# ENABLING NEW VOICES THROUGH MARK MAKING AND PERSONAL CONNECTION IN DIGITAL KNITWEAR PRACTICES

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**Abstract**

How do digital modes of knit design extend and enhance opportunities for new voices and expression to be captured in contemporary knitted textiles?

The process of designing and programming within a digital knit environment leans towards a technical framework of garment production, restricted in design possibilities due to the complexities of programming and machine parameters. This framework is riddled with limitations and presents as method for designing around established constraints. Technician capability, commercial considerations, and limited access to equipment and expertise further reduce the opportunity for diverse aesthetic and expression. The result is seen in the predominant output of industrial knit design as standardised silhouettes, patterns and stitch structures.

While the authors recognise the validity of such limitations, this paper addresses some of the perceived challenges by demonstrating the opportunities that exist within existing technological parameters. This research, conducted on Shima Seiki digital knit technologies at AUT University's Textile and Design Laboratory focussed on methods of design that begin, and remain, outside of the technology's digital design system. Templates and methods for engaging with the technology through widely available design software are established, allowing for a diverse range of aesthetic expression to be captured within industrial knitwear production. Value is placed on gesture, expression and storytelling as means of bypassing expected knitwear-based outcomes. In contrast to the common compromise of design translations with industrial technologies, creative control remains with the practitioner retaining original artistic outcomes and meaning within the knitted textile.

Discussions within this paper intend to communicate the intrinsic value of textile materials as expressive vehicles for wider meaning and expression.

There is a deep history of knitted textiles as a major component of many individual and group artist and designer practices, particularly the role knitwear has played in feminist and queer activism. Traditionally, voices heard through knit-based art reflect domestic, hand-made, and craft-oriented material processes. This research adds to this history through encouraging access for practitioners outside of fashion and textile disciplines to utilise emerging technologies for their own practice—overcoming the constrain of personal connection or technical knowledge in the material process of developing knitwear.

Adapting methods of knitted textile and knitwear design broadens access to advanced knit technologies allowing for diversity of voices in knitwear production. The simplification of technical processes and growing understanding of retaining the maker's touch in knitted textiles presents a research avenue that focuses on increasing access to all, and challenges limitations of digitally knitted textiles.

## Introduction

Across craft practices and mediums, digital technologies have been seen to challenge collaboration between technology and human expression and identity. As technologies are introduced, specialised programming and unfamiliar machine processes often require additional skills or new expertise. While these conditions also exist in the digital knit environment, there are additional complexities arising from the industrial nature of the technology and the resulting economic limitations of manufacturing. Hand-knitted textiles continue to evoke notions of a widely accessible handicraft process embedded with personal meaning and community expression. This is contrasted against the highly industrial, standardised and technical outcomes of contemporary knitwear production.

The paper begins by discussing how the digitisation of knit design and manufacturing processes has limited human interaction with the digital knit medium. Factors that impact access into the digital field are introduced, including the narrowly focused, intended proficiency within traditional pathways of industry apprenticeship models or degree-level academic courses. Alongside this, there is limited demonstration of the technologies extensive capability, such that variable methods of teaching and delivery across universities and industry often lead to uncertainty around digital knits parameters and possibilities.

As a result, there has been limited room for the breadth of expression and engagement in digital knit, that we see in hand and domestic knit mediums. In the knowledge that digital knit technologies and their associated software afford a diverse range of design possibilities and expressions, this research considers how a broader range of practitioners can engage with digitally knitted cloth as a medium to express their self or community worldview.

The need for alternative pathways for engaging with digital knit is further reinforced by consideration of the evolving digital knit landscape in which knitted textiles are increasingly being explored and applied in new disciplines and applications. Moreover, understanding the role of knitted outputs in contemporary culture highlights an ongoing obligation for academic

consideration, and the opportunity to examine how knitting remains relevant as both an industrial / commercial and personal / domestic mode of making art and design objects.

Research contained within the following text emerges from a team practice in response to a need to re-engage students returning to campus post-COVID and the opportunity this provided to connect more broadly across disciplines at AUT University (AUT). Students have access to four Shima Seiki knit technologies at the university's Textile and Design Laboratory, each with different knit specialisations and six Apex design systems. The paper discusses the principles considered in developing new resources and learning paths and details phases of development alongside the key learnings at each phase. It concludes with a discussion as to how approaches documented within the paper create a more inclusive learning environment for practitioners outside of specialised knit or textile practices; increasing access to digital knitting tools and increasing diversity of voices in the field.

## Literature Review

### *Loss of expression in digitised knitting*

Digital knitting technology has evolved with the aim of optimising speed, efficiency and rates of production (Chandra, 2022). As such, the technologies have primarily been adopted in industrial knitwear production, and by the occasional educational institute. These sophisticated textile technologies come at a high financial cost, with control of the technology contained within a closed format, proprietary software. Commercial knitwear manufacturers have broad access to knitting technology but are restricted by commercial goals which limit design experimentation and economically unviable areas of research. Experimental advances in this area are of less importance than efficient production, and opportunities for designers to test new or unique design concepts are narrow.

Pathways for learning in the digital knitting context are primarily aimed at high-level proficiency applied to fashion or interior disciplines. Whether through an apprenticeship model or a degree path in academia, years of learning are required to comprehensively understand the design system and machine operation. In these instances, access to technology becomes key to the extent of the learning, and subsequently, the breadth of design outcomes.

Within academia, knit technology has traditionally been positioned within a degree pathway, with the expectation that students engage in consecutive years of practice to establish an expertise in a specialised area or application of the medium. Academic theses related to knitting can be complex and highly detailed. Rather than simplifying a process, it tends to reflect the specialised nature of its inception; mainly the writer communicates in the same method of their learning—repeating ideas, language and terminology specific to knitwear training. Learning outcomes based on knit-related resources becomes dependent on the level of existing training of the reader, potentially excluding many researchers from efficiently gaining knowledge at all.

More recently, there has been an adoption of technology by businesses outside of knitwear, or interdisciplinary groups within academic institutes,[1] largely driven by increased awareness of the advanced textile fabrication capabilities of the technology. In such cases, performance-related aspects tend to be prioritised with the development of technical fabrics or outcomes in applications such as footwear, biotech, or wearable e-textiles rather than visual design, art or expressive outcomes.

Mechanical knitting is also seen to limit expression as the role of maker (technician) and designer have become separated (Taylor, 2015), and the distance between hand and technology in the making of textiles has come to reflect divides between craft outputs and industry production (Smelik, 2018). As a result, historically social and communal textile activities are replaced by technicians and technology—restricting wider artist and designer involvement with the medium and limiting the communality of the practice (Montagna and Santos, 2017, p. 219).

## Existing Opportunities for Expression in Digitally Designed Knitting

Despite the technical differences between hand versus machine-made, there is a shared experience in all knitting processes through the containment of an individual's creative voice whether it be art, fashion or other knitted products. This is shown by a range of creative expressions within student work at AUT University. Notably, postgraduate students have demonstrated the application of digital knit as a medium in outcomes that would not be possible in hand-knit practices. For example, Figure 1 shows work produced by Finn Godbolt, in which new programming techniques combine external software and proprietary knitting software to extend typical possibilities for knitted jacquards.

[1] For example, Knitwear Lab (https://knitwearlab.nl/) and the Faculty of Design, Architecture and Building at UTS, Australia.

Figure 1. Knitted jacquard displaying enhanced possibilities for image translation into knit.

Such work exemplifies the emergence of experimental thinking and making processes enabled in educational settings, especially at a postgraduate level, as a result of unrestrained access, no commercial constraints and a degree of proficiency in a narrow area of specialisation.

For example, addressing a perceived constraint in digitally knitting textiles, in this case limitation of colours, enhanced opportunities for translation of complex imagery into knitted materials (Godbolt, 2018). This extends possibilities for artists to embed gesture, nuance, multiple colours and therefore unrestricted expression and individual voice within a knitted textile. Though developed by a specialised programmer, resulting processes utilise Adobe software to predesign knitted outcomes before knit programming commences—increasing accessibility to wider audiences and enhancing design opportunities for practitioners. This also allows designers more control over the visual outcome, reducing the potential for compromise at the technical programming stage.

Outside of the academic context are a small number of industry developments which further highlight the opportunity for digital knit to act as a medium for personal expression. These businesses challenge the historical limitations around access to advanced knit technologies and their standardised outcomes through alternative pathways of engagement and differing levels of customisation.

*Unmade* was an early player in this area (Figure 2), launching software that supported on-demand manufacturing by allowing a user to customise placement and colours of a library of designs on a range of knitwear silhouettes (https://www.unmade.com/).

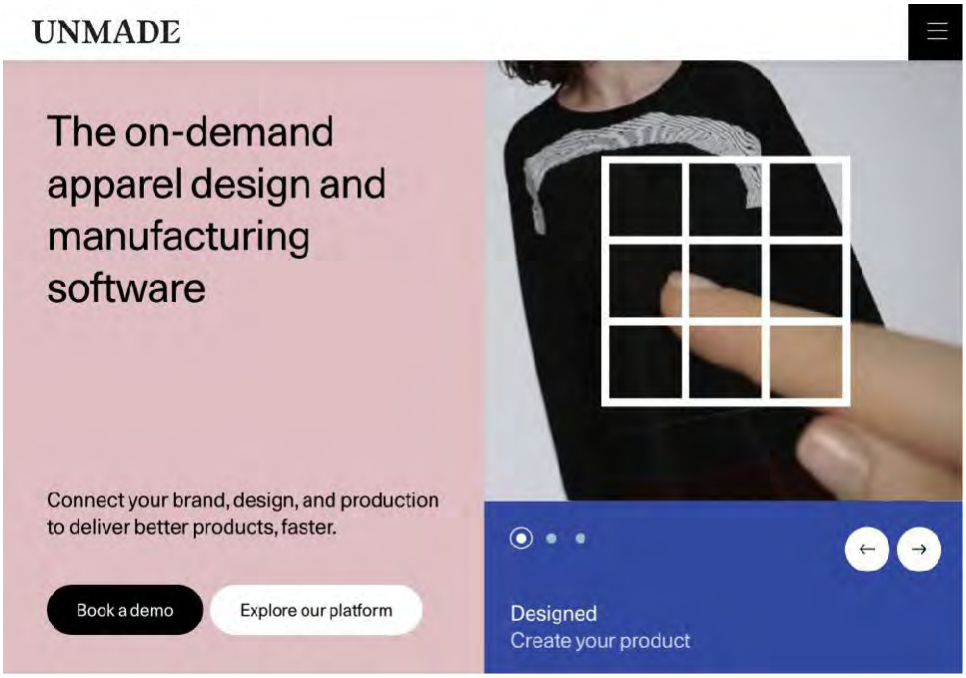


Figure 2. Unmade online platform for custom designed knitwear.

A significant extension of this concept is seen within the recently launched *Knitup* (https://home.knitup.io/) which acts as an intermediary between designer and manufacturer. This is achieved through an innovative digital design platform which allows users to design their own garments with customisable features. The user-friendly platform (Figure 3) offers a broader range of knitwear and product silhouettes than is contained within the technology's own software, alongside extensive stitch and yarn libraries. Of interest is embedding one's own visual or graphic designs onto the knit form (Figure 4). With no minimum order quantity, this model provides access to innovative digital knit capability without the need for any knit or textiles knowledge—allowing for an unprecedented breadth of practitioner engagement while retaining a significant level of creative freedom.


Figure 3. Knitup online platform for custom designed knitwear.

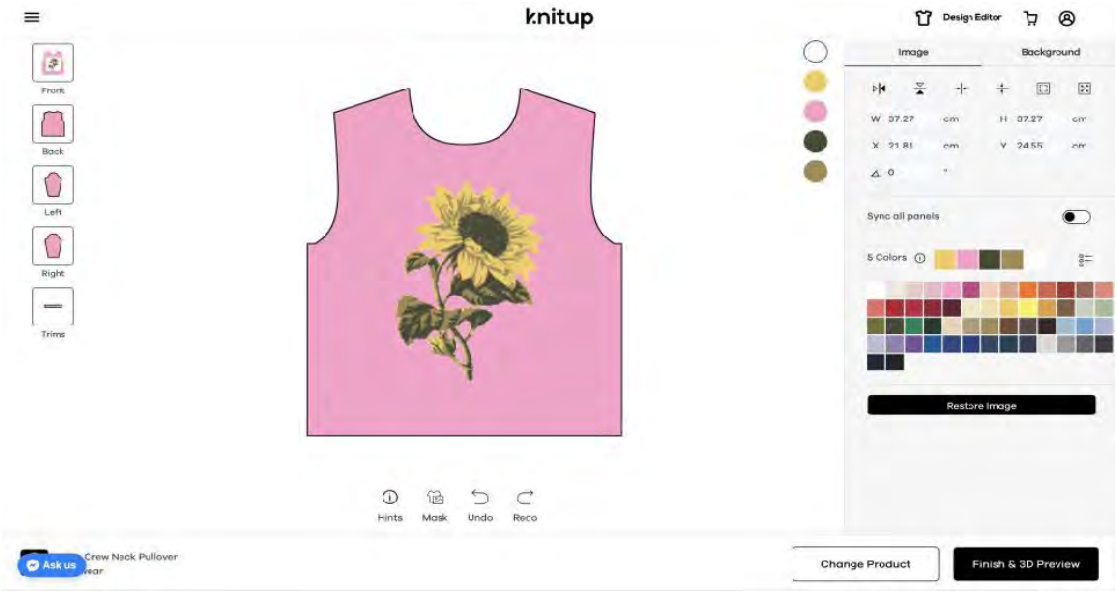


Figure 4. Custom design interface for Knitup.

Both *Unmade* and *Knitup* provide broader access and expression through new software that sits alongside existing technologies. In contrast, *Kniterate* is a UK-based company offering an affordable and compact version of industrial knitting machines for domestic use. *Kniterate* machines are mechanically powered with a digital interface and can shape, cast-on and cast-off, knit a range of structures and can translate different coloured designs within a jacquard material—all major components of the much larger industrial knitting machines. While *Kniterate* machines lack the three-dimensional (3-D) seamless knitwear capabilities of industrial machines, they offer many features of relevance to small scale artists and designers who use knitted textiles within their practice. This is achieved at a significantly lower cost than industrial knitting machines and without the need for a dedicated technician.

These examples show the opportunity to extend the expression, art and activism of hand knit into the digital context and broaden the diversity of voices within this community through new pathways.

A notable display of multi-skill-level technological frameworks of learning and making can be seen in 3-D printing resources. The technology is supported by a range of contributors who create resources and tutorials for open-access availability in platforms such as YouTube and online educational platforms such as *Lynda.com*. Though 3-D printing equipment is more widely available and affordable than digital knitting, the skillset to achieve complex outcomes requires practice and training. Entry level design concepts and personal expression are possible for all users, from new to experienced practitioners. High-quality, technical design is afforded to those who continue to experiment and train in the area.

This research stems from a shared belief that knitwear technologies could follow the same pathway of offering accessible technology for practitioners with varied skill levels. As such, the approaches presented in this paper suggest a model of engagement and expression focused on connecting to the medium and what it offers, rather than being a proficient knit designer.

## Methodology

### *Pathways for enhanced engagement to digital knit mediums*

In recent years, a changing landscape of technology and design has led to the use of digital knitting for a wide range of non-garment applications. Notably, an increased presence of knitted textiles in engineering, architecture, spatial design, industrial design and health science displays a deviation from conventional fashion and textile-related projects. Applications in these areas often utilise the unique characteristics of knitted materials to extend the functional capacities of outcomes. While these areas prioritise experimental, performance-enhancing design, they sometimes combine this with expressive design aesthetics within their forms. Alongside the intention of increasing the visibility of diverse voices and expressions in knitted textiles, engaging practitioners from different disciplines requires expanding accessibility to technologies and processes to non-specialised makers.

This research recognizes the need for training and educating proficient knit experts. However, it suggests alternative pathways are also necessary to respond to an evolving digital knit landscape and to accommodate a broader range of engagement and outcomes. In this endeavour, the research is intended as a model of broader interdisciplinary teaching, where outcomes are not assumed or siloed into traditional discipline boundaries. Further, alternative forms of delivery are considered to accommodate a diversity of backgrounds and learning styles ranging from visual learners, artists and makers to engineers, programmers and digital designers.

A key aspect of this shift was consideration for the diversity in background knowledge and learning styles across a broader range of students and disciplines. The intention was to be open to a broad range of voices and applications, but without having expertise in the student's

discipline or potential application areas, the best way to provide this effectively was unknown. As Ambrose et al. (2010) noted in their research on the principles of smart teaching, it is important to understand how learners process what we teach them. The principles referenced within this text were also considered throughout the development.

Of note, this research and the development of resources were conducted by a team of four AUT University staff members. All team members had postgraduate qualifications in the area of knitted textiles, though they had come through the degree path at different times and had differing areas of specialization. The decision to develop the resources as a team rather than it being the responsibility of an individual was made for several reasons. With different pathways, specializations, teaching experience and design interests, it was considered beneficial to find a language and understanding that was common to all while keeping in mind the tacit understanding and discipline-specific terminology that needed to be articulated for new learners.

Further, this allowed for resources to be reviewed and tested across the team as they were initially developed. As phases of testing progressed the decision was also made to rotate the delivery of modules so that team members had the opportunity to gain an understanding around how each module was being received rather than this falling on one individual to interpret and respond to. This allowed for further discussions as a group, as to the outcomes of each session and how the findings at each phase should be further developed.

## Findings and Analysis

Delivering the new resources through a series of consecutive workshops helped to measure the ease and effectiveness of new teaching content. Designed to increase efficient teaching time and encourage quicker machine access, resources helped to expand the number of knitted outputs by embracing a social, group-led learning environment in conjunction with one-on-one teaching.

Traditional lecture-based teaching was replaced by in-person walk-throughs of software and resources that offer user-friendly, visual step-by-step instructions. As opposed to methodical, specialised paper-led teaching approaches, workshops were intended to act in a more creative and relatable capacity to foster interest and excitement around digital knitting processes.

Tables 1 to 3 outline the development of resources and key learnings at each phase of development.

Developing these resources is an ongoing process. Ease of teaching and effectiveness of outcomes are analysed from workshop feedback and resources are updated accordingly. As the team continues to provide workshops to varied disciplines, resource materials are revised to include adaptive terminologies for wider areas of study and application.

***Phase 1: Initial workshops***

The first workshops were delivered as students returned to campus after a year and a half of online learning due to COVID restrictions. The team were aware that most participants would have had no previous exposure to digital knitting, nor the opportunity to be working hands-on with new technologies for some time. Key findings in this phase included the need for shorter, sharper sessions with tangible rewards (knitted swatches or simulations) at each session. Also, of significance was the room to be more open and less prescribed with intended outcomes and to tailor the resources as such.

| | |
|---|---|
| Format and Participants | • Four workshops: each targeted at a different outcome – jacquard design, Whole Garment, e-textile, and tubular form.<br>• Delivered over four 2-hour sessions, with a session each week.<br>• Voluntary sign up of 20 students across the four workshops.<br>• Targeted disciplines with researcher assumptions on interest in outcomes.<br>• Attended by a range of levels from undergraduate to PhD.<br>• Disciplines of students included visual arts, fashion, creative technologies, electrical engineering, and industrial design. |
| Key Findings | • A 'Basic Setup' module is needed to introduce fundamental terminologies and provide a starting point for following specific technique modules. |
| | • Screenshots from software, specifically with highlighted information, are key for effective visual learning.<br>• Less emphasis on outcome, more focus on experimentation.<br>• Teaching may still be too long, detailed and specific. Future workshops should be divided more clearly into module phases.<br>• Quickly engage students with sampling processes and bypass unnecessary content. |

Table 1. Testing initial resources.

***Phase 2: Student studio workshops***

In this second phase, the team worked with lecturers to consider how similar workshops could be integrated or introduced within scheduled studio sessions. In some cases, one of the team attended studio classes to give a short introduction to the technology, and students attended sessions voluntarily. In other cases, students were expected to attend an introductory session as part of a scheduled class and could then choose to attend additional sessions in their own time. The intention was to allow scheduled time to introduce the technology, and once engaged, students could choose their own pathways.

Teaching resources were adapted from previous workshops to develop a modular resource system that allowed for shorter, independent sessions and to accommodate cross-disciplinary learning practices. Further, a modular system assists in teaching smaller sections of technical specific information while bypassing broader context that may hinder learning outcomes. In this way, a learner is provided a sense of 'mastery' with each module.

Modules for this phase were also more clearly defined in terms of content, but left more open ended in terms of potential outcomes or applications.

Students were introduced to the basic swatch setup content before choosing further detailed sessions depending on their interests. For example, all students regardless of discipline or background left the first session with a knitted swatch of their chosen stitch structure. The following sessions allowed for narrowing in on a specific application such as jacquard, shaping, garment, tubes, e-textiles and so on, giving each student opportunities for using acquired skills within their wider studio-based projects and graduate collections (Figure 5).

Key findings in this phase reinforced a broad interest in the machine process and engaging with the physical aspects of the fabrication, alongside the digital. The need for more samples to demonstrate possibilities and techniques for haptic learning was also noted.

| | |
|---|---|
| Format and Participants | • Multiple workshops throughout the semester.<br>• No targeted outcomes –all students take introductory course and then engage with further modules based on interest.<br>• Delivered as one 2-hour session with additional modules of a similar time.<br>• Attended by approximately 100 undergraduate level students.<br>• Attended by a range of disciplines with significantly increased engagement from industrial design, creative technologies and fashion.<br>• The team were unable to introduce the technology to arts and engineering students. There was a small amount of self-directed engagement but not enough to assess effectiveness of resources in these areas. |
| Key Findings | • Physical swatches and garment samples are needed to increase the opportunity for haptic learning.<br>• A wider range of stitch structure samples are needed to quickly understand the aesthetic and functional characteristics these introduce to knitted cloth.<br>• Limiting the range of yarns in workshop sessions for efficient sampling and quality control.<br>• Limiting session numbers so that each student has access to a design system and can follow resource modules step by step independently.<br>• Demonstrate potential of non-proprietary software (Adobe Photoshop and Illustrator) to be incorporated into the design process enabling engagement outside of lab hours. |

Table 2. Testing student workshops.


Figure 5. Student logo design embedded in jacquard knit.

***Phase 3: External client workshop***

In contrast to the workshop sessions' format, external client workshops involve intensive two-day delivery with a maximum of four participants. In this case, the workshop was focussed on developing a jacquard design using a small range of colours. Participants came from a range of backgrounds and experience, including two academics from different institutions with backgrounds in Te Ao Māori practices and sustainable textiles, and two undergraduate students from visual arts and graphic design courses at external institutes.

Participants were given resources before the workshop to allow for preparation and experimentation in design software such as Adobe Photoshop. Further, participants were encouraged to bring existing design work, art, and concepts into the sessions to allow for individual forms of expression.

External workshops differed from student workshops as participants were less outcome-focussed and more experimental with haptic sampling and iterative cycles of making. Despite participants receiving the same preparation time, resource access, machine time and technical assistance, outcomes demonstrated varied design styles, size, colour combinations and stitch structures across the sample range (Figure 6).

| | |
|---|---|
| Format and Participants | • A 2-day workshop<br>• Four participants<br>• Delivered as a series of short modules throughout the two days<br>• No prescribed outcome.<br>• Opportunities for one-on-one training and self-directed experimentation. |
| Key Findings | • The module system works for interdisciplinary teaching where participants may come from a range of backgrounds and with different levels of digital design skills<br>• Encouraging Adobe knowledge as a tool for processing designs outside of workshops. This helped reinforce the importance of knitting gauge and resolution of images while helping participants retain creative control of translating non-knit imagery into knitted textiles.<br>• Diversity of voices demonstrated within the outcomes; each participant was able to embed a strong connection/story into knitted cloth.<br>• Offering a limited range of materials helped to streamline teaching and decrease machine variables that hinder sampling processes.<br>• Feedback from participants included satisfaction with the number of tangible knitted outcomes, a comprehensive introduction to the software and machine technology, and the desire to further utilise knitting technology in their respective disciplines. |

Table 3. Testing external client workshops.


Figure 6. Various knitted samples made by external workshop participants.

As a result of these three phases of workshops, the Textile and Design Laboratory witnessed a significant increase in student engagement, with student-led knit projects far surpassing previous years' outputs.

## Discussion

This research asserts that digital knit technology is a vehicle for creativity and design, as well as commercial production. Strategies were formed for inclusive, interdisciplinary access to the technology, and resources were developed and tested to support new pathways for engagement. New workshop resources were intended to bypass unnecessary and specialised content to increase a wider understanding of knit processes and allow each student to develop an outcome in a short timeframe.

Overall, key findings from the three phases of workshops included:

- Resources should be summative, visual, and easy to digest.
- Essential knit-based terminology introduced prior to workshops supports greater learning outcomes.

- Engagement increases when students can produce a physical outcome in a quick timeframe.
- Non-proprietary software terminology (for example, Adobe Suite tools) used in conjunction with knit terminology allows for knit constraints to be understood using broadly accessible and familiar language.

The team found that many practitioners require immediate results in the form of physical samples, virtual simulations, or tangible swatches. Breaking down the learning into smaller modules with outcomes at each phase allowed for moments of 'mastery,' and excitement, which in turn motivated students to attend further sessions. In addition, as opposed to the model of engagement with *Knitup* outlined previously, whereby physical connection to the making is entirely removed, the team found that students were keen to engage with the physical machine-making process. Incorporating time to engage with the machine set-up was seen to support students who preferred a hands-on approach to learning as well as forming a stronger connection between the student and their outcome.

The next phase of development considers the need for integrating contemporary teaching methodologies into existing resource content. Moore (2014) proposes the use of video content, step-by-step visual instruction, and mobile phone-accessible resources for the 'digital native' learner who prefers the use of interactive and digital tools in learning processes. Further resources are needed to demonstrate and visually explain variables of knit outcomes. An essential element of this is an extensive physical swatch and sample library for tangible, example-based resources. A focus on student / participant needs and varied ways of learning is informing the continuing development of resource content; the intention being to provide instructional and informative resources and teaching while not being prescriptive in order to encourage a breadth of expression and outcomes.

## Conclusion

The current digital knitting environment is advanced and complex, with a field of practice that has been occupied by proficiently trained and standardized knitting experts. However, it also offers opportunities for varied and expressive engagement by non-expert practitioners. To broaden accessibility and outcomes, there is a need for alternative methods of teaching that bypass the preconceived complexity without reducing the potential for experimentation and expression.

New resources developed in this research are intended to support engagement for budding practitioners across a broad range of disciples and backgrounds. Despite using the same resources across workshops, the adaptability of a modular resource framework helps focus on necessary content for the workshop participant.

After completing introductory workshops, students and clients specialised in one of the more focused knit project resources. By completing one or all resources, students gain immense levels of knowledge in an efficient and user-friendly method.

Methods of engagement using widely accessible software, such as Adobe Suite, are included within the resources. Such software can be used in conjunction with the technologies proprietary design system to further extend and enhance expression within the digital knitted medium.

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