Teaching Interactive Music Systems: a Research-Oriented, Project-Based Graduate Course in a Multidisciplinary Master's Program

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Abstract

This paper presents a project-based, research-oriented graduate course in Interactive Music Systems delivered to a multidisciplinary cohort at the University of Oslo, grounded in a strong NIME perspective and constructive alignment among intended learning outcomes, teaching and learning activities, and assessment tasks. A flipped-classroom model and a Bela + Pure Data toolchain scaffold eleven workshops, progressing from foundational electronics and mapping to a standalone, performable digital musical instrument prototype showcased in a final course concert. Portfolio-based assessment combines open documentation with a short NIME-style academic paper. Analysis of student data and feedback from 2022 to 2024 indicates high engagement and strong outcomes, successful research integration, several projects accepted in the NIME paper track, and robust deliverables. Student feedback highlights hands-on strengths and high satisfaction, while persistent challenges remain around fabrication and time constraints, which in turn inform actionable guidance for NIME pedagogy.

Keywords

NIME Pedagogy, Interactive Music Systems (IMS), Digital Musical Instruments (DMI), Constructive Alignment, Project-based Learning, Constructionism, Flipped Classroom, Active Learning, Portfolio Assessment

1 Introduction

Higher-education offerings focused on NIME—often framed as interactive music systems (IMS), digital musical instruments (DMI), or computer music—span engineering, design, and music programs and vary widely in emphasis, format, and outcomes. No universal curriculum exists because NIME is inherently interdisciplinary, drawing from computer science, signal processing, HCI, artificial intelligence and machine learning, performance/composition, and perception/cognition. Program context typically shapes emphasis: engineering-led offerings foreground real-time systems and sensing; design programs center embodied interaction and mapping; arts and music academies prioritize performance and practice-based inquiry; cross-disciplinary programs blend instrument craft, system design, and creative practice. Nonacademic workshops and DIY/maker communities further expand access and methods.

Designing effective NIME pedagogy is challenging. Differences in institutional traditions, diverse student backgrounds, and the breadth of required skills complicate alignment among aims, activities, and assessment. Few instructors learned NIME through formal coursework, amplifying variability in course design. This paper presents a project-based, research-oriented graduate course in IMS with a strong NIME perspective, delivered to a diverse cohort within a multidisciplinary master's program. We outline intended learning outcomes (ILOs), teaching and learning activities (TLAs), assessment tasks, syllabus, tools and infrastructure, and underpinning pedagogy, and we summarize student feedback. Our aim is to document a replicable, research-led approach that integrates technical competence, performative practice, and aesthetic reflection, offering actionable guidance for instructors.

2 NIME Education

NIME-related education spans long-running courses, intensives, and cross-institutional modules, revealing common practices and persistent tensions. Across the literature, project- and performance-centered learning, iterative prototyping, and accessible toolchains are foregrounded, while challenges recur around beginner-friendly texts, balancing technical and artistic aims, heterogeneous cohorts, and performance readiness.

Seminal offerings established a blueprint that blends lectures, labs, and group projects within carefully configured prototyping environments, using interaction-design methods to scaffold ideation and implementation [21, 33]. Other programs distribute NIME themes across multiple modules to cultivate performance craft and professional practice beyond functional prototypes, extending into concert and installation contexts [19]. Where no music technology program exists, multidisciplinary teamwork has bridged arts and engineering via complementary groups spanning music theory, sensors, protocols, and programming [20].

Inclusive strategies attend to diverse backgrounds. To empower non-musicians, playful, practice-led activities—such as an "unplugged interface orchestra"—decenter technical mastery and build confidence through embodied experimentation [32]. Embodied "action–sound" approaches similarly prioritize bodily movement and performability, moving from acoustic-object exploration to analog/digital builds, with live performance as a pedagogical anchor [16]. With intentionally constrained toolchains, rotating designer/performer/listener roles sharpen attention to gesture-to-sound mapping and expressiveness, while structured peer evaluations make progress traceable [17].

Several formats and communities broaden access and learning trajectories. Short-format, cross-campus workshops leverage networked classrooms, physical computing, improvisation, and reflective blogging to build STEAM competencies and distributed

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communities of practice [36]. Broader frameworks situate instrument building as "musicking," integrating DIY/maker culture and accessible fabrication to couple tool-making with musical expression [6]. Survey-style offerings at venues such as SIGGRAPH have distilled NIME design principles and case studies for wider audiences [9]. Beyond higher education, initiatives targeting youth employ scaffolded toolkits and craft-based practices (e-textiles, everyday-object instruments) to foster inclusion, agency, and progression from building to sharing and focusing [1, 13, 14, 29]. Research-through-art-and-design residencies—treating teachers and learners as peers—foreground frugality, raw processes, and shared authorship to cultivate resilient NIME communities [5].

Together, these strands articulate design trade-offs and strategies—constructive alignment, authentic assessment, constrained yet expressive toolchains, rehearsal for performance readiness, and reflective critique—that inform our course's alignment, workshop structure, feedback practices, and technical infrastructure.

2.1 Trends and Challenges in NIME Pedagogy

Across reported offerings, several trends recur. Courses are project-based and practice-led, with students iteratively prototyping DMIs and culminating in performance-centered outcomes that require rehearsal and stage-readiness. Toolchains emphasize accessibility (e.g., visual programming + microcontrollers/sensors), sometimes intentionally constrained to focus attention on mapping and expressiveness; rotating roles (designer/performer/listener) and peer critique support reflective practice. Multidisciplinary collaboration is common, leveraging complementary skills across arts and engineering, and STEAM framing (including blogging and making) is used to build community and confidence.

Persistent challenges mirror this breadth. Instructors face a lack of beginner-oriented texts, ongoing toolchain maintenance, and the need to balance artistic/aesthetic goals with engineering rigor. Heterogeneous cohorts complicate pacing: non-technical students may lack foundations in electronics, audio programming, and fabrication, while technically strong students may need support in performance craft and aesthetics. Short formats compress reflection and iteration, and performance readiness demands robust prototypes and time for practice. Teamwork can expand scope but may dilute individual mastery; conversely, individual projects can limit ambition. Evaluating expressiveness, embodiment, and musicality remains difficult to standardize. Attitudes toward nontraditional instruments and default interface conventions (buttons/knobs/faders) can constrain imagination. Finally, instructional breadth (hardware, software, interaction design, composition, improvisation) strains staffing and contact hours, creating a recurring trade-off between foundational coverage and available time.

3 Course Design and Delivery

This section describes the course Interactive Music Systems MCT4054[1], offered by the Department of Musicology at the University of Oslo (UiO). The course carries 10 ECTS credits; 1 ECTS corresponds to approximately 25–30 hours of student work, including classes, independent study, and examinations.

3.1 Course Description and ILOs

On the UiO website, the course description and intended learning outcomes (ILOs) are as follows:

The aim of the course is to develop knowledge of and practical experience with the design and implementation of systems intended for real-time sonic or musical interaction. This may be in the form of a performance-oriented musical instrument or various types of interactive sonic systems that explore collaborative physical or virtual music-making.

Having completed the course, the student will:

- *be familiar with principles for the design and evaluation of musical human–computer interaction* (ILO1)*;*
- *have knowledge of different types of sensors and input devices, and strategies for acquisition, filtering, and mapping of sensor data* (ILO2)*;*
- *be able to design and prototype hardware and software components of a complete musical instrument or other interactive sonic system* (ILO3)*;*
- *have hands-on experience with sensor data acquisition and the mapping of sensor data to sound synthesis/processing engines* (ILO4)*;*
- *be able to reflect on the aesthetic qualities of interactive music systems* (ILO5).

3.2 Program Context and Student Profile

Interactive Music Systems is an elective course in the international Music, Communication and Technology (MCT)[2] master's program (120 ECTS, two years), which educates "technological humanists" through research-led teaching and four macro-areas: networked performance, machine learning for sound/music, motion capture, and IMS. The program integrates methods from the sciences and the arts and emphasizes advanced skills in analysis, design, development, communication, and ethically grounded research. Admissions span arts/humanities, social sciences, informatics, and engineering; applicants must document competencies in both music and technology, yielding diverse, international cohorts that include recent graduates and professionals. Typically taken by all MCT students, the MCT4054 course is also open to master's and PhD students from other departments, with most external enrollments coming from the Department of Informatics. There are no formal prerequisites; familiarity with visual programming for sound and music and basic electronics is highly recommended.

3.3 Pedagogical Approach

The course integrates complementary principles. Constructive alignment [3] links ILOs, TLAs, assessment, and program aims; because assessment drives learning [3, 7], tasks are authentic, promote functioning knowledge and soft skills, and reduce misconduct [26, 30]. Project-based learning [30] draws on problem-based methods [2]; students define their own projects, integrating prior and new knowledge for deeper understanding [18]. Our approach also aligns with constructionism [12]: students learn by creating public, shareable artifacts—digital musical instruments, performances, and documentation—around which critique and discussion unfold, with workshops supporting iterative "bricolage" through accessible toolkits and incremental, working solutions .

Assessment balances formative and summative components. Formative feedback is timely and actionable [15, 31], with follow-up activities closing the feedback loop [4, 35]. Summative, criterion-referenced evaluation uses a concise rubric to support self-assessment [25]. In class, active learning predominates

[1]https://www.uio.no/studier/emner/hf/imv/MCT4054/

[2]https://www.uio.no/english/studies/programmes/mct-master/

[10, 27] within a flipped classroom: content is delivered asynchronously (videos, readings, discussion boards) to prepare in-class practical work [24, 28], supported by comprehensive materials in the Learning Management System (LMS). Elements of team-based learning [23, 29] promote accountability and readiness checks.

Compared to typical Product Design or Music/HCI offerings that culminate in concept pitches or screen-based/laptop prototypes, this course: (i) requires a standalone, embedded, battery-operable instrument demonstrated in a live performance; (ii) emphasizes rehearsal, robustness, and stage-readiness as learning goals; (iii) constrains the toolchain to foreground mapping and embodied control rather than software feature breadth; (iv) uses constructionist, public-facing assessment (blog, open documentation, portfolio) in place of a single report/exam; and (v) integrates research writing and mixed-methods evaluation that routinely feed into NIME submissions.

3.3.1 Academic support. Beyond standard lectures and labs, academic support included: (i) weekly, annotated feedback on submissions with follow-up activities to close the loop; (ii) in-workshop live-coding "clinics" and just-in-time demos targeting common blockers; (iii) staged project approvals with methodological guidance (ethics, evaluation design, literature integration); and (iv) editorial mentoring on the short paper for students opting to submit to NIME. The approach coupled performance coaching and public-facing documentation with research-led writing support.

3.4 Course History

From 2019 to 2021 the course ran as a 5 ECTS intensive (two weeks of flipped preparation + two weeks of daily workshops) within the joint MCT program with the Norwegian University of Science and Technology (NTNU), delivered across two campuses via high-end teleconferencing systems. While effective for immersion, the format consistently limited reflection, iteration, and performance preparation: students struggled to consolidate learning, to mature mappings and enclosures, and to rehearse reliably for a concert. From 2022 to 2024, the course ran as a 10 ECTS, semester-long offering with minor annual improvements; this shift enabled earlier playable instrument prototypes, provided more rehearsal and practice opportunities, and created space to reflect on the topics learned in the course, apply them in practice, and iteratively refine designs, leading to more even progress across mixed backgrounds. Since 2025, it has been paused amid a major revision of the hosting program.

3.5 Teaching and Learning Activities

The course runs over 16 weeks and includes an initial 2-hour orientation (week 1, logistics and Bela kit distribution), followed by 11 weekly, mandatory 4-hour workshops, and concluding portfolio/performance activities. We implement a flipped-classroom model: before each workshop, students watch short video segments and complete targeted readings (see per-workshop lists in Appendix A), and post questions or insights to the LMS. A brief readiness check at the start of each meeting is used formatively to calibrate emphasis and pacing.

Contact time is organized to maximize practical work: short targeted explanations and demonstrations are interleaved with extended blocks of task-based implementation and iteration. Brief show-and-tell moments consolidate learning through quick demos and reflective critique, emphasizing playability, robustness, and expressive control.

The 4-hour block reduces setup/teardown overhead for hardware, affords multiple design–test–refine cycles within a single meeting, and supports rehearsal toward performance-ready prototypes. After each workshop, students adapt the day's tasks to their project trajectory and engage with optional readings. Details on tools and infrastructure are provided in Subsection 3.6; alignment to assessment is elaborated in Subsection 3.8.

3.6 Tools and Technical Infrastructure

Each student receives a Bela[3]-based hardware kit[4], shown in Figure 1, including a first-generation Bela board, a breadboard, basic electronic components, sensors and I/O, and wires/cables. Battery-powered speakers and battery packs are available to encourage standalone, seamless instruments, and a small radio transmitter is available to connect to room speakers for demonstrations and concerts. Pure Data (Pd)[5] is used to program Bela; example and template circuits are prepared in Fritzing[6]. A customized Bela image includes the following Pd libraries: ELSE,[7] Cyclone,[8] neuralnet,[9] and SFApdLib[10]. The image also includes additional software and mixed Pd/C++ projects for non-natively supported digital sensors (e.g., the LSM9DS1 IMU[11]).

Figure 1: The Bela-based hardware kit available to students.

[3]https://bela.io/
[4]https://www.hf.uio.no/imv/english/about/rooms-and-equipment/makerspace-documentation/index.html#BelaKits
[5]https://puredata.info/
[6]https://fritzing.org/
[7]https://github.com/porres/pd-else
[8]https://github.com/porres/pd-cyclone
[9]https://github.com/alexdrymonitis/neuralnet
[10]https://github.com/stefanofasciani/SFApdLib
[11]https://www.st.com/en/mems-and-sensors/lsm9ds1.html

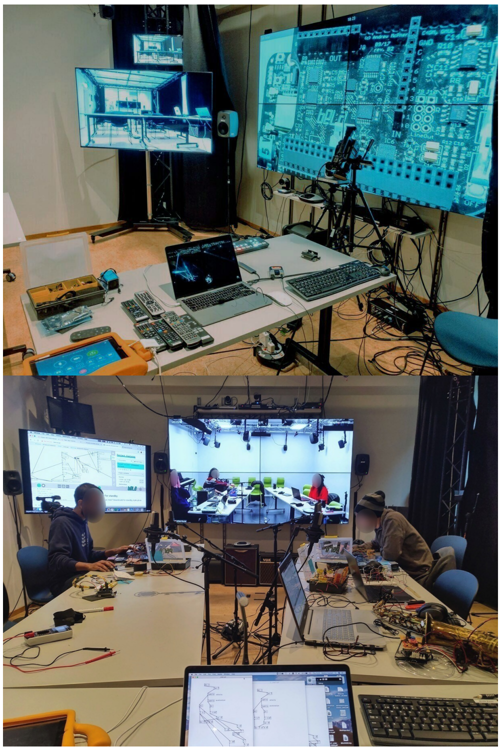

Figure 2: Room configurations used for the course, including multi-screen AV, a close-up electronics camera, and remote participation facilities.

The course room provides multi-screen AV, close-up views of electronics, and support for remote attendance. Figure 2 shows configurations also used in prior cross-campus joint offerings. Students have access to a makerspace[12] with a range of electronic components and prototyping tools; a laser cutter and 3D printer were recently added. To reduce friction and enable reliable rehearsal toward the concert, students received pre-imaged Bela systems, loaner sensors, and a replace-on-failure policy for critical parts.

Bela was chosen to maximize fast, accessible prototyping of standalone DMIs for a heterogeneous cohort. It offers very low and stable end-to-end latency with synchronous audio/control I/O; Pd-based development with immediate deploy-to-device (avoiding low-level C for most tasks); cable-minimal, battery-powered, stage-ready operation; and robust analog I/O and timing suitable for real-time gestural work. The course prepares students for further DMI/IMS design without platform lock-in: sensing, normalization, mapping design, evaluation methods, documentation, and Pd practices transfer to other embedded and desktop environments. For small series or one-offs, Bela remains efficient; migrating to microcontroller-centric designs is sensible mainly for production.

Compared to a microcontroller tethered to a laptop running Pd, Bela reduces latency and jitter, removes OS/driver variability and extra cabling, unifies timing between audio and control, and improves reliability in rehearsal and performance. The tethered alternative is viable where budgets require it, but it adds latency, setup complexity, and dependence on host configurations.

[12] https://www.hf.uio.no/imv/english/about/rooms-and-equipment/makerspace/

3.6.1 Cost, Logistics, and Scalability. Resourcing a hands-on, performance-oriented IMS course requires predictable costs and roles. Our Bela-based kit cost was approximately EUR 250–300 per student at purchase (first-generation Bela, breadboard, sensors/actuators, cabling, small battery speaker, battery pack). Reusable items (boards, speakers, durable sensors) were amortized across cohorts; consumables (wires, perfboard, small components) and replace-on-failure parts added EUR 10–20 per student per semester. A few overflow kits and spares reduced downtime.

Staffing consisted of one instructor who also managed kit logistics, loan pools, and facilities. The LMS hosted example patches/circuits, a Q&A forum, and checklists for staged assignments. A light maintenance cycle—one day pre-semester to reimage boards, verify Pd libraries, and test hardware—kept the pipeline reliable.

Where Bela is unavailable, three scalable alternatives are viable: (i) microcontroller sensor front ends with Pd on laptops (lowest cost, but added latency/jitter, cabling, and OS variability); (ii) Raspberry Pi with optimized audio kernels (moderate cost; requires external ADCs or a microcontroller front end for analog sensors, or I^{2}C/SPI sensors; additional system administration for low-latency audio, scheduling, and headless boot services); (iii) Daisy/Teensy in C/C++ (higher learning curve; greater development complexity for sound-synthesis and DSP; excellent performance).

3.7 Workshop Format and Sequence

Each 4-hour workshop follows a consistent arc that ties flipped pre-work to practical tasks and iteration. A typical flow allocates about 15–20 min for a readiness check (auto-graded quizzes with solutions discussed in small groups and plenary) and focused discussion to surface misconceptions and refine terminology; 30–35 min for a concise synthesis and targeted demonstrations connecting assigned materials (Appendix A) to the day's design focus; roughly 100–110 min for extended practical tasks (3–4 increasingly open-ended items) that feed directly into project work, with brief just-in-time live-coding interludes to address common blockers and model incremental, working solutions; and 20–25 min for quick demos and reflective critique emphasizing instrumentality, embodiment, and technical correctness.

Practical tasks combine circuit construction or integration, corresponding Pd patches, mapping iterations, measurement/verification, and short documentation checkpoints to track decisions and issues.

The sequence scaffolds from foundational concepts and skills—interaction design, electronics fundamentals, and gesture-to-sound mapping—through intermediate techniques—controller principles, signal-rate processing in Pd, and expanded sensing—into advanced topics such as haptics and capacitive sensing, multidimensional motion with IMUs, machine-learning-assisted mappings, fabrication for stage-ready systems, and mixed-methods evaluation. Final meetings emphasize rehearsal, user studies, and performance preparation. Full per-workshop topics, practical activities, and associated readings appear in Appendix A.

3.8 Assessment and Assignments

Assignments are introduced in class 2–3 weeks ahead of each deadline and discussed alongside common issues during subsequent workshops. Submissions and individualized feedback (returned within one week) are handled via the LMS. Readiness checks and in-class lab work inform emphasis and pacing for upcoming deliverables. Portfolio exam eligibility requires satisfactory completion of in-semester assignments and at least 80% workshop attendance. The portfolio, submitted in the exam period, compiles designated assignments with revisions; it comprises Assignments 2, 3, 7, and 8 (see Appendix B for details). Unlike conventional exam formats, the portfolio prioritizes public communication, reproducibility, and research integration, aligning assessment with concert performance and open documentation.

Eight mandatory assignments scaffold learning from foundational skills to a performance-ready IMS and a reflective written output. The first three assignments are common and tightly aligned with early workshops and flipped activities; the remaining milestones are individualized and synchronize with the workshop sequence to support prototyping, evaluation, rehearsal, and dissemination. Prompt summaries, timing, portfolio inclusion, and alignment to workshops are provided in Appendix B, with per-workshop topics and readings in Appendix A.

3.8.1 Course Project. Students conceptualize, implement, assemble, document, evaluate, and perform with an IMS prototype—e.g., solo or collaborative instrument, augmentation, installation, or musical training system. Designs must be grounded in at least ten scholarly sources (five from the course and five independently selected). Prototypes must use the course toolchain (Bela + Pd with provided electronics), run in real time as standalone devices, and include at least two distinct continuous sensing modalities. Projects require prior approval; substantial changes require renewed approval. Use of external components requires prior authorization.

Assessment is individual; coordinated, complementary systems are permitted if each outcome is independent, complete, and meaningful. Performing with the designed instrument is required. Participation in a public concert is highly encouraged but not mandatory: students who opt out must submit a private performance video to the LMS that demonstrates their IMS in use. Project-related deliverables are captured in the portfolio: public communication and full technical documentation (Assignment 7) and an academic paper using the NIME template (Assignment 8). For those who perform in the concert, the recording may be used for Assignment 7 subject to consent. The course requires a stand-alone, embedded instrument; a demonstrated performance (public or privately recorded); and two assessed, constructionist deliverables: public documentation and an academic paper.

3.9 Grading

Portfolio exams are graded using UiO's A–F scale (A = highest pass; F = fail). Two examiners, including the course coordinator/instructor, assess each portfolio. A marking rubric ensures transparency and guidance; completed, annotated rubrics are returned as the grade rationale. Appendix D provides band descriptors (A–F; for brevity, only A is included). Weighting: Assignments 2–3 (two criteria; 20%) and the individual project (Assignments 7–8; four criteria; 80%).

3.10 Course Evaluation

Students evaluate the course through multiple, time-staged channels. Mid-semester, the cohort meets without teaching staff to reflect on activities and propose improvements, enabling timely adjustments. Before exams, students complete an individual, anonymous survey on self-learning and course organization, with open comments, detailed in Appendix C. The same day, a final group discussion consolidates insights and suggests future measures. Together, these steps capture individual and collective perspectives to improve teaching and learning.

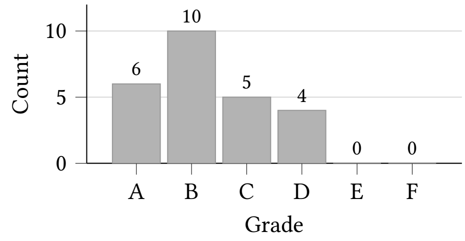

Figure 3: Portfolio exam grade distribution.

4 Cohort and Outcomes

This section summarizes three course offerings (2022–2024). Twenty-six students completed the course: 19 from the MCT master's program (73.1%); the remainder included 3 Informatics master's students (11.5%), 2 PhD students in Informatics/Musicology (7.7%), 1 Musicology master's student (3.8%), and 1 Erasmus student (3.8%). Academic backgrounds were mixed: 5 from computer science/engineering (19.2%), 6 from arts/music (23.1%), and 15 from interdisciplinary programs such as music technology (57.7%). About two thirds entered directly after the bachelor's; the rest returned with 5–10 years of industry experience.

4.1 Student Outcome

Of 26 students, 25 met requirements, submitted portfolios, and passed (96.2%). Figure 3 shows that 64% earned A–B grades. Final grades did not correlate with academic background, but weaker familiarity with visual programming for sound/music (e.g., Pd) was associated with lower grades. Of the 25 completers, 23 built standalone prototypes performed at the final concert; most performances ran smoothly (see recording[13], limited to consented items).

Students with an A were encouraged to submit their work to NIME, with the course coordinator and second examiner offering co-authorship support. Of six A students, five submitted improved papers; four were accepted [8, 11, 22, 34] (one oral presentation in 2023; one oral and two posters presentations in 2024), including a Best Demo award [8]. The course calendar helps: portfolios are graded mid-December; NIME deadlines typically fall in late January.

4.2 Student Projects

Most projects are documented via blog posts.[14] Figure 4 shows selected 2023 instruments/interfaces at a development stage approximately two weeks before the concert.

All students chose individual projects, aligning with personal artistic/musical interests. Many trained instrumentalists built hyper/augmented versions of their acoustic instruments (including augmented microphones for vocalists); others designed interfaces that reuse existing instrumental dexterity. About two thirds—often without formal training on an acoustic instrument—built alternate controllers in the NIME sense, frequently

[13]https://youtu.be/ySrjSWU_Mf8
[14]https://mct-master.github.io/interactive-music/. Note that not all posts correspond to final course projects; some document Assignment 2 or extracurricular work.

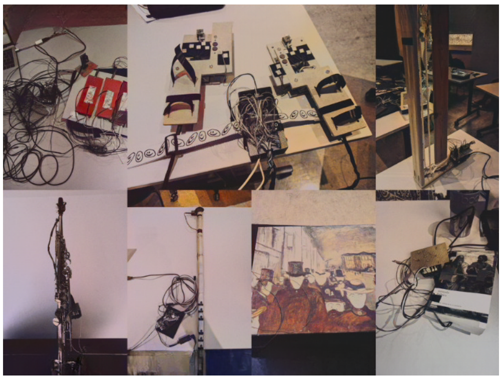

Figure 4: Early-stage prototypes of selected 2023 instruments/interfaces, approximately two weeks before the course concert.

inspired by existing NIMEs without copying them. Resource constraints fostered frugal, everyday-object designs (e.g., book, mop, Easter egg, chips can, bicycle helmet, mountain bike). Eight of 19 MCT students later chose master's theses closely aligned with the course, indicating a pipeline from coursework to research and practice.

To channel inspiration while avoiding cloning, students were required to position their designs within established NIME lineages and to articulate "what is borrowed" (e.g., interaction metaphor, sensing) versus "what is novel" (e.g., mapping strategy, gesture vocabulary, feedback, evaluation focus).

4.3 Student Course Evaluations

Twenty-one survey responses (Table 1) indicate high self-reported achievement of ILOs, consistent with the grade distribution in Figure 3. Course structure, clarity, and resources were rated positively, with slight improvements over time. The most critical item—still satisfactory—was workload, with large standard deviations suggesting polarized experiences, especially around completing a functional hardware prototype by the deadline.

From open responses and discussions, students valued the hands-on focus, the balance of theory and practice, clear milestones, rapid feedback, and comprehensive LMS resources. Access to hardware kits, sensors, tools, and Bela supported experimentation; machine learning—often used in student projects—and HCI components broadened perspectives on design and mapping. Autonomy and creative relevance were widely appreciated.

Suggested improvements included more in-class project time and support, more frequent showcases, and workshops focused on project-specific debugging. Students also requested earlier and deeper coverage of electronics and fabrication. Pacing and resource constraints were noted. Recent iterations address these points.

4.4 Course Challenges and Opportunities

Course challenges align with the literature (Section 2.1): breadth across artistic/technical domains, variable preparation in electronics/audio programming, and tight timelines. Some are mitigated at the program level, others within the course, but several persist. The course is engaging and well regarded, yet tensions remain. Many students initially default to conventional controllers (buttons, knobs, faders), narrowing design imagination. Without a standard textbook, the syllabus and toolchain require continual updates and maintenance. Inviting multiple perspectives—for example, departmental PhD students as guest contributors during workshops—helps broaden the academic context.

Workload and pacing were the most persistent frictions. The earlier 5 ECTS intensive concentrated pressure: students had limited time to digest concepts, fabricate enclosures, and rehearse. In the 10 ECTS version, shifting contact hours toward project-studio time, moving electronics/fabrication earlier, inserting frequent showcases with micro-deadlines, and using clearer scoping templates all helped. Over-ambitious scopes remained a risk, so a mid-semester scope review now enforces a feature freeze roughly two weeks before the concert. Shortening the course beyond the 5 ECTS core outlined in Course History is not advisable: rehearsal and evaluation quality degrade quickly, performance reliability drops, and mixed-background cohorts diverge more.

To encourage thinking beyond conventional controllers, we combine content exposure and structured constraints. Early workshops pair taxonomies and seminal NIME case studies with curated video examples and reflective prompts that explicitly separate "what is borrowed" from "what is novel." Design studios include de-familiarization exercises (no buttons/knobs; materiality-first prototypes using found objects), embodied ideation with acoustic objects, and critique sessions centered on affordances, control intimacy, and mapping diversity. Rotating performer/listener/designer roles, small "mapping études," and repertoire analyses help students connect precedents to their own practice; for many, sustained contact with NIME literature and performances is what shifts design imagination once integrated with their personal musical background.

Assessment design aims to be robust—and resilient, not immune—to AI misuse. Projects are highly idiosyncratic and personally situated, blending students' own repertoires and performance goals; this individuality raises the bar for generic AI outputs. The project is decomposed into staged milestones (proposal, prototype check-ins, user-study plan, documentation, performance) that must be demonstrated in class or submitted via the LMS with media evidence and versioned artifacts, making sudden unexplained leaps conspicuous. In-room micro-demos and brief oral explanations require students to discuss mapping choices, circuit details, and Pd patches; inconsistencies between written claims and live understanding tend to surface quickly. We ask for commented patches, schematic provenance, and build photos; LMS timestamps and repository histories document evolution. None of this renders misconduct impossible, but together these measures increase accountability and make AI-only work hard to sustain across weeks, especially when students must extend and explain their own designs in public critique and performance.

Platform trade-offs also intersect with equity and reliability. We considered microcontroller + laptop Pd, Raspberry Pi variants, and Daisy/Teensy + C/C++; lower-cost paths are feasible for learning but add latency/jitter, OS/driver variability, and cabling, reducing stage robustness. Bela + Pd minimized setup friction and supported mixed-background cohorts well; where Bela is not feasible, a microcontroller for sensor acquisition plus Pd on student/university laptops is a workable but less performance-ready path.

Fabrication remains a recurrent constraint: quality enclosures elevate outcomes, but teaching design-for-fabrication in one course is impractical despite access to 3D printers and laser cutters. We therefore cover essential, sometimes undergraduate-level material explicitly to avoid leaving anyone behind, and we advocate program-level support for deeper fabrication. Finally, while

Table 1: Results of the individual student survey: per-year and cumulative item means (standard deviations), with n indicating the number of respondents. Responses use a 1–5 Likert scale (1 = strongly disagree, 5 = strongly agree). Question texts are abbreviated; see Appendix C for full wording by label.

Label	Question (short)	2022 (n=10)	2023 (n=9)	2024 (n=2)	Overall (n=21)
ILO1	Familiar with principles for design/evaluation of musical HCI	4.400 (0.699)	4.667 (0.500)	4.500 (0.707)	4.524 (0.601)
ILO2	Knowledge of sensors, acquisition, filtering, mapping	4.300 (0.675)	4.556 (0.527)	4.500 (0.707)	4.430 (0.598)
ILO3	Able to design/prototype hardware & software components	4.100 (0.738)	4.556 (0.527)	4.500 (0.707)	4.333 (0.659)
ILO4	Hands-on experience with sensor acquisition & mapping	4.500 (0.527)	4.667 (0.500)	4.500 (0.707)	4.572 (0.507)
ILO5	Able to reflect on aesthetic qualities of interactive music systems	4.300 (0.675)	4.556 (0.527)	4.500 (0.707)	4.430 (0.598)
C1	The course was well structured and managed	3.600 (0.966)	4.667 (0.500)	4.500 (0.707)	4.143 (0.910)
C2	Course contents communicated clearly by the teacher	4.300 (0.675)	4.778 (0.441)	4.500 (0.707)	4.524 (0.602)
C3	Learning outcomes were made clear at the beginning	4.900 (0.316)	4.778 (0.441)	4.500 (0.707)	4.810 (0.402)
C4	Workload and amount of material appropriate/manageable	3.700 (1.059)	3.667 (0.707)	3.500 (2.121)	3.668 (0.966)
C5	Learning material & Canvas of good quality	4.600 (0.699)	4.667 (0.745)	4.000 (1.414)	4.572 (0.761)
C6	Preparation material/guidelines helped workshops	4.200 (0.632)	4.444 (0.726)	4.000 (1.414)	4.286 (0.717)
C7	Activities stimulated critical thinking/participation	4.400 (0.699)	4.667 (0.707)	4.500 (0.707)	4.524 (0.679)
C8	Received satisfactory support/help by the teacher	4.700 (0.483)	4.778 (0.441)	4.500 (0.707)	4.714 (0.463)
C9	Assignments returned with helpful feedback and in time	4.600 (0.516)	4.667 (0.745)	3.500 (2.121)	4.524 (0.827)
C10	Assessment & exam aligned with outcomes/activities	4.500 (0.527)	4.667 (0.500)	4.500 (0.707)	4.572 (0.507)
C11	Assessment criteria clearly stated beforehand	4.500 (0.527)	4.667 (0.500)	4.500 (0.707)	4.572 (0.507)
C12	Course relevant and well-integrated in program	4.700 (0.483)	4.667 (0.500)	4.500 (0.707)	4.667 (0.483)
C13	Learning supported by resources (portal, room, etc.)	4.400 (0.699)	4.667 (0.500)	4.500 (0.707)	4.524 (0.601)
C14	Overall satisfied; would recommend	4.200 (0.789)	4.667 (0.500)	4.500 (0.707)	4.429 (0.676)

larger cohorts might motivate group projects for staff load reasons, we prioritize individual projects to ensure each student practices the full pipeline (electronics, mapping, synthesis, evaluation, documentation, performance). Related literature notes that group specialization can limit breadth; individual accountability better supports the ILOs and avoids leaving students under-prepared for subsequent courses that assume end-to-end competence.

4.5 Limitations and Generalizability

This report reflects a single-institution context with small cohorts, a defined toolchain (Bela + Pd), and access to a dedicated makerspace and AV-equipped classroom. While we argue the pedagogical approach is platform-agnostic, performance robustness and rehearsal culture benefited from our infrastructure and kit policy; institutions adopting lower-cost or tethered alternatives may need to budget extra time for setup variability and debugging. Cohort size (n=26 over three years) limits inferential claims from survey means, and self-reports do not substitute for independent performance assessment. Finally, our emphasis on individual projects favors end-to-end mastery but may not suit programs that prioritize large, collaborative builds; in such cases, we recommend hybrid models with individual mapping études to maintain breadth.

5 Conclusion

We presented a research-led approach to Interactive Music Systems in a multidisciplinary graduate context, aligning intended learning outcomes, hands-on workshops, and a portfolio examination with public documentation and performance. A common toolchain (Bela + Pd) and staged milestones enabled diverse cohorts to deliver robust, standalone DMIs bridging technical implementation and artistic practice. Several projects progressed to peer-reviewed NIME publications, evidencing feasibility and relevance.

Student evaluations show strong engagement, clarity, and resource quality, while noting challenges in workload, fabrication, time constraints, and heterogeneous backgrounds. Future iterations will shift more contact time to project work, scaffold electronics/fabrication earlier, and integrate new recorded lectures and targeted tutorials. We share our syllabus, assignments, and rubric as a replicable template for NIME pedagogy coupling technical depth with performative and aesthetic inquiry.

6 Ethical Standards

The author conducted this work in accordance with the ethical guidelines of the University of Oslo and applicable data-protection regulations (GDPR). The study draws on anonymized student data collected with informed consent for research purposes. Any non-anonymized material included in or linked from this paper consists of multimedia or text that is already publicly available and either used with the students' written consent or originally published by the students themselves. The author declares no competing interests: course platforms and tools were chosen for their pedagogical fit, stability, and accessibility, independent of any relationships with the companies involved. AI tools provided by the University of Oslo were used for spell-checking and grammar during draft editing. The same tools, given the input data, were used to automatically generate the LaTeX code for Figure 3 and Table 1.

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A Workshop Topics and Readings

A.1 Workshop 1

A.1.1 Topics and Practical Work.

- Theoretical: Foundations of interaction and sonic interaction design; waves of HCI; physical computing for IMS; taxonomies of musical instruments and DMIs; NIME overview (history, milestones, contributions).
- Practical: Power up Bela, open the IDE, confirm audio; best practices for neat, verifiable breadboard work.

A.1.2 Mandatory Readings.

Book Chapters.

- Keislar, D. (2011). A Historical View of Computer Music Technology. In *The Oxford Handbook of Computer Music.* Oxford University Press.
- Holland, S., Wilkie, K., Mulholland, P., & Seago, A. (2013). Music Interaction: Understanding Music and Human-Computer Interaction. In *Music and Human–Computer Interaction* (pp. 1–28). Springer.

- Holland, S., Mudd, T., Wilkie-McKenna, K., McPherson, A., & Wanderley, M. M. (2019). Understanding Music Interaction, and Why It Matters. In *New Directions in Music and Human–Computer Interaction* (pp. 1–20). Springer.

A.1.3 Optional Readings.

Books.

- Verplank, B. (2009). *Interaction Design Sketchbook.* Link

Papers.

- Mathews, M. V. (1963). The Digital Computer as a Musical Instrument. *Science*, 142(3592), 553–557.
- Wanderley, M. M. (2023). Prehistoric NIME: Revisiting Research on New Musical Interfaces in the Computer Music Community before NIME. In *Proceedings of New Interfaces for Musical Expression (NIME 2023),* Mexico City, Mexico.

Videos.

- Corno, F. (n.d.). What is HCI? *YouTube.* Link
- Wang, G. (n.d.). Artful Design: Technology in Search of the Sublime! *YouTube.* Link

A.2 Workshop 2

A.2.1 Topics and Practical Work.

- Theoretical: Core electronics (voltage, current, resistance, power); sensors/actuators; ADC/DAC; signal conditioning; breadboard prototyping; Bela I/O and levels.
- Practical: Build a button–potentiometer interface; verify with a multimeter; explore how sampling rate, resolution, and buffering affect control feel.

A.2.2 Mandatory Readings.

Book Chapters.

- Fitzgerald S., & Shiloh M. (2012). *Arduino Project Book*, pp. 6–10 and 21–23.

Videos.

- Basic Electronics for Beginners. *YouTube.* Link
- How to Use a Breadboard. *YouTube.* Link

Websites.

- What is Bela? Link
- Bela hardware. Link
- Bela software. Link
- Bela and Pure Data. Link
- Understanding Real Time. Link
- Bela and BeagleBoard. Link

A.3 Workshop 3

A.3.1 Topics and Practical Work.

- Theoretical: The computer as instrument; gesture-to-sound mapping; gestural data acquisition; interaction modes/dimensions; normalization concepts.
- Practical: Analyze ranges; normalize to 0–1; prototype one-to-one and combined mappings (e.g., amplitude/pitch) with force-sensitive sensors.

A.3.2 Mandatory Readings.

Papers.

- Hunt, A., Wanderley, M. M., & Kirk, R. (2000). Towards a Model for Instrumental Mapping in Expert Musical Interaction. In *Proceedings of the International Computer Music Conference (ICMC).*
- Wanderley, M. M., & Depalle, P. (2004). Gestural Control of Sound Synthesis. *Proceedings of the IEEE*, 92(4), 632–644.
- Drummond, J. (2009). Understanding Interactive Systems. *Organised Sound*, 14(2), 124–133.

Book Chapters.

- Paine, G. (2011). Gesture and Morphology in Laptop Music Performance. In *The Oxford Handbook of Computer Music.* Oxford University Press.

A.3.3 Optional Readings.

Papers.

- Hunt, A., Wanderley, M. M., & Paradis, M. (2003). The Importance of Parameter Mapping in Electronic Instrument Design. *Journal of New Music Research*, 32(4), 429–440.
- Magnusson, T. (2010). Designing Constraints: Composing and Performing with Digital Musical Systems. *Computer Music Journal*, 34(4), 62–73.

Books.

- Paradiso, J. (1998). Electronic Music Interfaces. Link

A.4 Workshop 4

A.4.1 Topics and Practical Work.

- Theoretical: Concepts of musical instruments; controller design principles; IMS design/evaluation models; expressivity, affordances, constraints, control intimacy.
- Practical: Pd signal-rate techniques for gestural input and control; debouncing; nonlinear mappings and thresholding.

A.4.2 Mandatory Readings.

Papers.

- Cook, P. R. (2001). Principles for Designing Computer Music Controllers. In *Proceedings of New Interfaces for Musical Expression (NIME).*
- Cook, P. R. (2009). Re-Designing Principles for Computer Music Controllers: A Case Study of SqueezeVox Maggie. In *Proceedings of New Interfaces for Musical Expression (NIME).*
- Dobrian, C., & Koppelman, D. (2006). The 'E' in NIME: Musical Expression with New Computer Interfaces. In *Proceedings of New Interfaces for Musical Expression (NIME).*

Book Chapters.

- Tanaka, A. (2012). Sensor-Based Musical Instruments and Interactive Music. In *The Oxford Handbook of Computer Music.* Oxford University Press.
- Holland, S., Mudd, T., Wilkie-McKenna, K., McPherson, A., & Wanderley, M. M. (2019). A Design Workbench for Interactive Music Systems. In *New Directions in Music and Human–Computer Interaction* (pp. 23–40). Springer.

A.4.3 Optional Readings.

Papers.

- Wessel, D., & Wright, M. (2002). Problems and Prospects for Intimate Musical Control of Computers. *Computer Music Journal*, 26(3), 11–22.
- Magnusson, T. (2010). Designing Constraints: Composing and Performing with Digital Musical Systems. *Computer Music Journal*, 34(4), 62–73.

A.5 Workshop 5

A.5.1 Topics and Practical Work.

- Theoretical: Advanced Bela workflows; networking; GUIs; sensor toolkit overview.
- Practical: Work with microphones, accelerometers, distance sensors, and thumb joystick; apply audio filtering and envelope estimation; denoise; derive velocity/acceleration features; generate trigger-like outputs from continuous sensors.

No readings.

A.6 Workshop 6

A.6.1 Topics and Practical Work.

- Theoretical: Playing difficulty, learning curves, engagement and motivation; haptics and force feedback; capacitive sensing.
- Practical: Capacitive sensing setup and calibration; actuators and haptics; PWM-based visual/tactile feedback; apply to motors and LEDs.

A.6.2 Mandatory Readings.

Book Chapters.

- McDermott, J., Gifford, T., Bouwer, A., & Wagy, M. (2013). Should Music Interaction Be Easy? In *Music and Human-Computer Interaction* (pp. 29–47). Springer.
- Wallis, I., Ingalls, T., Campana, E., & Vuong, C. (2013). Amateur Musicians, Long-Term Engagement, and HCI. In *Music and Human–Computer Interaction* (pp. 49–66). Springer.
- Tanaka, A. (2019). Embodied Musical Interaction. In *New Directions in Music and Human–Computer Interaction* (pp. 135–154). Springer.

Papers.

- Frisson, C., & Wanderley, M. M. (2023). Challenges and Opportunities of Force Feedback in Music. *Arts*, 12(4), 147.

A.6.3 Optional Readings.

Book Chapters.

- Wilkie, K., Holland, S., & Mulholland, P. (2013). Towards a Participatory Approach for Interaction Design Based on Conceptual Metaphor Theory: A Case Study from Music Interaction. In *Music and Human–Computer Interaction* (pp. 259–270). Springer.
- Mudd, T. (2019). Material-Oriented Musical Interactions. In *New Directions in Music and Human–Computer Interaction* (pp. 123–133). Springer.

Website.

- Music Cognition and Embodiment. CNMAT. Link

A.7 Workshop 7

A.7.1 Topics and Practical Work.

- Theoretical: Skill development; perspectives of performer, spectator, designer; digital lutherie and heuristics; multi-axis design spaces for comparison.
- Practical: Advanced IMU/accelerometer use; map multidimensional motion with continuity; assign dimensions to continuous/discrete control and event triggers.

A.7.2 Mandatory Readings.

Book Chapters.

- Gurevich, M. (2014). Skill in Interactive Digital Music Systems. In *The Oxford Handbook of Interactive Audio*. Oxford University Press.

Papers.

- Jordà, S. (2004). Instruments and Players: Some Thoughts on Digital Lutherie. *Journal of New Music Research*, 33(3), 321–341.
- Sullivan, J., Guastavino, C., & Wanderley, M. M. (2021). Surveying Digital Musical Instrument Use in Active Practice. *Journal of New Music Research*, 50(5), 469–486.
- Birnbaum, D., Fiebrink, R., Malloch, J., & Wanderley, M. M. (2005). Towards a Dimension Space for Musical Devices. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME).*

A.7.3 Optional Readings.

Papers.

- Wanderley, M. M. (2023). Prehistoric NIME: Revisiting Research on New Musical Interfaces in the Computer Music Community before NIME. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME).*
- Masu, R., Morreale, F., & Jensenius, A. R. (2023). The O in NIME: Reflecting on the Importance of Reusing and Repurposing Old Musical Instruments. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME).*
- Renney, N., Gaster, B., Mitchell, T., & Renney, H. (2022). Studying How Digital Luthiers Choose Their Tools. In *Proceedings of the CHI Conference on Human Factors in Computing Systems.*

A.8 Workshop 8

A.8.1 Topics and Practical Work.

- Theoretical: ML as a creative tool; dataset capture; model portability; interactive training and real-time responsiveness.
- Practical: Collect datasets; train classification/regression; export and run real-time inference to control synthesis with multidimensional or aggregated scalar sensors.

A.8.2 Mandatory Readings.

Book Chapters.

- Caramiaux, B., & Fiebrink, R. A. (2018). The Machine Learning Algorithm as Creative Musical Tool. In *The Oxford Handbook of Algorithmic Music* (pp. 181–208). Oxford University Press.

Papers.

- Jourdan, T., & Caramiaux, B. (2023). Machine Learning for Musical Expression: A Systematic Literature Review. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME).*

A.8.3 *Optional Readings.*

Papers.

- Jourdan, T., & Caramiaux, B. (2023). Culture and Politics of Machine Learning in NIME: A Preliminary Qualitative Inquiry. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME).*

Book Chapters.

- Holland, S., & Fiebrink, R. (2019). Machine Learning, Music and Creativity: An Interview with Rebecca Fiebrink. In *New Directions in Music and Human–Computer Interaction* (pp. 259–267). Springer.

A.9 Workshop 9

A.9.1 *Topics and Practical Work.*

- Practical focus: Assembly and fabrication for performance-ready systems; move from breadboard to perfboard/custom expansion boards; clean wiring; battery-powered standalone operation; optimize for stability and latency; prototype DIY sensors.

No readings.

A.10 Workshop 10

A.10.1 *Topics and Practical Work.*

- Theoretical: IMS evaluation; HCI-informed methods/metaphors; task design/modeling to video analysis; planning user studies; perspectives (performer/audience/designer); usability and long-term experience.
- Practical: Design and pilot studies; logging/recording; mixed-methods analysis to guide iteration.

A.10.2 *Mandatory Readings.*

Papers.

- O'Modhrain, S. (2011). A Framework for the Evaluation of Digital Musical Instruments. *Computer Music Journal*, 35(1), 28–42.
- Wanderley, M. M., & Orio, N. (2002). Evaluation of Input Devices for Musical Expression: Borrowing Tools from HCI. *Computer Music Journal*, 26(3), 62–76.
- Kiefer, C., Collins, N., & Fitzpatrick, G. (2008). HCI Methodology for Evaluating Musical Controllers: A Case Study. In *Proceedings of New Interfaces for Musical Expression (NIME)* (pp. 87–90).

Book Chapters.

- Xambó, A., Laney, R., Dobbyn, C., & Jordà, S. (2013). Video Analysis for Evaluating Music Interaction: Musical Tabletops. In *Music and Human–Computer Interaction* (pp. 241–258). Springer.

A.10.3 *Optional Readings.*

Book Chapters.

- McPherson, A., & Verplank, B. (2019). The Poetry of Strange Connections: An Interview with Bill Verplank. In *New Directions in Music and Human–Computer Interaction* (pp. 61–70). Springer.
- McPherson, A., & Benford, S. (2019). Music, Design and Ethnography: An Interview with Steve Benford. In *New Directions in Music and Human–Computer Interaction* (pp. 213–220). Springer.

Papers.

- Merendino, N., Lepri, G., Rodà, A., & Masu, R. (2023). Redesigning the Chowndolo: A Reflection-on-Action Analysis to Identify Sustainable Strategies for NIME Design. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME).*
- Armitage, J., Magnusson, T., & McPherson, A. (2023). Studying Subtle and Detailed Digital Lutherie: Motivational Contexts and Technical Needs. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME).*

A.11 Workshop 11

A.11.1 *Topics and Practical Work.*

- Theoretical: Course wrap-up; concert guidelines, technical rider, program, rehearsal.
- Practical: Peer user-study activity in coordinated groups; finalize documentation/media; return kits and borrowed parts.

No readings.

B Assignments and Portfolio Requirements

B.1 Assignment 1

- Portfolio: Not included
- Due: Week 3
- Task: Bela-based IMS with push button, LDR, LED (simple, specific functions).
- Deliverables: Commented Pd patch; short demo video.
- Purpose: Early toolchain proficiency; core skills.
- Alignment: Workshops 1–2 (foundations, electronics; Appendix A).

B.2 Assignment 2

- Portfolio: Included
- Due: Week 5
- Task: Critical review of an independently sourced IMS; publish on MCT Blog[15].
- Deliverables: Blog post framed by course topics to date.
- Purpose: Literature discovery; critical evaluation; reflection.
- Alignment: Workshops 1–3 (instrument concepts, mapping; Appendix A).

B.3 Assignment 3

- Portfolio: Included
- Due: Week 7
- Task: Design and preliminary evaluation of a Bela-based IMS using a 2-axis joystick + button; mono audio.

[15]https://mct-master.github.io/interactive-music/

- Constraints: Synthesis-only; signal-rate joystick; mappings beyond three 1:1 links.
- Deliverables: Commented Pd patch; short demo video.
- Purpose: Explore mapping complexity and affordances under constraints.
- Alignment: Workshops 3–4 (gesture-to-sound, controller principles; Appendix A).

B.4 Assignment 4

- Portfolio: Not included
- Due: Week 8 (revise within 5 days after feedback)
- Task: Project proposal (IMS name, features, controller/mapping/synthesis overview, hardware, feasibility, compliance).
- Follow-up: Include 5 linked scholarly sources explicitly related to the project.
- Purpose: Scope/feasibility check; research grounding; peer inspiration.
- Alignment: Workshops 4–5 (design models, expanded sensing; Appendix A).

B.5 Assignment 5

- Portfolio: Not included
- Due: Week 11
- Task: First fully functional IMS prototype (breadboard acceptable but discouraged).
- Deliverables: Short narrated demo video; highlight limitations.
- Purpose: Early implementation; surface hardware/software challenges.
- Alignment: Workshops 5–7 (signal-rate processing, IMUs, design heuristics; Appendix A).

B.6 Assignment 6

- Portfolio: Not included
- Due: Week 13 (study sessions during Workshop 11)
- Task: Small user study on own IMS; participate in peers' studies.
- Deliverables: Pre-study plan (protocol, instruments, consent, refs); post-study reflection.
- Purpose: Close evaluation–feedback loop; freeze near-final prototype ~2 weeks pre-concert.
- Alignment: Workshop 10 (evaluation methods; Appendix A).

B.7 Assignment 7

- Portfolio: Included
- Due: Week 15
- Task: ~1000-word public blog post on MCT Blog describing the IMS and including a performance video of a standalone, wire-free device.
- Video source: Either the public concert recording (with consent) or a privately recorded performance submitted to the LMS if the student opted out of the concert. If consent for public dissemination is not granted, the post may use edited excerpts or images while the full performance video remains private for assessment.
- Additional: Complete technical documentation (design files, circuits, Pd patches, dependencies, assembly/BoM, notes).
- Purpose: Public communication; open, reproducible documentation; demonstrated performance with the designed instrument.
- Alignment: Workshops 8–9 (ML mappings where relevant; fabrication for stage-readiness; Appendix A).

B.8 Assignment 8

- Portfolio: Included
- Due: Week 16 (optional draft in Week 15)
- Task: Short academic paper (~4000 words) using NIME template.
- References: ≥ 10 total (≥ 5 independent beyond A4; ≥ 5 course readings).
- Recommended Sections: Abstract; Intro/Motivation; Related Work/Background; Design/Components; Implementation; Evaluation; Conclusion.
- Also Submit: Revised portfolio compiling in-portfolio assignments.
- Purpose: Integrate research writing, reflection, critique, and first-person experience.
- Alignment: Synthesizes entire Workshop Sequence; feeds into examination.

C Course Evaluation Survey

Please fill in this course survey. There are two aims for this survey: provide feedback on the course and self-evaluate your learning. We highly encourage filling out the questionnaire, but it is entirely voluntary. The data will be stored anonymously and may be used in education-based research papers and presentations.

C.1 Learning self-evaluation

Possible answers: 1 strongly disagree; 2 disagree; 3 neutral; 4 agree; 5 strongly agree; 0 not applicable.

- I am familiar with the principles for design and evaluation of musical human-computer interaction (ILO1).
- I have knowledge of different types of sensors and input devices, and strategies for acquisition, filtering and mapping of sensor data (ILO2).
- I am able to design and prototype both hardware and software components of a complete musical instrument or other kind of interactive sonic system (ILO3).
- I have hands-on experience with sensor data acquisition and mapping of sensor data to sound synthesis/processing engines (ILO4).
- I am able to reflect on the aesthetic qualities of interactive music systems (ILO5).

C.2 Feedback on the course

Possible answers: 1 strongly disagree; 2 disagree; 3 neutral; 4 agree; 5 strongly agree; 0 not applicable.

- The course was well structured and managed (C1).
- The course contents were communicated clearly by the teacher (C2).
- The learning outcomes of the course were made clear to me at the beginning of the course (C3).
- The workload and the amount of material covered in the course were appropriate and manageable for the time available (C4).
- The learning material and the eLearning site (Canvas) provided for this course were of good quality (C5).

- The provided preparation material and guidelines have helped me to cope with the workshop activities (C6).
- The learning activities stimulated my critical thinking about this subject and encouraged participation in discussions (C7).
- In this course I have received satisfactory support or help by the teacher when needed (C8).
- Assignments have been returned with helpful feedback and in time to prepare for other assessment tasks (C9).
- The assessment tasks and the exam were well aligned with the learning outcomes and with the learning activities (C10).
- The assessment criteria were clearly stated before I started to work on the assessment task or prepare for the examination (C11).
- This course was relevant and well-integrated within the context of the study program (C12).
- My learning in this course was well supported by resources (portal, laboratory, library, special equipment, online resources, etc.) (C13).
- Overall, I am satisfied with this course and I would recommend it to others (C14).

C.3 Open Questions

- Briefly, list up three things you liked or found useful about this course.
- Briefly, list up three things of this course that you struggled with or would have liked to see improved.

D Marking Rubric

Only marking criteria versus band-A descriptors are included.

- Critical review of an independently selected IMS published on the MCT Blog (weighting 10%, associated with Assignment 2).
  - A:
    The review flows well and is accessible to readers without specific prior knowledge of IMS.
    The selected perspectives are appropriate for the post length; observations, considerations, critique, and reflection are deep and appropriate, showing strong familiarity with course topics.
    There is excellent integration of relevant multimedia and external references.
    The post complies with all requirements.
- Design, implement, and preliminarily evaluate a Bela-based IMS with given I/O constraints (weighting 10%, associated with Assignment 3).
  - A:
    The IMS includes an original and complex mapping, resulting in engaging interactions despite the simplicity of the input device.
    The Bela-based IMS is well organized in patches/subpatches and excellently documented through comments, making it easy to understand and modify the working principles of the IMS (mapping and sound engine).
    All IMS functionalities are clearly demonstrated in the video.
- Extent to which the paper (primarily) and the blog post describe and evaluate the IMS with respect to theories, methods, principles, and existing works in the field (weighting 30%, associated with the individual project deliverables submitted in Assignments 7 and 8).
  - A:
    The IMS design is well detailed, excellently supported by diverse literature, and extensively compared with the state of the art in the specific domain.
    A sound and suitable strategy is used for preliminary evaluation; analysis of results and reflections demonstrate significant competence in this field of study.
    The number of cited and well-integrated papers exceeds the minimum requirement.
- Conceptual and technical sophistication of the IMS design and implementation (weighting 30%, associated with the individual project submitted in Assignments 7 and 8).
  - A:
    The conceptual and technical design of the IMS is original, well considered, and appropriately complex, supporting intended musical expression goals as well as short- and long-term engagement and intimate musical control.
    A standalone, robust, and elegant proof-of-concept prototype has been fully implemented and assembled to a standard that enables musical performance and comprehensive evaluation.
    The design is fully compliant with all project requirements.
- Design files and technical documentation (weighting 10%, associated with the individual project deliverables submitted in Assignments 7 and 8).
  - A: The set of design files is complete, neat, well organized, and excellently documented, allowing another expert in the field to easily replicate the system, understand in detail how it works, and modify or improve any aspect.
    Components sourced elsewhere have been appropriately mentioned and credited in the documentation.
- Presentation style and organization of paper and blog post (weighting 10%, associated with the individual project deliverables submitted in Assignments 7 and 8).
  - A:
    The paper and post are written in a flowing manner, are concise, and have an excellent logical structure.
    The language (academic for the paper, non-academic for the post) is appropriate for audiences with (paper) or without (post) expertise in music technology and interactive music systems.
    There is excellent use of illustrations, tables, diagrams, images, multimedia, and hyperlinks, which are well integrated in the body text.
    All cited literature is well integrated into the paper.
    The paper is fully compliant with the NIME template and citations/references are fully compliant with the IEEE/ACM style.