Exploring augmented reality as craft material *

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Abstract. Craft making is associated with tradition, cultural preservation, and skilled hand-making techniques. While there are examples of digital craft making analyses in the literature, Augmented Reality (AR) applied to craft making practice has not been explored, yet applying AR to craft making practices could bring insight into methods of combining virtual and physical materials. This paper investigates how AR is considered by craft makers. We find that narrative is essentially physically located in craft objects, and while virtual elements may describe and annotate an artefact, it is not considered part of the craft artefact's narrative.

Keywords: Craft Making in HCI · Augmented Reality · Computational Materials

1 Introduction

Craft making is associated with traditional practices, cultural preservation and skilled hand-making techniques [38]. Alongside this deep connection to cultural traditions, craft making practices have increasingly incorporated digital technologies, often resulting in new traditional-digital hybrid making processes [17] [39]. Craft has thus been of recent interest in the Human-Computer Interaction (HCI) community as a way of investigating 'materiality' in making practices (e.g. [7], [23] and the conceptualization of computation as a material [44]).

While attention has been given to analyses of a number of materials and digital tools in craft, the particular technology of Augmented Reality (AR) applied to craft making practices has not been explored. AR is a range of interactive technologies that allow a user to experience virtual content superimposed on the real world [5]. Since AR consists of systems that connect virtual content to physical objects without observable interactions between them, subjecting this technology to craft making practices (and vice versa) can shed light on methods of combining virtual and physical materials, and offer further reflection on the nature of 'immaterial' materials in making.

We use *critical making* to investigate AR as craft material. Critical making examines how social understandings are expressed in made objects through intermittent steps of conceptual analysis, exploratory making and prototype construction, and reflective critique [33] p. 253. Critical making stems from *critical design*, which explores the social contexts, ethical assumptions and values

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that shape making practices and their reflections in the made objects themselves [6, 18].

Critical making is an appropriate method to investigate AR in craft making because craft is replete with culturally-embedded values and associations, e.g. Arts and Crafts movement in the UK [2, 26]. Thus, any understanding of craft making with virtual components should consider these attributes that shape making processes. In addition, the reflective user-design practice invites the influence and opinions of craft practitioners, which makes craft makers primary stakeholders in developments arising from this research.

This research presents the conceptual analysis stage in a critical making framework, which involves compiling relevant concepts and theories for further work. We do this through an empirical investigation into how craft makers understand their own practices and values associated with these practices and whether AR is believed to fit with these practices. We first interview craft makers about their making processes and conception of material. Then we construct an AR craft prototype and conduct analysis with craft makers to understand whether they perceive AR virtual content as aligned with craft values.

The main over-arching questions investigated in this research are:

- What attributes of craft do expert makers view as important in the context of craft making with AR technologies?
- How do craft makers understand AR technologies as a potential material?
- How do users receive a simple AR for craft prototype based on the findings, what are promising directions to explore in future research?

The overarching theme that emerged is the importance and nature of narrative in a craft object. Narrative is necessarily physically expressed. To understand an object's tradition or history, one must touch and observe the artefact. Since computation is immaterial, it cannot manifest as an inherent narrative. However, the artefact requires additional information to "fill in" the story or wider cultural context the maker wishes to highlight. This leaves room for computation to assist narrative, and there is disagreement as to whether this allows computation to be considered to be a material and have a narrative in itself.

2 Background

2.1 Attributes of Craft

Traditional craft making is defined as small-scale production of functional or decorative objects [34], and commonly associated with practices involving natural materials such as pottery, ceramics, metal-working, wood turning, weaving, and textiles. However, what is considered craft evolves in conceptualisation through socio-cultural, historical, and technological contexts [10]. Attributes and values of craft making include:

- *Skill and Expertise* [8,38]: to craft is to "participate skillfully in some small-scale process" [2], p. 311. Sennett [38] argues that craftsmanship is an innate desire to do skilled, practiced work with full engagement for its own sake.

- *Embodied Practice through Hand-Making:* craft is knowledge of a process through learned coordination of the body, and hand-making is the exemplar of embodied practice [25, 29].
- *Close Proximity with Physical Material* [1]: A material's unique and uncertain 'feedback' to the maker's manipulation shapes the making process. Pye ([2], p. 342) coined this balance between uncertainty and craftsmanship 'the workmanship of risk'.

2.2 Computation as a Craft Material or Medium

Recent work in *digital craft* (or hybrid craft [22, 47]) bridges the conceptual gap between traditional and modern making practices by "combining emerging technologies with hands-on physical making practices, leading to the production of digital artifacts (such as code)" ([31], p. 720). Thus, digital craft making is investigated to inform the role of material, or 'materiality', in making and interaction design practices e.g. [41,46]. Much of this work involved experimental making with craft materials, including clay pottery [37], leather making [42], and woven basketry [47].

In craft, data and computation [19] interact with instantiating physical objects, which situates computation as 'immaterial'. Vallgaarda and Sokoler coin 'computational composites' to describe the expression of computation through integration with physical materials ([44] p. 514). They argue that since the inner workings of computational processes are not perceivable to the human eye, material properties of computation can only be studied through its composition with directly observable materials and its form-giving abilities [45].

The role of communication lends computation to be conceptualised as a *medium* rather than a material [20]. A medium uses physical properties to convey a message through consistent organization (e.g. film, comics) [28]. Gross et al. [23] identified three main material approaches to making: Tangible User Interfaces (TUIs) present computation in physical form, computation as metaphysical material, and craft applied to HCI extends communicating tradition to digital making. The interconnected role of physical, immaterial, and communication resemble the notion of medium, and highlight the potential of expanding crafts traditional narratives through digital components.

2.3 Related Work: Craft and Augmented Reality

Mobile Augmented Reality: *Augmented reality* (AR) refers to a range of interactive technology systems that allow a user to experience virtual content superimposed on the real world [5, 27]. *Virtual content* can be textual, audio, symbolic, or 2D and 3D graphical visualizations positioned in a user's real world view in a "spatially contextual or intelligent manner" ([4] p. 2) using sophisticated hardware and computer vision techniques.

We limit the scope of our investigation to *marker-based AR* technologies that can be implemented as a mobile phone application. Marker-based AR identifies and tracks a designated object, image or surface in the real world using a camera and overlays content according to the marker position ([3], p. 12-3).

AR Craft: The Spyn Toolkit was developed to investigate how the memories and thoughts that makers have while making an object can be virtually embedded into the created object [35, 36]. Spyn is a mobile phone application that allows knitters to record audio, visual and textual information throughout the making process, and associate them with locations in the final knitted piece. The authors found that recipients of the craft objects with virtual 'notes' reacted positively to these virtual elements, which made the crafts more personal.

3 Understanding Making Processes and the Conceptualisation of Material

We interview craft makers' to gain insight into makers perspectives on their own making practices. We asked makers to identify the attributes and principles they consider integral to craft making, and whether AR can serve as a potential material for their particular type of craft making.

3.1 Method

We conducted a qualitative study consisting of semi-structured expert interviews [11] with self-described craft makers. Craft makers are experts of their particular making practices, which includes unique understandings of the affordances of their chosen materials and tools, as well as insights into how these materials may interact with computational or virtual elements.

Interview Participants: We selected interviewees from a number of making contexts in order to gain insights into the diverse experience of makers. Craft making is done in a variety of contexts which shape the values associated with the making process. For instance, craft is made and sold through self-employed businesses, makerspaces, designer-maker fairs and galleries [40]. Craft is also a leisure activity [32], and features in political activism against mass consumption [15]. Finally, the characteristics of craft-based businesses in the UK tend to significantly differ between rural and urban areas in production scale and access to materials, tools and networks [9, 15].

We approached twelve potential interviewees that between them represent most of the contexts just described, with nine participants agreeing to be interviewed. Table 1 provides a summary of each participant's making context, primary craft type, and location where they make, sell and/or show their work. The interviewees vary in use of computation in their work, with some having digital technology significantly feature in their work and others using only traditional making techniques. Ute was the only participant to have created an AR application. All names have been changed to maintain anonymity, and all interviewees gave written consent to participate in this study.

Interview Structure: A semi-structured interview format was chosen to ensure consistency between interviews while allowing flexibility to probe based on interviewees' responses. The questionnaire consisted of twelve questions with additional probes as needed. Questions centered around interviewees' own reflections on their making practices, how they understand materials and whether

Table 1. Semi-Structured Interview Participant Summary

Interview Participants			
Name	Making Context	Craft Type	Location
James	Self-Employed Small Business	Digital Visual Art, Digital Illustration, Printing	Urban
Sophie	Self-Employed Small Business, Teaching	Knitting, Sewing, Garment and Cushion Design	Urban
Rachel	Designer in Residence	Research through Making, Textiles, Ceramics, Jesmonite, 3D Printing and Laser Scanning	Urban
Lotte	Self-Employed Small Business and Studio	Weaving, Sewing, Textiles, Garment Making	Urban
Christine	Academic Researcher and Repair Activist	Exploratory Making, Textiles	Urban
Karina	Self-Employed Small Business	Painted Silk Scarves, Printed Illustration	Urban and Rural
Robert	Self-Employed Small Business, Teaching	Ceramics, Pottery, Painting	Rural
Elizabeth	Self-Employed Small Business	Narrative Textiles and Costumes	Rural
Ute	Academic Researcher and Craft Activist	E-textiles, Urban knitting, 3D printing	Urban

computation and digital technology fits in that understanding, and their views on incorporating AR into their craft practices. A short demonstration of simple marker-based AR technologies was also prepared to prompt discussion. Interview lengths varied between 22 minutes and roughly 1 hour. The interviews took place between June 9th - 23rd 2019 in various locations in the UK. All interviews were recorded and transcribed by the first author.

Data Analysis: All transcripts were analyzed using *thematic analysis* (TA), which is a common method for analysing semi-structured interviews, with the aim of "minimally organising and describing the data set in (rich) detail" ([12], p. 6). In contrast to content analysis, which organizes data by its manifest content and takes the frequency of topic occurrence into account [43], TA takes the manifest and latent meanings in the data as more fundamental to theme organization than frequency. This better reflects a shared sense of meaning through the experiences described in the data ([13] p. 57). As this study is concerned with investigating makers' perceptions and experiences with craft making, we find TA to be a better fit in a critical making framework. An inductive coding strategy was used [24], meaning that categories and themes were not predetermined before analysis but rather induced directly from the data set. The themes discovered are described below.

3.2 Results

Theme 1: Craft Making is Articulating Ideas Physically with some External Constraints using Various Approaches to Hand-Making

Craft Making is Instantiating a (Vague) Idea into Physical Form through Whatever Means Required: The most fundamental component of craft making, ac-

cording both traditional makers and makers who use digital technologies, is instantiating or working out an idea into a physical form. All participants, except the two purely traditional makers, stressed that the idea of what they want to make comes first and making techniques were then chosen or learned as required to actualize the idea. Traditional makers further emphasised that while having an idea to work from is important, the idea was described as vague, undefined, and primarily developed through the making process itself. They impressed that interaction with and understanding the physicality of that material is what primarily shapes the idea of what they are making rather than pure conceptualization.

Hand-making is Equated with Thinking or Mediated Interaction with Materials through Tools: Stemming from this, there was also a disparity between traditional and digital makers on the role of hand-making: traditional makers emphasised hand-making as embodied knowledge, while the makers more familiar with digital technologies perceived hand-making as only one, albeit fundamental way of interfacing with materials. Traditional makers explicitly described hand-making as the direct link between the conception of what to make into the direct physical manipulation of materials. For instance, Elizabeth is a a traditional maker who using textiles, sewing and other techniques of assemblage to make elaborate costumes and set pieces. She stated: "It's almost, I think through my fingers, they know what to do."

Participants who employ digital technology in their work also perceived hand-making as essential to craft, however they emphasised the potential interactions between tools and materials. Rachel is a designer-maker who investigates combining traditional and digital making techniques, and posited expanding hand-making to include building and maintenance of machines:

> ...but then there's also the interesting argument in if the machines been made by hand. Let's say its a ceramic extruding 3D printer that's fed by hand and most of the time it will be stopping it and starting it and cleaning it... it's very high maintenance, then there's just as much handwork that's going into that. But with craft, it's making something, it has to have an element of hand.

The conception situates hand-making as any part of the process where hands interact with materials or tools. Nonetheless, machine maintenance is not explicitly considered as "thinking" according to traditional makers.

Theme 2: Craft Materials are Defined by Purposeful Physical Manipulation

Craft Materials are Anything that is Interacted with Purposefully: Both makers familiar with digital technologies and traditional makers characterised *craft materials* as anything that is used purposefully. Therefore, a deliberate and reasoned making process defines craft rather than using a specific type of material. Specifically how a material is used purposefully is more elusive. Again traditional makers emphasise direct interaction and experimentation with materials,

and "finding" the resulting craft artefact through the making process. Robert, who makes hand-built pots that often incorporate found natural objects such as stones and twigs, described making as fitting the pot to the found object:

> So basically, I look at the stick and just get used to it being around and think, what sort of shape is it wanting. Does it want to be on the top of something, tall and narrow, does it want to be broad, squat, does it want something rough or something really quiet and sleek.

Both traditional and digital practitioners agreed that purpose is found in pushing materials to their limits through considered experimentation. However, makers familiar with digital technology highlighted that purpose is often situated in researching how to use a specific tool, or the properties of material.

Computation Must Purposefully Interact with Physical Objects to be a Craft Material - Therefore, AR is not a Material: As evidenced in the previous category, the participants were open to anything being a craft material, including computation. However unlike the traditional and physical materials that are more commonly used in craft, computation was given further stipulations on how and where it could be used specifically in craft making. First, because computation is not physically observable, it may become a material only if it interacts with a physical object. This follows the notion of 'computational composites' described by Vallgaarda and Sokoler [44] as discussed in section 2.2. Interaction with physical objects includes computation that describes and shapes physical materials as found in digital fabrication techniques.

Second, there was skepticism as to whether computation can be used purposefully because is cannot be experimented with or shaped by hand. Computation and other digital technologies were seen to be "cutting corners" and shortening the making process, which takes out the times and deliberation inherent to craft making and reduces its value. Elizabeth stated her disappointment with digital enhancements in photos, which expended to virtual elements incorporated with craft artefacts:

> ... it's a bit depressing. It's amazing that's there but then, the fact that it doesn't exist. I suppose that's the thing that somebody's setting up these incredible shoots and actually making it manifest in the real world. I think there's a big difference between that, and being able to press a few buttons and make something that looks like it is but actually it isn't... I've got a lot of respect for people who actually make things actually happen in the real world.

Third, virtual elements that do not explicitly interact with physical objects in an observable way, like AR, are consequently not materials. Several participants noted that AR technology was not yet sophisticated enough to be used in a "tactile" manner necessary for craft making. In addition, there was again skepticism about the ability to purposefully incorporate AR - it was noted that video and audio can already supplement physical artefacts, and therefore AR was not necessary or needed.

Theme 3: A Craft Object's Narrative is Fundamentally Physically Situated

A Craft Object's Narrative Exists on a Spectrum of Being More or Less Physically Bound: The most salient theme that emerged was the explication of what it means for a craft object to have a *narrative*. Craft is generally characterised as having 'authenticity', history, or a story due to links with cultural tradition. But what does it really mean for a physical object to have and communicate a narrative? While all participants agreed that craft is synonymous with narrative, its comprehension differed between participants.

How a craft object conveys narrative was described either as more or less abstracted from the actual craft object. Traditional makers placed narrative as the physical object itself - therefore, it can only be communicated through perceptual and sensational interactions with that object. A person can access the narrative by touching, observing, and subsequently get impressions of where, how, and why that object was made. For example, Robert described how many of his ceramics pieces 'echo' natural landscapes:

> ... there's two slates, they were found at the seaside and it was in Cornwall where there was some distant hills, landscape hills, and then cliffs and the sea, so I poured glaze on that just to have vaguely a sort of landscape-y feel to it, just to echo the place where I found them.

In this case, location is central to that artefacts narrative. While an observer may not learn this precise information from looking at the piece, it nevertheless may invoke a response due to the inspiration that shaped it.

Some participants, on the other hand, conceived narrative as situated in the larger social context that additionally informs the artefacts meaning. Narrative therefore not only manifests through observations of the object, but also through affiliated concepts and philosophies. Christine, for instance, works with repair activist groups to support more sustainable consumption practices. She described allowing people to practice sewing on an old sweater before trying to repair their own clothing:

> ... people don't always want to do their first darn on their precious jumper that they're really upset they've got a hole in... so I take (the sweater) with me, people can have a go on it, they can cut holes they can stitch into it, they can test things out on it. So it's a kind of record of those workshops, its a record of other people's work. Otherwise there would really be no record of all of those kinds of things.

A person observing the sweater will most likely gain any understanding of the meaning behind the craft practices displayed on it without additional access to the associated craft activism workshops. Therefore the artefact alone is insufficient to convey what it most meaningful about it and further social context is required.

Error Generates Narrative, Reproductive Making Processes Kills Narrative: Both traditional and digital makers agreed evidence of"trials and errors" that belie an artefact as hand-made create narrative, while digital fabrication and computation erase markers of individuality and narrative. This supports the notion that narrative is primarily physically situated, and the direct manipulation of materials to instantiate an idea are what points to the narrative. Several participants mentioned that there is no purpose in creating an item that appears "perfect" as digital fabrication can accomplish this create multiple identical products. An error-free object is depersonalised therefore devoid of interesting narrative.

AR may Give Definition to Opaque Narrative but is not Innate Narrative: Finally, participants broadly agreed that AR elements may present annotations that inform viewers about an object's narrative, but the AR elements themselves are not part of the object's narrative. Most participants were accepting of AR as an additional element to an artefact - AR may be used to present recorded personal statements, or present additional images and video related to the objects historical or cultural context. However, because these are virtual components that are not observed to interact physically, these additions are not conceived as part of an artefacts narrative.

One participant, however, argued that a physical craft object alone cannot communicate a precise meaning. Ute is a researcher who uses both traditional and digital making in her work. In the case of a quilt-making project that involved collaboration, she stated:

> Using actually augmented reality that doesn't affect the physical artefact, but just overlays it with those different experiences in some way. If you think about maybe first giving my voice and overlaying it, and then it's the voice of my co-creator who is telling a different story about it, I think that would be really interesting because it would be closing the gap between the meanings that we as crafters put into our stuff so the audience can understand.

Unlike most other participants, Ute was familiar with AR and other digital technologies and supported the disseminating information about projects through channels such as social media. Traditional makers, on the other hand, found the idea of further defining craft objects meaning through words to be confining and undesirable.

4 Craft Maker's Reflections on AR Craft Virtual Content

We investigated whether the type of AR virtual content influences makers perceptions regarding AR as amenable to craft. The results of the semi-structured interviews demonstrated that AR must be incorporated purposefully with the physical artefact, and may at least further define the meanings associated with the object despite not being inherent to the narrative. We build an AR craft prototype that features several types of virtual content, namely audio, 3D models, and representations of hand recordings, and have several makers reflect on the extent to which the type of virtual content fulfills these criteria.

4.1 Participants

Craft makers and sellers were approached at a craft market and asked if they wanted to participate in a short study. Five people were approached with four agreeing to participate by signing a consent form. All participants were from a small business context, and therefore only represent one craft context.

Participant 1, James, was also an interviewee in the first study and was asked to participate in the second study after expressing interest. James creates and sells hand-drawn digital illustrations, and therefore has experience with digital tools. Participant 2 fixes, improves, and sells small items such as bespoke watches, and therefore has knowledge of mechanical making tools. Participant 3 is a traditional painter and illustrator who also works at a market stall selling custom knitted scarves. Participant 4 creates and sells sustainable clothing items in a permanent store next to the market, and is familiar with sewing and weaving.

4.2 AR Craft Prototype

An experimental prototype was constructed to demonstrate simple AR technologies. The prototype is an AR block jewellery piece, and consists of three wooden blocks on a braided string. The wooden block faces were painted using water colours, acrylic paint, and ink. The theme of the necklace was the 'countryside in the UK Cotswolds', and the scenes on the block faces represent common rural landscapes, farm animals and products representative of the area. Figure 1 exhibits the various scenes painted on the blocks.

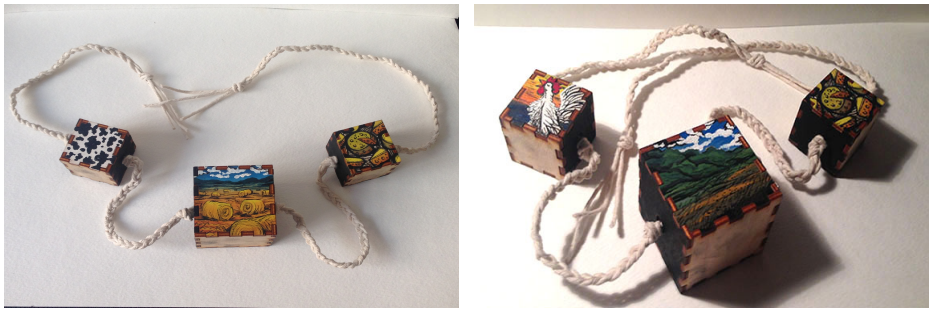

Fig. 1. Augmented Block Jewellery physical artefacts

The flat surfaces of the block faces could easy be photographed and made into image targets for marker-based AR. Each block was painted to have two image targets to therefore display two pieces of virtual content. The virtual content on each block is as follows:

- *Block 1: Farm Animals* - One block face depicts a spotted cow pattern that produces an animated 3D model of a cow, and another block face depicts painting of a rooster that produces an animated 3D model of a chicken.

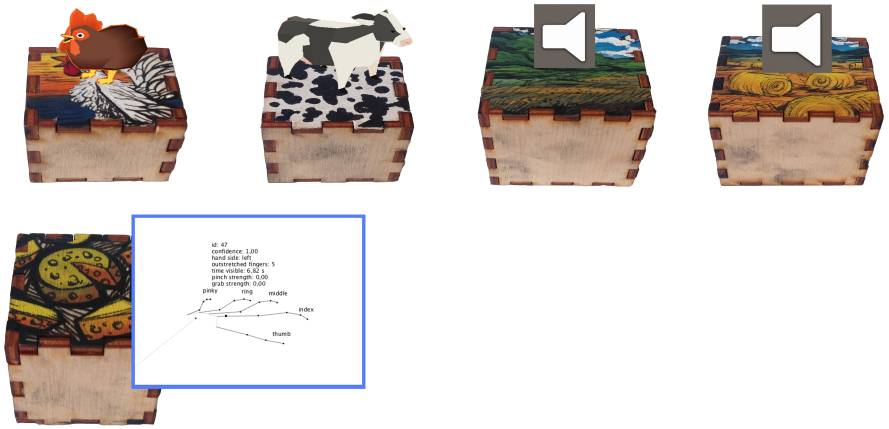

Fig. 2. AR Craft Prototype: Virtual Content per each Block Face

- *Block 2: Landscape Scenes* - One block face depicts hills and valleys, and another block face depicts a farm landscape with hay bails. Both block faces produce two audio recordings each that were recorded in the Cotswolds. The audio recordings start and stop according to the tracking state of the image targets.
- *Block 3: Cheese* - This block only has one augmented painting, which depicts cheeses. The cheese block face produces an over-layed recording of hand motions that were captured by the Leap Motion sensor. The recorded hand movements were produced during the actual painting process.

The virtual content for Block 1 and Block 2 were created using the Unity + Vuforia SDK. The virtual content for Block 3 was made and attached using Processing + NyARToolkit, as well as the recordings produced by Processing sketches that captured the hand movements from a Leap Motion sensor. The virtual content for each block face is shown in Figure 2.

4.3 Methods

Each participant was provided a quick demo of the prototype including instructions on how to elicit the virtual content on a laptop screen. The participants were given free range to interact with the prototype to produce the AR virtual content themselves.

After this short demo the participants were asked several open-ended questions regarding aspects and opinions of the prototype to determine whether participants conceived the virtual content as contributing the same or differently to the AR craft prototype. These discussions were recorded and transcribed by the first author. The data was analysed using thematic analysis, which used to analyse the semi-structured interviews described in section 3.1. The emergent themes are described below.

4.4 Results

Disagreement as to Whether AR Craft Includes the AR Technical System: Overall, all participants except participant 4 perceived the AR virtual content and technical system as an integral composite of the complete piece, rather than the physical artefact alone to be a complete or 'whole' object in itself. Participant 1 noted that the AR content appeared 'embedded' rather than 'added-on'. When asked specifically about the virtual content, participants 2, 3 and 4 sought clarification as to whether the virtual content referred to what was shown on the laptop screen, or the entire AR system. When prompted for their impressions, participants 2 and 3 claimed that the entire apparatus of the physical object, laptop with the camera and screen, and the virtual content on the screen were all part of one whole craft object. Participant 4 did not find the AR content to add anything interesting to the physical artefact.

Virtual Content should add Information/Impressions to the Physical Artefact: All participants (except participant 4) treated all types of virtual content as equally part of the whole object, however participants preferred virtual content that added new information or impressions to supplement their own interpretation of the physical artefact. Participant 1, for instance, was most interested in the 3D model content but preferred the cow to the chicken because it was "more of a discovery... where the for the other image (it is clear that) it is definitely going to be a chicken". Participant 3, on the other hand, favored the audio content because it contributed to the overall mood of the landscape image. When prompted further, this participant posited that the AR technologies were materials because material is "whatever brings out the mood", and audio was a supplementary and novel domain to enhance that mood as visual information was already available on the physical artefact.

Virtual Content of Hand-Recordings are not Self-Evident: None of the participants endorsed the hand-recording virtual content as especially informative or interesting. Participant 2 posited that the recordings were not accessible to understand on their own, and required further information to know that these recordings were of the hand-making process. As a visual artist, participant 3 was not interested in an already known technique but preferred to see a novel technique displayed. Participant 1 suggested either showing more 'impressionistic' recordings that are open to interpretation, or more precise recordings that can be used as a teaching tool rather than evoke an aesthetic response.

5 Discussion and Conclusion

The purpose of this study was to explore craft makers reflections on their making processes and how AR elements comply with these processes and their associated values. We conducted semi-structured interviews to inquire directly with craft makers about their own making techniques, and supplemented this by having

craft makers reflect on the role of different types of virtual content on an AR craft prototype. The primary finding was an elaboration of the concept of narrative as situated in a physical object. Overall, the narrative inherent in a craft object is tied to its physical properties. Since AR consists of virtual components and technological systems that do not have observable interactions with physical artefact, it is unclear to makers how virtual content can be meaningfully or purposefully incorporated as a craft material - one direction suggested in the second study, however, is using non-visual domains to supplement the visual properties of the physical artefact.

The results corroborate with articulated understandings of computation and craft described in section 2. The participants substantiated the common attributes associated with craft making, including hand-making, purposeful and deliberate making processes. Traditional makers especially supported Pye's concept of 'the workmanship of risk'([2], p. 342) through material interactions and evidence of trial and error in making. In addition, the participants maintained the notion of computation as 'immaterial', and necessarily a composite with a physical artefact [44, 45].

Overall, the findings suggest AR can be considered a medium rather than a material because of the priority of narrative communication, as well as taking into account the whole AR technology setup and physical artefact as part of the communicative system [20, 23]. Nevertheless, the rules and capabilities of the medium have yet to be defined. The virtual elements alone were described as being more or less amenable to craft practices depending on the maker's desire for a 'definitive' versus 'impressionistic' narrative. Traditional makers begin making through nascent, vague ideas that are filled in through feedback from material interactions, and subsequently deny virtual elements are able to contribute to this physical narrative. Other makers who highlighted social contexts that shape an object's narrative, however, open up room for virtual elements to contribute with supplementary information, which may also be more or less definitive/impressionistic. Only one participant fully endorsed personal recordings as narrative inherent, which suggests that while personal recordings may enhance an object (e.g. the Spyn toolkit [35, 36], these additions have yet to be considered the narrative of the object itself.

6 Future Work

As the purpose of this research is to lay the groundwork for further work into AR craft in a critical making framework, there are many fruitful directions for future work. First, it would be beneficial to investigate making processes through collaborative workshops with craft makers and AR practitioners building (functioning or non-functioning) AR craft prototypes (e.g. [22]). A shortcoming of this study is the interviewees lack of making experience with AR technologies. While the reflections on their own making processes is useful as conceptual analysis, a next step is assessing how these conceptions can be expressed, or fall short of being expressed, in AR craft objects made by makers themselves.

Second, the second study can be expanded to include additional exploratory prototypes, as well as add participants from other craft making contexts. Additional prototypes could attempt to instantiate different levels of 'defined' narrative - for instance, personal audio recordings, impressionistic hand-recordings, virtual 'craft simulations' (e.g. [14]), and other methods of preserving cultural heritage [16,21,30] - and have makers further reflect on their role in contributing to the craft objects narrative.

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