Crafting Digital Musical Instruments: An Exploratory Workshop Study

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ABSTRACT

In digital musical instrument design, different tools and methods offer a variety of approaches for constraining the exploration of musical gestures and sounds. Toolkits made of modular components usefully constrain exploration towards simple, quick and functional combinations, and methods such as sketching and model-making alternatively allow imagination and narrative to guide exploration. In this work we sought to investigate a context where these approaches to exploration were combined. We designed a craft workshop for 20 musical instrument designers, where groups were given the same partly-finished instrument to craft for one hour with raw materials, and though the task was open ended, they were prompted to focus on subtle details that might distinguish their instruments. Despite the prompt the groups diverged dramatically in intent and style, and generated gestural language rapidly and flexibly. By the end, each group had developed a distinctive approach to constraint, exploratory style, collaboration and interpretation of the instrument and workshop materials. We reflect on this outcome to discuss advantages and disadvantages to integrating digital musical instrument design tools and methods, and how to further investigate and extend this approach.

Author Keywords

Craft, design methods, design tools, musical instruments

CCS Concepts

•**Applied computing** → **Sound and music computing;** Performing arts; •**Human-centered computing** → *Interface design prototyping;*

1. INTRODUCTION

Magnusson [13] emphasises the pronounced epistemic dimension of digital instruments when compared to acoustic ones; digital instruments are created top-down through prior absorption of a technical, symbolic body of knowledge, after which an explicit implementation is designed. In contrast, they describe acoustic instrument creation as being tied to bottom-up processes; acoustic and mechanical properties of materials are explored experientially leading to their configuration into instruments. With acoustic materials, Magnusson describes, "the sound generation (and the required knowledge of it) is given to us for free by nature" [14].

Acknowledging the benefits of this direct relationship with material, many digital instruments and design tools aim to give designers and players a comparable freedom to explore. Many examples of this exist, such as in modular synthesis where notionally symbolic circuits are explored as hands-on material [6]. Software arts practitioners and tool makers have emphasised the importance of materiality and craft in exploring code [3, 12]. Innovative works in e-textiles [25] and paper electronics [24] integrate functionality directly into materials, inviting new ways to explore function and form. An altogether different exploratory experience is provided by instrument design methods employing sketching, fiction and imagination [1, 17].

Inspired by these various approaches, we were motivated to investigate a context where the constraints of a toolkit [14] and the openness of craft-inspired [11] model-making coincide. We created a workshop where groups of participants used crafting materials to modify a kit-based digital musical instrument prototype that we described as "unfinished" to encourage exploration. In this work we seek to interpret the responses and outcomes to gain insight into the impact of combining different styles of constraints, and to understand how different materials affect exploratory process in digital musical instrument design.

The next section of this paper contrasts different approaches to supporting exploration in digital musical instrument design. Subsequently the workshop design is detailed, and the outcomes are reported on and discussed. We conclude by reflecting on their possible consequences for combining instrument design tools and methods.

2. BACKGROUND

2.1 Comparing across toolkits and methods

Digital instrument design toolkits are useful design aids that abstract implementation details into modular parts whose combination can be rapidly explored. Toolkits reflect specific musical cultures and knowledges [13] such as instrument classification systems [4] and synthesis approaches, which through abstraction gain extra flexibility allowing for novel recombinations. One disadvantage of toolkits is that the original material qualities of the parts are no longer present; a tangible media token of cardboard, plastic or wallpaper will still perform the same function [23]. Another disadvantage is that in reifying familiar bodies of knowledge, they make bottom-up exploration outside of those boundaries difficult at the expense of artistic appropriation [5, 8].

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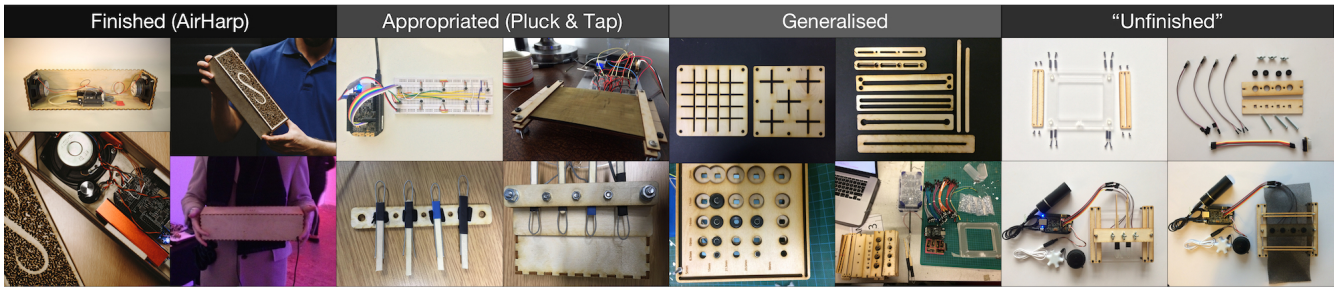

Figure 1: Un-crafting [20] the ‘finished’ *AirHarp* into the *Unfinished Instrument*.

While evidence suggests that expert toolkit users overcome the toolkit’s influence [3], for beginners it is easy to mistake a toolkit’s perspective for the art and craft itself [18].

Alternative approaches to toolkit-based design exploration aim to provide different constraints. They propose that where design media exerts less influence on which ideas are easy to represent, the designer can instead explore personal expression and imagination [22]. These approaches are often led by material and conceptual interests, taking inspiration from craft principles [11] and traditional design methods like sketching [17] and fictional model-making [1]. Unlike with design toolkits, in these methods designers are sometimes distanced from real interactions and behaviours as these instead take on looser or imaginary forms. Ultimately, these differing approaches to exploration could offer complimentary benefits to digital luthiers.

2.2 Addressing diverse needs in digital lutherie

Digital luthiers are highly interdisciplinary practitioners who often perform combined roles of inventor, maker and player [10, 19]. As designers they need to explore the implementation, look and feel, and role of their designs as separate and integrated issues [9], typically as part of a non-linear process [7]. In their process they need to not only formulate and synthesise new ideas, but also take reified ideas and prototypes and make them “malleable” [1] through decomposition and dissection [20].

Recognising these diverse needs, we designed a workshop facilitating exploration using both toolkit and craft-inspired approaches to investigate the following questions:

- How do participants explore in an environment featuring both a kit-based instrument and crafting materials?
- How do they balance the material constraints against the constraints of their own ideas?
- How do they develop musical gestures?

3. WORKSHOP DESIGN

A digital lutherie workshop focusing on craft practice was held during NIME 2017. It was free and open to anyone registered for NIME, and no submission was required. We expected but did not require participants to be digital luthiers, and participants with experience in traditional or acoustic instrument making or non-musical crafts were also welcome. The organisers gave an introduction to the subject area, where they introduced a theme of craft in NIME [2] as a starting point for discussion. We devised a crafting activity that would compliment discussions and reflection about craft in NIME, and how it can be shared in the community.

3.1 The Unfinished Instrument

The goal of the activity was to facilitate open ended crafting of a prototype instrument, that could appear to be “unfinished” and subjectively reinterpreted. This process is illustrated in Figure 1 and started with appropriating [5] and un-crafting [20] an existing instrument called the AirHarp[1] developed by Chris Heinrichs in C++ using the Bela platform [15], chosen for its flexible synthesis of virtual string sounds using audio-rate sensor inputs. Its physical model excited by an accelerometer was replaced with up to eight low cost microphone capsules. This offered a high-bandwidth connection between physical behaviour and sonic response, necessary for facilitating gestural interaction using a wide variety of materials.

To provide a contrast to previous workshops and integrate with the crafting materials, we focused on mechanical instead of software and electronic modularity. Simple and repeatable prototypes were developed using the microphone capsules, that would facilitate physical modification via materials available from a craft modelling store. Two gestural interactions were offered as demonstration: a plucking configuration featuring wooden tines clamped across the microphone cavity, and a tapping configuration which allowed different surface materials to be clamped across all of the microphones to form a surface.

These two example configurations were then generalised in terms of their physical structure, such that both could be made from the same basic components. Introducing flexibility into the design required trial and error to strike a balance between openness and robustness; for example the microphones had to sit firmly in place but still be movable, and the physical structure featured slots instead of holes where possible to make it adjustable. The final design[2] was presented to participants along with its two pre-explored configurations (pluck and tap).

3.2 Crafting environment

The room consisted of tables for small groups of 2-5 to sit around facing each other. There was a long table at one side of the room displaying a variety of tools and crafting materials. The organisers presented the opening discussion from a projector at the front and provided technical support around the room.

Materials were selected for their familiarity and tactile and acoustic variety, and included rods of aluminium, brass, wood and plastic, sheets of various foams and metal meshes, paper, corrugated card, thick card, cork balls and granules, folding clips, and googley eyes. Tools included scissors, wire cutters, jewellery pliers and cutters, adhesives, double sided tape and foam tape, duct tape, blu tack, notepads, pens and miniature cameras. Each group had at least one camera which they could use to document their crafting (consent forms were signed for filming). Tools and materials could be used in any quantity by any group at any time.

[1]Search AirHarp in http://github.com/bela/belaplatform
[2]http://bit.ly/theunfinishedinstrument

3.3 Data collection

Immediately before and after the workshop, participants shared their reflections on their own craft practice and their crafting experience. Days after the workshop, reflections and feedback were gathered from participants via in-person interviews and an online survey.

4. OUTCOMES

The workshop had 20 participants encompassing research, instrument design, teaching, composing and performance. They were split into four groups (G1-4) but were given no brief for how they should collaborate. In this section, the groups' crafting process and outcomes are described. Participants' reflections are then thematised based on the questions in 2.2. An emergent theme of collaboration process is also presented.

4.1 Overview of outcomes

4.1.1 Group 1

G1 split into two subgroups and worked with two separate instruments (termed G1A and G1B).

G1A: *"It started out with the elastic bands in the way of it just being easy to get a string effect on the string sound and do multiple sensors at once. Then we started with duct tape and getting the sound of pulling the tape off the other tape to get the kind of like [ripping] sound which was really nice. And [redacted] suggested velcro which kind of wound up in this way [scrapes velcro] where you can play it like a plucked harp like thing. And then it's also just really fun to whip it [with a giant foam stick]."*

G1B: *"We just split different microphones onto separate layers so you can play them. And it could be like a multi-player sort of instrument [two players demonstrate]. And we thought about developing different materials for each layer to get different sounds. That's pretty much it."*

4.1.2 Group 2

G2's instrument was demonstrated as two versions. The first was described as a 'feedback organ' where cardboard tubes could be telescopically lengthened to produce different timbres of feedback, with each microphone isolated.

G2: *"One group member suggested something where we could throw objects into it and they would rattle around. Then, we decided that the tubes were cool, but would feel more like an instrument if they were different lengths, even though that wasn't necessarily functional."*

The second was based on striking the cardboard tubes, and featured a code modification affecting timbre.

G2: *"We changed the code in an attempt to make the instrument slowly change octaves, but mis-judged the size of the buffer so we created an extremely fast arpeggiator (like 8-bit video game polyphony) instead, which turned out to give our instrument a unique sound."*

4.1.3 Group 3

G3 split into two subgroups working with two separate instruments (G3A and G3B).

G3A: *"We tried to figure out the different parameters of the mass damping but we sort of got slightly lost and got some help to reboot the project. With 30 seconds left we switched to the pluck model so all it does is just do the original pluck thing. So musically it's very uninteresting [...] But what we've got is this nice little visual representation of the evolution of the instrument."*

G3B separated their instrument into four sub-instruments, three of which were demonstrated.

G3B: *"We tried to extend each single microphone and explore a single microphone, and I think as a whole it would have been [the idea] to come together at the end. We explored different kinds of sound aesthetics, trying to understand actually what those mics could do and it was quite limited. In my case I've made this sandwich and inside it there's the microphone and some bolts, so if you shake it hard, then you get some sound."*

"This [second sub-instrument] is even more basic, well you can do this [plucks string against mesh] and [scrapes mesh]. I think the acoustic sounds are more interesting than those coming from the loudspeaker. One way to use this instrument would be to combine these two sound sources."

"Here's one final rudimentary part [third sub-instrument]. It doubles as a crucifix, it's a tapping mechanism, you can slightly hear it if you twist it around, that's what I came up with."

4.1.4 Group 4

G4: *"I guess at first we were frustrated with having limited notes, so we tried a lot of things. Somehow the feedback seemed to be inspirational and we started to come up with ways of thinking about the whole animal. We added speaker rattles and we looked at ways to create effects acoustically [the group begin performing]. This is the subtractive synthesis bit [microphone attached to a hacksaw]. So the same idea as [G3B] to mix the acoustic sound."*

4.2 Exploring constraints and constraining exploration

Most participants said they intended to explore the instrument and materials rather than start with a specific goal. This extended to setting aside our suggestion about focusing on subtle details.

G2: *"Our intentions were quite geared towards the exploration side anyway so that continued throughout."*

G4: *"What was interesting was to discover an instrument and to basically try to make music with it. So I would say even though maybe the goal was not announced like that, we didn't try at all like theoretically thinking about how to improve this instrument [...] we just tried to kind of okay we have this situation let's try to make music."*

G2: *"I think we wanted to do something different from what the other groups did. I don't think we said that explicitly to each other, though."*

Where initial ideas were pursued, it sometimes turned out that the design constraints were not supportive.

G3: *"We had this grand idea of having this sort of spring reverb that was going to allow us to pluck it whilst these [strings] would carry on vibrating and then the balls would continue that in a physical way."*

G3: *"The thing that I wanted to achieve is to get away from this pluck stuff and this was my only idea [pulling string through mesh]."*

While the initial conditions of the instrument did not thrill, and the option to modify the code was there, participants still mostly preferred to continue exploring.

G1: *"I personally made a conscious decision that I was not going to try to change the code that was running on the device because I didn't want to be in that headspace."*

G1: *"Once you get into trying different things with it, you don't really think about that aspect of the instrument so much, which I think is important. Because you can spend all this time tuning the sound, but then you need to spend some time tuning interaction or exploring interaction as well."*

Once the participants became more familiar with the con-

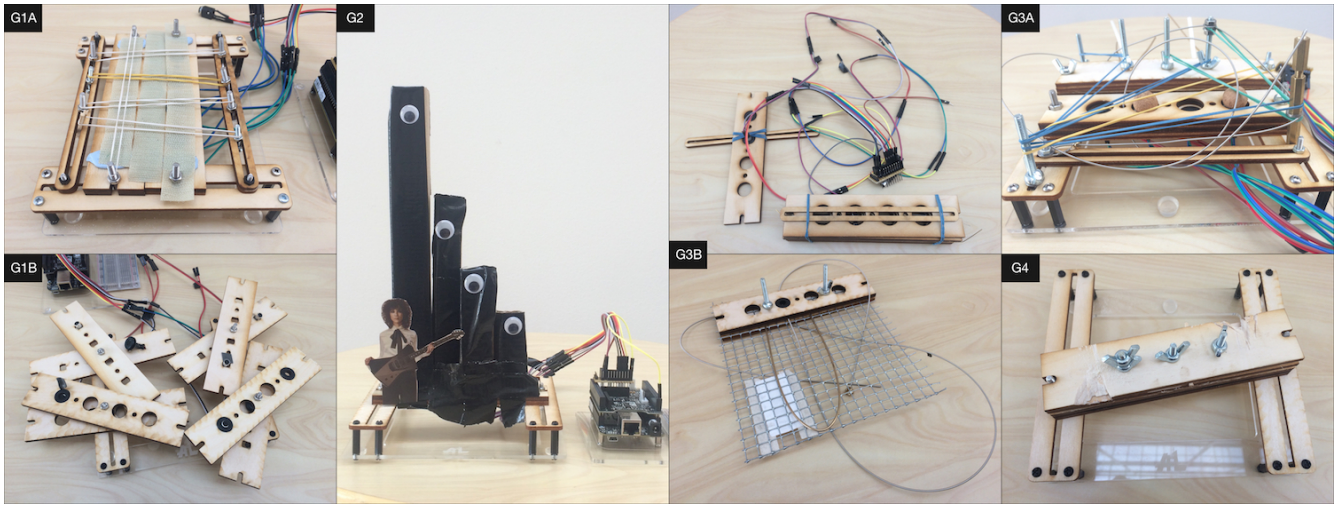

Figure 2: Final states of the *Unfinished Instruments*. Not pictured is the full extent of G4's instrument which included an extra, larger speaker, guitar string and a hacksaw.

straints, they explored through a succession of making, playing and continuous iteration.
G1: *"There was an aspect for me that is like it wasn't so precious, it wasn't like a thing that I had built up in my head as being like, oh I really want to try this specific thing."*
G1: *"Coming into it not really having a clear goal or a clear expectation made the exploration more fun and lighthearted, I think it's analogous to music making."*
G2: *"We were free to really think about the physical interaction and the visual details that would influence how the instrument was played."*
G2: *"We were all very quick to discard something if it didn't look right."*
G3: *"[It was] more or less chaotic, which is a good thing if you wish to expand the design space."*

As this process developed over time, there were points of little verbal discussion and instead a shared focus on doing.
G4: *"We specifically acted and we interacted in and not too much discussion but like, oh you did that let me let me add that, or you did that let me cut that."*
G2: *"It's kind of just like a feedback system just like idea bouncing back and forth."*
G2: *"It ended up being implemented through playing modes."*
G4: *"I actually never experienced like those things, it was like hmm so I'm doing as I'm experimenting as I'm in doing."*
G2: *"It felt like it was very responsive; I am coming with one idea and and we could just, yes try it out, oh no it doesn't work, uh-huh okay [...] It wasn't any like darlings that you want to keep and very like quick to come up with some new ideas when something wasn't working."*

One participant in G4 reflected on the divergence away from the brief.
G4: *"Because everyone in the room was creative, it came to not at all micro differences but huge differences even in the philosophy of music making or instrument building and the results themselves. Actually I loved many of the instruments that the other groups did and they were super different."*

4.3 Exploring sound, gesture and materials

In their initial explorations, groups tested out the behaviour of the instrument, and in some cases these trials were dissatisfying or unrewarding, but groups later returned to the same gestures.

G3: *"One of our first problems was that it was really quiet, so we first of all tried to make a more directional cone so we could turn up the gain without it feeding back. That wasn't entirely successful."*
G2: *"One group member suggested something where we could throw objects into it and they would rattle around. We worked for a while trying to make that work (cardboard tubes, plastic eggs, different materials thrown in) but we didn't have the right materials to get a good bounce."*
G2: *"In my head my ambition was more the acoustic sound [...] but I didn't think it through that it was actually destroying the sources [microphones]. One of the other things that quickly annoyed me was how responsive it felt [...] it sounds so the same every time [...] so we went looking for more variation."*

It was not long before the groups had accumulated differing collections of materials at their tables. The open layout of the table seemed to suggest ideas.
G2: *"It's good to actually arrive there and have all this broad range of material and to experience the freedom you know like the creative freedom that it provides."*
G1: *"It was interesting to have this is a kind of playground to explore different kinds of tactility that was then serving as inspiration for something totally different."*

New gestures often resulted from the incidental combination of ideas, and failed ideas resulted in raw materials being reused in new ones.
G1: *"[G1 participant] was interested started out with ripping tape off and then that developed to the velcro, and then at first we just tried to put the two side-by-side and then kind of by accident realised that they complemented each other [...] like fret noise on a guitar, there's a bit of a lead up and then a more definite pluck sound."*

The process of combining and transforming materials and gestures were compared to sketching and sculpture, and happened more rapidly as materials accumulated on tables.
G4: *"I found the bass string and some metal and that give me like a rough idea to try to sketch."*
G2: *"[The process] became very much focused on the sculpture."*
G4: *"At the end we were always kind of performing with it or trying it to make sound that was really interesting."*

4.4 Exploring collaborative process

The groups diverged in their approach to collaboration (see Figure 3), and took advantage of the flexibility of the instrument's design to re-configure as their collaborative style required.

G1: *"You specified to collaborate in groups but you didn't really go beyond that with the detail of how to collaborate, so it was really nice to see how the different groups came out with very different ways of working together. We kind of split it in half and made two instruments between four people."*

G3B: *"Initially because there was four of us working on it we tried to extend each single microphone and each explore a single microphone, and I think as a whole it would have been [the idea] to come together at the end."*

G1: *"The activity and the group environment was super inspiring, to see what everyone else came up with from the same initial state."*

G2: *"Sometimes we would each take a particular task [...] and sometimes one of us would decide to experiment with a new idea while the others worked on something else."*

Across groups, ideas were shared explicitly and implicitly.

G1: *"Someone else actually pointed out that connection and then it made it a little bit more usable."*

G2: *"This kind of feedback idea was very collective idea so it wasn't one person's."*

G2: *"It was interesting because I never made an instrument in a group process like that."*

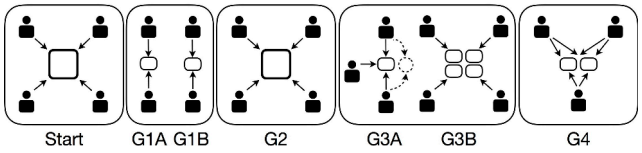

Figure 3: Variation of group organisation and instrument structure compared with starting point.

5. DISCUSSION

5.1 Exploring constraints and constraining exploration

The brief presented the workshop as an opportunity to reflect on subtle differences between outcomes given an identical starting point, however this was mismatched with the unconstrained environment. Instead of responding to this brief, most responded to what emerged from their ideas and engaging with each other. Although this scripting of the workshop was light and open responses were welcomed, it inadvertently motivated playful subversion and appropriation. To engage with subtle differences of craft, an alternative strategy could involve participants presenting and comparing their own instruments that have similar functions, forms or design processes.

The goal of un-crafting [20] the AirHarp into the Unfinished Instrument was to present something complete in terms of synthesis and sensors, but open to interpretation in terms of performance and gestures. While the instrument could only be "re-crafted" so much in one hour, the instruments exhibited personality and style, and they inspired collaboration and discussion. Some participants wanted the code to be more accessible, and some were generally dissatisfied with the resulting artifact itself but still saw value in how it represented their group process. The shortcomings of the instrument's sound and sensors and the potential for its parts to be recombined or reinterpreted, seemed to just about balance frustration with motivation.

5.2 Exploring sound, gesture and materials

The workshop environment encouraged mixing a variety of approaches including design, bricolage and performance. The layout of materials across a long table inspired ideas through visual survey, and their abundance and malleability led to their combination and destruction as needed. Participants were aided by not being attached to materialised ideas, perhaps due to the familiarity and low cost of the materials. This contrasts with circuitry-based workshops where participants interacted in a cautious and apprehensive manner [16]. The instrument parts were used and repurposed in surprising ways, sometimes fictitious ones as in G2's instrument. Some groups distinguished between instrument parts and crafting materials, while others blurred this line completely.

After initial disappointment with the instrument's lack of responsiveness, participants discovered stroking, hitting, scraping, throwing, twisting, pulling, pushing, sawing, singing, shaking, whacking, dropping and more. The hands-on way of working offered fast iteration of testing gestural ideas and sharing and critiquing the results, to the extent that many ideas were explored simultaneously. A notable pattern of activity across groups was the curation of a portfolio of gestures, which were continuously refined as new materials were incorporated into the instrument. When demonstrating their instruments to each other at the end of the workshop, participants were not required to perform however this was vital to some groups. The outcomes indicate that"making the instrument malleable" [1] is not only applicable in fictional model-making scenarios.

5.3 Exploring collaborative process

One of the more surprising aspects of the workshop was the diversity of collaboration it afforded the participants, as depicted by Figure 3. Even the more experienced participants commented that this workshop offered them a way of working that their current practice and community does not. There were no apparent barriers to dynamically configuring group organisation, roles and process, or any notable friction between verbal and non-verbal communication, or overtly performative or design-led activity. The workshop facilitated participants to use their existing skills, experience and interests, or simply respond to what emerged, without dividing labour in the group or enforcing rigid role play. Exploring the design environment's affordances was a shared experience across groups, as observing an idea contributed to one's own understanding. Some ideas were felt to be collectively owned such as feedback. The environment's openness allowed different collaborative styles to emerge.

5.4 Suggestions for further investigation

To provide deeper evaluation of this workshop method, we recommend a comparative approach with other tools and methods. We perceive potential in further integration of electronic and digital crafting materials and methods such as e-textiles, paper electronics and live coding. Such materials could not only be more pragmatic, but also more open and inclusive in terms of subjective exploration [25, 24, 21]. Since participants seemed to curate collections of gestures in the workshop, amplifying this behaviour with tools for rapid capture and comparison of gestural ideas could also be a promising line of investigation.

6. CONCLUSION

The process of exploring gesture in digital musical instrument design involves a complex interplay between what an instrument can do versus what its creators and players would ideally like it to do. Tools and methods often address these issues through two styles of exploration; toolkits encouraging exploration through constraining actual instrument behaviour, and sketching and model-making encouraging exploration guided by imagination. While independent exploration of these issues is beneficial, we sought to investigate the potential of supporting designers to explore them concurrently through a craft-inspired workshop method. We found that reformulating an existing instrument to have a modular mechanical structure and combining it with crafting materials enabled rapid, open exploration of gesture. Groups also restructured the instruments' form to suit their gestural ideas, and the group setting of the workshop fostered diverse collaborative process. Further investigation is needed to identify how this method compares with those that inspired it, and where in a larger scale design process it might be appropriate and effective.

7. ACKNOWLEDGMENTS

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