Metaphors, mental models, and multiplicity: Understanding student perception of digital literacy

Jason Tham, Texas Tech University
Kenyan Degles Burnham, Texas Tech University
Daniel L. Hocutt, University of Richmond
Nupoor Ranade, North Carolina State University
John Misak, New York Institute of Technology
Ann Hill Duin, University of Minnesota
Isabel Pedersen, Ontario Tech University
Jessica Lynn Campbell, University of Central Florida

HIGHLIGHTS

- Current discussions frame metaphoric expressions as the prevalent resort for sensemaking; student responses reveal that mental models are more common as a reference when faced with an unfamiliar technology.
- Multiplying our approaches to digital literacy helps students recognize the digital tools they encounter as vibrant, creative, and expressive.
- Understanding of digital literacy requires a broad approach that takes into account the many experiences learners bring to their use of digital tools.

ABSTRACT

This study examines student perception of digital literacy from their engagement with the Fabric of Digital Life, a digital archive of emerging technologies. Through grounded theory analysis we identified the ways students make sense of an unfamiliar technology. Our results show students assign metaphors to understand a new digital platform, apply mental models transferred from previous conceptual domains onto new technologies, and express multiply-layered approaches that facilitated their digital literacy development—an indication for instructors to orient toward an expansive description of digital literacy that caters to student learning needs as well as their professional futures.

Keywords: Digital literacy, metaphors, mental models, digital pedagogy

INTRODUCTION

The digital literacy imperative is magnified by numerous events in the last few years that demanded greater technological competency, critical and ethical thinking, and sense of digital citizenship. From foreign state-backed hacking campaigns to fake news (and alternative facts) to corporate data breaches to a nationwide migration to online learning due to a global health crisis, we and our students have found ourselves in increasingly challenging moments that necessitate better focus and dedication to the development of digital literacy than we currently do. To this end, we are motivated to develop an understanding of digital literacy by the means of a multi-institutional collaboration. In this report, we examine the deployment of an emerging technologies database called Fabric of Digital Life (https://fabricofdigitallife.com; henceforth "Fabric") in four rhetoric and writing courses at three institutions. By paying attention to how students relate new technologies to cognitive frames like metaphors and mental models, this pilot study identifies the theoretical, pedagogical, and research implications of these conceptual references in the development of digital literacy.

To the computers-and-writing community, the digital literacy imperative is not a new exigency. Scholars who have been advocating for digital pedagogy or digitally enhanced instruction have been paying attention to the affordances, constraints, opportunities, and risks involved in the cultivation of students' digital literacy. As part of this effort, our field has generated a collection of definitions and conceptualizations of digital literacy. Of note is Gail Hawisher and Cindy Selfe's body of scholarship in computers and literacy studies. Former co-editors of *Computers and Composition*, Hawisher and Selfe are trailblazers who have set the course for a humanistic approach to considering how technology affects literacy in different contexts. Their early collections—*Critical Perspectives on Computers and Composition Instruction* (Hawisher & Selfe, 1989), *Literacy, Technology, and Society* (Hawisher & Selfe, 1997), and *Passions, Pedagogies, and 21st Century Technologies* (Hawisher & Selfe, 1999)—urged scholars to pay attention to the socio-technical milieu in which technology circulates within the classroom and beyond. Their latest work with Patrick Berry, *Transnational Literate Lives in Digital Times* (Berry, Hawisher, & Selfe, 2012), considered digital literacies (in plural form) in the context of our everyday lives and examines how digital media influence literate practices.

Across writing studies writ large, scholars have discussed digital literacy in terms of hypertext and cultural literacy (Tuman, 1992); information literacy (Clark, 1995), sociotechnological theories (Duin & Hansen, 1996), materiality of literacy (Haas, 1996), cyberliteracy (Gurak, 2001), technological literacy (Breuch, 2002; Hovde & Renguette, 2017), layered or multiliteracies (Cargile-Cook, 2002; Selber, 2004), "electracy" (Ulmer, 2003), and code/coding literacy (Vee, 2017; Duin & Tham, 2018; Byrd, 2020). It goes without saying, we have a plethora of digital literacy conceptualizations and definitions at our disposal.

In their European Union's DigEuLit project, Allen Martin and Jan Grudziecki (2006) defined digital literacy as the cultivation of "awareness, attitude and ability ... to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analyse and synthesize digital resources, construct new knowledge, create media expressions, and communicate with others, in the context of [this] specific life situation[s], in order to enable constructive social action; and to reflect upon this process" (p. 255). This definition provides a global description of digital literacy that focuses on the learner's development of knowledge, skills, and social sensitivity in dealing with digital communication. Focusing more specifically in the applied nature of digital literacy, Rachel Spilka (2010) in her edited volume

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

Digital Literacy for Technical Communication combined Selfe and Hawisher's (2002) and Breuch's (2002) definitions and defined digital literacy as:

> Theory and practice that focus on use of digital technology, including the ability to read, write, and communicate using digital technology, the ability to think critically about digital technology, and consideration of social, cultural, political, and educational values associated with those activities. (p. 8)

Nevertheless, Spilka (2010) noted the challenges and opportunities in the inconsistent ways digital literacy is defined: "There is no agreement in the literature about whether this (digital literacy)—or any other term—is most accurate in describing what now constitutes the goal of effective writing and communication in digital environments" (p. 6). More than a decade later, we still face a similar challenge, although the term "digital literacy" is by and large ubiquitous in our scholarly discourse. Given the ever-growing, ever-evolving nature of digital technologies, it remains daunting and confusing for students and instructors alike to understand what digital literacy encapsulates. As educators from a host of different institutions, we as authors of this article share a belief that it is necessary to gauge student perceptions and their ways of understanding digital literacy as we design and deploy pedagogical approaches that seek to promote the development of digital literacy. We see the potential in student narratives through their own frames of reference because, as Berry, Hawisher, and Selfe (2012) showed us, these narratives account for local perspectives, personal backgrounds, sociohistorical contexts, and embodied experiences. For this reason, we have taken upon ourselves a student-centered study of digital literacy definition as part of an intercontinental project.

In this article, we report a slice of our findings from the deployment of Fabric in rhetoric and writing courses, and present qualitative results on student perception of digital literacy from their engagement with the digital archive. We have employed student surveys and grounded theory analysis methodology to identify the ways students make sense of an unfamiliar technology. Our pilot study results show students assign metaphors to understand a new digital research platform, apply mental models transferred from previous conceptual domains onto new technologies, and express multiply-layered approaches that facilitate their digital literacy development. Based on these observations, we discuss strategies for leveraging students' perceptions and orienting toward an expansive description of digital literacy that caters to student learning needs as well as their professional futures.

LITERATURE REVIEW

Our project started prior to the COVID-19 pandemic. During the development of this study, however, colleges and universities were faced with a unique challenge that *The Chronicle of Higher Education* called, "The Great Online-Learning Experiment" (Zimmerman, 2020). As educational institutions were suddenly forced to shift their teaching and learning into online modalities due to this global crisis, the digital imperative in academia has become more evident than ever. As a result of this transition, many students faced challenges in accessing the resources needed to continue their education. With reduced infrastructural support such as campus libraries, reliable internet services, and other institutional support to course materials, the existing technological divide among students has further exacerbated and aggravated the disparity of an always-already non-neutral learning space. Over the course of our study, the rise of cultural movements to combat systemic violence and racial discrimination

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

has also prompted renewed vigor and scholarship into anti-racist rhetoric. As these movements fight against social injustice, we observe a growing need for antiracist pedagogies within digital literacy development. Academic institutions are challenged with questions of privilege, access, power, and positionality as they address the pressing problems of divide and discrimination: What tools should instructors and students use to maintain quality of instruction? How should new tools or technologies be introduced within a short window of time? What accommodations should instructors and college administrators consider? How might students react to change? What implementations serve to bridge or aggravate existing circumstances that widen inequality in access? These are legitimate and paramount questions that shed light onto the current importance of digital literacy in higher education.

As we investigate students' perception and methods of understanding new digital technology, we are conscientious about the rhetorical situation amid the unprecedented challenges facing students and instructors during the time of our writing, as well as the prior experiences that inform how different stakeholders navigate such uncertainty. Nevertheless, our exigence remains inspired by the need to understand, primarily, how students make sense of new digital encounters and learn to leverage technologies for their own growth. In the following literature synthesis section, we provide some theoretical models that have influenced our way of discerning the relationship between digital literacy and how it is constructed.

Frameworks of Digital Literacy

In studying the digitally literate practices employed by students, we have sought to avoid "the literacy myth" that Krista Bryson (2012) revealed in the narratives and structure of the Digital Archive of Literacy Narratives (DALN). The "literacy myth" is a belief that is particularly pervasive in the American society, "that literacy is a guarantor of success in all areas of life" (Bryson, 2012, p. 255), a positivist pitfall that Harvey J. Graff (1979/1991) originally observed. With this guiding principle, we examined a number of contemporary frameworks for describing and defining digital literacy. We first turned to work completed by Virginia Tech's Digital Literacy Task Force (DLTF), whose institutional exigency mirrors our motivations in this project.

In describing the DLTF process in developing an institution-specific framework for digital literacy, Julia Feerrar (2019) introduced the exigency as follows: "As digital technologies continue to influence teaching, learning and research, colleges and universities are developing and expanding digital literacy programs to ensure that students can not only use digital tools but also critically consume and create a variety of content" (p. 91). Focusing on the specific needs at Virginia Tech, the DLTF framework sought to address shortcomings in approaches that fail to address mastery of symbolic, persuasive, and emotional dimensions of digital media and instead focused on the mastery of information (see Buckingham, 2010). The DLTF framework places the learner in the center, critically engaging with and producing data, information, and media as they build seven core competencies toward digital literacy in five modes of activity (refer to Figure 1).

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

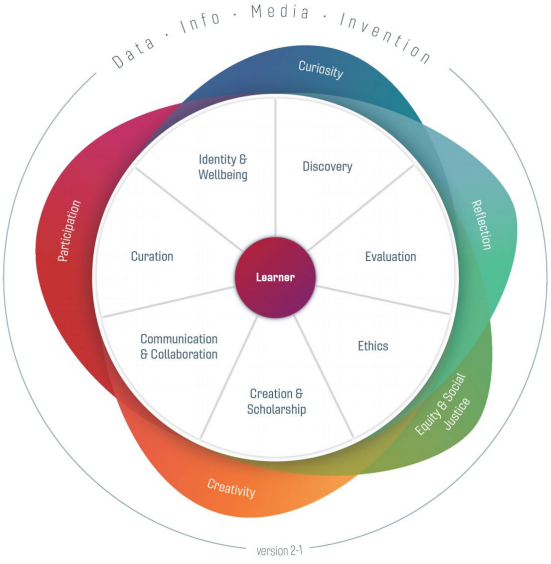


Figure 1. Framework for digital literacy at Virginia Tech, version 2-1. The visual shows how the learner interacts with seven core competencies, based on five value frames of activity, through the lenses afforded by data, information, media, invention and other emerging literacies. ("University Libraries launches digital literacy framework," 2018, p. 16).

The DLTF framework builds on existing models that we found useful, such as the Association of College and Research Libraries (ACRL, 2016) Framework for Information Literacy for Higher Education and the Joint Information Systems Committee's (JISC) (2015, 2019) Digital Capability Framework. Because the JISC framework is designed for wide applicability across many organizations, we gravitated toward its approach as inherently layered and applicable across professional and academic fields. A UK-based nonprofit organization that researches and publishes information on digital literacies, JISC (2020) positions digital literacies as "capabilities which equip someone to live, learn and work in a digital society" (n.p.). The JISC framework (Figure 2) identifies six core areas that develop digital productivity and proficiency; defined by the ways individuals and organizations interact with information communication technologies (ICT) (JISC, 2019, p. 3). The JISC framework visualizes ICT proficiency at the core, surrounded by four key areas:

- Information, data, and media literacies (shown in green).
- Digital creation, problem solving, and innovation (shown in purple).
- Digital communication, collaboration, and participation (shown in red).
- Digital learning and development (shown in orange).

Encompassing these four key areas are digital identity and wellbeing—the learner's capacity to manage, develop, and self-actualize their digital identity (JISC, 2019, p. 8). Like the DLTF framework, the JISC framework provided a foundation and keywords to guide our ongoing examination of student digital literacy. Nonetheless, these frameworks operate from a prescriptive approach that focuses mainly on productivity and proficiency. Based on our collective experience in teaching with technologies, we

recognized a need not just to assign competency-based heuristics but also to strive to understand what's happening when students engage and use new digital technologies. We noted the lack of inductive studies in the context of digital literacy that warranted the present research. By *induction* we mean starting with the students themselves as autonomic learners who process unfamiliar objects or situations using their prior experience and personal conception of the task at hand.

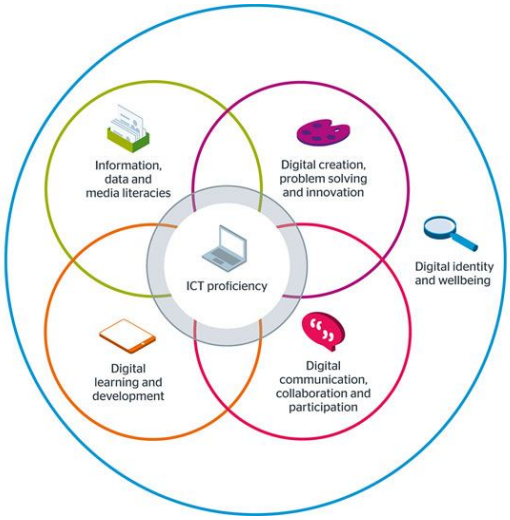


Figure 2. The JISC Digital Capability Framework (JISC, 2015). The framework shows four key areas and an overarching competency enveloping ICT proficiency as the core of digital literacy.

Without pre-determining what constitutes a certain digital literacy or competency, we focus on the cognitive engagement students exhibit when encountering new technologies. To examine what this cognitive engagement looks like, we turn to literature in mental conceptualizations of digital interactions—i.e., metaphors and mental models.

Metaphors for Digital Interactions

Again, our study seeks to gauge how students perceive digital literacy. We note that computers-and-writing scholars have already been invested in studying how students from all walks of life encounter, experience, and examine technologies across different learning environments. The field's collective scholarship has generated abundant literature on digital learning and digital cultures. As it is evident in published research and pedagogical practices, digital literacy is a staple prowess of the field. Yet, despite best efforts, there remain gaps in the conceptualization and theorizing of digital literacy. In "Blinded by the Letter: Why Are We Using Literacy as a Metaphor for Everything Else?" Anne Wysocki and Johndan Johnson-Eilola (1999) critiqued the constant and often uninformed use of "literacy" as a god-term of sorts in describing students' engagement with technology, and argued for what the term shouldn't and won't do:

> When we speak of "technological literacy," then, or of "computer literacy" or of "[fill-in-the-blank] literacy," we probably mean that we wish to give others some basic, neutral,

> context-less set of skills whose acquisition will bring the bearer economic and social goods and privileges. (p. 352)
>
> No single term—such as "literacy"—can support the weight of the shifting, contingent activities we have been describing. (p. 366)

Through unpacking the "bundles" of literacy in terms of its politics, Wysocki and Johnson-Eilola noted that scholars should be mindful about literacy's socio-historical baggage, and that rhetoric and writing studies need other models or metaphors to account more precisely for the differentiated dynamics involving discourse and technology. While "digital literacy" may be too embedded in education's discourses to replace, we agree with the need to examine more closely the ideologies of and within the literacy metaphor.

Our study is also preceded by scholarship that has demonstrated a critical approach to digital literacy. Cynthia Selfe and Richard Selfe (1994) in their landmark argument, "Politics of the Interface," noted why instructors of writing technology should pay attention to ideological challenges in the visual representations (e.g., icons, windows) and verbal analogies (e.g., saving, downloading, clicking) in human-technology interactions. Along with Wysocki and Johnson-Eilola's (1999) argument, we have been called to consider metaphors more critically and carefully as they are often accompanied by cultural, ideological, and political nuances that could propel certain values and restrain others.

Conceptualizations of digital interactions are influenced by surrounding contexts. In *Alien Phenomenology*, Ian Bogost (2012) explained that although certain (digital) experiences can be perceived as commonplace phenomena that can be easily measured, recorded, or observed, they are however "not identical to the *characterization* of that experience by something else" (p. 63; italics original). The characterization of any experience is subject to the ecological contexts surrounding the experience. Bogost (2012) argued that this subjectivity can only be made sense through metaphorized object relations: "[T]hings render one another in infinite chains of weaker and weaker correlation, each altering and distorting the last such that its sense is rendered nonsense. It's not turtles all the way down, but metaphors" (p. 84).

While we so often presume based on generalized findings that learners of digital technology rely on intuition and personal background to develop appropriate skills and competencies, we overlook the characterization of that experience that could be of interest and importance to literacy researchers. This characterization, as Bogost suggested, can be examined from the ways in which learners explain how they have conceptualized or figured out a new *thing* through object-oriented ontology—more concretely through metaphorical expressions and relations. It is necessary to note, however, that metaphors in information literacy work only when a shared understanding of meaning is maintained by its users (Brown, 2018). We are thus curious about the common metaphorical references used by our students in understanding digital technologies.

We also note Phillip Wolff and Dedre Gentner's (2011) attributes of metaphor: *directional projection* and *emergent commonality*. According to Wolff and Gentner, metaphors have both of these distinct behaviors—a source domain is used to inferentially modify a target domain and a commonality is drawn between a source and target domain. These behaviors encompass the directional projection and emerging commonality behaviors of metaphors, respectively. Wolff & Gentner's (2011) collaboration reflects efforts to synthesize these two seemingly disparate behaviors into a cohesive theory by applying

Gentner's (1983) structure-mapping theory to metaphors. Structure-mapping theory states that the strength and efficacy of an analogy is based on the strength and efficacy of the relationship between two objects and not the overlap or relation of attributes (Gentner, 1983, p. 1483). Wolff and Gentner (2011) showed that structure-mapping theory synthesizes the two disparate aspects of metaphors into a synthesized process of structural alignment and later directional mapping. Their work explains how the metaphors cited in our student responses could exhibit both behaviors of metaphor.

From Metaphors to Mental Models

Metaphors work by connecting conceptual domains through condensed analogies. Dispelling the older view that metaphor involves the figurative use of poetic language, George Lakoff (1993) stated that "the locus of metaphor is not in language at all, but in the way we conceptualize one mental domain in terms of another" (p. 203). Gunther Kress (1997) explained that "we make new meanings, by the processes of metaphor" (p. 74). His multimodal theory of new media literacy privileges metaphor as a key function in the process of meaning-making (Kress, 2003, p. 36). Building upon Lakoff's (1987) metaphorical idealized cognitive model—an extension of Lakoff and Mark Johnson's (1980) masterpiece, *Metaphors We Live By*—Carolina Girón-García and Ignasi Navarro Ferrando (2014) showed that digital technology users and learners rely on cultural identifications and metaphorical mappings to "help elucidate the connection between spontaneous digital literacy and culture" (p. 177). Their study makes a case for the use of *mental references* when dealing with incognizant elements of digital interactions.

Since we are interested in students' mental perception of digital literacy, we draw the connection between digital interaction and metaphorical mapping by studying Girón-García and Navarro Ferrando earlier work that classified several online genres or "cybergenres" of digital navigation patterns (2014, p.161). These genres are the expression of the mental models used in online navigation that transfer from traditional conceptual domains to new digital domains. These mental models are extensions of those used by Navarro Ferrando and A.J. Silvestre (2009), such as the metaphorical domains of the "house," "site," "journey," and "book." Of interest to our research is how these navigation patterns are related to the themes that emerge from the student responses. To what degree does the metaphor of the "net" or "journey" overlap with student responses about conceptualizing emerging technologies and technological processes? In our later analysis, we look for instances of student-supplied metaphors and mental models that resemble these cybergenres, if any.

As cognitive shortcuts, mental models are not new to writing studies. Rhetoric and composition scholars may learn from technical and professional communication studies, where there is a body of literature that focuses on digital literacy from the perspectives of experience design and information architecture, as well as cognitive psychology and human factors theories. For example, Kirk St.Amant (2017) applied script-prototype theory—which posits that human behaviors largely fall into analogous patterns—to study the experience of intercultural users of technology and technical communication. Don Norman's (2013) oft-cited book, *The Design of Everyday Things,* demonstrates how mental models are important in facilitating human-system interactions and minimizing the learning curve:

> Mental models, as the name implies, are the conceptual models in people's minds that represent their understanding of how things work. Different people may hold different mental models of the same item. Indeed, a single person might have multiple models of the same item, each dealing with a different aspect of its operations: the models can even be in conflict. (p. 26)

Numerous resources indicate that mental models are incomplete and constantly evolving and that they typically contain errors and contradictions, providing simplified explanations of something complex (Culatta, 2020). Given that use of mental models tends to minimize expenditure of mental energy, users will often practice accommodation and assimilation as a way to avoid more in-depth thinking (Piaget, 1952; Redish, 1994). The assimilation principle relates to modifying or extending one's existing mental model, how what one currently knows influences how we incorporate new information and experiences. For instance, referring to the Fabric website as a library of resources builds on what users know and use. The accommodation principle relates to changing an existing mental model, something that is very difficult to do in that the proposed replacement must be understandable, plausible, useful, and be seen in conflict with predictions based on one's current mental model.

Through their partnership at the Nielsen Norman Group, Norman and Jacob Nielsen study how mental models can be applied in the learning of digital technology. Nielsen (2010) reported an important element in mental model:

> A mental model is based on belief, not facts: that is, it's a model of what users know (or think they know) about a system such as your website. Hopefully, users' thinking is closely related to reality because they base their predictions about the system on their mental models and thus plan their future actions based on how that model predicts the appropriate course. (n.d.)

Although mental model theories are infrequent in composition scholarship, the purpose of such applications is similar to the use of metaphors. For example, Beth Hewett and Terese Thonus (2019) reported on the usefulness of strategic "metaphorical feedback" in helping student writers "make the cognitive leap" in meaning-focused revisions.

By and large, we summarize a close relationship between metaphors and digital experiences. But to draw a distinction, we note that metaphors typically represent descriptive relationships between two or more references, while mental models describe related connections using representations found in reality that could be mapped onto another analog or digital world. Nonetheless, our literature synthesis showed the relevance of metaphors and mental models in conceptualizing digital literacy.

ABOUT THE STUDY: FABRIC OF DIGITAL LIFE AS INCUBATOR OF DIGITAL LITERACY

Our IRB-approved project is supported by a research grant sponsored by the Council for Programs in Technical and Scientific Communication—titled, Building Digital Literacy through Exploration and Curation—to explore digital literacy using Fabric. First phase implementation in Spring 2019 involved the three PIs engaging their students in exploring, collecting, and curating artifacts for the Fabric. Second phase implementation in Fall 2019 recruited a cross-institutional international Building Digital Literacy (BDL) team of scholar-teachers (including the authors) to collaborate and engage their students in exploring, collecting, and curating artifacts for the Fabric. While the BDL team has since grown, this article reflects research completed through December 2019.

In this project, we have been challenged to develop a common understanding of what we mean when using the term "digital literacy" as it relates to Fabric and the emerging technologies our students are examining. As an open-access, crowdsourced digital archive, Fabric describes its archiving strategy as follows: "International researchers and curators collect and catalogue digital artifacts (objects)

surrounding the emergence of very personal and embodied technologies that promise to alter everyday life" ("About," 2020). Using descriptions, depictions, and metadata, the archive collects digital representations of emerging embodied technologies and records those representations as they were depicted in society at the moment of collection (refer to Figure 3). Fabric concentrates on the emergence of platforms—carryable, wearable, implantable, ingestible, embeddable, and robotical—as they are represented in multiple, overlapping discourses, which are also identified in the metadata. As such, the archive isn't simply a collection of technologies; rather, it's a collection of digital representations of embodied digital technologies as they existed at a particular moment in time and place. As one may learn on the platform, "Fabric lets you explore the nature of emergence, the discourses that surround it, the ways we participate with it, and the rhetoric that helps engender it" ("About," 2020). Developing an understanding of Fabric's artifacts and their relation to each other in the bigger picture of emerging technologies requires digital literacy.

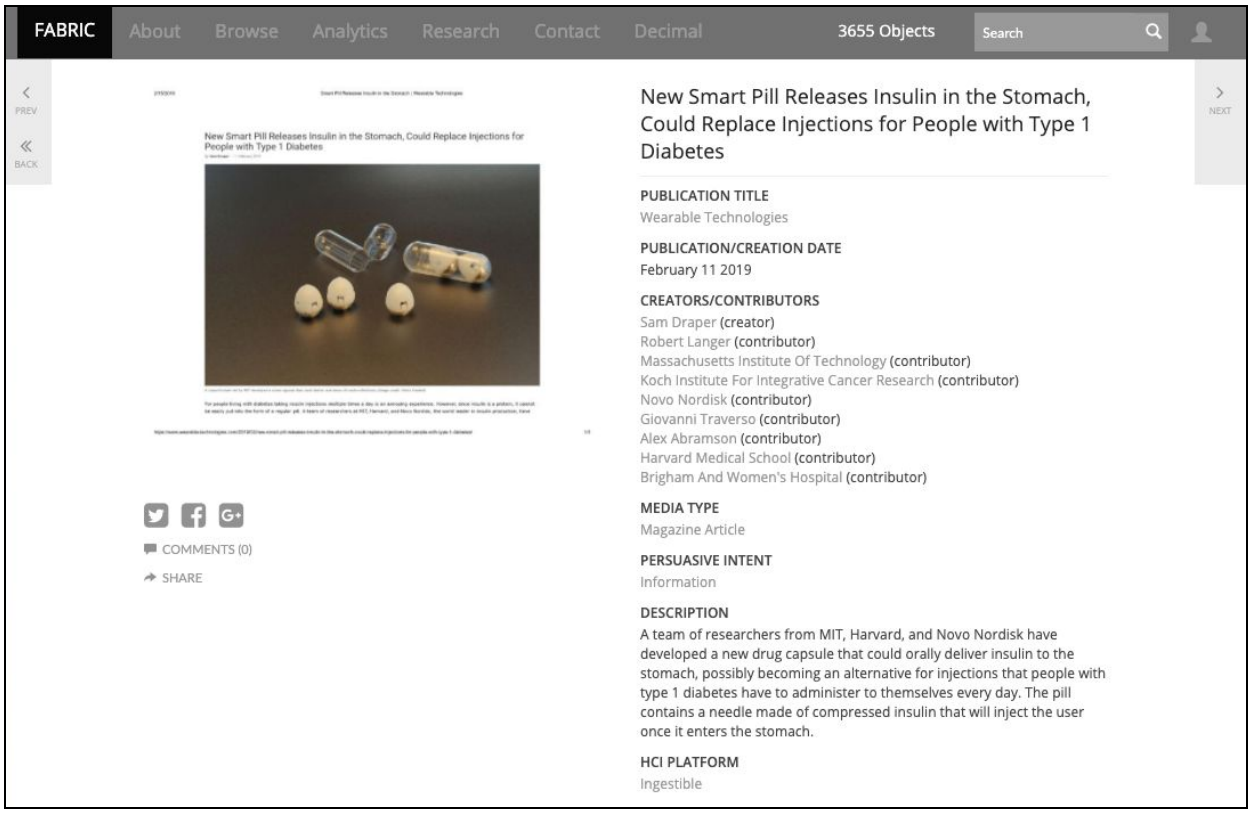


Figure 3. A sample archived object on Fabric with its metadata display. This screen capture shows how a digital artifact is typically displayed next to information such as publication title, creation date, creator and contributor information, media type, persuasive intent, object description, and human-computer interaction (HCI) platform.

In the context of BDL and Fabric, we have previously used the term "digital literacy" to describe a user's ability to develop a meaningful understanding of the technological representations included and their relationship to the archive's infrastructure, information architecture, archiving strategy, and collections. Fabric concentrates on inventions and their complex states of emergence. In other words,

understanding the archive and its organizational structure is a meaning-making activity that users undergo to extract meaningful narratives from structured symbolic representations of embodied digital technologies collected and depicted during their emergence in society. We have sought to use the Fabric as a learning database in which digital literacy can be cultivated and exercised. We have asked our students to engage with Fabric in either of these ways:

- Examine: Here students explore the objects in a collection, examining what counts as an object: an invention, a prototype, a physical product, a website about an invention, a response to a news story/article/video about a invention, a case study on the use of a product, etc. They can also focus on the potential challenges and opportunities that an object holds for technical and professional communication; share about their collection interests; and pay attention to archival actions like the naming of objects, assigning tags, and writing descriptions, etc.
- Contribute: Here students learn to archive single objects (or media representations) and understand existing keywords and metadata. Students read resources on archiving as a scholarly and research activity. They pay attention to archival actions like naming an object, assigning tags, and writing descriptions (as shown in Figure 3). Students also learn to use media editing tools like graphics and video editors to create a thumbnail for the archived object.
- Curate: Here students envision, create, and submit a new collection for possible publication at Fabric based on a thesis or unique point of view. Students identify and propose artifacts from within and outside of Fabric, completing a curation collection form that includes an overview/abstract of the collection that explains their argument, URLs for the artifacts, and keywords. They complete a Google (or Excel) sheet for metadata planning that includes the name of the artifact, persuasive intention, media type, publication title and date, description, technology and marketing keywords, classification, source/web address and additional detail (Figure 4). Students upload the artifacts to Fabric, working with the archivist to ensure appropriate metadata, registration, and submission.

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

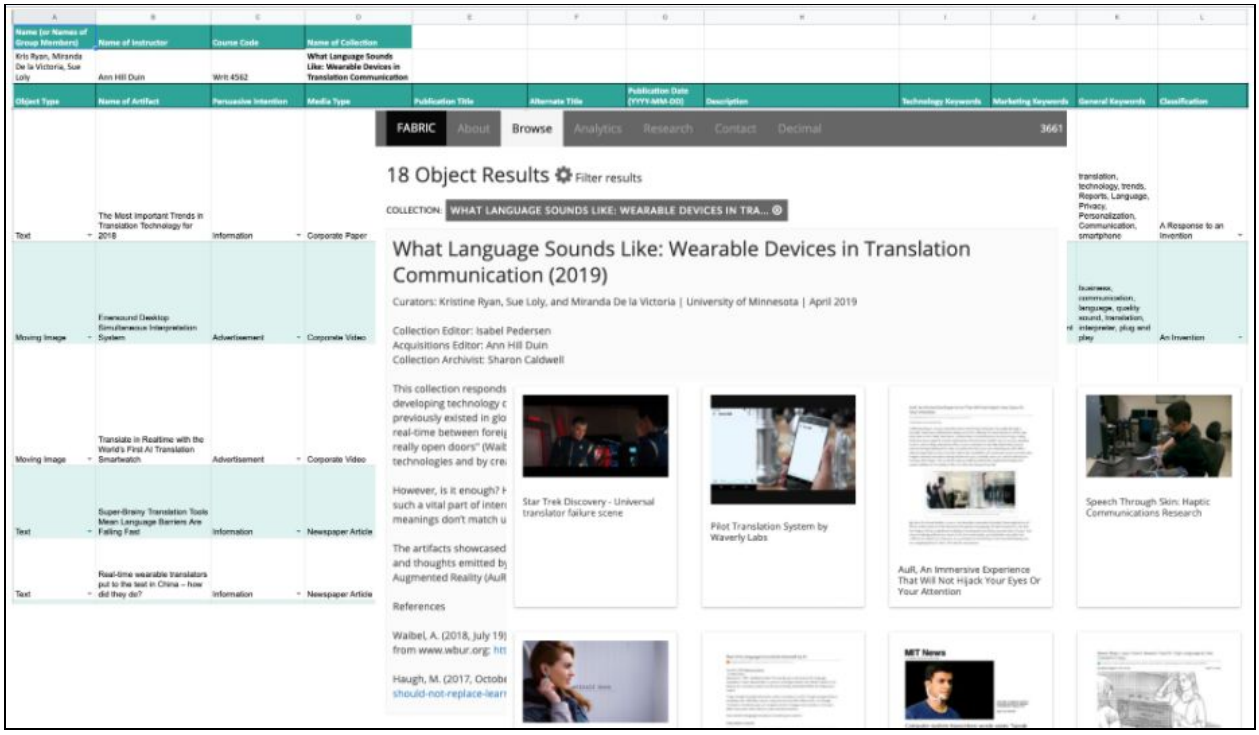


Figure 4. A sample student workflow in curating a collection on Fabric (left to right). Students collect and submit metadata information about their artifacts on a shared Google Spreadsheet; the metadata are uploaded and published to a public-facing webpage on Fabric, which includes the curated objects in a browsable gallery view. (see individual screen captures and elaboration in Appendix C).

As a result of examining, contributing and/or curating collections as part of Fabric, we are interested in how students develop digital literacy and so we asked them to report on their experience. Our guiding research questions were:

- What metaphors and mental models do students employ when engaging novel technologies?
- What can these metaphors and mental models tell us about student perception of digital literacy?

To address these questions, we collected student responses via a focused survey. In the next section, we describe our methodological framework for data collection and analysis.

Data Collection and Analysis

We had a hunch that students were engaging with Fabric differently in terms of their reliance on prior experiences and conceptual models. The varying courses in which Fabric was introduced, which included rhetorical theory, composition pedagogy, computer coding, and technical writing, suggested students' engagement would be influenced by a wide range of experiences. So, when we surveyed our students at the end of their Fabric-related assignments, we specifically asked this question: "Were there any mental models, metaphors, or other experiences you've had that you used as a way to understand the Fabric collection as you worked with it? If so, can you say a little about them?" Given the range of courses and institutional contexts using Fabric in this project, we did not provide a common definition of

the terms “metaphor” or “mental model,” opting instead to encourage participants to answer the question using their existing understanding of the terms. While not every instructor involved in our project chose to survey their students, those who did include this specific question in their questionnaire, among other questions tailored to the instructor’s course objectives and interests. For this article, we extracted student responses to the above question from four courses (by instructors H, N, C, and K). From these four sets of surveys, we collected 28 student responses that addressed the above question. After filtering out null responses, 16 of these responses were considered applicable for analysis (refer to Appendix A).

To reach an understanding of student conceptualizations, we adopted Johnny Saldaña’s (2009) qualitative coding methodology. Saldaña’s grounded theory analysis involves a two-cycle coding process; the first coding cycle (also called initial coding) identifies patterns from the raw data, and the second cycle identifies categories from codes. Following this mechanism, three of the authors analyzed each response to produce the first cycle of codes. Each coder worked independently and created their codes included in Appendix B (columns DH, KB, and JT). This coding approach is generally favored by researchers for its ubiquitous application in qualitative studies (Saldaña, 2009, p. 81) and for the flexibility it grants to each coder in the first coding cycle. In our case, it lets us incorporate multiple angles to the attributes in student responses. The first angle (column 1: DH) involved separating the subject and the object whose attributes modify the subject. This approach mapped the relationship of the source domain to the target domain using the same terminology—i.e., the “tenor” and “vehicle” that I. A. Richards (1976) introduced to literary criticism. The second angle (column 2: KB) also separated the source and target domains, with emphasis on the actions or processes that modify the target domain. The third angle (column 3: JT) outlined ideas and themes that are predominant within the data, providing a more discrete account of each student response. Combined, these three schemes provided a holistic vantage of the mechanics, process, and preliminary categories within the student responses.

During the second coding cycle, also known as focused coding, the three coders collectively identified patterns and dimensions from the first coding cycle. At this stage, codes have been organized and synthesized before being assembled into categories; these categories are phrases or terms that describe what a unit of data is about. These categories formed the basis of our understanding of student conceptualization of digital literacy. Our collective analysis of primary coding data revealed a sharp contrast between levels of abstraction in the student responses. Some of the responses contained both mental models and metaphors that were more concrete, (relying on physical or digital analogs as the source domain), whereas others relied on further removed abstractions from any real or physical phenomena. This observation allowed the coders to classify and code each response according to four categories: 1) tangible metaphor, 2) intangible metaphor, 3) tangible mental model, and 4) intangible mental model. Here, tangibility is used to mark responses that are grounded in a specific experience, physical object, or technology. Further abstractions from these groundings were labeled as “intangible.” We employed the distinction we noted in our literature review: whereas a metaphor establishes a descriptive relationship between two or more references, a mental model describes a mapping of reality unto an analog or digital application.

In some cases, multiple instances were found in a single student response. For example, in the K01 sample, the student responded with a comparison of putting puzzle pieces together to build a collection. This instance showed the student’s synthesizing of a relationship between a physical object (a puzzle) and mapping it to a digital domain (a collection in an archive), resulting in a metaphor that was based on a real-world, analog grounding. In the same response, the student also presented an intangible

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

mental model, when they wrote: "...I would have to put the pieces, artifacts, together in a way that formed an entire idea or story as described by the curators" (K01). This student was not making a direct comparison as much as they are expressing an abstract observation about Fabric collections having rhetorical qualities in the same manner as a puzzle being an image when fully assembled. This mental model was considered intangible in that it's describing an abstract concept—just like communicating an idea, telling a story, or creating a narrative.

FINDINGS AND DISCUSSIONS

Table 1 shows the coding results for the 16 student responses coded in the four categories established in the previous section. Table 2 shows the cross-tabulation of these categories.

Table 1. The coding results of the 16 applicable student responses.

DataID	Tangible Metaphor	Intangible Metaphor	Tangible Mental Model	Intangible Mental Model
H01	1			1
H02	1			
H03			1	
N02			1	
N05			1	
N06				1
C03			1	
C06	1			2
C07			1	
C08			1	1
C12			1	
K01	1			1
K03		1	1	1
K04	1			
K05	1			
K07		1		1

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

Table 2. Number of instances across the four categories identified in the second-cycle coding.

	Tangible	Intangible	**Subtotal**
Metaphor	6	2	**8**
Mental model	8	8	**16**
Subtotal	**14**	**10**	

As expected, separating the data into tangible and intangible categories produced subject similarity. The tangible metaphors were mostly derived from real objects, except H01 where the subject was the process of planning a wedding. An interesting note is that five out of six of the tangible metaphors, the exception being K04, were completely unrelated from digital subject domains (such as a computer, or a website). In sharp contrast, tangible mental models were overwhelmingly related to digital subject matter. Due to a small sample set of intangible metaphors, we did not make any generalization about them; the ones that were identified in this category related to conceptualizing "the bigger picture" and understanding how smaller abstract or physical components create larger ideas or structures.

As described previously, tangible mental models have a particular focus on the technology, computers, and programming. This might suggest that these conceptualizations are a result of experience or exposure to various programs, computing concepts, and software. These specific expressions seemed interested in evaluating Fabric's functional qualities by drawing from these outside domains. They seemed to focus on how Fabric works, and how Fabric functions. The intangible mental models have a wide focus in terms of subject, but in terms of purpose, these conceptualizations are all geared towards conceptualizing how Fabric works and not what Fabric means or why Fabric might be important. A notable exception would be K01 where a student used their conceptualization to express how a Fabric collection has rhetorical or narrative value.

Overall, students' responses differed significantly within the tangible mental models and tangible metaphors. Where tangible metaphors held domain variety, tangible mental models were almost all related to digital processes, experiences, and environments. Tangible mental models also seemed to focus predominantly on function (how Fabric works), not purpose (what Fabric means). Intangible metaphors were a small category and the responses in this category seemed to focus on understanding larger concepts through smaller components. Students responded with intangible metaphors only if they responded with intangible mental models.

As shown in Tables 1 and 2, we coded eight instances of metaphors and 16 instances of mental models as references that students used to understand or describe their experience with Fabric. As noted in our methodological overview, some of the student responses were coded with multiple instances due to their layered or extended descriptions. The difference between the instances of metaphors and mental models poses an interesting contrast to existing literature on the conceptualization of digital literacy. While current discussions frame metaphoric expressions as the prevalent resort for sensemaking, the student responses revealed that mental models are more common as a reference when faced with an unfamiliar interface such as Fabric. This finding supports our proposition to extend understanding of digital literacy beyond functional skills and theoretical frameworks—to pay attention to the role of cognitive references in the process of developing digital literacy. The results here suggest that mental

models, tangible or intangible, are prominent in this process, and should be given more considerations in our conceptualization of digital literacy.

The number of mental models we coded warrants closer attention to what they may suggest about digital literacy. One response we coded for mental models emphasized the way networked communications (phone, email, texting) combine in layers while simultaneously enabling social connections (K03). These two mental models, networked communications and social connections, pointed toward a conception of digital literacy as intermodal and social while technologically mediated. Another response we coded for mental models connected the process of sorting items for display in a yard sale to the organizational structure of the Fabric site (C06). We coded the sorting process as one mental model and the process of preparing sorted items for an audience as another mental model. Combining these mental models points toward a conception of digital literacy as both infrastructural and audience-focused, where both an internal organizational framework (infrastructure) and an outward-facing interface (audience-focused) are necessary to understand the collection. A third response we coded for mental models used the evolution of graphical user interfaces to better understand the emergency of click-and-drag programming interfaces (N05). This mental model pointed toward a conception of digital literacy as cultural-historical, requiring knowledge of technology's evolutionary history to understand current processes. These mental models suggested that digital literacy frameworks should account for even more, to include layers of intermodal interconnections, infrastructural intersections with user-centered design, and cultural-historical awareness of technological evolution.

Further extending the influence of mental models in students' responses, we discovered instances where students used or described mental models as their response. For example, one student responded, "No, I just worked with what was said. It made it easy to just learn the coding through using different situations" (N02). The student claimed to have used neither metaphors nor mental models in approaching the Fabric, yet they used "coding" to describe a mental and physical process engaged to learn and apply knowledge to "different situations." Here, the cognitive process and understanding of coding helps understand presumably new situations. Another student responded with a metaphor of their own: "Take it with a grain of salt. There is a lot of mixed information on new technologies and each one has there [sic] own agenda" (K07). The use of the "grain of salt" metaphor, part of an adage meaning *don't take it too seriously*, revealed multiple metaphors at work. Using the adage in response to a question about metaphors and mental models engaged in approaching the Fabric suggests the student needed to use a mental model (one that communicates an attitude toward new technologies) in order to explain how they used metaphors and mental models in approaching the Fabric. This suggests that familiar mental models build upon themselves and one another when approaching complex, unfamiliar content like Fabric. A third student used online cloud storage as a mental model that helped them approach Fabric while simultaneously denying metaphors or mental models were useful: "I cannot think of any mental methods, metaphors, or experiences that I used to understand this better. Having knowledge of cloud storage and how it stimulates collaboration was the main piece I used to understand the Fabric of Digital Life" (C07). The student's use of cloud storage as a mental model to explain how collaboration is enabled, even encouraged, helped them approach the Fabric website. In each of these cases, mental models are being used to scaffold understanding of the Fabric website even if their use is unrecognized or unidentified. This finding suggests that mental models may be built into the way students approached Fabric, and provided useful methods, noticed or unrecognized, to unravel complexity.

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

Theoretical Implications

When we proposed the question, "Were there any mental models, metaphors, or other experiences you've had that you used as a way to understand the Fabric collection as you worked with it," we anticipated responses that built on students' experience with physical collections, like museums and galleries. The variety of metaphors and mental models presented in the student responses, both intended and unintended, surprised us. But our theoretical approach pointed toward digital literacy as multiply layered, and we should not have been so surprised. Virginia Tech's digital literacy framework and the JISC digital capability framework both present digital literacy as requiring collections of skills and abilities, of cognitive and creative approaches, to successfully navigate digital creations like the Fabric collection. Students' responses were a useful, hands-on reminder that teaching digital literacy requires an approach that multiplies rather than narrows students' engagement with digital texts.

Our misinterpretation of metaphorical domains, the assumption that Fabric would be imagined as a museum or art gallery, led us to a more nuanced understanding of how our students make meanings. Our expectations to see students referencing the domains noted in Navarro Ferrando and Silvestre's (2009) cybergenres were also subverted. From the cognitive metaphor point of view, Mark Johnson (1987) argued that reasoning based on metaphor is "neither arbitrary nor unstructured" (p. 127). Our study supported this claim in several instances. Examples of student responses from the tangible metaphor category exhibited a *path schema* that mapped learning states onto physical locations or goals. In these cases, learning about Fabric to meet assignment expectations was interpreted in terms of *planning a wedding* (H01), *organizing a garage sale* (C06), or *finishing a puzzle* (K01). Acquiring a literacy skill was envisioned in terms of an event (or implicit event) that marked (1) a purpose, (2) a sequence of physical actions, and finally closure in a physical result. In these cases, students imagined Fabric as a path that had to be traversed, which could be likened to achieving a purpose, i.e., Fabric was compared to a successfully planned wedding, an organized garage sale, or a completed puzzle. In these cases, we noticed that students used metaphor as a resource drawing from their own relevant cultural experiences in complex visual terms.

Technical communication scholarship recognizes and promotes approaches to digital literacy that multiply rather than isolate individual skills and outcomes. Kelli Cargile Cook's (2002) theoretical frame provides guidance to understand what's happening in multiple domains, across technological, rhetorical, ethical, and critical layers, when students engage with digital technologies. In advocating for a *multiliteracies* mindset for the digital age, Stuart Selber (2004) argues that we, at the nexus of technology, literacy, and pedagogy, should attend to multiple concerns of digital learning, applications, and implications. Our question about metaphors, mental models, and experiences should elicit a wide variety of responses because digital literacy relies on multiple models and metaphors to help connect the novel to the known.

When we ask our students to engage with digital tools like Fabric, our pilot results suggest we should encourage students to make as many different connections as possible from their own experiences to understand the digital tool. Multiplying our approaches to digital literacy ensures that students recognize the digital tools they encounter as vibrant, creative, and expressive. The more frequently and clearly students can connect digital experiences to their own mental models, the more clearly they will recognize their agency to engage digital tools to create novel approaches to the problems facing societies reliant upon digital technologies. Channeling the New London Group's (1996) multiliteracies pedagogical

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

approach, Selber's direction highlights the role of digital literacy education in cultivating well-rounded global citizens of the modern knowledge community. Encouraging students to relate their digital experiences to multiple aspects of their broader social experiences is one way to cultivate such citizens.

Pedagogical Implications

This research aimed at understanding digital literacy in light of the role students played in familiarizing themselves with digital technologies using prior experience and personal conception of the task at hand. Rather than expanding on or resituating the existing digital literacy frameworks, we recommend updating our pedagogical processes to reflect the impact of mental models resulting out of this study. We learned that metaphors play a significant role in this induction process for students. Lakoff and Johnson's influential work (1980) demonstrated the importance of metaphors in our daily lives. However, metaphor can highlight certain features while suppressing others (Selfe & Selfe, 1994). Metaphors can be appropriate because they sanction actions, justify inferences, and help us set goals. Additionally, metaphors are subjective as they are partly culturally determined and partly tied to personal past experiences. Therefore, it becomes difficult to fully understand how much a student may be drawing from metaphors to shape their understanding of concepts discussed in the classroom. Although used extensively in digital literacy practices, very little research helps us study the impact of metaphors on our pedagogical practices. Kristie S. Fleckenstein, Clay Spinuzzi, Rebecca Rickly, & Carole Clark Papper (2008) suggested the use of '"ecological metaphor" as a harmonious way of thinking about research. Citing John Law's (2004) work they argued that metaphors used to organize research of a phenomenon must align with that phenomenon because the methods, rules and additional practices required to conduct research help to produce the reality that we accrue. Without such alignment, the knowledge we create and the applications derived from that knowledge can be limited and misleading.

We suggest that instead of replacing frameworks to incorporate mental models, instructors adapt their understanding to create a multidimensional, multilayered literacy framework. The process of paying attention to and including metaphoric mental models in classrooms should begin at the start of a course. The first time students are introduced to a technology, they feel the need to explore it, categorize it, store it and work with it based on a preconceived understanding of how it would help them achieve their short-term goals. Another approach is to consider fragmentation by features. Digital literacy aspects can be looked upon as a collection of activities, situations, actors and phenomena. Metaphors should be considered as opportunities for students to dissect these into specific goals or features. This will provide insights into the systematic knowledge development process. An ecological orientation will enable us to argue for an understanding of reality in ways that the students might find persuasive, but is likely incomplete and distorted.

An instructor should consider how mental models and metaphors affect their students' interpretations of learning technology. Technology often serves as an engagement point for classrooms, with instructors assuming an increase in digital tools signifies meeting students at their level. Instructor actions that have an intent to include and increase access may, in fact have the opposite effect. Students identify their own digital literacy from compartmentalized spaces and this can have a deleterious effect on learning with technology. Some students know how to use their phone for social media but not for accessing a learning management system (LMS) or creating a document, despite the relative similarity in tasks. Other students may overestimate their digital literacy, forming a mental model of technology that

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

encompasses multiple aspects. This also applies to those who fear new technology. Knowing these models can help instructors design courses and leverage available tools more effectively.

It might serve instructors to poll students and identify areas of concern before implementing a technological intervention in class. Not doing so can cause disengagement, as users of technology who do not immediately follow along tend to give up on it. Instructors can easily misdiagnose this disengagement and attribute it to material rather than delivery medium. Therefore, students may appear to struggle applying what they learn in class to their writing, when their struggle may exist within the boundaries of the technology. They should dive deeper into the competencies and views of their students, as evidenced by the spread of responses given in this sampling. It should be considered akin to student reactions to the word "writing" which students often compare to "difficult" and create a mental model based on self-perceived deficiencies based on a bad grade school experience.

Fabric can be a useful and multipurpose resource that has significant pedagogical implications for instructors and students. Fabric can be used as an online database for which students are able to explore the various technologies, discover emerging innovations, and learn about digital tools, such as the online database. It can also be leveraged in a constructive approach that positions students in various real-world scenarios that has them work through problems and develop solutions. We provide two exemplary uses of Fabric in one author's technical communication course (see Appendix D) to demonstrate the potential implications of engaging Fabric in instructional design.

Research Implications

The initial findings from our study suggest a need for further research into metaphorical expressions of digital literacy and the mental models used by novice technology users to navigate uncertainty. Our focus on novice users suggests the importance of defining terms like "metaphor" and "mental models" for participants prior to completing the survey, thus ensuring that participants, already experiencing discomfort with uncertainty, are not also struggling to understand what they think the researchers are looking for. Future deployments of this survey will provide those definitions. In this pilot research, we have noted how metaphors and mental models can be conceptual guides for developing digital literacy. However, our research has focused on such development at the individual level. An important observation from Girón-García & Navarro Ferrando's (2014) study we referenced earlier was that the user and technology designer can be both engaged in the process of conceptualization during activities of navigation and ideation (p. 177). This underscores a crucial implication of our research as we seek to improve research practices and application in digital literacy; not only should we analyze the conceptual models of our curriculum, site, and the Fabric users, we should also seek to understand how these conceptualizations can be co-constructed. In two of our student responses (C03 and C08), there were mentions of group-based approaches to understanding new technology. We find these reflections to be intriguing although they were not an emphasis in the present report. Future research may consider addressing the collaborative nature of conceptual models and collective literacies.

Additionally, the findings from this pilot study were bounded by our coding methods. We chose the simple two-cycle coding methodology as this was our first attempt at marking up the student responses. Having completed this study, we note the opportunity to slice the data in different ways. During our first coding cycle, we noticed specific references in the student responses (such as H02) that indicate potential benefits in highlighting the technological processes and subjects in the student

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

responses instead of just metaphors and mental models. For proof of concept, we attempted a round of elemental coding called process coding (Saldaña, 2009, p. 77) and found that most student responses contained a concentration of gerunds and action statements that illustrated different relationships and processes that the student had conceptualized within their response. Process coding is not generally used as a sole coding approach but it can be used as another primary coding method to enhance the depth of our findings. It may allow us to examine how each action or process contributes to a student's conceptual model while also identifying what physical-world experiences the student uses to describe these actions and processes. We reserve this research direction for a future study.

CONCLUSION

This study forwards the argument that understanding of digital literacy requires a broad approach that takes into account the many experiences learners bring to their use of digital tools. While we do not replace any existing frameworks or definitions for digital literacy—as they must consider the local contexts in which the frameworks or definitions are deployed—we learned from our study that student perceptions of their own digital literacy (and instructor's awareness of such) are informed by prior experiences by means of metaphors and mental models. These conceptualizations can shape how they learn with technology. As such, instructors should gauge their students' perception of digital literacy and design courses accordingly. Instructors should incorporate a variety of digital technologies into coursework that allow students to practice multidimensions of digital literacy, and Fabric is a useful resource to meet this end.

As part of a larger project, this study is only beginning to scratch the surface of our digital literacy imperative. From a methodological standpoint, future studies should increase the number of student responses and include other ways of collecting responses, such as in-depth or focus group interviews. As we proposed, analysis of student responses may focus on the relationship between mental references and physical actions through elemental process coding. Elsewhere, we continue to report findings from our BDL collaborative research by entering discussions around digital threshold concepts and the uses of collaborative autoethnography—by which we hope to expand our collective understanding of digital literacy.

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

APPENDIX A: STUDENT RESPONSES

DataID	Original Responses
H01	I can remember back in about 2005, I was planning my own wedding. I can remember looking for ideas online, but I do not remember the deluge of ideas that exist now. I really don't remember Pinterest or Google Images being popular. A couple years later, I found myself jealous that people had so many ideas for weddings or big events. They were getting them from Pinterest and other online sites. The Fabric collection is something with which I identify that experience; I would love to know just what my searches looked like back in 2005. What actually came back to me when I searched for some ideas. I am sure it looked different than it does now!
H02	I pictured a classroom calculator pocket organizer. (My imaginary one had clear pockets. Math teachers use these to account for calculators; lots of people use similar contraptions to hold shoes. Many classrooms have them now to corral cell phones. They are used daily, but what goes in the pockets can vary from year to year, decade to decade. In my imagination, each pocket represented a collection for Fabric. Don't know why, but this helped me understand what I needed to do for our "pocket" for educational technology.
H03	It probably does not sound similar to anyone reading this, but I had to start understanding it the way I understand my role as a special education teacher. Prior to being an general English teacher, I was a special education teacher and case manager for students with disabilities. When I went to write a student's Individualized Education Plan every year, I would look at several different things in their files and previous reports, one of which was, to anyone else, just a list of numbers. Those numbers, however, held multiple meanings and implications at one time; they were scores that placed students on a scale that compared with other students with that same disability while also comparing that one student at that age in that moment in time with himself from a previous age in a previous moment in time. That number also held significance in terms of what goals and modifications and accommodations that student would need, and so on and so forth. It was just a number, the way an image is just an image. But held from various angles, it both represented and implied a lot more than just a number.** I have no idea if that makes sense, and probably does not even adequately answer this question, but that is what I had to think about for this assignment in order to have it make sense to me.
N02	No, I just worked with what was said. It made it easy to just learn the coding through using different situations.
N05	Yes, with GUIs* and other ways programming evolved into click-and-drag programming
N06	yes, the short Netflix video was very helpful for supplying the electrical circuit metaphor
C03	Not exactly, I think a lot of the work that we did with the forum activity and associated small-group discussion regarding how the fabric worked was where I gathered most of my helpful insight/understanding from!
C06	It is not an experience I have ever had, but something that comes to mind (in terms of a metaphor) in a way to further understand Fabric as we worked with it is kind of like categorizing objects as if you were holding a garage sale. At some garage sales, objects are laid out in "like objects" so that people are able to easily recognize where certain things are and can find what they are looking for. For instance, there could be a "Baby" section/area where there are baby clothes, baby accessories, baby car seats, strollers, etc. Categorizing objects and organizing them in this way makes it easy for the shopper; likewise in Fabric, we had to categorize and organize our objects so that it could further be filtered and found by other users on Fabric. This makes collecting information easier for the viewer/user of Fabric.
C07	I cannot think of any mental methods, metaphors, or experiences that I used to understand this better. Having knowledge of cloud storage and how it stimulates collaboration was the main piece I used to understand the Fabric of Digital Life.
C08	I kept in mind that Fabric of Digital Life is a computer program, and that it is a direct reflection of the work my group and I put into it. This helped me navigate through Fabric of Digital Life and helped my understanding of the activity.
C12	I would say working on the excel sheet where we put all the information on it helped me better visualize the purpose of Fabric. Learning how to analyze our objects and see what categories they fit in help us understand the process too.

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

K01	I kind of understood it as an idea puzzle or a story puzzle where I would have to put the pieces, artifacts, together in a way that formed an entire idea or story as described by the curators. *That is as close as I came to a mental model or metaphor.
K03	I like to think about peoples' webs of others who they interact with in layers. Some talk on the phone, some use email, some text, but everyone is somehow, indirectly connected with every single other person by some means. The connection between one another is only getting stronger as technology progresses.
K04	I did not have many metaphores, however, I could see these as a persuasive/informational source to get out a ton of information regarding a topic to your target audience.
K05	We disscused many methods like a cookbook for example that helped show the many ways of communicating the information. There were also many other examples like the textbook we used.
K07	Take it with a grain of salt. There is a lot of mixed information on new technologies and each one has there own agenda. What was important for me to understand is not to take each one has the most important and credible information. Use a whole lot of sources to piece them together.

APPENDIX B: FIRST & SECOND-CYCLE CODING OF STUDENT RESPONSES

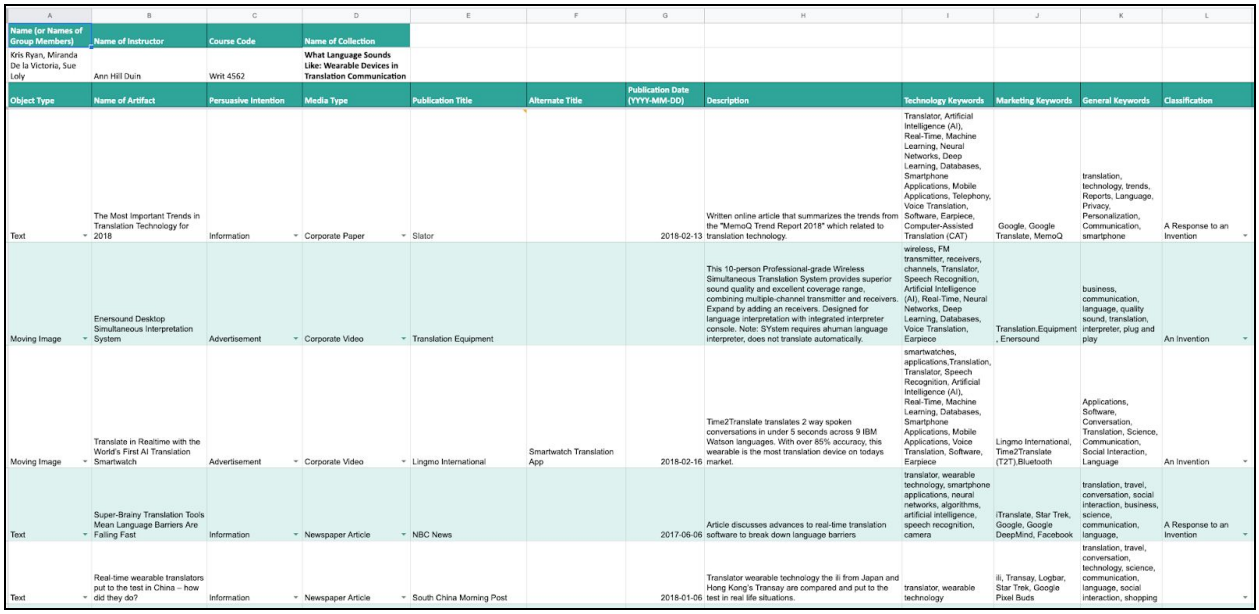
N=16 (usable responses)

Data ID	**1ST-CYCLE CODING:**			**2ND-CYCLE CODING: COLLECTIVE**
	Coder: DH	**Coder: KB**	**Coder: JT**	
H01	Planning wedding → navigating FoDL & curating collection [finding ideas on Pinterest]	Searching, browsing, and collecting ideas while planning a wedding → Curating collections and artifacts on Fabric	Comparing to a major personal event Relating to Instagram/Google Photos	Tangible (planning wedding) Metaphor Intangible (using Pinterest) Mental model
H02	Collecting items in pocket organizer → understanding structure of FoDL [may be used to hold multiple different items beyond "intended" purpose; cf. Norman's signifiers]	Accounting for, "pocketing", and corralling objects in a pocket organizer → Curating and collecting content on Fabric	Comparing to a calculator organizer Using image representation	Tangible Metaphor
H03	Numbers on sheet → code developed to ascribe meaning to FoDL [IEP documents as boundary object, c.f. Star & Griesemer, Popham, Wilson & Herndl?]	Analyzing and grouping SPEC student's assessments and scores in relation to one another over time → Collecting and curating objects for future fabric audiences	Relating to special teaching experience Attempting to understand meaning of activity	Tangible Mental model (student assessment)
N02	Application to different situations			Tangible Mental model (coding as

				application)
N05	Evolution for click-and-drag programming → capturing early stage of tech evolution in FoDL	Change of technology → representation of Collection/curation	Referencing specific computing interaction	Tangible Mental model
N06	Need more context for the electrical circuit metaphor		Referring to Netflix and electrical circuit	Intangible Mental model
C03	Forum activity & small group discussion → understanding FoDL	Forums (specific activity) → Way that FoDL works/operates	Relying on group discussion insights	Tangible Mental model
C06	Categorizing garage sale items → categorize and organize FoDL objects	Holding/creating a garage sale and sorting objects for garage sale audience → Creating a collection for a specific type of audience or genre of collection on Fabric	Identifying the experience as new Using categorizing (sorting) metaphor Making information usable through categories	Tangible (garage sale) Metaphor Intangible (sorting) Mental model Intangible (preparing for users) Mental model
C07	Collaboration enabled by cloud storage → better understand FoDL [unclear how]	Collaborative work on shared (cloud-storage) platforms → How FoDL curators work together	Connecting to cloud computing/management/collaboration	Tangible Mental model
C08	Computer program → FoDL [helped navigate FoDL & understand activity]	Group effort and work → Curated material on fabric	Recognizing the archive as a program	Tangible (program) Mental model Intangible Mental model (input/output)
C12	Categorizing in Excel → purpose of FoDL [helped visualize organization of artifacts in FoDL]	Putting information into an Excel spreadsheet → Collecting and categorizing objects in Fabric	Highlighting the visual aspect of organization and categories	Tangible Mental model
K01	puzzle pieces → entire idea/story [as defined by curators]	Pieces of a puzzle assembled to reveal idea or narrative → Making a collection in Fabric.	Relating to a puzzle Forming a story	Tangible (puzzle) Metaphor Intangible (story of the collection) Mental model
K03	Technologies (in Fabric?) → layers of connections [social structure]	People have “webs of interaction” that are connected to everyone, interactions are layered, technology facilitates the	Referring to web/networks as layers Referencing communicative activities	Intangible Metaphor (Web) Tangible Mental model

		connection of people to each other/the conversation? → FoDL? [FoDL is a layer?]	Foreseeing the advancement of technologies	(communication technologies) Intangible Mental model (social connections)
K04	These (technologies?) → information source [for targeted communication]	Rhetorical action → FoDL	Recognizing persuasive/rhetorical effects	Tangible Metaphor (information source)
K05	Cookbook → way of communicating information [methods for understanding Fabric?]	Information in a Cookbook → Fabric holds information and can be interpreted/communicated in various ways.	Relating to a cookbook	Tangible Metaphor
K07	"Take it with a grain of salt" → understanding the whole by looking at the whole, not the parts [of Fabric?]	Information has an agenda → [FoDL has an agenda?]	Highlighting the importance of information literacy	Intangible Metaphor (agenda) Intangible Mental model (own participation in making sense of information)

APPENDIX C: SCREEN CAPTURES OF STUDENT ARCHIVING PROCESS



Name (or Names of Group Members)	Name of Instructor	Course Code	Name of Collection
Kris Ryan, Miranda De la Victoria, Sue Loly	Ann Hill Duin	Writ 4562	What Language Sounds Like: Wearable Devices in Translation Communication

Object Type	Name of Artifact	Persuasive Intention	Media Type	Publication Title	Alternate Title	Publication Date (YYYY-MM-DD)	Description	Technology Keywords	Marketing Keywords	General Keywords	Classification
Text	The Most Important Trends in Translation Technology for 2018	Information	Corporate Paper	Slator		2018-02-13	Written online article that summarizes the trends from the "MemoQ Trend Report 2018" which related to translation technology.	Translator, Artificial Intelligence (AI), Real-Time, Machine Learning, Neural Networks, Deep Learning, Databases, Smartphone Applications, Mobile Applications, Telephony, Voice Translation, Software, Earpiece, Computer-Assisted Translation (CAT)	Google, Google Translate, MemoQ	translation, technology, trends, Reports, Language, Privacy, Personalization, Communication, smartphone	A Response to an Invention
Moving Image	Enersound Desktop Simultaneous Interpretation System	Advertisement	Corporate Video	Translation Equipment			This 10-person Professional-grade Wireless Simultaneous Translation System provides superior sound quality and excellent coverage range, combining multiple-channel transmitter and receivers. Expand by adding an receivers. Designed for language interpretation with integrated interpreter console. Note: SYstem requires ahuman language interpreter, does not translate automatically.	wireless, FM transmitter, receivers, channels, Translator, Speech Recognition, Artificial Intelligence (AI), Real-Time, Neural Networks, Deep Learning, Databases, Voice Translation, Earpiece	Translation.Equipment, Enersound	business, communication, language, quality sound, translation, interpreter, plug and play	An Invention
Moving Image	Translate in Realtime with the World's First AI Translation Smartwatch	Advertisement	Corporate Video	Lingmo International	Smartwatch Translation App	2018-02-16	Time2Translate translates 2 way spoken conversations in under 5 seconds across 9 IBM Watson languages. With over 85% accuracy, this wearable is the most translation device on todays market.	smartwatches, applications,Translation, Translator, Speech Recognition, Artificial Intelligence (AI), Real-Time, Machine Learning, Databases, Smartphone Applications, Mobile Applications, Voice Translation, Software, Earpiece	Lingmo International, Time2Translate (T2T),Bluetooth	Applications, Software, Conversation, Translation, Science, Communication, Social Interaction, Language	An Invention
Text	Super-Brainy Translation Tools Mean Language Barriers Are Falling Fast	Information	Newspaper Article	NBC News		2017-06-06	Article discusses advances to real-time translation software to break down language barriers	translator, wearable technology, smartphone applications, neural networks, algorithms, artificial intelligence, speech recognition, camera	iTranslate, Star Trek, Google, Google DeepMind, Facebook	translation, travel, conversation, social interaction, business, science, communication, language,	A Response to an Invention
Text	Real-time wearable translators put to the test in China – how did they do?	Information	Newspaper Article	South China Morning Post		2018-01-06	Translator wearable technology the ili from Japan and Hong Kong's Transay are compared and put to the test in real life situations.	transiator, wearable technology	ili, Transay, Logbar, Star Trek, Google Pixel Buds	translation, travel, conversation, technology, science, communication, language, social interaction, shopping	

Figure 5. Initial sorting and metadata management: Students use spreadsheets to identify objects in a curated collection and assign appropriate metadata to each category within an object.

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

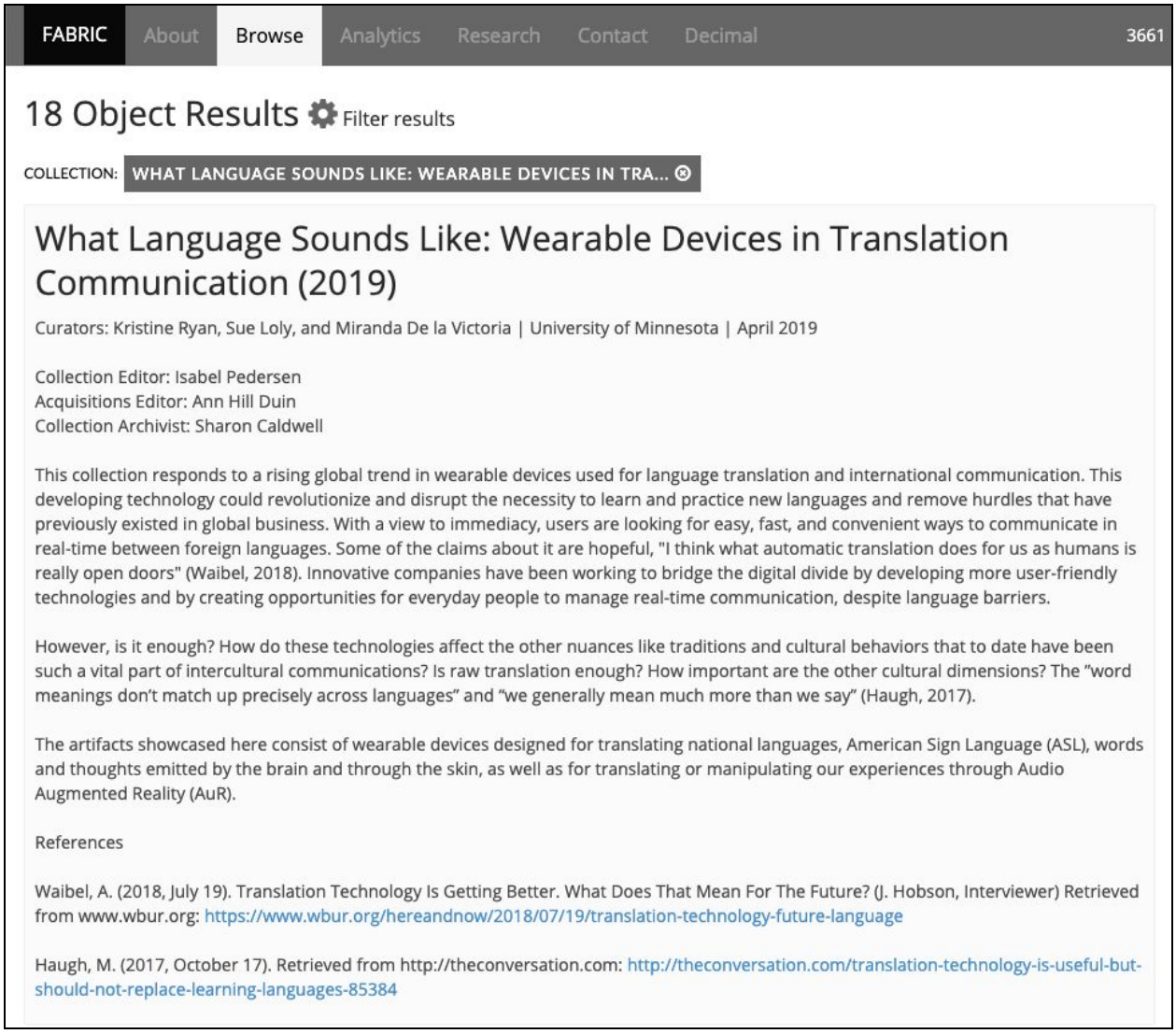


Figure 6. Front-end publication on Fabric: This is what a "collection" looks like when the students have completed a curation and published it to the Fabric collection page. Each collection consists of curatorial and editorial information, as well as an introduction that provides context to the curated objects.

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

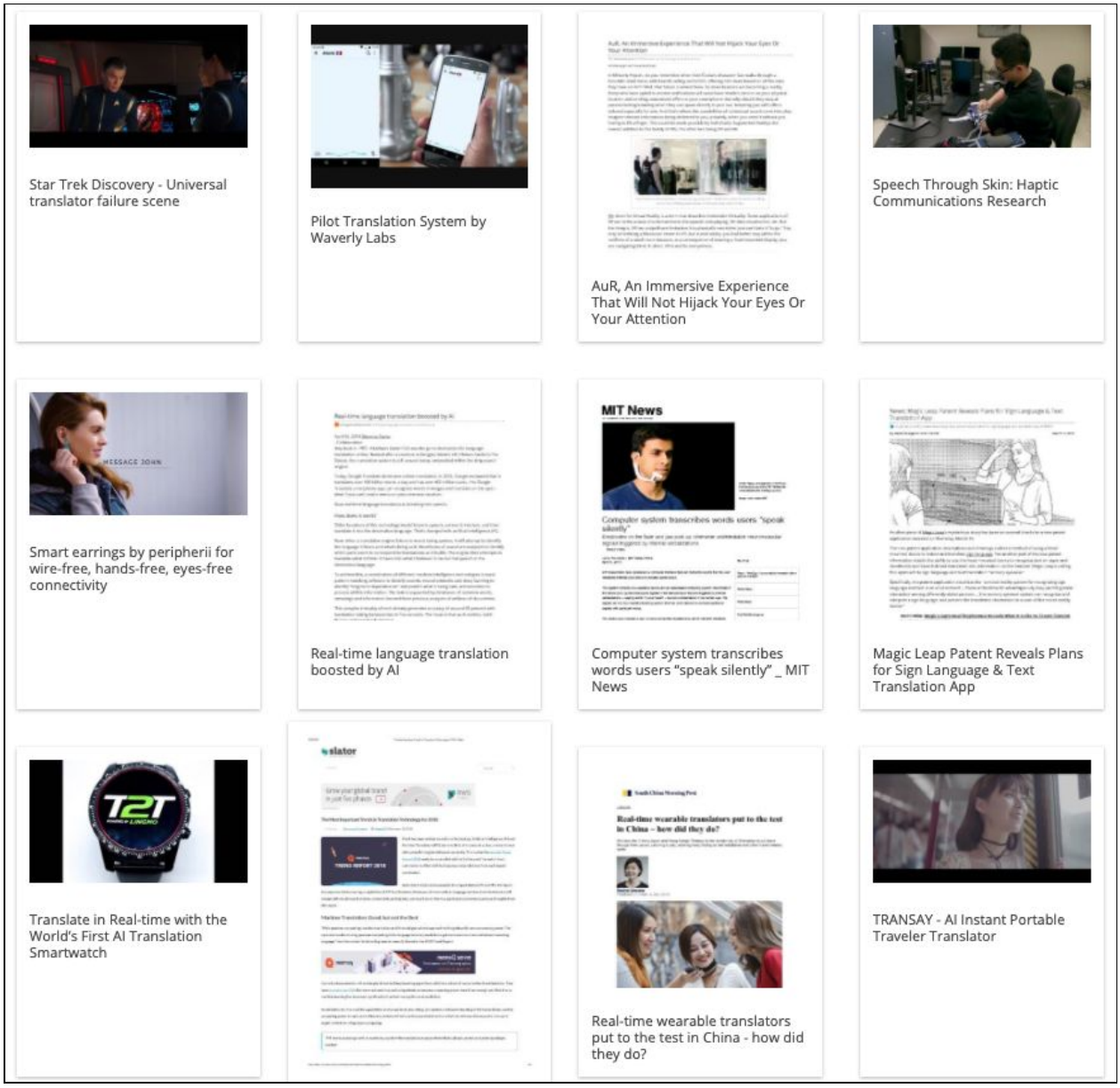


Figure 7. Browsable overview of objects in a collection: Below the introduction in a collection is a gallery view of objects curated with thumbnail images of the individual objects. Viewers can click on any thumbnail to open the object page shown in Figure 3 of our article.

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

APPENDIX D: EXAMPLES OF PEDAGOGICAL USES OF FABRIC

One main goal of any teaching situation is to have students become equipped with the knowledge, skills, and confidence to apply what they know to novel situations. This is afforded through the process of innovation. Harri Jalonen (2012) asserts that, "uncertainty is inherent in the innovation process" (n.p.). Thus, we believe that positioning students in situations of uncertainty is where learning occurs. The intersection of digital literacy, Fabric, and uncertainty can be a transformational experience for students, and was perceived to occur from students' reflections and responses to the assignments described above. For more assignment examples, consult our forthcoming article (Davis et al., forthcoming) where we document Fabric-based assignments and their associated learning objectives and outcomes.

Assignment: Students explore Fabric, review the various archived technologies, conduct audience analyses, and discuss results.

- **Activity**: Students selected a technology or an artifact that was interesting or relevant to them and performed an audience analysis. Students responded with an evaluation of the intended audience including what attributes might influence or shape the audience's interpretation, understanding, and use of the artifact.
- **Rationale**: For technical communicators, understanding one's audience is an essential part in the composition and delivery of communications.

Assignment: Students imagine they are composing a proposal to the Fabric curator committee to add a technology or artifact to a collection.

- **Activity**: Students collaborated with students from another course to write the proposal, meaning they negotiated communication methods and work efforts, used digital tools, and performed conflict resolutions throughout the assignment. Students were allowed the flexibility to select what collaborative tools and methods they used, and found that students were more engaged and discovered unique ways to support their proposal by calling attention to costs, benefits to target audience, uniqueness of the materials to construct the technology, as well as used unique sources of information as evidence. These were among the many strategies students used to research, source, and collaborative to compose and design the proposal.
- **Rationale**: Technical communicators regularly collaborate on communication projects that involve multiple stakeholders. Students collaborated with students from another course for the assignment; as a result, the instructor described this assignment as similar to work situations as individuals connect with clients and other employees on a global level using digital tools.

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

REFERENCES

About. (2020). Fabric of Digital Life. Retrieved from https://fabricofdigitallife.com/index.php/About/Index

ACRL. (2016). Framework for information literacy for higher education. Retrieved from http://www.ala.org/acrl/standards/ilframework

Berry, Patrick W., Hawisher, Gail E., & Selfe, Cynthia L. (2012). *Transnational literate lives in digital times*. Logan, UT: Utah State University Press/Computers and Composition Digital Press. Retrieved from https://ccdigitalpress.org/transnational

Bogost, Ian. (2012). *Alien phenomenology, or what it's like to be a thing*. Minneapolis, MN: University of Minnesota Press.

Brown, Elizabeth. (2018). *Learning through metaphor: An introduction to metaphors in information literacy*. Estonia, UK: Innovative Libraries Press.

Bryson, Krista. (2012). The literacy myth in the Digital Archive of Literacy Narratives. *Computers and Composition, 29*(3), 254–268.

Buckingham D. (2010) Defining digital literacy. In B. Bachmair (Ed.), *Medienbildung in neuen Kulturräumen* (pp. 59–71). VS Verlag für Sozialwissenschaften.

Byrd, Antonio. (2020). "Like coming home": African Americans tinkering and playing toward a computer code bootcamp. *College Composition and Communication, 71*(3), 426–452.

Cargile Cook, Kelli. (2002). Layered literacies: A theoretical frame for technical communication pedagogy. *Technical Communication Quarterly, 11*(1), 5–29.

Clark, Irene. (1995). Information literacy and the writing center. *Computers and Composition, 12*(2), 203–209.

Culatta, Richard. (2020). Mental models. InstructionalDesign.org. Retrieved from https://www.instructionaldesign.org/concepts/mental-models/

Davis, Katlynne; Hocutt, Daniel; Stambler, Danielle; Veeramootho, Chakrika; Tham, Jason; Duin, Ann Hill; Ranade, Nupoor; Misak, John; Pedersen, Isabel. (Forthcoming). Fostering student digital literacy through the Fabric of Digital Life. *Journal of Interactive Technology and Pedagogy*.

Digital Literacy Task Force Report (2016). *Digital literacy task force report*, Blacksburg, VA: Virginia Tech.

Feerrar, Julia. (2019). Development of a framework for digital literacy. *Reference Services Review, 47*(2), 91–105.

Fleckenstein, Kristie S.; Spinuzzi, Clay; Rickly, Rebecca J; & Clark Papper, Carole. (2008). The importance of harmony: An ecological metaphor for writing research. *College Composition and Communication, 60*(2), 388–419.

Gentner, Dedre. (1983). Structure-mapping: A theoretical framework for analogy. *Cognitive Science, 7*(2), 155–170.

Gibbons, Sarah. (2016). Design Thinking 101. Nielsen Norman Group. Retrieved from https://www.nngroup.com/articles/design-thinking/

Girón-García, Carol & Navarro Ferrando, Ignasi. (2014). Digital literacy and metaphorical models. *Multidisciplinary Journal for Education, Social and Technological Sciences, 1*(2), 160–180.

Graff, Harvey J. (1991). *The literacy myth: Cultural integration and social structure in the nineteenth century*. New Brunswick, NJ: Transaction Publishers. Originally published in 1979.

Accepted author manuscript: Consult published version for citation at https://doi.org/10.1016/j.compcom.2021.102628

Hawisher, Gail E, & Selfe, Cynthia L. (Eds.) (1989). Critical perspectives on computers and composition instruction. New York, ny: Teachers College Press.

Hawisher, Gail E, & Selfe, Cynthia L. (Eds.) (1997). Literacy, technology, and society: Confronting the issues. Upper Saddle River, N.J: Prentice Hall.

Hawisher, Gail E, & Selfe, Cynthia L. (Eds.) (1999). Passions, pedagogies, and 21st century technologies. Logan, UT: Utah State University Press.

Hewett, Beth L. & Thonus, Terese. (2019). Online metaphorical feedback and students' textual revisions: An embodied cognitive experience. *Computers and Composition, 54*, 1–22.

Jalonen, Harri. (2012). The uncertainty of innovation: A systematic review of the literature. *Journal of Management Research, 4*(1), 1–47. Retrieved from http://www.macrothink.org/journal/index.php/jmr/article/view/1039

JISC. (2015). *Developing students' digital literacy*. Retrieved from https://www.jisc.ac.uk/guides/developing-students-digital-literacy

JISC. (2019). *JISC digital capabilities framework: The six elements defined*. Retrieved from http://repository.jisc.ac.uk/7278/1/BDCP-DC-Framework-Individual-6E-110319.pdf

JISC. (2020). What is digital capability? Retrieved from https://digitalcapability.jisc.ac.uk/what-is-digital-capability/

JISC. (n.d.). Individual digital capabilities. Retrieved from https://digitalcapability.jisc.ac.uk/what-is-digital-capability/individual-digital-capabilities/

Johnson, Mark. (1987). *The body in the mind: The bodily basis of meaning, imagination, and reason.* Chicago, IL: University of Chicago Press.

Kress, Gunther. (1997). *Before writing: Rethinking the paths to literacy.* London, UK: Routledge.

Kress, Gunther. (2003). *Literacy in the new media age.* London, UK: Routledge.

Lakoff, George. (1987). *Women, fire, and dangerous things: What categories reveal about the mind.* Chicago, IL: University of Chicago Press.

Lakoff, George & Johnson, Mark (1980). *Metaphors we live by*. Chicago, IL: University of Chicago Press.

Lakoff, George. (1993). The contemporary theory of metaphor. In Andrew Ortony (Ed.), *Metaphor and thought (2nd edition)* (pp. 202–251). Cambridge, UK: Cambridge University Press.

Law, John. (2004). *After methods: Mess in social science research*. London, UK: Routledge.

Martin, Allan & Grudziecki, Jan. (2006). DigEuLit: Concepts and tools for digital literacy development. *Innovations in Teaching and Learning in Information and Computer Sciences, 5*(4), 249–267.

New London Group. (1996). A pedagogy of multiliteracies: Designing social futures. *Harvard Educational Review, 66*(1), 60–93.

Navarro Ferrando, Ignasi & Silvestre, A.J. (2009). The role of ICMs in cybergenre representation and reading modes. In M. Navarro Coy (Ed.), Practical approaches to foreign language teaching and learning. Linguistic Insights 78 (pp. 269–292). Berlin/NY: Peter Lang.

Nielsen, Jacob. (2010). Mental models. Nielsen Norman Group. Retrieved from https://www.nngroup.com/articles/mental-models/

Norman, Don. (2013). *The design of everyday things. Revised and expanded edition*. New York, NY: Basic Books.

Redish, Edward F. (1994). The implications of cognitive studies for teaching physics. *American Journal of Physics, 62*(6), 796–803.

Richards, Ivar A. (1979). *The Philosophy of Rhetoric*. London, UK: Oxford University Press.

Selber, Stuart. (2004). *Multiliteracies for a digital age.* Carbondale, IL: Southern Illinois University Press.

Selfe, Cynthia L. & Hawisher, Gail E. (2002). A historical look at electronic literacy: Implications for the education of technical communicators. *Journal of Business and Technical Communication, 16*(3), 231–276.

Selfe, Cynthia L. & Selfe, Richard. (1994). Politics of the interface: Power and its exercise in electronic contact zones. *College Composition and Communication, 45*(4), 480–504.

St.Amant, Kirk. (2017). Of scripts and prototypes: A two-part approach to user experience design for international contexts. *Technical Communication, 64*(2), 113–125.

Tyner, Kathleen. (1998). *Literacy in a digital world: Teaching and learning in the age of information.* Mahwah, NJ: Lawrence Erlbaum Associates.

University Libraries launches digital literacy framework. (2018, March 8). *Virginia Tech Daily*. Retrieved from https://vtnews.vt.edu/articles/2018/03/univlib-digitalliteracy.html

Wolff, Phillip & Gentner, Dedre. (2011). Structure-mapping in metaphor comprehension. *Cognitive Science, 35*(8), 1456–1488.

Wysocki, Anne F. & Johnson-Eilola, Johndan. (1999). Blinded by the letter: Why are we using literacy as a metaphor for everything else? In G.E. Hawisher and C.L. Selfe (Eds.), *Passions, pedagogies and 21st century technologies* (pp. 349–368). Logan, UT: Utah State University Press.

Zimmerman, Jonathan. (2020, March 10). Coronavirus and the great online-learning experiment. *The Chronicle of Higher Education*. Retrieved from https://www.chronicle.com/article/Coronavirusthe-Great/248216