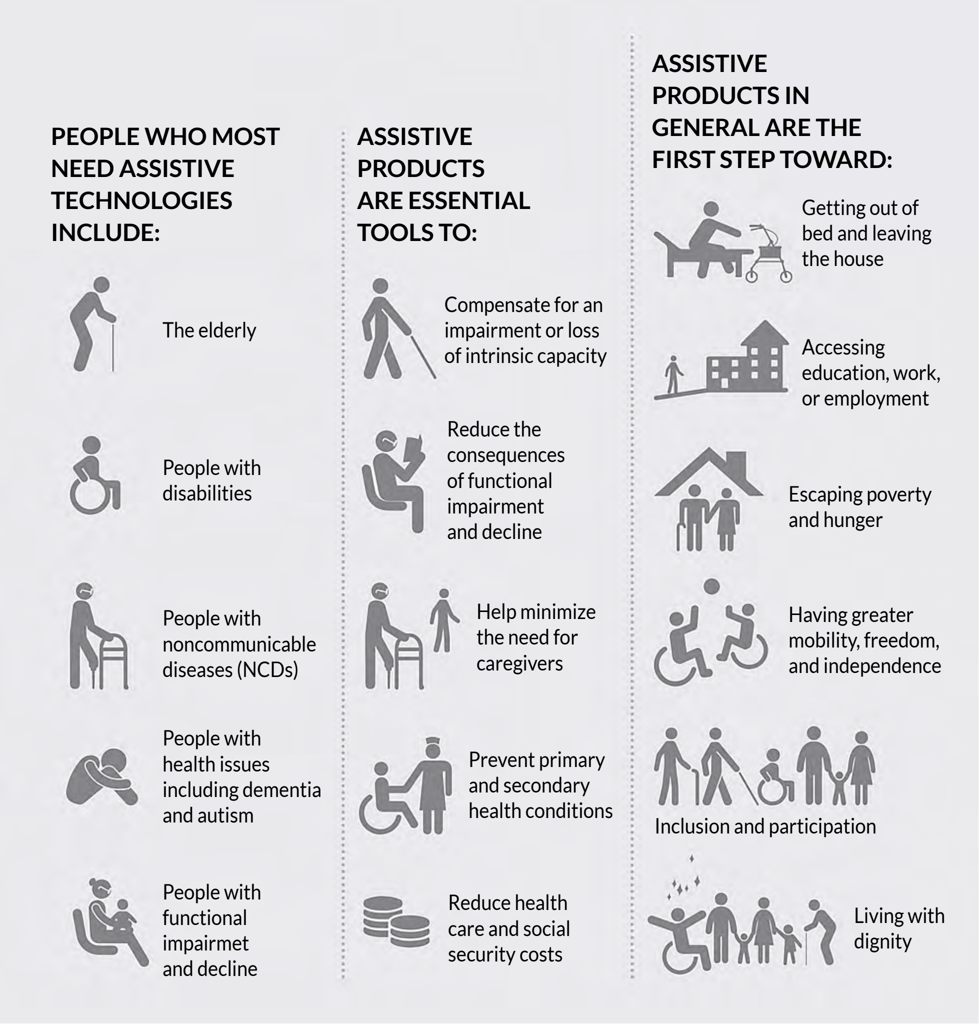
Physical AT: the creation or adaptation of simple devices, such as grabbers, handles, or extenders;
Digital AT: accessible interfaces, such as simplified applications, screen readers, or interactive PDFs;
Graphic AT: books, folders, informational materials, and labels.

This classification helps participants to identify quickly which classes of assistive artifacts can be created for any given context, even without prior experience in Engineering, Design, AT, or related fields. We recommend consulting technical reports such as the **Global Report on Assistive Technology** (WHO, 2022) for further information.

In the following section, some current contexts that are priorities for AT are presented.

Assistive Technology (AT)

Priority Contexts



Source: WHO (2017)

CDIO

CDIO (Conceive, Design, Implement, Operate) is a model created in the early 2000s by MIT educators and Swedish universities with the purpose of bringing engineering education and professional practice closer together. Today, it is adopted by institutions such as MIT, Stanford, and the University of São Paulo (USP).

The framework organizes the development of products, systems, and services into four stages:

Conceive: identifying the problem, defining priority needs, and understanding the context of use.

Design: generating alternatives, translating requirements into design decisions, and developing solutions.

Implement: building functional prototypes and analyzing technical and usability aspects.

Operate: simulating use situations and analyzing and discussing necessary adjustments, always at an exploratory level, not intended to pursue technical or clinical validation.

CDIO Standards
In this book, we do not address the CDIO Standards for accreditation. The CDIO Standards are guidelines created to support institutions that wish to implement the model in a structured way. They address topics such as pedagogical best practices, minimum infrastructure for prototyping, educator training, and competency assessment throughout the CDIO cycle.

The Standards are mentioned to situate readers who wish to learn more about the methodology, its origins, and its credibility. Facilitators do not need to study or apply them in order to conduct the sprints. The emphasis of this book is the adaptation of the model for the development of conceptual prototypes in Assistive Technology using an agile-format style.

CDIO
for Assistive Technology

Assistive Technology (AT) involves specific challenges related to functional diversity and different contexts of use. Applying CDIO with sprints to Assistive Technology makes it possible to transform real needs into functional solutions through a process with methodological rigor and recognizable stages.

Sprint 1 – Conceive: defines the problem, functional barriers, and the user's contextual demands. This stage encourages understanding of "What is missing" and why the solution is necessary, considering the person's daily life, limitations, and risks.

Sprint 2 – Design: formats the generation and selection of alternatives based on the problem, using reliable sources such as scientific articles, case studies, standards, and technical reports to support the proposed assistive artifact. Themes such as ergonomics, accessibility, safety, interaction, context of use, and materials are defined based on the data collected. Engineering and Design converge to support decisions, which must be documented. Review cycles prevent superficial proposals or those misaligned with the identified problem.

Sprint 3 – Implement: enables the construction of low- or medium-fidelity functional models to test hypotheses and possibilities for simulation. This stage is essential to realign the group with the initial problem and to function as a checkpoint, reducing errors and scope deviations before the next phase.

Sprint 4 – Operate: consists of simulating the solution as closely as possible to the real context of use. This stage reveals whether the conceptual prototype fulfills its function and meets the user's needs, considering the simulated context. The entire process is documented and, even without technical or clinical validity or user testing, can serve as a basis for the development of a final product.

CDIO applied to AT develops Engineering and Design competencies such as context analysis, decision records, and simulated evaluation of use, risks, and communication of results.

The model promotes a creative process grounded in technical foundations, in which participants learn by doing, simulating, and reflecting on conceptual prototyping, while also becoming sensitized to the social inclusion of people with disabilities and the elderly.

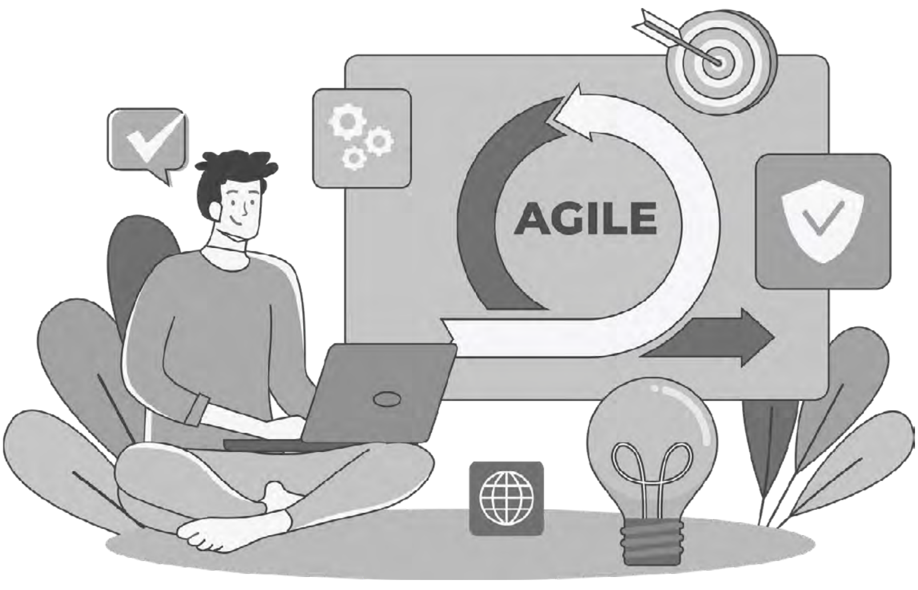
Sprints

Sprints are agile work cycles designed to guide a team from understanding a problem to building a tangible solution within a limited period of time. They structure the process into clearly defined stages, with established objectives and deliverables, encouraging well-grounded and rapid decision-making while promoting active learning.

The concept of the sprint originated in the fields of design and innovation, but it was systematized by Jake Knapp at Google Ventures in the 2010s. In the original model, a sprint compresses months of work into a single week, combining focus, collaboration, and rapid experimentation to reduce risks before larger investments in product development are made. This format has become a recurring practice in Engineering, Design, and technology projects.

CDIO in a sprint-based format for Assistive Technology prioritizes methodological rigor. Unlike Knapp's model, the proposed adaptation does not assume testing with real users or technical or clinical validation. The sprints here operate at a conceptual and exploratory level, focusing on simulation, logic of use, and reflection on whether the solution addresses the problem.

Each sprint corresponds to a stage of the CDIO cycle and results in documented deliverables that organize the process, reduce or eliminate scope deviations, and make the process traceable and replicable—factors that characterize methodological rigor.



Minimum Deliverable
(of the Sprint)

In agile methodologies, the minimum deliverable corresponds to the essential outcome considered "done" at the end of a work cycle, defined based on the scope and established criteria. This concept helps to keep the focus, document progress, and guide decision-making processes in short cycles.

In CDIO for Assistive Technology, the minimum deliverable represents the essential result that each session must produce, such as a record, an alternative solution, project drafts, a list of decisions, or the conceptual prototype as decided upon at the beginning of the sprint.

The facilitator defines the deliverable and communicates it to the participants at the beginning of every session, considering the available time, the profile of the group, and the type of Assistive Technology under development. Defining the minimum deliverable directs the actions to be carried out during the sprint.

Conceptual Prototype

A conceptual prototype is a simplified representation of a solution, created to explore the logic of how an artifact works and how it might be used before any technical development takes place.

In CDIO–AT, the conceptual prototype uses low-cost representations such as drafts, basic models, wireframes, or physical or digital simulations.

It makes it possible to verify whether the proposal makes sense for the user and the defined context, supporting early decisions with coherence regarding the feasibility of the concept. It has no technical, clinical, or final-product character. Therefore, its function is to support design reasoning, reflection on use, and communication of the idea.

Users
Needs Assessment

The user is the person who experiences the functional barrier that motivates the project. This may be an older adult, a person with a permanent disability, or someone with a temporary limitation. In Assistive Technology, the starting point is to understand who the person is, what they do, their context, and the challenges they face.

Needs assessment can be conducted without direct contact with users, through indirect and observational methods that adhere to ethical standards and privacy. These approaches use public or pre-existing data to identify patterns of use, recurring difficulties, and functional barriers.

The most common methods include:

Non-invasive observation: analysis of behavior in public spaces, with no direct interaction or identification of individuals, in order to recognize frequent difficulties in the use of environments, products, or services.

Anonymous online monitoring: use of aggregated statistics, keyword searches, and general browsing patterns to identify demands and usability problems in digital contexts.

Analysis of existing data: review of previous research, reports, general usage metrics, or institutional records to identify trends and recurring problems. Heuristic evaluations, such as those systematized by the Nielsen Norman Group (NN/g), can support this analysis.

Secondary research: consultation of academic studies, technical norms, public demographic data, market reports, and analyses of similar solutions. These methods are prioritized due to their suitability for the exploratory nature of CDIO–AT and for the development of conceptual prototypes without direct contact with users, while maintaining ethical rigor and methodological coherence.

Based on the needs assessment, a robust theoretical framework is established for the development of the user persona.

The user persona

In CDIO applied to Assistive Technology, the classical persona model commonly used in marketing and UX (centered on narrative empathy, lifestyle, and subjective traits) is not adequate, as it may shift the focus away from the functional barrier and not contribute effectively to the development of a conceptual AT prototype.

In CDIO–AT, the persona must emphasize the elements associated with the problem, the context of use, and the functional barrier.

The User Persona tool in CDIO–AT:

- aligns with the problem statement (Sprint 1);
- guides the creation and selection of solutions (Sprint 2);
- directs conceptual prototyping and use simulation (Sprint 3);
- supports the evaluation of the conceptual prototype (Sprint 4).

Examples of essential data for the persona in CDIO–AT:

- User: an older adult with reduced mobility;
- Activity: taking a shower safely;
- Context of use: house bathroom, wet floor, lack of support bars;
- Functional barrier: fall risk and transfer difficulties;
- Evidence: analysis of case studies in scientific literature.

This approach keeps the method focused on function and real use, ensuring project coherence throughout the entire CDIO–AT cycle.

Iteration and Context of Use

In the field of design, the concept of iteration is defined by the Nielsen Norman Group (NNGroup) as a process of continuous refinement based on testing, evaluation, and correction of flaws.

In this book, iteration is adopted at a conceptual and exploratory level, without testing with real users.

In CDIO applied to Assistive Technology, to iterate means to systematically review design decisions, incorporating evidence, group reflection, use simulations, and technical reviews by specialists. Iteration refers to the progressive adjustment of the solution, maintaining alignment with the persona, the problem statement, the identified functional barrier, and the context of use.

The context of use refers to the conditions under which the user performs an activity. It considers who this person is, what they do, where the action takes place, and what resources are available, in physical, digital, graphic, or hybrid environments.

Examples of context of use:

- Physical (space, lighting, noise, furniture, circulation);
- Digital (devices, interfaces, connectivity, navigation flow);
- Graphic (visual information, typography, contrast, hierarchy, printed or visual media).

Understanding the context of use guides design-decision processes that are more appropriate to the user's real conditions and needs.

Functional Barrier

A functional barrier is any limitation that makes it difficult to perform any daily activity, whether of a motor, sensory, cognitive, communicational, or self-care nature. Identifying the functional barrier is essential to define the problem and to avoid solutions that are generic or disconnected from the user's reality.

Examples from the common life: packages that are difficult to open, such as overly adhesive seals or tightly screwed caps, pose challenges for older adults with arthritis; household appliances whose controls are not tactile-friendly for visually impaired users; and the lack of adequate communication resources creates barriers for hearing-impaired people, among many other cases.

Active Learning

In active learning, participants assume a central role in the construction of knowledge, while the facilitator guides the process through structured discussions and problem-solving activities.

Knowledge is developed through co-creation and collaboration, fostering critical reflection, autonomy, and teamwork.

In the CDIO framework, active learning occurs as participants investigate real problems, develop sprint deliverables, test hypotheses, discuss decisions, and review results. Learning by doing, in this context, means recording evidence-based information, generating data, and using it to reflect on the process and guide the next steps.

Evidence and Social Impact (in CDIO–AT)

Evidence consists of credible information, facts, or data that support a statement or hypothesis.

In CDIO applied to Assistive Technology, **evidence** results from the observation, documentation, and analysis of the assistive artifact development process. Evidence indicates what worked, what did not, and which adjustments are necessary.

Social impact, in international frameworks such as those adopted by the United Nations (UN), is understood through the analysis of quantitative and qualitative indicators used to measure benefits that generate real changes in people's lives, generally aligned with the Sustainable Development Goals (SDGs).

In the CDIO model for Assistive Technology adopted in this book, the aim is not to measure impact through financial metrics or formal evaluation methods, but rather to reflect on the coherence of the developed solution with the user's real context, supporting their autonomy and independence in daily activities and enabling social inclusion.

Synthesis
Chapter 1

This chapter presented the essential concepts for conducting a CDIO process applied to Assistive Technology, a field that requires understanding real needs, functional barriers, and the user's context of use. Based on this conceptual foundation, the facilitator can deepen the topics according to the participants' profiles and the type of Assistive Technology being developed.

The CDIO framework, organized into sprints, structures the process in short, iterative cycles that involve conceptual prototyping, usage simulation, evidence generation, and reflection on use within a defined context. Concluding each sprint with a pitch strengthens solution communication and supports decision-making throughout the process.

Chapter 2 will present the suggested tools for operationalizing the method. These tools assist the facilitator and participants in conducting the sprints, organizing teamwork, recording decisions, and reflecting on the knowledge generated, reinforcing active learning.

The facilitator may select the tools deemed most appropriate according to the group profile, the application context, and the type of conceptual prototype to be developed.

The use of the Miro platform is recommended, as it provides sufficient resources in its free version for visual organization and collaborative work. At the end of the activity, the material can be exported as a PDF and stored on a shared drive, which will serve as the general repository for the process.

It is recommended to organize the drive by sprints, with subfolders for each group and files clearly tagged for each activity, ensuring traceability and easy access to information.

CHAPTER 2
Conceptual Tools

Conceptual tools assist in organizing, visualizing, and understanding complex ideas and their interrelationships. They transform abstract reasoning into representations that support analysis and decision-making for problem solving situations.

These tools, such as mind maps, diagrams, matrices, and models, are widely used in educational, scientific, and management contexts to synthesize information, structure analyses, organize decisions, and map processes.

Conceptual tools support design thinking throughout the CDIO–AT sprints, facilitating communication among the facilitator, participants, and reviewers while reducing ambiguities during the development of conceptual prototypes.

Objective
This chapter presents the suggested conceptual tools to be used in the CDIO method during sprints. The suggestions should be appropriate for the development of Assistive Technology (AT) conceptual prototypes.

The proposed tools are not prescriptive in nature. They may be used, adapted, or replaced by others more adequate to the application context, the group profile, the type of assistive artifact under development, and the defined level of complexity.

The suggested tools are:

RACI MATRIX
Distribution of roles and responsibilities within the group. Important: responsibilities may be adjusted at each meeting following the group's determination.

MIND MAPS / DIAGRAMS
Tools for creating mind maps, flows, process organization and documentation.

USER PERSONA
The user persona is defined functionally and based on evidence.

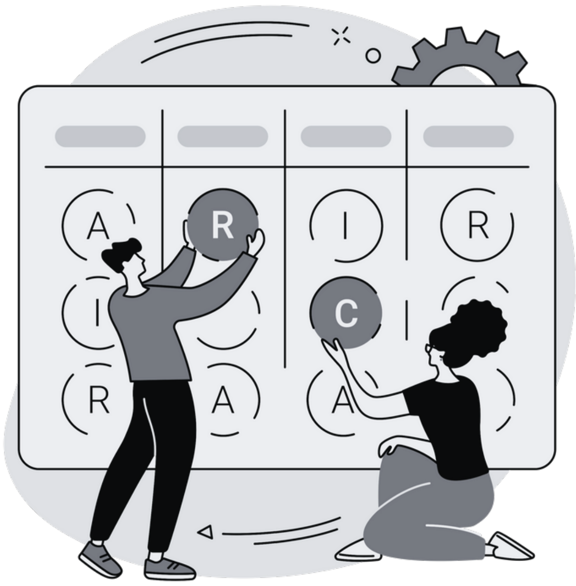
SOP – Standard Operating Procedure for Peer Review
Document for recording decisions, evidence, and deliverables for each sprint. Ensures traceability and continuity of design reasoning. Peer review is a collaborative, non-evaluative practice. It contributes to reflection, adjustments, active learning, and expansion of the group's repertoire.

SOP-TR – Technical Review by Specialists
Expert review in the area corresponding to the type of AT. Instrument for analyzing the coherence between the AT prototype idea and professional best practices and user experience. It does not constitute technical or clinical validation.

PITCH
Tool for communication and process synthesis in each meeting. Intermediate sprint pitches last up to 3 minutes, and the final pitch up to 5 minutes.

A3 CANVAS
Tool for process synthesis and documentation. Final communication instrument for project presentation to the committee.

R.A.C.I. Matrix



The RACI Matrix originated in project management and was popularized between the 1970s and 1980s by consulting firms and institutions such as McKinsey & Company and the Defense Systems Management College, now the Defense Acquisition University (DAU), in the United States.

Subsequently, it became established as a tool used in project management methodologies, such as PMBOK, due to its ability to facilitate team coordination and decision traceability.

The acronym RACI represents four functions assigned to each task:
R — Responsible: the person who performs the activity.
A — Accountable: the person who makes the final decision and is answerable for the outcome.
C — Consulted: the person who provides information or technical input.
I — Informed: the person who monitors progress and receives updates.

The RACI Matrix is used to organize the roles and responsibilities of each member of the workgroups in each sprint activity.

Assignments can be adjusted at each meeting according to the stage of the process stage and the needs of the group, without compromising the continuity of the method.

By structuring responsibilities, the RACI Matrix prevents overlap of roles and rework, improves communication among participants, and supports the organized conduct of sprints.

Mind Maps, Diagrams, etc.

These tools are used to explore the problem, structure information, and compare solution alternatives. They support the initial organization of thinking and the visualization of relationships of the problem, the user, the context, evidence, and decisions together.

Conceptual tools can include mind maps, flow diagrams, relationship schemes, or simple visual boards, in both physical and digital formats. Handmade drafts, diagrams on paper, post-its, and whiteboards are fully appropriate, especially in face-to-face settings or other contexts in which resources are scarce.

In digital environments, the facilitator can use collaborative visual platforms such as Miro, which integrates mind maps, flows, and diagrams all in a single interface.

The free version is sufficient for conducting the sprints. It is recommended that each group work on their projects, exporting the records as PDFs at the end for process archiving and traceability.

SOP
Standard Operating Procedure

The Standard Operating Procedure (SOP) originated in work organization during the Industrial Revolution and was initially used in Frederick Taylor's Scientific Management. Over time, SOPs were recognized as quality management instruments, appearing in standards such as ISO 9001, which are used to standardize processes.

Its purpose is to document, in a structured manner, the decisions made based on analyzed evidence and the deliverables of each sprint, indicating what was done, why it was done, and what adjustments are necessary in subsequent stages.

In CDIO sprints, the SOP ensures continuity of design reasoning and alignment across the Conceive, Design, Implement, and Operate stages, enabling traceability and supporting active learning while maintaining scope alignment and methodological coherence throughout the process.

The SOP must be developed by the group according to the type of Assistive Technology prototype being created.

Persona

The “persona” tool in CDIO–AT:

- grounds the problem statement (Sprint 1);
- guides ideation and solution choices (Sprint 2);
- directs simulated testing and conceptual prototyping (Sprint 3);
- supports evaluation of coherence and social impact (Sprint 4).

It is not intended to create narrative empathy but to maintain functional and technical coherence throughout the CDIO cycle.

Functional Identification

- User profile (e.g., elderly people, visually-impaired people, person with temporary motor limitation)
- Age range (when relevant)
- Functional condition related to the barrier

Context of Use (environmental conditions influencing use)

- Where does the activity occur?
- Physical (e.g., bathroom, kitchen, public space)
- Digital (e.g., application, system, interface)
- Graphic (e.g., label, instruction, signage)

Functional Barrier

- Physical, sensory, cognitive, communicational barrier, individually or combined.

Pitch

Intermediate and Final

A pitch is a brief presentation that summarizes a problem and demonstrates the validity of a solution addressing that specific need. The format emerged in the Silicon Valley innovation ecosystem in the 1990s and became established as a tool to communicate ideas in an objective and structured manner.

In the context of CDIO applied to Assistive Technology, the pitch is a communication tool used to present straightforwardly the identified problem, the proposed solution, and the main learning gains from the process, making the decisions taken, the design reasoning applied, and the evidence supporting the proposal explicit.

Throughout the sprints, each meeting concludes with a short pitch of up to three minutes. The pitch in CDIO is neither commercial nor persuasive in nature. Its purpose is to communicate the new developments and explain the choices made.

A final pitch of up to five minutes occurs at the end of the CDIO cycle. At this stage, the pitch, aligned with the A3 Canvas, presents a synthesis of the assistive artifact development, including the problem, conceptual prototype, and simulated use in response to the problem-statement. The final pitch serves as a tool for communication, synthesis, and reflection on the CDIO cycle.

A3 Canvas

The A3 Canvas is a conceptual tool for process synthesis, used to present, on a single page, the complete development journey of a conceptual prototype in CDIO. Its purpose is to organize and communicate the terms of the problem, the problem addressed, important decisions, and the learning gains throughout the sprint, in a clear and organized manner.

The A3 Canvas is inspired by the A3 format adopted in engineering and visual management. It brings together essential information, such as: **the problem-statement, the user and context of use, the alternatives considered, the chosen solution, design decisions, the record of the conceptual prototype, the main points from the technical review, insights or hypotheses resulting from the process, and the expected social impact.**

The A3 Canvas is filled in at the end of the sprints and used as a documentation and communication tool in the final presentation to the committee. It allows evaluators to understand the entire project without needing to access detailed records of each stage.

The facilitator should develop a standard A3 Canvas for all groups, according to the participants' profile and the type of Assistive Technology.

The A3 Canvas does not constitute technical or clinical validation. Its use is conceptual and exploratory, supporting active learning, systematization of design reasoning, and concise communication of the choices made throughout the development of the Assistive Technology prototype.

Reviews

Technical Review (SOP-TR)

The Technical Review (TR) is a conceptual analysis conducted by an experienced professional in accessibility and work with people with disabilities or the elderly. Such agents are occupational therapists, physiotherapists, engineers, UX designers, among others.
The choice of technical reviewer depends on the category of Assistive Technology under development (physical, digital, or graphic). The TR takes place before conceptual prototyping, aiming to identify conceptual inconsistencies, risks, and mandatory adjustments prior to the Sprint 3 prototype. It does not amount to a technical, clinical, or regulatory validation.

Peer Review (SOP-PR)

Peer reviews occur at the end of each sprint and aim to support decisions, identify necessary adjustments, reduce risks, and generate evidence of learning. They do not validate technical or clinical of solutions, nor do they compare teams.
Peer review is conducted based on the evidence presented by participants, with the purpose of promoting collective reflection, group alignment, and adjustments throughout all sprints.

Final Committee (SOP-FC)

The final committee evaluates the coherence of the conceptual prototype with the problem-statement, the simulated use, and the consistency of the process documentation, verifying adherence to the CDIO–AT method.
This review occurs during the final presentation (Meeting 4 – Operate), when the final version of the conceptual prototype is presented along with the A3 Canvas, the usage simulation, and the final pitch.

For committee specialists, the Likert scale is recommended to standardize the evaluation of the conceptual prototype, considering criteria such as solution coherence with the problem and simulated use, documentation quality, and potential social impact.

The scale does not validate solutions, rank prototypes, or compare teams. Its purpose is to support critical analysis of the process and the communication of the presented solution.

SOP

Example 1 (Sprint 1 — Conceive)
Problem Identification and Initial Evidence

1. Project Identification
- Provisional title:
- Group:
- Date:
- Type of AT: ( ) Physical ( ) Digital ( ) Graphic

2. User Persona
- Age range:
- Functional condition related to the problem:
  ( ) Motor ( ) Visual ( ) Auditory ( ) Cognitive ( ) Mixed
- Affected activity:
- Context of use:
  Functional Barrier (objective description)
  Concise explanation of the obstacle that prevents the activity from being performed.

3. Consulted Evidence
(Record the minimum necessary to demonstrate that the problem is real.)
- Brief observations or reports:
- Relevant documents/standards (e.g., NBR 9050)
- Reliable sources (2–4 articles, reports, or datasets)

4. Problem Statement (mandatory)
Suggest elements for a problem-statement template (non-prescriptive): how to [verb] [activity] for [user] in [context], considering [functional barrier]?

5. Initial Ideas (simple drafts)

6. Decisions recorded after peer review (up to 5 items):
1.
2.
3.
4.
5.

Synthesis

Chapter 2

This chapter presented a list of suggested conceptual tools to be used in CDIO sprints for Assistive Technology. They are not prescriptive and can be adapted according to the CDIO application context.

The focus is on organizing teamwork, recording decisions and evidence, and communicating the process throughout the meetings.

The suggested tools support decision making based on evidence and keep continuous alignment with the user persona, functional barrier, problem-centered scope, in addition to serving as instruments for process analysis and reflection that foster active learning.

The next chapter presents general guidance for the facilitator, detailing how to apply the suggested tools in the conduction of the sprints.

CHAPTER 3

General Guidelines for the Facilitator

Roles

Facilitator

The facilitator guides the process and ensures alignment with CDIO–AT. They organize the sprints, manage meeting time, and oversee the use of tools. They do not propose solutions: their role is to guide design reasoning, stimulate reflection, and ensure that the process remains exploratory, free from technical or clinical validation.

Participants

Participants act as creators and analysts of the process. They study the problem, generate alternatives, build conceptual prototypes, record decisions, and share learning gains. They also conduct peer reviews to align solutions and strengthen collective learning.

Reviewers

At the end of each meeting, the facilitator promotes a peer review (between groups), in which one group analyzes another group's work, considering the problem, solution coherence, and alignment with user needs based on documented evidence. Observations should be brief and aimed at immediate adjustments to the artifact and documentation. Reviews should be conducted objectively, respectfully, and focused on improving the prototype. Review occurs at three distinct points in the CDIO–AT cycle:

- Peer Review: at the end of each meeting.
- Technical Review (TR): conducted by a specialist between Sprints 2 and 3.
- Final Committee: in meeting 4, based on the A3 Canvas and final pitch.

Reviewers do not validate products or certify solutions. Their role is to support decisions, identify inconsistencies, and qualify design reasoning. Technical review must be conducted by a professional compatible with the type of Assistive Technology under development.

Type of AT	Specialist	Main Criteria	Reference Examples
Physical (e.g., orthosis, assistive artifacts with functional adaptations, furniture, environment)	Physiotherapist or Occupational Therapist	Anatomical fit, comfort, effort, ergonomics	NBR 9050
Digital (e.g., application or simple interface)	UX Designer or software engineer	Navigation, contrast, flow, and logic of interaction	WCAG 2.2
Graphic (e.g., instructions, brochures, visual elements)	Graphic designer or visual educator	Legibility, contrast, visual hierarchy	ISO 9186, WCAG for print

Prototypes

Scope Definition

The facilitator must predefine, during the planning of the CDIO–AT, the project scope in terms of levels of conceptual prototype complexity, which indicate the expected degree of detail at the end of the sprints.

These levels do not represent quality and/or technical maturity. They function as scope delimitations, chosen by the facilitator according to:

- the group profile (professionals, innovation teams, startups, research students, undergraduates, or communities);
- the technical maturity of the group;
- the resources available in the environment (company, classroom, laboratory, or FabLab).

We suggest different delivery levels that the facilitator may adopt:

Level 1: simple representations of the idea and generation of alternatives, such as hand drafts or basic visual flows.
Level 2: initial models allowing internal simulations, such as simple assemblies, basic navigable prototypes, or preliminary layouts.
Level 3: more complete conceptual models for use simulation in a controlled setting, such as physical prototypes in 3D printing or wood, complete digital flows, or graphic materials in a conceptual version.

Presentation Pitch

The presentation pitch should take place at the end of every meeting. The facilitator is expected to organize a short pitch of up to three minutes per group.

The purpose of the pitch is not to compete, but to share what has been learned, verify alignment with the problem statement, and make the progress of the conceptual prototype visible.

Each group should clearly and objectively present the user persona, the problem being addressed, how the proposed solution works, and the evidence generated during the process.

The facilitator is responsible for:
- ensuring respect for the allocated time;
- maintaining focus on the problem, the user, and the context of use;
- encouraging attentive listening between groups;
- avoiding comparative judgments or evaluative rankings.

At the end of the pitch, the facilitator must have the groups record decisions, adjustments, and learning gains in the SOP corresponding to the sprint, ensuring traceability of the process.

Pitch Structure

To maintain clarity, focus, and equitable time, the facilitator should ensure that every pitch follows the same time limit for all groups (3 minutes timed) and includes three essential elements:

1. Problem
Identify the user persona, their real need, and the context of use.

2. Solution
Describe what the group developed, the primary function addressed by the proposal, and how it responds to the functional barrier identified for the persona.

3. Evidence
Demonstrate the conceptual prototype and the simulated tests performed, indicating:

- whether the solution meets the defined need;
- whether the logic of operation is consistent with the context;
- which aspects of use and accessibility still need improvement.

The facilitator must emphasize that the pitch is to reflect the learning gains and decisions from the sprint, not a competitive approach.

CDIO Sprints

In CDIO sprints, each meeting functions as a short and structured work cycle. The facilitator must communicate clearly the objective of the meeting and the minimum required deliverables.

It is recommended that the meeting follows a simple and replicable rhythm:

- Planning (20%) – define the meeting objective and expected deliverable.
- Doing (50%) – build, test, and adjust the conceptual prototype.
- Sharing (20%) – present what has been developed and discuss decisions.
- Recording and Reflecting (10%) – consolidate learning, adjustments, and decisions in the sprint SOP.

The meeting concludes with structured documentation in an SOP, which consolidates the peer review, records what worked, what needs adjustment, and guides the next activities. This record ensures traceability and reproducibility of the process, central elements of methodological rigor, and maintains the solution's coherence with the problem defined in Sprint 1.

Simple Language

Throughout all meetings, communication should be clear, direct, and accessible. Using simple language is the facilitator's responsibility and a pedagogical practice aligned with the inclusive nature of Assistive Technology.

Practical Principles

1. Clarity

- Use short sentences.
- Prefer direct verbs.
- Focus on one idea per sentence or paragraph.

2. Connection

- Offer explanations using concrete situations.
- Relate concepts to the user's daily life and the artifact under development.
- Avoid abstract explanations when a simple example suffices.

3. Conciseness

- Avoid technical jargon.
- Explain specific terms immediately.
- Do not accumulate multiple concepts in the same explanation.

Practical Application

When explaining a task say what to do, why it should be done, and where to record it. Check understanding with simple questions such as: "Is this clear to everyone?" or "Would you like me to repeat any step?"

Prefer familiar words over technical vocabulary whenever possible. Examples of adapting to simple language:

Instead of: "Heuristic validation of the prototype" → Prefer: "Quick test to see if the prototype is easy to use."

Instead of: "Analysis of functional coherence" → Use: "Check if the solution really helps the user."

Normative Reference

These guidelines follow ABNT NBR ISO 24495-1 – Simple Language, which recommends comprehensible, objective, and audience-adequate communication.

Accessibility Checklist for the Facilitator

This checklist helps the facilitator in creating an accessible, predictable, and inclusive environment, taking into account space, materials, communication, and meeting dynamics. **Use it before each meeting.**

1. Physical Environment
- An unobstructed circulation space.
- Stable tables and chairs, allowing frontal or lateral approach.
- Uniform lighting, without glare.
- Noise control; avoid echo or continuous sounds.
- Preferential seats for people with reduced mobility.

2. Materials and Communication
- Adequate contrast (dark text on light background or vice versa).
- Simple and legible font (minimum 14 pt); avoid decorative fonts.
- Short texts, with direct sentences and one idea per line.
- Explanations in simple steps, numbered when possible.
- Use visual demonstrations (drawing, object, or gesture).
- Read aloud when necessary, at a moderate pace.
- Do not speak while facing away from the audience (this allows for lip reading).
- Verify understanding with open questions, for example: "Would you like me to repeat a step?" or "Is everything clear so far?"

3. Comfort, Predictability, and Participation
- Present the meeting agenda at the beginning.
- Announce changes in activity or pace.
- Include brief breaks for relaxation.
- Offer extra time when necessary.
- Allow different forms of participation: speaking, writing, drawing, or audio.
- Reinforce that the process is exploratory and there are no "right" answers.

4. Accessible Slides (when used)
- Simple background, high contrast, no texture.
- Large text: 28–32 pt; titles above 40 pt.
- Minimal amount of text (up to 6 lines per slide).
- One idea per slide.
- Images with clear function in sufficient detail.
- Avoid fast, flashing, or automatic animations.
- Use simple icons, always with labels.
- Avoid similar colors (e.g., green/red).
- Verbalize content and describe images when necessary.
- Allow enough time for reading before advancing.

Conceive

If you can't decide what problem you're solving, you're not ready to move forward.
— Jake Knapp

Sprint 1

Objective
Define the user persona, describe the functional barrier, understand the real problem in the user's context, and formulate a clearly delimited problem statement, avoiding ambiguities.

Important
The entire process of adapting CDIO to Assistive Technology occurs at an exploratory level. No tests with real users are conducted. Any direct interaction with elderly persons or people with disabilities requires formal ethical approval and informed consent (TCLE), depending on the research context.
The duration of each stage is flexible and should be adjusted by the facilitator according to the group's profile and maturity.

Deliverables of Sprint 1
- User persona
- Defined problem-statement
- Duly filled RACI Matrix
- SOP 1 (user, activity, barrier, and evidence)
- Presented pitch

Conducting Sprint 1

1. Opening (define the alloted time)
- Explain what Assistive Technology is and the CDIO cycle.
- Present the sequence of activities and deliverables of the sprint.
- Guide how to collect evidence.
- Explain that decisions made in Sprint 1 guide all subsequent sprints.
- Make it clear that Sprint 1 does not create solutions; it defines one user, one problem, one context.

2. Definition of Roles – RACI Matrix (allocate time)
- Give a quick explanation of the RACI matrix.
- Each group defines responsibilities for the tasks in Sprint 1.
- Roles can be adjusted in subsequent sprints.
- The facilitator leads but does not assume any task in any group.

3. Evidence Collection (allocate time)
The problem must be real, observable, and documented. Accepted sources include:
- Non-invasive observations;
- Norms and technical documents;
- Two to four (2-4) reliable sources (articles, case studies, technical reports).

4. Formulation of the problem-statement (allocate time)
The statement must include: one user, one barrier, and one context.

Examples of Problem Statements by Type of Assistive Technology

Physical AT (house bathroom / older person)
"How can an older adult safely take a bath in their home bathroom, considering reduced mobility and risk of falling?"

Digital AT (Class instructions / hearing-impaired person)
"How can a deaf person have a good experience following class instructions in an educational environment, considering auditory communication barriers?"

Graphic AT (Medication leaflet / visually-impaired person)
"What could be done so a visually-impaired person understand the instructions contained on a medication, considering the lack of visual access to printed content?"

5. Pitch

6. SOP 1

Design

> *Good design is not about finding the right answer, but about choosing the best option among many.*
>
> *— John Heskett*

Sprint 2

Objective

Transform the problem-statement and evidence from Meeting 1 into solution alternatives, select the most coherent option, and record the initial conceptual model in SOP 2 (Version 1), preparing the group for the technical review that will take place between Meeting 2 and Meeting 3.

Sprint Deliverables

- Multiple ideas generated and documented (drafts, diagrams, mind maps)
- Main solution selected and justified
- Peer review (among groups) completed
- Technical reviewer (specialist) assigned
- Pitch presented
- SOP 2 – Version 1 completed (attach alternatives, usage method, and potential materials) to be presented to the technical reviewer.

Conducting Sprint 2

1. Opening (allocate time)

- Review the problem statement, user persona, functional barrier, and evidence (SOP 1).
- Emphasize that all design decisions must directly respond to the problem statement.
- Explain the focus of the meeting: generate alternatives and, at the end, compare and select only one solution.

2. Ideation – Generating Alternatives (allocate time)

- Employ simple and quick methods according to the group profile: handmade drafts; brainstorming and mind maps (hand-drawn or digital, e.g., Miro, Figma, Canva, PowerPoint); simulations with everyday objects.

3. Evidence Collection (allocate time)

Guide the selection of one alternative based on the following criteria:

- Accessibility: Does it address the functional barrier?
- Simplicity: Is it understandable and easy to use?
- Feasibility: Can it be prototyped in Meeting 3 with the available resources?
- Coherence with the problem statement.

Record the justification of the choice in SOP 2.

4. Peer Review

- Record in SOP 2 only the comments that show relevance for adjustments and presentation to the technical reviewer (the specialist).

5. Technical Review – Guidance

Each group should identify and contact an appropriate technical reviewer according to the type of Assistive Technology:

Physical AT: physiotherapist, occupational therapist, engineer, or product/environment designer.
Digital AT: UX designer, educator, or digital accessibility specialist.
Graphic AT: graphic designer, visual educator, or occupational therapist.
The technical review occurs between Meeting 2 and Meeting 3.

6. Pitch (3 minutes per group)

7. SOP 2 – Version 2 (mandatory)

Version 2 of SOP 2 occurs after discussion with the technical reviewer. The group must:

- Record suggestions received;
- Adjust the proposal as needed;
- Justify decisions maintained or changed.

SOP 2 – Version 2 is mandatory and must be completed before Meeting 3.

8. Summary

During Meeting 2, groups generate alternatives, perform peer review, and select the solution most coherent with the problem statement.
SOP 2 – Version 1 records the group's initial reasoning, choices, and justifications before consultation with specialists.
SOP 2 – Version 2, developed between Meetings 2 and 3, incorporates professional feedback and necessary adjustments to align the proposal with the user and the problem. This prevents late corrections during prototyping and creates a solid conceptual basis for Sprint 3. Professional review is mandatory at this stage in the CDIO–AT method.

Implement

Prototyping is not about getting it right on the first try, but rather about learning faster.
— IDEO

Sprint 3

Objective
Implement the conceptual prototype based on the solution defined in Meeting 2, incorporate adjustments indicated by the Technical Reviewer (SOP-TR), and define which simulated tests will be conducted in Meeting 4.

Deliverables of Sprint 3
- Reviewed SOP-TR (Version 2)
- Conceptual prototype implemented
- Definition of simulated tests (to be presented in Meeting 4)
- Draft of the A3 Canvas
- Short pitch presented

Without SOP-TR (Version 2), the final prototype cannot be presented to the final review commettee in Meeting 4.

Conducting Sprint 3

1. Opening (allocate time)
- Review SOP 1 (user, activity, barrier, and evidence).
- Confirm whether Version 2 of the SOP-RT has been completed.
- Reinforce the guideline for the meeting: planning the implementation of the conceptual prototype (define which simulated tests will be conducted to visualize the use of artifact).

2. Ideation – Generating Alternatives (allocate time)
- Emphasize that the prototype is conceptual, not a final product.
- It is designed to test functionality and clarity, not technical performance.
- Minimum criteria: clear primary function; use in context; coherence with the problem-statement; application of SOP-TR adjustments.

3. Prototype Implementation (allocate time)
Based on SOP 2 and SOP-TR, the group:
- Builds the final version of the conceptual prototype (physical, digital, or graphic), incorporating adjustments suggested by specialists.
- Records decisions and adjustments in SOP 3.
- Documents the process visually (photos, videos, etc.).
- Verifies adherence to the problem defined in Sprint 1.
- Plans the simulated use for the final review panel.
- Drafts the A3 Canvas for the next sprint.

4. Internal Quick Tests (Simulated)
The groups test the simulations and request feedback from other groups to gain additional insights, observing:
- Comprehension: Is it easy to understand the use without explanation?
- Effort: Does it require force, repetitive movements, or uncomfortable postures?
- Adherence: Does it address the problem statement?
- Functionality: Does it fulfill the main function, is it intuitive and safe?
- Evidence: Does it reflect the initial findings?

5. Pitch (3 minutes per group)
- Presentation of the A3 Canvas draft.
- Adjustments implemented based on technical reviewer feedback.
- Definition of simulated tests for the final review panel in Sprint 4 (Operate).

6. Synthesis
Sprint 3 transforms the selected solution into a functional conceptual prototype, incorporates specialized technical contributions, and prepares the final use simulation.
Presenting the A3 Canvas draft for peer review helps the group review the entire process before closing the CDIO–AT cycle in Meeting 4.

Operate

O

The true test of design is not how it looks, but how it works in real life.
— Donald Norman

Sprint 4

Objective
Evaluate the conceptual prototype through simulated use via the final pitch, consolidate the learning gains from the four sprints based on process evidence, and close the CDIO–AT cycle. The focus is on analyzing the coherence of the solution with the problem-statement.

Deliverables of Sprint 4

- Final conceptual prototype (physical, digital, or graphic)
- A3 Canvas ready for presentation
- Final pitch (5 minutes, including simulated use)
- Review by the panel using the Likert scale
- Collective CDIO evaluation: “Good, Bad, Could be better”

Likert Scale
The Likert scale is a simple instrument that organizes the panel’s judgment into graduated levels (1–5), allowing structured recording of perceptions regarding the coherence of the process and the conceptual prototype. It has no validation or ranking function.

Sprint 4 – Facilitation

1. Opening (set time)
- Recall the CDIO-in-sprints cycle applied to Assistive Technology.
- Present the meeting flow: exhibition (prototype and A3 Canvas) → pitch with simulated use → panel review → final reflection on the process.

2. Exhibition Setup
- The facilitator can allow some time time for final adjustments of the simulation and completion of the A3 Canvas.
- Each group organizes its station with:
    - Conceptual prototype
    - A3 Canvas
    - Video showing simulated use

3. A3 Canvas – Required Elements
- Project title
- User and context of use
- Problem-statement (Sprint 1)
- Decisions (what was chosen and why)
- Main points from the technical review (POP-RT)
- Insights, hypotheses, or next steps
- Expected social impact

4. Final Pitch (5 minutes per group)
Pivotal moment of the Operate phase. Integrates presentation and simulated use. The facilitator controls the time. The demonstration must clearly show:
- How the solution is used
- How it reduces the functional barrier.

5. Final Review by the Expert Panel
Suggested composition of the panel:
- one professional in the area of Assistive Technology
- one designer (product, graphic, UX, or related)
- one engineer (mechanical, product, civil)
- one volunteer with disability or elderly person, as reviewer (not user), if possible, with formal consent (TCLE)

6. Evaluation using the Likert scale (1–5).
Panelists assess the prototype according to the following suggestions:
- Problem clarity: 1–5, is the problem clearly defined in relation to the user, activity, and context?
- Solution coherence: 1–5, does the proposed solution address the defined problem?
- Simulated use: 1–5, is the prototype's simulated use understandable and coherent with the persona and context?
- Communication: 1–5, does the presentation (A3 Canvas + pitch) clearly communicate the process, decisions, and learning gains?

CDIO Review by the Facilitator

Metadesign-Oriented Reflection in CDIO–AT

The **"Good, Bad, Could Be Better"** activity is dedicated to reviewing the method itself, not the prototype. Its objective is reflective: to look beyond the specific project and analyze how the process was structured, conducted, and experienced throughout the sprints, as well as the perceptions of the final panel (ratings of the prototypes).

The facilitator guides reflection using three key questions for the groups:

- Good: What worked well in the CDIO–AT process (sprint structure, timing, tools, collaboration, panel results)?
- Bad: What were the limitations and difficulties encountered during the process (resources, time for task development, decisions, documentation, reviews)?
- Could Be Better: What suggestions for improvement could be applied in future editions (tools, roles, pace, or environment)?

At this stage, participants reflect on how well they designed, decisions were made, and the method influenced their work. This reflection is a practice of Metadesign: reflecting on the design of the design process itself.

For the purposes of this book, Metadesign refers to reflecting on the creation of the artifact, project conditions, methods, tools, rules, roles, and environments throughout the CDIO process.

For the facilitator, this review allows identification of what worked well and what needs to be improved in future applications of the method, adapting it to different contexts (educational, corporate, community).

For participants, reflecting on their learning closes the CDIO–AT cycle.

Considerations and Perspectives

This book presented an adaptation of the CDIO model applied to the development of conceptual prototypes in Assistive Technology across physical, digital, and graphic dimensions.

It is considered that the sprint-based format has brought agility to the process while maintaining methodological rigor, and it can be applied in different contexts, such as product development courses in engineering and design programs, extension projects, interdisciplinary environments, prototyping laboratories, and innovation spaces.

Regardless of the application scenario, the objective remains the same: to develop inclusive design thinking, evidence-driven and connected to real demands, with a focus on accessibility, methodological rigor, and social impact.

In this method, methodological rigor relies on three essential dimensions: transparency, by making explicit what was done, why it was done, and how it was conducted; traceability, by ensuring systematic recording of decisions, evidence, and analyses; and replicability, by allowing the methodological path to be revisited, analyzed, or adapted in other contexts.

Methodological delimitations and evolution toward product

The CDIO in sprints, as well as the Sprint proposed by Knapp, does not guarantee, by itself, the transformation of a prototype into a final product. Its role is to create the necessary conditions to decide whether it is worthwhile to work on the solution.

At the end of the sprint cycle, what is obtained is not a finished product, but:

- a conceptual prototype capable of simulating the user experience at an exploratory level;
- a clear set of tested hypotheses, indicating what makes sense, what needs adjustment, and what should be discarded;
- documented evidence that reduces decisions based on assumptions or “guesses”;
- a shared vision among engineering, design, and assistive technology teams regarding the problem, the solution, and functional priorities.

It is important to emphasize that the conceptual prototype is not a product. For this, additional cycles of technical development, testing with real users (when applicable), and development and production processes are required.

Extent and Contribution

The CDIO–AT methodology can support educators, researchers, undergraduate research students, and facilitating professionals interested in developing products and services in a structured, accessible, and user-centered manner, contributing to the strengthening of Assistive Technology as a field of innovation in products and social inclusion.

This work is dedicated to elderly people with disabilities, their families and caregivers, who struggle with barriers, as well as to educators, facilitators, researchers, and professionals who choose to work with this population with empathy, responsibility, and social commitment.

May this book honor these efforts and inspire more accessible practices in the development of products and services, both now and in the future.

A note on the use of AI – Artificial Intelligence

The preparation of this book was supported by Generative Artificial Intelligence tools (LanguageTool and ChatGPT, version 5.2, December 2025), used exclusively for textual organization and grammatical revision.

AI was not employed to generate data, analyses, research results, or scientific conclusions, nor to replace the academic, methodological, or ethical judgment of the author, who assumes full responsibility for the content of the work.

The use of these resources followed the principles of transparency, responsibility, and respect for authorship, in accordance with the Guidelines for the Ethical and Responsible Use of Generative Artificial Intelligence of UFPR (2025).

Both the layout and illustrative images were produced by the author with the help of the Canva platform (Pro version), using layout resources, stock images, and visual filters for editorial purposes.

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CDIO