ABSTRACT
This paper discusses a theoretical approach and method of making in computational design and construction. The project examines digital and analogue building practices through a social anthropological and STS lens to better understand the use of technology in complex making environments. We position this with respect to contemporary investigations of materials in architecture which use physical and virtual prototyping and collaborative building. Our investigation extends this work by parsing complex making through ethnographic analysis. In doing so we seek to recalibrate computational design methods which privilege rote execution of digital form. This inquiry challenges ideas of agency and intention as ‘enabled’ by new technologies or materials. Rather, we investigate the troubling (as well as extension) of explicit designer intentions by the tacit intentions of technologies. Our approach is a trans-disciplinary investigation synthesizing architectural making and ethnographic analysis. We draw on humanistic and social science theories which examine activities of human-technology exchange and architectural practices of algorithmic design and fabrication. We investigate experimental design processes through prototyping architectural components and assemblies. These activities are examined by collecting data on human-technology interactions through field notes, journals, sketches, and video recordings. Our goal is to foster (and acknowledge) more complex, socially constructed methods of design and fabrication. This work in progress, using a cement composite fabric, is a preliminary study for a larger project looking at complex making in coordination with public engagement.
INTRODUCTION

Background

“Lap, Twist, Knot” (Figure 1) is set in an experimental making context at the Dalhousie University School of Architecture in Halifax, Nova Scotia. Our study tests the potentials of new fiber and textile-based architectural materials through a collaborative and craft-based approach to socio-material inquiry. Recent scholarship in digital design and fabrication has developed attention towards algorithmic form in fiber arts practices (Ahlquist 2015; Sabin 2013; Zwierzycki, Vestartas, Heinrich, Ayres 2017) and collective building (Nicholas, Stasiuk, Schork 2014; Vasey, Grossman, Kerrick, Nagy 2016). Our work adopts similar material and methodological interests – including algorithmic design and fabrication - but we extend the scope and implications of the research through our consideration of digital practice and collaborative making from social-anthropological and STS (Science and Technology Studies) perspectives. Methodologically, we employ architectural processes of digital and analogue design including material testing, scale modeling, full scale building, parametric simulation, digital modeling, and photogrammetry; and social anthropological methods of video recording and field notes.

The work in progress pilots a trans-disciplinary research partnership that includes a Research-Creation team producing architectural works, and an Insight team conducting ethnography. These teams are led by the primary investigator, James, a researcher in architecture, along with three student research assistants: Aziza, Liam, and Ryan. The Insight team also includes Claire, a socio-cultural anthropologist and material culture studies scholar at the University of Nebraska-Lincoln.

Theory of Design

Our research methods interrogate Lambros Malafouris’ concept of the ‘extended intentional state’ (Malafouris 2010) and its applicability to digital design and fabrication. Malafouris’ theory challenges traditional theories of design which presume the origin of a design as a mental image (arising in the mind of the designer), subsequently imposed on inert material substance. Instead, he offers the example of the symmetrically-shaped Acheulean handaxe and insists that the idea of symmetry did not occur as a mental image before the first chiseling of stone. Rather, it emerged during a process of thinking with and through a “hammer stone” and “core” (Figure 2).

Malafouris discusses how the hammer stone does not simply execute explicit instructions or provide explicit feedback. Instead, it works in concert with the handler’s tacit intentions while also exercising its own tacit intentionality.

To further parse the notion of intentionality in tools and technology, we find Don Ihde’s Technics and Praxis useful (Ihde 1979). He introduces two fundamental relationships between humans and technology. Embodiment relations (such as wearing a pair of glasses) which couple human action and technology: enabling us to “reach out” into the world.

(human-technology) --> world

And Hermeneutic relations (such as a thermometer) that couple phenomena and technology: allowing us to “register” or interpret the world.

human --> (technology-world)

Like the hammer stone, these technologies radically limit (or editorialize) the data they provide. Glasses exclude

2. The knapper first thinks through, with and about the stone in an 'extended intentional state.'

peripheral vision. Thermometers give only numeric or visual information. These kind of limitations – these tacit intentionalities - augment or otherwise impact explicit decisions in digital design and construction contexts. Our hypothesis is that digital design and fabrication outcomes are a result of not only explicit designer intent, but occur alongside moments of grappling with tools and materials and their various intentionalities in addition to tacit individual and collective decisions.

METHODS
To investigate this hypothesis we conducted a five-day reflexive building experiment: designing and building an architectural component, and recording and reflecting on our activities as we did so.

Research-Creation Methods
This experiment furthered earlier investigations of a novel cement composite - Fabric Reinforced Cementitious Matrix (FRCM) (Figure 3). This material is initially flexible and malleable and then cures to a hardened form. It is typically used as a repair material and this work in progress sought to better understand its application for constructing stand-alone building components and assemblies. The investigation culminated with the erection of a full-scale prototype (Figure 4) derived from earlier maquettes (Figure 5) of the fiber composite and a digital parametric model (Figure 6).

The final physical prototype uses an economical FRCM substitute using quick set grout and adhesive and is computed by repetitive patterned movement inspired by the maypole folk dance (Figure 7). The braiding of the maypole is a kind of algorithmic making. Our adaptation explored the morphology of large scale laps, twists (or hitches) and knots (Figure 8). A lap is a slip connection derived from braiding. A twist, or hitch, is borrowed from the fiber art of macramé and forms adjustable, nodal connections to provide robust control over object morphology. And the knot - a clove hitch - tightens as tension is applied to establish fixed points in the form.

Insight Methods
Each day started with discussion among the team members which covered the day ahead, previous activities, and topics related to the study. After working on tasks developing the final prototype, which were video recorded, we engaged in a period of written reflection. Claire joined the activities through video conferencing, and collaborated on interpretation of the data in the post-construction phase: itself a collaborative process of intellectual making.

The work in progress piloted methods of auto-ethnography for future building experiments. Auto-ethnography involves the simultaneous creation and collection of data on social and cultural experience, as well as participation.
in its analysis (Ellis 2010). The concept underpinning this practice is that anthropological knowledge and research is performed and constructed by subjects as ethnographers, as much as by expert anthropologists.

RESULTS

Literal and Critical Readings

In reviewing the data, we consider Ihde’s discussion of the translation of intention through media in hermeneutic relations. As an analogue to scientists’ reading of instruments, Ihde describes the process of interpreting text through a tape recorded reading. In this analogy, rather than reading text (or hearing it directly), the text interpreted through a tape recording is transformed by coughs, paper shuffling, and other peripheral noise. Through this noise, Ihde observes, the meaning of the text is obscured. In reading scientific instruments, Ihde claims, the uncalibrated eye can conflate the noise and signal, losing the meaning of the text. Distinguishing between literal and critical readings, Ihde notes that literal readings take media at face value and mistake noise as a part of signal. Critical readings, however, are calibrated; parsing this overlap.

As designers we develop literacy around design instruments (technology and design media such as sketches, renderings, site plans, etc.) and learn to parse noise from signal. This is especially evident in architectural education contexts. But like Malafouris’s knapper, this calibration is not immediate. It occurs in an extended intentional state of ongoing engagement with the media and instruments themselves, as well as engagements with peers, instructors, and critics.

Transcriptions

The activities of “Lap, Twist, Knot” were a process of calibration in order to better understand the potentialities of the algorithm we would use for making. In Liam’s words we were developing criteria for “the evaluation of the inputs and the selection... of the outcomes...” Below we review selected transcriptions around a concern about inputs: the ratio of people to ropes in the final constructions. The maypole folk dance traditionally brings together a community and allocates one person per strand of rope. In our experiment, however, we used three to four people for six ropes. Some of the rationales for and impacts of this decision are discussed below.

Day 1

The first day introduced the Research Creation team to the method developed by Amber, a previous research assistant. Aziza described this, as well as some tacit influences on the final structure (previous models, length of material), in her reflection that day: “…we learned how to... create a helical structure inspired by Maypole dance patterns by watching [a] video... The technique then was tested using different amounts of ropes (3 and 4 pairs), finally deciding on using 6 pairs of ropes for the final structure. The decision was informed by previously constructed scale models and the length of the material in possession.”

Day 2

During the second day we rehearsed building at full scale. In addressing the mismatch ratio of people to ropes, Ryan and Aziza demonstrated here the benefits of an evenly matched ratio: no cleats, tight twists, and stronger form.
1:56:41 J - We need six people to do what?
1:56:42 R - If we had six people we wouldn't need to use the cleats and everyone would just have their own rope.
1:56:47 A - Yeah, and this [pointing to loose rope] wouldn't happen.
1:56:48 J - Oh, you don’t think that would happen?
1:56:51 A - No, because you are pulling tight.

In this instance, Ryan and Aziza are speaking from the position of an embodiment relation. Their bodies have previously coupled with the ropes to receive feedback from the process. This confers an authority and conviction to their actions and statements. As a result we revisited our earlier decision and weighed the uncertainties of time, materials, and personnel against this person-to-rope mismatch. Our final work-around maintained a six-rope build, but focused on a coordination of roles during construction.

Day 3

However, in an independent process of calibration, Aziza continued to reflect on this work-around in a critical hermeneutic reading of the design media (videos, dance, rope, bodies) that she had so far observed.

“I question the efficiency of the 3 person choreography... it deviates from the idea of a maypole dance... It would be more efficient to have 6 people participate in the making of the sculpture - each person assigned a rope... This... will reduce...the length of [time for] making the sculpture.”

These transcriptions depict the conflict between a literal reading of form (previous maquettes, digital models) and tacit constraints (material and personnel) versus the benefits of a critical matching of inputs. Although we established a choreography for this build, it was not an adaptable or elegant one. It was a work-around, not a method. This has established principles for future experiments; in particular a priority to match participants to ropes.

CONCLUSION
Discussion
The transcription reveals collective and individual voices working to critically rather than literally read design studies of digital models, physical maquettes, videos, and full scale mock-ups. Although this calibration is paired with instruments, it also occurs in a larger community of actors: materials, tools, people, and environments collaborative and competing with explicit and tacit intentionalities. Ryan and Aziza’s words and gestures while building, and Liam and Aziza’s writing, reflect insights gleaned through a messy, tangled process of call-and-response between human, material, environmental and technological actors. Malafouris’s model omits this larger social context in his example of the stone knapper: For instance, the likely existence of other knappers along with cultural traditions of learning or sharing practical knowledge about stone and how to work it. Moreover, the axe and its design must be considered in light of the entire lifeworld of hunters, gatherers, meat cutters, etc. This suggests broader and more inclusive models of intentionality exchange, the exchange of concepts or ideas through multiple means, and the expression of intention or its emergence across many spectra.

Future
Over the next two years we will carry out a series of reflexive building experiments in public space. Each experiment will build successively on the previous to refine our techniques of auto-ethnography, our methods of collaborative building, and our ongoing calibration around the methods and media of computational design and construction. As we refine methods of building and recording, we will also begin to include public audiences in our process. This will then consider the full spectrum of the community of actors with investments in architectural production: including public, non-expert audiences and participants. Our explicit intention is that this approach may yield methods of critical reading of design media, critical use of new technologies, and instruments for making that are socially as well as technologically situated.

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IMAGE CREDITS
Figure 2: Malafouris 2010, fig. 1.3; redrawn from Stout & Chaminade, fig. 1.
Figure 7: Lincoln 1907, p 23.
Figure 8: Andres 1973, p 153 & 155
All other drawings and images by the authors and project team.

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