

Chapter 7

Evaluation methods and usability tests

7.1 Observational studies

In this section, we will describe the methodology adopted to carry out two observational studies on the inclusive MIDI controller. An observational study is an empirical investigation that attempts to estimate the effects caused by a process when it is not possible to perform an experiment [144].

We conducted two observational studies. The first study was conducted at the *Laboratory of Music Informatics* (LIM) at the University of Milan. The second study was conducted during the period abroad of the author at Aalborg University in Copenhagen.

7.1.1 First Observational Study

The goal of this observational study is to test the accessibility of some functions of the inclusive MIDI controller when this tool is matched with the input devices users are accustomed to.

Regarding the categories of individuals involved in the research, the following roles have been identified:

- Participant – An individual aged 18 or older;
- Supervisor – A designated individual collaborating on the research project.

For experimentation, each participant is associated with a numerical identifier whose purpose is to link the various data collected to the same participant. Associations between participants' first names and their respective numerical identifiers

are stored only in paper format and are securely kept by the data controller. The personal data gathered from each participant are listed in Table 2. They are not expected to be disclosed or transferred to third parties. If this need emerges in the future, such data will be made strictly anonymous and/or presented in an aggregated form.

Personal Data	Response Type
Age	Range: “18-27”, “28-37”, “38-47”, “48-57”, “58-67”, “68-77”, “78-87”, “88-97”
Gender identity	“Man”, “Woman”, “Transgender”, “Non-binary/non-conforming”, “Prefer not to respond”
Health conditions or impairments	Open-ended response
Musical knowledge	“Little or none”, “Sufficient”, “Average”, “Good”, “Excellent”
Musical experience	“Little or none”, “Sufficient”, “Average”, “Good”, “Excellent”
Tools used for computer interaction	Open-ended response
Tools used for playing digital musical instruments	Open-ended response

Table 2: Personal data gathered for user profiling in the first observational study.

Research Question

The research question (RQ) and the hypothesis (H) underlying this observational study are the following:

- RQ — Can the inclusive MIDI controller be understood and used by people with different abilities?
- H — There is no specific user target for the inclusive MIDI controller. Each user can configure the software to employ the physical devices that she already knows or finds most congenial.

The basis of this question is the perspective that led to the design and implementation of the inclusive MIDI controller as an accessible tool to include the largest part of individuals, overcoming their possible physical, cognitive, or social impediments.

Research Protocol

The research protocol consists of the four phases detailed below.

Phase 1: Initial questionnaire and instrument setup — The supervisor collects the participant’s personal data through a specific questionnaire. During the administration of the questionnaire, the supervisor takes note of any additional comments from the participant. Subsequently, the supervisor configures the devices required for the study, including standard equipment (a computer and an audio interface) and, potentially, user-specific input devices. The software installed on the computer is the DAW *Ableton Live*, the inclusive MIDI controller, and *Open Broadcaster Software*, a free and open source software for video recording and live streaming. In general, the computer equipment and software are provided by the supervisor, but users are requested to bring their own hardware tools in case of special needs.

Phase 2: Training — During the training phase, the participant is guided and assisted in choosing the hardware device to use for the observational study. If the participant is already used to a specific tool and such a tool is available among the options, it will be employed; otherwise, the participant is asked to bring their own device or assistance will be provided in selecting an appropriate tool for the purpose. The same applies if the participant has never used any specific hardware tool before. Next, the software is presented, and its purpose and usage are explained. However, further details about the controls offered by the software are not provided to participants, as the test focuses on the user experience and aims to assess the design choices.

Phase 3: Test — During the test phase, the participant is asked to perform certain actions on the software without prior knowledge of its structure. The exercises planned during the study are shown in Table 3. During the testing phase, monitoring tools will be used to enable data collection [145]. Activity logging is implemented within the software used for the test to track user activities on it. Additionally, an audio (microphone) video and screen recording tool OBS (Open Broadcaster Software) are utilized. Notes are taken for each participant.

Phase 4: Questionnaire — At the end of the test phase, a questionnaire is administered to participants to investigate the perceived experience and gather their feedback. The questionnaire includes some closed responses on a 5-point Likert scale, where 1 implies “very little” and 5 means “very much”, as well as some open responses. The questions are shown in Table 4.

Participant Descriptions

Three users participated in the test activity, each with unique characteristics related to their age, sex, impairments, musical knowledge, musical experience, and tools used for computer interaction and playing digital musical instruments. The profiles of the



Figure 28: Participant 1’s expanded keyboard with keyguard and mouse with joystick.

Level	Task	Description
Base	1	Press Button 1
Base	2	Maximize the window to full screen
Intermediate	3	Access settings for Button 3
Intermediate	4	Set the number of pads to 6 for page 1
Advanced	5	For AuxPad 1, set Event to “note”, Type to “trigger”, Key 1 to “cursor right”, and Key 2 to “cursor left”
Advanced	6	Configure Pad 2 to navigate to Page 2

Table 3: Tasks for the test phase of the first observational study.

participants are summarized in Table 5.

Participant 1 (P1) is a woman aged between 18 and 27 years old, who faces the

Question	Response Type
How easy was the use of the software?	Closed response
How pleasant was the use of the software?	Closed response
How frustrating was the understanding of the software?	Closed response
How frustrating was the use of the software?	Closed response
What feelings or thoughts predominated your mind during the exercise?	Open-ended response

Table 4: Post test questionnaire of the first observational study.

User	Age	Gender	Impairments	Musical Knowledge	Musical Experience	Tools for Interaction / Musical Instruments
P1	18-27	Woman	Quadriplegia	Average	Good	Expanded keyboard w. keyguard, mouse w. joystick, / Pedal lift for drums
P2	48-57	Man	Daltonism	Good	Average	Mouse, keyboard, trackpad / N/A
P3	38-47	Man	Blindness	Average	Average	Screen reader, braille display / N/A

Table 5: Participant profiles of the first observational study.

challenge of quadriplegia. She self-reports an above-average level of musical experience and an average level of musical knowledge. Her computer interaction tools include an expanded keyboard with a keyguard and a mouse with a joystick (see Figure 28), facilitating her engagement with digital interfaces. For playing musical instruments, she uses a pedal lift for drums.

Participant 2 (P2), a man aged between 48 and 57 years old, experiences a light form of daltonism, a color vision deficiency. He possesses a good level of musical knowledge and an average level of musical experience. For computer interaction, he relies on conventional tools such as a mouse, keyboard, and trackpad, indicating proficiency in navigating digital interfaces. Although he does not use specific tools to play digital musical instruments, his participation provides insight into the experiences of people with light visual impairments in music-related activities.

Finally, Participant 3 (P3), a man between 38 and 47 years of age, faces the challenge of total blindness. He self-reports an average level of musical knowledge

and musical experience. His computer interaction tools include a screen reader and a braille display, enabling him to access digital content and interfaces through auditory and tactile feedback. He does not utilize specific tools for playing musical instruments.

Participants in our observational study have been chosen to represent a diverse range of ages, genders, impairments, musical backgrounds, and technological adaptations, thus providing valuable perspectives for understanding accessibility and inclusivity in digital music activities.

7.1.2 Second Observational Study

The second observational study aimed to compare the usability and user experience of the two developed front-ends: the first interface, based on the JUCE framework and the second interface, leveraging the Electron framework (see Section 6.1). The primary goal was to verify if the transition to a more classic and feature-rich layout (the second interface) improved performance or if the increased complexity introduced new barriers for users with specific needs. For this purpose, we chose to test the interfaces with music technology students, in order to obtain feedback on the musical aspects, the HCI aspects, and the usability.

Regarding the categories of individuals involved in the research, the same roles of the previous observational study have been identified:

- Participant – A student in music technology aged 18 or older;
- Supervisor – A designated individual collaborating on the research project.

Research Questions

The research questions (RQ) underlying this second observational study are the following:

- RQ1 — Is the inclusive MIDI controller (in its two versions) easy to be understood and used by students of music technologies?
- RQ2 — Which of the two interfaces is perceived as more effective and complete from a musical and ergonomic perspective?

Experimental Protocol

A specific group of participants was involved (see Table 6), ranging from 18 to 47 years of age. The sample students with varying degrees of music theory knowledge and technical expertise. This diversity was essential to test the “design-for-one” principle.

The study followed a mixed-methods approach. Quantitative data were collected via the System Usability Scale (SUS) [146] to assess the perceived usability of both interfaces. Qualitative data were gathered through a Post-Test Questionnaire (Table 7) and a “Think-Aloud” protocol during the execution of 10 standardized tasks (Table 8). These tasks required participants to configure the colored and auxiliary pads, save, reload and reset the setup, and manage MIDI sequences. The qualitative feedback was subsequently processed using Thematic Analysis according to the six-phase framework proposed by Braun and Clarke [147]: familiarization with the data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report.

Personal Data	Response Type
Age	Range: “18-27”, “28-37”, “38-47”
Gender identity	Open-ended response
Musical knowledge	“Little or none”, “Sufficient”, “Average”, “Good”, “Excellent”
Musical experience	“Little or none”, “Sufficient”, “Average”, “Good”, “Excellent”
Tools used for computer interaction	Open-ended response
Tools used for playing digital musical instruments or known tools	Open-ended response

Table 6: Personal data gathered for user profiling in the second observational study.

- Recruitment of Participants** Participants were recruited via a QR code that led to a Google Form during classes in the Sound and Music Computing specialization at Aalborg University. Participation was voluntary, and each student, after expressing interest in participating, provided their availability via a second Google Form.
- Informed Consent** At the agreed time, the supervisor ensured that the participant understood and accepted the informed consent. Acceptance was explicitly provided in writing. The supervisor printed the acceptance form and stored it in a secure, locked location.
- User Profiling and Instrumentation Setup** These phases were identical to those of the first observational study, which can be consulted in Section 7.1.1, the requested data can be seen in Table 6.

- **Participant training** During the training the two software interfaces were presented briefly, but their purpose and usage were not explained. No further details were added about the tools.
- **Test** The test phase consisted of 10 tasks, as shown in Table 8. During this phase, the supervisor took note of the participant's behavior and comments.
- **SUS Questionnaires** After the testing phase, participants received two SUS tests, one for each interface, the results of which are discussed in Section 7.2.2.
- **Post Test Questionnaire** Finally, a post test questionnaire was administered, the questions of which are shown in Table 7, all of which were open-ended. These results, together with the notes taken during the test phase, are discussed in Section 7.2.2.

Question	Response Type
What did you expect to be able to manage in these software and didn't find it?	Open-ended response
What do you think their uses might be and in what contexts?	Open-ended response
What could be improved in the two software?	Open-ended response
What features would you add in the two software?	Open-ended response

Table 7: Post test questionnaire of the second observational study.

Participants Description

Seven users participated in the test activity, each one was a student in the Sound and Music Computing specialization at Aalborg University. Their characteristics related to age, sex, musical knowledge, musical experience, and tools used for computer interaction and playing digital musical instruments are summarized in Table 9.

7.2 Results

This section provides a description of the results of the two observational studies described in Section 7.1.

Task	Interface	Description
1	1	Find the way to set up the colored buttons
2	1	Set the colored button 1 with the event chord, the type trigger, the note f8, the chord type maj7, the color cyan
3	1	Set the auxiliary pad 5 with the event note, the type hold, the note c4, the delay 100 ms, the color purple, the key 1 cursor left, the key 2 cursor right
4	1	Set the colored button 3 to loop the midi sequence in the following path, allowing the spacebar to reset it and transpose the sequence by 2 pitches
5	1	Save the setup you have done in the following path, and reset the software
6	1	Load the setup you saved in the previous step and set the auxiliary pad 1 to play the middle c note through key 1 for as long as it is held down
7	2	Find the way to set up the colored buttons
8	2	Set the colored button 1 with the output chord, the input trigger, the note f8, the chord type maj7
9	2	Set the key 1 with the output note, the input hold, the note c4, the delay 100 ms; set the key 3 in the same way
10	2	Set the colored button 3 to loop the midi sequence in the following path and transpose the sequence by 2 pitches

Table 8: Tasks for the test phase of the second observational study.

7.2.1 Results of the First Observational Study

This section provides a description of the results obtained by participants P1, P2, and P3 in achieving the tasks listed in Table 3.

Regarding *Task 1*, P1 successfully moved the joystick over Button 1 of the inclusive MIDI controller, producing the expected sound. However, when attempting to play the button by typing Key 1 on the keyboard, this action did not yield the desired result. P2 executed the action correctly and swiftly. Finally, due to his specific impairment, *Task 1* was not testable for P3.

Focusing on *Task 2*, all participants performed the action accurately and promptly. However, P2 encountered a challenge when attempting to click the button used for enlarging a window to full screen, as it was disabled. Instead, he resorted to dragging the edges of the window until they reached full-screen mode. Finally, he noticed the dedicated “full-screen” button.

User ID	Age	Gender	Musical Knowledge	Musical Experience	Tools for Computer Interaction / Musical Instruments
6444	28 - 37	White Male	excellent	excellent	Different bluetooth devices (mouse, keyboard, gamepad), audio devices (headphones, microphone), different sensors for musical interactive design, cameras / Keyboards, MIDI controllers, devices with embedded systems.
2502	18 - 27	She/her	good	good	Reapper, audacity (very little) / I don't play musical instruments, I know Midi keyboard and controllers, DAWs
3902	18 - 27	Male	little or none	sufficient	Ergonomic mouse, rollerball mouse, keyboard / Ableton and a small MIDI keyboard
3544	28 - 37	Male	good	good	Mouse and keyboard / MIDI keyboards/controllers
7488	18 - 27	Male	good	goodm	mouse, keyboard, touchpad / midi-keyboard
425	18 - 27	Male	average	good	Mouse, keyboard, midi keyboard, guitar (through usb cable) / blow sensor, piezo microphones
8835	38 - 47	male	excellent	excellent	Mouse, keyboard / Midi keyboard

Table 9: Participant profiles of the second observational study.

For *Task 3*, P1 thoughtfully moved the cursor to Button 3 of the inclusive MIDI controller and activated it, she attempted to access the settings but seemed unable to find the desired options. Eventually, she located the sidebar with the list of buttons and accessed the settings for Button 3. Concerning P2, first, he unsuccessfully attempted to access the settings directly from the button itself, then he clicked the Option button in order to explore the possibilities offered, once again not finding

what he was looking for, and he finally hit the Settings button, where he managed to perform the requested action. On the contrary, P3 performed the task accurately and quickly.

Regarding *Task 4*, all participants successfully opened the Page drop-down menu, even though the selected page was already correct. P3 encountered a challenge as the screen reader did not read the drop-down menu labels. Nevertheless, he completed the task swiftly, drawing on previous software experience.

P1 and P2 executed the action required by *Task 5* correctly and swiftly. P3 entered the correct settings, but he faced difficulty completing the task due to the screen reader not reading the labels of the drop-down menus. This problem also emerged during Task 4. The correct setting for *Task 5* is shown in Figure 14.

Finally, regarding *Task 6*, P1 was able to act correctly and swiftly. She only had to take a brief pause to figure out where to locate the command to navigate to a particular page. P2 initially attempted to set AuxPad 2 but corrected himself independently and was able to complete the task. Once again, P3 faced a similar challenge with the screen reader not reading drop-down menu labels, hindering task completion.

Post-Test Questionnaire

At the end of the test phase, a short questionnaire was administered to the participants to assess some aspects of the user experience (see Table 4). For closed responses, a 5-point Likert scale was adopted.

P1 reported a score of 4 for the ease of use and a score of 5 for the fun level. She expressed a level of frustration of 2 both in understanding and in using the software. She found the interface to be cute and fun, expressing a desire to use it again.

P2 reported a score of 5 for the ease of use and 2 for the fun level. He expressed a frustration level of 1 both in understanding and in using the software. In response to the last question, P2 remarked that he expected a behavior similar to his operating system, finding conversely some buttons unintuitive in their purpose.

Finally, P3 reported a score of 2 for the ease of use and a score of 3 for the fun level. He expressed a frustration level of 2 in understanding the software and a frustration level of 3 in using the software. For certain impairments, P3 experienced difficulty in discerning the current location within the interface and understanding the outcome of specific actions. He noted a lack of feedback following actions, leading to uncertainty about changes in state or context. These aspects resulted in an above-average level of frustration in using the software.

Discussion

The findings of this observational study highlight varying degrees of success and specific challenges faced by participants with diverse impairments. Overall, the majority of users completed the assigned tasks efficiently. However, certain accessibility barriers were identified regarding the compatibility of the interface with blind users. These issues were addressed in subsequent iterations; specifically, labels, combo boxes, and other UI components were optimized for seamless integration with both native and third-party screen readers. Consequently, these assistive technologies now provide clear auditory feedback, ensuring users can accurately verify their selections.

These enhancements were already integrated during the second observational study, even though the use of screen readers was not required at that stage. While the software is currently commercially available, the present version is not intended to be definitive regarding accessibility features for visually impaired users. Rather, the project follows an iterative development model, with ongoing refinements aimed at continuously improving inclusivity and ease of use.

7.2.2 Results of the Second Observational Study

The results of the second observational study provided a nuanced comparison between the two interfaces. While the second one was recognized as more visually complete, the data suggests that it was perceived as more tricky and cognitively demanding than the original inclusive MIDI controller interface.

Quantitative Results

The quantitative results from Table 10 indicate a general trend toward higher usability for the first interface.

Participants with high musical proficiency (for example ID 7488 and ID 6444) maintained high scores (above 80, "Best Imaginable") for both interfaces. However, for users with lower musical familiarity, a visible drop in the SUS score was recorded when moving to the second interface. Notably, participant ID 425 reported a score of 42.5 (Poor) for the first interface, which plummeted to 27.5 for the second one. Similarly, ID 3902 showed a decrease from 62.5 to 57.5. These results suggest that while the feature set of the second interface is broader, the interface layout may lack the immediate discoverability required for inclusive use.

Qualitative Results

Following the Braun and Clarke [147] methodology, the qualitative feedback from the post test questionnaire and observations was synthesized into four main themes:

User ID	SUS Score 1 st Interface	Grade	Rank	SUS Score 2 nd Interface	Grade	Rank
6444	80	A-	Best imaginable	80	A-	Best imaginable
2502	75	B	Excellent	72.5	C+	Good
3902	62.5	D	Okay	57.5	D	Okay
3544	72.5	C+	Good	72.5	C+	Good
7488	92.5	A	Best imaginable	92.5	A	Best imaginable
425	42.5	F	Poor	27.5	F	Poor
8834	50	F	Poor	67.5	C+	Good

Table 10: Results from the post test questionnaire of the second observational study.

- Discoverability vs. Complexity. Participants described the first interface as “mysterious” but ultimately more rewarding once the mapping logic was understood. In contrast, the second one was perceived as “more alike to other platforms” but prone to hidden functionalities. Participant ID 8835 noted that functionalities should not be hidden and suggested that settings for each pad should be placed “just next to it” to avoid navigation fatigue.
- Inconsistency in Interaction Modalities. A recurring theme was the lack of consistency between input devices. Some UI elements in the second interface supported both keyboard and mouse selection, while others (like the delay selector) only supported one, leading to confusion. ID 3902 remarked that the delay selector was “cumbersome to use”, emphasizing that not everything could be interacted with in the same way.
- The Need for Auditory and Visual Feedback Loops. Users across both interfaces expressed a strong desire for real-time feedback. ID 6444 suggested that the software should “demonstrate auditively the changes made to the configuration” (e.g. hearing the difference between trigger and hold during the setup phase). The lack of feedback following actions in the second interface led to an “above-average level of frustration” for the participant ID 425, who struggled to discern state changes.
- Aesthetic and Performance Efficiency. The speed of the interface was not just a technical metric but a user experience barrier. One participant complained that animations in the second interface were “too slow” when moving the cursor, hindering the feeling of a real-time musical performance. Furthermore, the

request for “inspiring factory-presets” (ID 8834) indicates that users seek a starting point to reduce the initial cognitive load of configuration.

The comparison and further tests based on these results revealed that the simpler, JUICE-based inclusive MIDI controller remains more accessible for users with visual and motor restrictions. The second one, while musically more powerful, requires further optimization in terms of label reading for screen readers, UI consistency, and the reduction of hidden menus to reach the same level of inclusivity as the first software.

7.2.3 Discussion

During the doctoral period, the two observational studies described in this chapter were conducted. The first one aimed to evaluate the ability of heterogeneous users to complete selected tasks of increasing difficulty, while the second included more specific tasks and aimed to evaluate the best interface for an dedicated audience (music technology students). For both studies, it was difficult to find a large number of participants. For the first study, finding participants with the required profile was not a trivial task. Indeed, to have a comprehensive overview, users should have had various types of cognitive and physical disabilities, used heterogeneous input devices and tools, possessed musical interests, and have had diversified levels of musical skills. Similarly, for the second study, only volunteer music technology students at Aalborg University in Copenhagen were available, and the course does not include a large number of people.

For this reason, we chose to carry out observational studies, as often proposed in the literature for collaborative interfaces[148]. Such a study gave us the possibility to observe the usability of the inclusive MIDI controller perceived by different types of real users and gather some quantitative data to drive future improvements.

Despite the limited number of participants, which cannot be considered representative of the entire target population, this studies allowed us to validate the design, highlight some limitations, and understand which of the two interfaces showed more problems.

In the evaluation of the results, it is important to note that for both studies, it was a blind test and that the participants had no previous training on the interfaces. A positive aspect emerging from the post-test questionnaires is the low level of frustration in understanding and using the softwares.

It is also important to underline that these observational studies provided fundamental insights into the effectiveness of the Inclusive MIDI Controller, while simultaneously highlighting several areas for improvement and some limitations that must be addressed.

Despite the encouraging results, certain structural limitations emerged. First, the feedback was gathered from a relatively small number of participants, which, while providing deep qualitative data, may not represent the full spectrum of diversity within the target population. Furthermore, it became evident that not every type of disability is currently managed with the same level of granularity. For instance, while the eye-tracking integration proved successful for users with severe motor impairments, other accessibility barriers, particularly those related to complex cognitive loads or specific visual impairments, remain only partially addressed.

The evaluation process yielded several key lessons:

- The interface is not always immediately intuitive for the end-user. Currently, the system often relies on a facilitator (such as a music teacher or educator) to handle the initial configuration. This dependency is partially mitigated by the user manual authored by Maestri[123], but it highlights a gap in the software's self-explanatory capabilities.
- A significant finding was the lack of sufficient visual and auditory feedback during the setup phase. For an ADMI, it is crucial that the user receives immediate sonic or visual confirmation of how a specific setting (e.g., a change in MIDI mapping or sensitivity) alters the instrument's behavior before starting the actual performance.

It is important to underline that many limitations identified in the second observational study were specifically linked to the second interface prototype. The feedback received suggested that its complexity hindered rather than helped the user. Consequently, the decision to move forward with a more streamlined approach was a direct result of these user-centric observations.

The gathered feedback provides a clear roadmap for the development of an improved, novel prototype. The primary objective for future iterations will be to transition from a mediated tool to a fully autonomous one. Future development will focus on the importance of direct user agency, by redesigning the configuration workflow to allow the end-user to set up the software and begin playing without any external assistance; the integrated feedback loops by implementing real-time auditory previews of settings, ensuring that every adjustment provides an immediate sound-check to guide the user; and in refined interaction design. Drawing from the lessons of the second study, the new prototype will prioritize the simplicity of the first JUCE-based interface, while expanding its compatibility with assistive technologies to ensure a broader range of disabilities are effectively supported.

In line with the above discussion, due to its industrial nature, the development project for the inclusive MIDI controller does not end with this thesis. Other research and development processes will be undertaken, together with further observational

studies, all aimed at improving usability and making the instrument accessible to an ever-wider audience.

Conclusion

This thesis represents the culmination of an industrial Ph.D. path focused on bridging the gap between advanced music technology and human diversity. By operating at the intersection of academic research and market-oriented development, this work has sought to transform the concept of music accessibility from a marginal concern into a central pillar of modern digital lutherie. The following conclusion synthesizes the theoretical journey, the industrial results achieved, and the ongoing nature of the project.

The first part of this work established a rigorous theoretical foundation, moving from the broad definitions of accessibility, inclusivity, and usability toward their specific applications in the musical domain. By embracing the principles of Universal Design and Ability-Based Design (ABD), this research challenged the historical "normative body" paradigm of Western music, which often views physical variance as a deficit to be corrected rather than a resource for expression. The scope of this investigation was intentionally broad, recognizing that accessibility is a systemic requirement. We explored the "material culture" of music, analyzing how barriers are embedded not only in digital interfaces but also in scores, archival materials, and physical performance environments. Through the study of the Ricordi Historical Archive and the application of the IEEE 1599 multilayer format, we demonstrated how the decoupling of musical information in logic, notation, and performance, can open alternative access channels for the visually and motor impaired. Furthermore, the exploration of MIDI 2.0 and its Capability Inquiry (MIDI-CI) mechanism highlighted a technological shift that allows for the first time a "negotiated" autonomy, where instruments and software can dynamically adapt to the specific needs of the musician.

The second part of the thesis documented the design, implementation, and evaluation of an inclusive MIDI controller, co-developed with Audio Modeling S.r.l. as a market-ready product. This industrial project served as the practical validation of the theoretical premises explored in the first part. The development process emphasized hardware abstraction and the "commodity principle", allowing users to control professional-grade sounds through affordable, everyday devices such as webcams, gaming controllers, or eye trackers. By implementing two distinct iterations of the user interface, one focused on immediate discoverability through JUCE and another on feature-rich customization through Electron, the project tries to address the diverse needs of both novice learners and professional musicians. The empirical evaluation through observational studies provided crucial insights. While the technological solutions were shown to significantly lower the barriers to entry, the results emphasized that accessibility is not merely a technical fix but a relational process. The integration of music therapy principles and the definition of a tailored pedagogical method proved that for an ADMI to be successful, it must foster "intentional expression" and "interdependent musicianship".

Although this thesis concludes here, the project it describes is in its infancy. While the inclusive MIDI controller is already available on the market, as a significant achievement for an industrial PhD, we do not consider the development finished. Choosing the most suitable front-end, the integration of MIDI 2.0 managers, and the initial results of our usability tests have highlighted new avenues for improvement. The feedback from users with impairments and music technology students has clearly indicated that the path toward total inclusivity requires constant refinement of UI consistency, the reduction of cognitive load, and the expansion of auditory and visual feedback loops. In many ways, the release of the product onto the market marks a new beginning rather than an end. The development will continue beyond this Ph.D., treating the current version as a foundation for a broader ecosystem of inclusive musical tools. In conclusion, this work demonstrates that when academic research is paired with industrial innovation, it is possible to create tools that do not just compensate for disability, but actively empower ability. By redefining the music instrument as a distributed, adaptable system, we move closer to a world where the joy of musical creation is a universal right, accessible to every individual regardless of their physical or cognitive profile.

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Project developed at the Laboratorio di Informatica Musicale (LIM)

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