

A Playful Approach to Teaching NIME: Pedagogical Methods from a Practice-Based Perspective

Enrique Tomás
Tangible Music Lab
University of Art and Design Linz
Domgasse 1, 4010 Linz, Austria
Enrique.Tomas@ufg.at

ABSTRACT

This paper reports on the experience gained after five years of teaching a NIME master course designed specifically for artists. A playful pedagogical approach based on practice-based methods is presented and evaluated. My goal was introducing the art of NIME design and performance giving less emphasis to technology. Instead of letting technology determine how we teach and think during the class, I propose fostering at first the student's active construction and understanding of the field experimenting with physical materials, sound production and bodily movements. For this intention I developed a few classroom exercises which my students had to study and practice. During this period of five years, 95 students attended the course. At the end of the semester course, each student designed, built and performed a new interface for musical expression in front of an audience. Thus, I describe and discuss the benefits of applying playfulness and practice-based methods for teaching NIME in art universities as well as some lessons learned from this pedagogical experience.

Author Keywords

NIME teaching, practice-based methods, artistic education.

CCS Concepts

• *Human-centered computing~Interaction design~Interaction design process and methods~User centered design* • *General and reference~Document types~Reference works* • *Applied computing~Arts and humanities~Sound and music computing*

1. INTRODUCTION

A crucial question for our community is how the art of NIME should be taught. In particular, which pedagogical methods boost learning and foster both creativity and technical knowledge. Because every pedagogical plan must be adapted to the students' profile, there is no magical formula for teaching NIME. Therefore, documenting, evaluating and sharing our best teaching practices seems to be the only way to inform other educators and improve our pedagogical methods.

Developing successful pedagogical strategies is not obvious in our field. There exists a whole range of difficulties which must be taken into consideration. For example, the influence of traditional training methods still existing at many academies. A NIME course at a technical university may introduce NIME as a highly specialized case of human computer interaction. In contrast, music universities may

benefit from orienting the course towards musical composition and instrumental technique. A pragmatic solution would be merging a well-balanced amount of methods imported from various fields. However, we may admit that not so many university teachers have a background in a diversity of pedagogical methods. In fact, many of us have never received a single regular NIME class in our alma mater. We all mostly learned NIME by doing, by following tutorials or attending workshops at local and independent cultural centers.

This paper describes the results of five years of educational journey experimenting with various methods and classroom exercises. During this period, I evaluated the results obtained after applying different pedagogical exercises. At the end of every semester, I exhaustively analyzed the experiences and refined my strategy for the next course. It took me three years to define a set of valid practice-based methods for my target group: a class of fifteen media art students.

2. BACKGROUND AND CONTEXT

The one-semester course "Playful Interfaces" is part of the Interface Culture master program at the University of Art and Design Linz (Austria). The course goal is threefold: designing and building musical interfaces, developing performative skills and producing musical works for the same interfaces.

The experience described in this paper refers to the period between the years 2014 and 2019. The course has a duration of one academic semester. However, the first class is given in October and the last one at the end of January. Then, considering Christmas festivities, the course lasts four months. It is organized in ten meetings of two hours of duration each one. Additionally, students have to prepare a final concert in January which usually involves another 20 hours of personal work.

Every year the course was attended by 15 to 20 students. The total, 95 students attended and finalized the course. The 60 percent are women. Only the 24 percent of the students had musical knowledge and the 10 percent had already performed music in public. Of the total sum of students, the 59 percent demonstrated enough technical skills in programming and physical computing. As it is normal in our art university, most students showed skills in art production and handcrafts. Students' knowledge profile is highly heterogeneous. Their typical fields of expertise are fine arts, audiovisual creation, art installation, graphic design and conceptual art. For many of them, this course opens a window of opportunity to discover their personal interests in sound art and music.

3. PREPARING A NIME COURSE

In 2014 my university requested me to develop a semester course on NIME. A consequent decision was collecting as much information as possible about similar master programs. Online I could find some courses and their syllabus. However, there was little information available about methods and pedagogical materials employed.



Licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0). Copyright remains with the author(s).

NIME'20, July 21-25, 2020, Royal Birmingham Conservatoire, Birmingham City University, Birmingham, United Kingdom.

Methods could sometimes be inferred from the actual activities proposed (e.g. analysis of instruments and artists, experiments with circuit bending, etc.). However, detailed documentation about teaching contexts or pedagogical strategies were usually non-accessible. Additionally, I looked for academic publications related to the issue in question. In 2014, I could only find a few reports on experiences after teaching NIME courses at universities [3,5,6,7,8,9]. In 2020 this lack of reports is still remarkable and only a few more references can be added to the same list [5,17]. Under these circumstances, I decided to experiment and create my own pedagogical approaches. In that moment I decided that I would focus my attention on the idea of playfulness proposing practice-based activities. It took me three iterations -three years- until I could find the adequate balance of methods and exercises.

4. PLAYFULNESS

In the last decade, the evolutionary purpose of play has been described [14]. The activity of play is universal among all human cultures. Scientists think it serves to either train us physically, socially or cognitively. Then, what does it mean to be playful? Playfulness is a mindset whereby people approach everyday activities with neither a clear goal nor real-world consequences. The philosopher Maria Lugones [11] describes playfulness as:

"an openness to being a fool, which is a combination of not worrying about competence, not being self-important, not taking norms as sacred and finding ambiguity and double edges a source of wisdom and delight".

Acting playfully always involves certain methodological irresponsibility or incompetence. As the researcher Dina Z. Belluigi [2] defends, "a playful attempt is always an effort towards subverting conventions of consoling certitude. Acting playfully allow for recontextualizing ourselves with a sense of irresponsibility to imagine and represent differently". Interestingly, artistic practice-based methods are typical for enabling disruptions to normative positioning of artist, respondent and subject. In the same manner, Foucault's heteronomy [4] has been described as a practical critique that takes the form of a possible transgression of limits. The practice of playfulness would then fit perfectly to the family of art methods. In fact, we often project our artistic processes in a conscious but incompetent way to the outside regulations. This is often the mechanism for unveiling alternative realities present in the objects which surround us in the world.

Practice-based methods are activities undertaken in order to gain new knowledge partly by means of practice and the outcomes of that practice [1]. Learning NIME using practice-based activities means reflecting on the outcomes produced from our practical experimentation with musical interfaces. Artistic activities, like in the case of NIME, are often inclusive of idiosyncratic, pluralistic and individual contributions. For instance, as a teacher I can introduce students -in a traditional methodological way- to the concept of mapping. However, it is difficult to explain to the same students -if not impossible- the mapping decisions taken by Atau Tanaka in his performance Myogram. These decisions are mostly practice-based. Practice-based learning does not mean practicing some 'a prioristic' knowledge (e.g. programming a routine to map MIDI data into sound). It means actively constructing a personal vision of the limits and possibilities of the field (e.g. exploring the artistic limits of some data to sound mapping algorithm).

My personal approach to practice-based learning is the additional introduction of playfulness as the central energy driving curiosity and experimentation. Ideally, the classroom becomes a learning space in which NIME-making is not understood as an object but as a meaningful and embodied educational event.



Figure 1. Delicate windmills equipped with encoders are transformed into musical interfaces by two students of the course (Kerstin Kollmann and Tommaso Malato).

5. COURSE DESCRIPTION

Recent and exhaustive contributions to the field of art education have appeared in extensive compilations of methods during the last decade. For instance, Chemi and Du [2] refer to the global trends described by Wagner [18] and the work produced by UNESCO and OECD. As I explained in the previous section, my pedagogical strategy was the active understanding of the particularities of NIME through practice-based activities developed in the class. Obviously, the course cannot only consist of practical assignments. Other training formats and methods are also necessary and complementary. For example, when one needs to transfer very pragmatic knowledge to the students (e.g. how to connect a push button to a microcontroller).

5.1 Learning formats

The class workflow is a mixed structure of three formats: frontal class, workshop and practice-based assignments.

5.1.1 Frontal Class: Learning from an expert

It is the typical method for knowledge transference. However, frontal class is often complemented with collective discussions about the topics involved. The teacher should guide its development through pertinent questions, audiovisual materials and comments.

5.1.2 Workshop: learning from others

Students bring to practice some technical knowledge, usually with the help of a toolkit. It normally consists of building or programming some device. For example, for understanding the MIDI protocol, students practice controlling a virtual instrument with a simple interface. These exercises are totally functional and instrumental. They are proposed for the better understanding of some technical knowledge.

5.1.3 Practice-based assignments

In this learning format students are requested to practice art production with NIMES. This activity consists of an assignment that students have to publicly present one week later. It always involves the production of an artistic sound performance of around two to three minutes of duration. Students are aimed at co-creating these performances together with a few more colleagues. The topic of the assignment is exhaustively briefed during the class. All performances are carefully presented publicly at the beginning of the next class. After that, they are collectively evaluated.

These weekly assignments are in fact the key moments when students study and develop new bodily and performative skills. Usually, after having practiced one or two of these exercises, students intuitively start to develop skills they even were not aware of. For instance, I observed how students without any musical education started to take good care of dynamics and timbral balance between musical voices. They intuitively discovered the importance of these expressive features when they were preparing their assignments together with other students.

Finally, the collective evaluation of these performances plays a very important role in my methodology. The teacher, especially in this moment, must give honest feedback about the quality of the performance. Students often bring great artistic ideas that they don't know very well how to manage. The teacher's feedback may remark important aspects to facilitate creation. For example, the adequate use of the body (visible tensions, position on stage, body language, etc.), the use of sound materials (limitation of material, ways of developing it, how to prepare new ones, etc.), how to expand their sonic features (using dynamics, mastering, effects, etc.), the artistic conceptualization and realization of the original idea, etc.

5.2 Contents

I decided that my NIME course had to cover the following content blocks:

- Development of performative and playful skills: understanding the mechanisms for engaging playfully into performative musical actions using interfaces or any other sound object.
- History of NIME and its main personalities: appreciation of previous artwork made by electronic music practitioners and awareness of contemporary artistic trends.
- Technical Skills:
 - Microcontroller programming using friendly toolkits for capturing sensor data and enabling communicating via MIDI or OSC protocols.
 - Basic audio synthesis and mapping strategies for transforming sensor data into sound features.
- Development of design skills: learning how to encode an artistic intention into functional NIME designs.

5.3 Course Structure

Each semester course is usually divided into two main parts. The first phase is dedicated to deliver knowledge and practicing specific aspects of artistic production with NIMEs. This first phase involves 20 hours distributed in ten sessions of two hours.

The second phase of the course concentrates in the physical production of a digital musical instrument and the preparation of a concert. Students make a design proposal and together with other colleagues co-create a sound performance. This phase involves at least another 20 hours of personal work.

5.4 Technical tools and frameworks

During the first phase of their training, students' material is a kit based on a Teensy LC development board. It facilitates enormously the task of programming professional USB MIDI controllers at a relatively low price. Also, the Teensy environment offers out-of-the-box examples for creating MIDI controllers. Students can easily run these examples and experiment with simple sensors such as photo-resistors. Audio synthesis is first explained introducing attractive open source virtual instruments. After this, students learn how to manage MIDI data in Pure Data or Max/Msp. My experience has showed me that using these

toolkits absolute beginners are able to create their own MIDI controllers after four hours of practice -the 20% of the total training time-.



Figure 2. Interface inspired by Andean Quipu (talking knots) by Patricia Cadavid.

During the final production phase students are free to employ other technical frameworks. It is their responsibility to find additional toolkits for the adequate production of their projects. For example, when wireless transmission is needed, students have used ESP32 or ESP2866 development kits. Projects involving wearable technologies usually have been produced with frameworks like FLORA. Also it is important to remark that the great majority of students decided to produce their projects with the same kit they used during the training phase (a Teensy LC board). During this phase students mostly decided to program their audio synthesis engines with Pure Data and Max/Msp. Only if students were not technically skilled at all, they used digital audio workstations like Reaper, Live Ableton and Logic.

5.5 Evaluation Formats

Students are evaluated considering the originality of the assignments and instruments produced, the acquired performative skills, their competence to design and perform as well as the quality of the musical work presented during the final concert.

6. PRACTICE-BASED ASSIGNMENTS

This section describes five original exercises I developed for my classes. They take the form of performative assignments. I created them after observing that, although my students were technically competent, they had serious issues in respect to:

- Staging a performance
- Organizing sound materials and balance between instruments or musical voices
- Finding more embodied relations with technology
- Co-creating musical interfaces and musical performances
- Conceptualizing ideas for developing a performance

These exercises can be developed during the class time or they can also be proposed as assignments. In order to foster collaboration, I aimed my students to work in groups of three or four people.

6.1 Re-thinking embodiment with apps

How can students practically explore concepts like affordance and constraint? How can they intuitively elaborate a simplified version of Don Ihde's [12] taxonomy of relations to technology? This exercise was elaborated considering these questions. It has a duration of one hour.

These are the instructions:

- Install the open source application MobMuPlat¹ in your smartphone. Open the examples and explore them. You will find how to sonify sensor data and touch activity.
- Reflect on the relations created between the app, you and the smartphone. For example, sonify your hand movements using one of the examples. Then improvise for five minutes with it. How does the relation with the interface influence your sound interaction? Are you playing a creative sonification through the interface? Discuss it with your colleagues and share it with the class.
- Now rethink playfully your embodied relation with the app. Touching the screen with the tip of your fingers is not anymore allowed. Do not hold your phone with your hand. Explore and create playful and physically embodied interactions with the app. Show what you found out to the rest of the class.

With this example, interesting results are soon intuitively created. For instance, students modulated timbre by introducing the smartphone into their mouths, or they embedded the device into cooking pots for controlling amplitude simply by opening and closing the lid or even they created flying smartphones. Students easily discovered the power of playful exploration to subvert the hermeneutic relations [12] digital technologies bear us through.

6.2 Play incessantly

A recurrent problem I observed was my students' difficulty for organizing meaningful conceptual sound performances. When the intention is more artistic than musical, finding an effective conceptualization of the piece will help towards the definition of the work. Interestingly, a seminal article by Alvin Lucier [10] describes the inherent power that "incessancy" affords to inspire new artistic works. Provoked by Lucier's inquiry, I created an assignment that students will prepare in groups for two hours². These are the instructions:

- Pick an object or a material which can produce sound when it is touched or activated by means of some physical interaction.
- Do something playful with this object. Choose a basic action and repeat it incessantly.
- Finish the action when a surprising event occurs.

The practice of incessancy helped my students to understand how much the playful exploration of a simple concept can help them towards art production. Sonically, the exercise is also quite interesting as it requests students to focus on the minimal sound nuances produced between repetitions of the chosen action. More importantly, this exercise serves to structure their listening. Some outcomes of this exercise were tearing off paper stripes to the millimeter level (sound and action span get structured) and hammering a musical score until surprisingly the hammer broke.

6.3 The unplugged interface orchestra

I observed how often technical specifications overwhelmed my students during the design process. They were quite frustrated by the difficulty of designing creatively -and playfully- while they also had to take into consideration the functional level of technical features and limitations (e.g. what a sensor can and cannot capture). However, a central course goal was fostering students' imagination allowing for

novel and playful interface creation. Thus, I proposed an exercise to reduce their respect and dependency to technical specifications. I called it 'the unplugged interface orchestra'³. It can be developed within one hour:

- Envision a cool novel NIME. It doesn't matter if you really know how to technically produce it or not.
- Take a large piece of paper, or carton, and draw it in real scale with as much detail as you can. Paint it maybe and cut it. Do not forget to add a drawn USB port and an unplugged USB cable!
- Now work out the sound mapping. Your voice is the synthesizer. Let your body decide how it sounds. Fix this mapping while singing, making noises or vocalizing.
- Explore it musically. Prepare a two to three minutes jam session with other colleagues. Present it.

Interestingly, I observed how easily students fixed gesture to sound mapping. First, this exercise allows rapid ideation of interfaces in a more playful and less technically dependent way. Second, it helps students to develop a more confident relationship with technology as they feel completely in control of their unplugged devices.

6.4 The computer mouse interface challenge

My art students usually showed tons of creative energy. However, they didn't quite well manage the issue of having too many ideas. Especially at the design phase. For this reason, I proposed the following exercise. It is a design challenge inspired by the typical design thinking cycle [13]. Students will need two hours to develop it and they must work in groups of at least five persons. These are the instructions:

- Find a solution for the following challenge: "design and build a digital instrument for a mouse or group of mice (the animals, obviously)".
- First, inform yourselves. Become a mice expert. Look for information in Internet, especially videos. Do you really know how do they move; what do they really like more and how do they interact with the world?
- Then ideate playfully. Each student in the group works independently and proposes at least ten playful solutions. Each idea is sketched on a different piece of paper.
- Students within the group gather and look at the solutions. Identify similar patterns and group them.
- Define collectively the minimum requirements to determine an acceptable solution. Include playfulness as one of the specifications. Write a list of requirements.
- Among the solutions suggested, find those ones which really fit to your requirements. Do you really like them? If you agree with it, then prototype it. If not, repeat the previous steps.
- Present your process and results to the rest of the class. Compare and evaluate your results.

6.5 The final concert: The Musikkapelle

After having practiced all the previous exercises, students prepare the final concert I called the "Musikkapelle"⁴. During this phase students have ampler time to specialize and dig deeper into diverse design concepts and techniques. For this final concert, each student builds a digital music instrument and an improvisation of at least ten minutes

¹ MobMuPlat is an app by Daniel Iglesia allowing running Pure Data patches URL :<http://danieliglesia.com/mobmuplat/>

² I usually propose this exercise as an assignment which students have to prepare in groups out of the class time.

³ The name was inspired by the famous photo of the band Justice when they were captured playing -apparently live- on an unplugged MIDI controller.

⁴ In Austria, a Musikkapelle (Music Chapel) is a way to call traditional music brass bands.

with another two or three colleagues. This concert always takes place at well known venues in our city like. They are usually gallery spaces and concert halls. After the years, this concert luckily became quite popular to the local community.

The pedagogical approach for this activity is different. Learning is now personalized and tutored by me. Inspired by the long tradition of master and apprentice principle (obviously from a XXI century perspective), each student proposes a design and a performance. Depending on the student needs, I may organize various tutoring sessions for supporting its technical and artistic development. For these sessions to be effective, students need to feel they are in a safe environment for proposing playful ideas. A confident and honest communication, totally respectful with students' artistic intentions, is crucial to drive this process.



Figure 3. Student performing on a minimal capacitive musical interface (Hye Seong Jeon)

7. RESULTS

From an educational perspective the crucial question here deals with measuring how much and how well students have learned. Measuring student learning can be assessed through both direct and indirect measures. Direct measures may include homework, exams, essays and rubrics for oral and other performances. Examples of indirect measures include course evaluations, student surveys or course enrollment information. In both cases, it is imperative to evaluate whether the assessment aligns directly with some content, skill or competence expected from the student. In my case, the most important measurement deals with knowing if my students have acquired the minimum knowledge, skills and competences about NIME. These minimum requirements were defined in the section "Contents". This is my perception of what they have learned after my course:

1. Playful and performative skills: along the duration of the course, most students progressively incorporate these skills. The first and second assignments were crucial. Normally students' first assignments are badly performed as they don't have any reference to make them any better. Only after receiving teacher's feedback students begin to pay attention to performative aspects and develop these skills.
2. History of NIME: this is a weak point in my course as usually I do not have enough time to focus on many other artists' work. I gave an extensive list of NIME artists to my students, but not many of them put enough interest in remembering well these references.

3. Technical skills: students' feedback reveals that technical exercises were effective because they counted with a clear goal and deadline: the production of a digital musical instrument for the concert. Probably without this goal-oriented strategy students would have acquired less technical knowledge.
4. Design skills: all students were able to encode an artistic idea into the design of a physical instrument. However, the tutored sessions were crucial to support this process. I observed the importance of verbalizing artistic ideas. Additionally, a decisive task for the teacher is adapting a student's design idea to his or her actual technical and performative skills. If not, the process will surely fail later.

Describing it simply, this course served well to transform -in four months- a group of fifteen total newbie students into a dilettant but artistically competent band of NIME practitioners. After having obtained similar results during various consecutive years, I can affirm that the educational plan has succeeded for the context where it was applied (a media art master program of an art university).

8. DISCUSSION

8.1 Musical interfaces produced

During this period of five years my students created a fascinating catalogue of musical interfaces. Figures 1 to 3 show a few examples of these interfaces⁵. Without being exhaustive these interfaces include augmented acoustic instruments, computer vision interfaces, interfaces based on capturing the activity of biological agents like worms and microorganisms, capacitive touch, stretch, light, movement and inertia, mechatronic inventions, hacks of existing toys and gaming controllers, interfaces embedded into daily life objects, ferrofluids, water and ice, electromagnetic interference, alcohol detection, wearables, edible interfaces, vibration and impact interfaces, hacking of tape players and turntables, etc. The most important observations I can share about them are here:

- Every musical interface, among the 95 produced, was unique. Certainly, patterns of technological solutions and types of gestural interaction can be distinguished. However, every interface was created from a personal idiosyncratic and artistic intention. Thus, each of them is quite different in aspect and artistic intention from the others.
- More than 90% of these interfaces are highly gestural. It seems that my students preferred designing interfaces for experimenting with bodily movement than other types of less noisy and more functional interactions (e.g. an array of buttons).
- My students' inspiration was clearly not informed by existing commercial musical interfaces. They preferred experimenting towards the production of unique aesthetic interfaces. In fact, the interface became 'the artwork' in many cases and not a mere instrument for a performance.

My interpretation of these observations is that students understood this course as another workshop or practice-based laboratory for art production. This fact may defend the suitability and benefits of introducing NIME courses in the curricula of art universities.

8.2 Musical results

As I explained in the context section, 90% of the students did not have any musical education when they started the course. Therefore,

⁵ More examples of the interfaces can be accessed at: https://www.flickr.com/photos/interface_cultures/albums/ searching for Musikkappelle.

orienting this course towards music -notes, harmonies, rhythm, etc.- would have been a total failure. However, introducing the principles of sound organization resulted into an effective strategy. After explanation of the basic theory of electroacoustic music creation, students were able to identify, combine and improvise with interesting sound materials. As if it was another artistic physical material, students developed the skills to compose and give form to interesting electronic sound textures.

In this case, students benefited from previous artistic education. Obviously, four months of training can rarely lead to the discovery of many NIME virtuosos. For this reason, the analysis and evaluation of musical results is relative to the duration of the course and more importantly, to the musical potential that students could develop after this course.

8.3 Practice-based methods: evaluation

The two main ingredients of this course are practice-based methods and its playful approach. The evaluation of the course now, five years after its beginning, is positive. But on the other hand, it took me at least three years to develop a clear understanding of how to apply practice-based methods in my classes. Therefore, the evaluation of the first two years of this course is completely different. Certainly, during those years' students learned plenty of things. They also designed and performed at the final concert. However, until I could not count with an adequate set of tested exercises, I could not develop well the course. In particular, it was difficult to keep a real playful atmosphere if I had to teach too many frontal classes and technical exercises. Objectively, the average of projects produced during the first years was less interesting than the ones produced during the last three. The big change in my educational plan happened when, as a teacher, I knew I was armed with a great set of playful exercises and practices. This fact improved enormously my confidence while teaching. It also improved my students' participation in the class.

My conclusion is that art students can benefit enormously from the introduction of practice-based approaches in courses where they have to deal with technology. These methods facilitate a language and a medium where art students can really engage [15].

8.4 Urgency of sharing teaching experiences

As I described in the first sections of this paper, there exist a lack of academic publications reporting complete experiences to the crucial question of how we should teach the art of NIME. In my opinion, more interest from our community should be put on the issue. Through better NIME courses we have the great opportunity to engage more students into a sustainable culture of learning, doing and performing. On the contrary, if we continue perpetuating misguided teaching strategies, we are doing little favor to our field

9. CONCLUSIONS

In this paper I have described a successful pedagogical story and a demanding journey towards the development of my own teaching methods. The results obtained show that the application of practice-based activities and playfulness can constitute a beneficial support for teaching NIME in art universities. Every teacher needs to produce specific adequate educational materials. With this paper, I am sharing the methods that I have developed and the structure of the course I have implemented. In my opinion, this information can be easily adapted by other teachers to be applied at other different academic environments.

10. REFERENCES

[1] Candy, L. and Edmonds, E.A. Practice-Based Research in the Creative Arts: Foundations and Futures from the Front

Line, *Leonardo*, Volume 51, Issue 1, February, pp 63-69, 2018.

[2] Chemi, T., & Du, X. (Eds). *Arts-Based Methods in Education Around the World*. (1 ed.) River Publishers. River Publishers Series in Innovation and Change in Education - Cross-cultural Perspective, 2017.

[3] Cook, P. Principles for designing computer music controllers. In *Proceedings of NIME 2001*, pages 1–4. National University of Singapore, 2001

[4] Foucault, M. “What is Enlightenment?” in *The Foucault Reader*, ed. Paul Rabinow, trans. Catherine Porter (New York: Pantheon Books, 1984), 32–50, 1984.

[5] Harriman, J. Start 'em Young: Digital Music Instrument for Education. *Proceedings of NIME 2015*, Louisiana State University, pp. 70–73, 2015.

[6] Jordà, S. & Mealla, S. A Methodological Framework for Teaching, Evaluating and Informing NIME Design with a Focus on Mapping and Expressiveness. *Proceedings of NIME*, Goldsmiths, London, pp. 233–238, 2014.

[7] Kapur, A., Cook, P. & Bryant, M. Teaching Computer Science to Digital Artists Through Music and Sound, 04/15/2012-03/31/2013, *Proceedings of the International Computer Music Conference 2013*, Perth, Australia, 2013.

[8] Leeuw H. & Jamminga, J. NIME Education at the HKU, Emphasizing performance. *Proceedings of NIME 2012*, University of Michigan, 2012.

[9] Paul D. Lehrman and Todd M. Ryan. Bridging the Gap Between Art and Science Education Through Teaching Electronic Musical Instrument Design. *Proceedings of NIME 2005*, pp. 136–139, 2005.

[10] Lucier, A. Origins of a Form: Acoustical Exploration, Science and Incessancy. *Leonardo Music Journal*, vol. 8, 1998, pp. 5–11, 1998.

[11] Lugones, M. Playfulness, “World”-Travelling, and Loving Perception, *Hypatia* 2 (2):3-19, 1987.

[12] Magnusson, T. Of Epistemic Tools: Musical instruments as cognitive extensions. *Organised Sound*, 14(2), 168-176, 2009.

[13] Razzouk, R. & Shute, V. What Is Design Thinking and Why Is It Important? *Review of Educational Research*. 82. 330-348, 2012.

[14] Schank, J.C. The evolution and function of play. *Journal of the International Society for Adaptative Behaviour*, Volume: 23 issue: 6, page(s): 329-330. First Published December 3, 2015.

[15] Tomás, E. How the Arts Can Help Tangible Interaction Design: A Critical Re-Oriented. *Informatics 4*, 31, 2017.

[16] Xambó, A. “Who Are the Women Authors in NIME? - Improving Gender Balance in NIME Research”. In *Proceedings of NIME '18*. Blacksburg, Virginia, USA. pp. 174-177, 2018.

[17] Xambó, A., Saue, S., Jensenius, A.R., Støckert, R. and Brandtsegg, Ø. (2019) “NIME Prototyping in Teams: A Participatory Approach to Teaching Physical Computing”. In *Proceedings of NIME '19*. Porto Alegre, Brazil. pp. 216–221, 2019.

[18] Wagner, E. Local-Global Concepts in Arts Education. in *International Yearbook for Research in Arts Education 3/2015: The Wisdom of the Many-Key Issues in Arts Education*, ED. S. Schonmann (Münster, NY: Waxmann Verlag), 24–29, 2015.